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FIFTH UNITED NATIONS REGIONAL CARTOGRAPHIC CONFERENCE FOR ASIA AND THE FAR EAST

8 - 22 March 1967, Canberra, Australia

Vol. 2. Proceedings of the Conference and Technical Papers

UNITED NATIONS

Department of Economic and Social Affairs

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FOREWORD

The official records of the Fifth United Nations Regional Cartographic Conference for Asia and the Far East, held in Canberra, Australia, from 8 to 22 March 1967, are issued, as were those of the previous conferences in two volumes: volume 1, *Report of the Conference*,[1] and the present publication, volume 2, *Proceedings of the Conference and Technical Papers*.

This volume is in two parts: part I contains the summary records of the eight plenary meetings, part II the texts of the technical and information papers submitted to the Conference by the participating Governments.

These technical papers are grouped according to the agenda item to which they relate. They have been edited in accordance with United Nations practices and requirements.

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the United Nations Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

[1] *Fifth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 1, *Report of the Conference* (United Nations publication, Sales No.: E.68.I.2).

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[1] Except for certain captions, the figures appearing in this volume have been reproduced from the papers submitted by Governments without alteration.

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SUMMARY RECORD OF THE FIRST PLENARY MEETING

Held at the Academy of Science, Canberra, Australia, on Wednesday, 8 March 1967, at 10.30 a.m.

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Temporary Chairman: **Mr. URETA, Executive Secretary of the Conference**

Present:

The representatives of the following: Australia, Cambodia, Canada, China, Democratic Republic of the Congo, Federal Republic of Germany, France, Holy See, India, Indonesia, Iran, Israel, Japan, Lebanon, Malaysia, Malta, Netherlands, New Zealand, Norway, Portugal, Peru, Philippines, Republic of Korea, Republic of Viet-Nam, Switzerland, Syria, Thailand, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland, United States of America, Western Samoa.

Observers from the following organizations: United Nations Educational, Scientific and Cultural Organization, Intergovernmental Oceanographic Commission, International Federation of Surveyors, International Geographical Union, International Hydrographic Bureau, International Society of Photogrammetry.

Address by the Rt. Hon. David Fairbairn, Minister for National Development, Commonwealth of Australia

Mr. FAIRBAIRN (Australia) welcomed the many visitors from overseas countries, from the ECAFE region and other parts of the world, Members of the United Nations as well as members of specialized agencies. He was glad of the opportunity to meet and learn from overseas visitors and to discusss with them the uses to be made of cartographic processes, particularly in the field of national development.

The definition of cartography that had been adopted for the purpose of the current meetings covered every operation in the preparation of all types of maps and charts, from original field surveys to the final printing of maps.

Scientific data superimposed on a basic topographic map might themselves result from intensive field surveys, including airborne surveys and laboratory research followed by analyses and synthesis. The topographic base map might have involved precision air photography and a basic geodetic survey including the use of electronic distance-measuring equipment, supplemented by modern airborne techniques of control survey and processed through computers and automatic stereoplotting equipment.

Australia had now completed the initial air photography of the continent and compiled all its maps, two-thirds of which had been published.

The Government had recently decided on a programme of 1:100,000 scale mapping, with 20 m contours, over the whole of Australia and New Guinea, and had instructed that the task be completed in the course of 1975. Co-ordination of Commonwealth and state activities in the programme would be effected through the National Mapping Council.

Australian resources investigations were being undertaken by government agencies. They included geological and geophysical regional mapping of the whole of Australia, generally at a scale of 1: 250,000, a regional gravity survey with coverage of one station per 50 square miles, while regional aeromagnetic and air radiometric surveys were also under way.

Seismic surveys were being used increasingly, particularly in petroleum exploration, and the science of geochemical analysis had also been used in exploration and assessment.

The Government's policy had been to provide useful data and create a climate favourable to mineral development, a policy that had paid handsome dividends in discoveries of mineral wealth during recent years.

Although Australia appeared to be well endowed with mineral wealth, it was sadly lacking in water, and the development of the interior for pastoral pursuits would depend on accurate assessment and careful utilization of the surface and sub-surface supplies. The Commonwealth and state governments were co-operating actively in that field.

In forestry and forest industries, scientific research was playing a major part in preparing the way for large-scale development, in the control of insect forest pests and also of fire.

Excellent work had been done by the Commonwealth Scientific and Industrial Research Organization (CSIRO) in the fields of soil survey and land use surveys.

On their visit to the Snowy Mountains area, the representatives would see and hear of the survey and cartographic techniques that were applied from the planning and development phases through to the completion of the vast engineering projects that were now in their final phases, and incidentally how carefully the available water was being used for the dual purposes of generating hydro-electric power and ultimately for irrigation.

He hoped that those would not be the only impressions of Canberra and Australia that the visitors would take away with them but that, when their deliberations were completed, they would feel that their visit had benefited them professionally and personally.

Australia would benefit from their visit and their collective professional skills and would in return endeavour to help the developing countries of the region to the best of its ability.

The delegates had a rewarding and indeed exciting task ahead of them as they applied their wide range of cartographic activities to the planning and development of the great region that they represented, and he expressed the hope that the Conference would be extremely successful.

Statement by the Temporary Chairman

The TEMPORARY CHAIRMAN, speaking on behalf of the Secretary-General of the United Nations, welcomed the delegates to the Fifth United Nations Regional Cartographic Conference for Asia and the Far East. He expressed his thanks to the Government of the Commonwealth of Australia for its cordial reception to delegates and its excellent arrangements for the Conference.

It was interesting to recall the last four conferences which had been held in the region, and how effective collaboration had been initiated among the cartographic services represented in all four, from the first in Mussoorie, India, in 1955, the second in Tokyo, Japan, in 1958, the third in Bangkok in 1961 and the fourth in Manila in 1964. The information which had been exchanged among the developing countries of the region and those already cartographically advanced had been to the mutual benefit of both.

He also stressed the important role of cartography in modern society, especially in connexion with the development of natural resources, transportation, navigation and more generally in economic planning.

Since the Manila conference, the countries of the region had launched many new projects to help accelerate their development. There had been increasing co-operation on the international level between countries on matters relating to cartography; for example, there was now a Map Information Office for the region in Bangkok and several of the countries were organizing or had already organized training centres to cover the various disciplines of surveying and mapping.

Since the Manila conference, the hypsometric tint scales which had been agreed upon by the working group appointed at the Bonn Technical Conference on the International Map of the World on the Millionth Scale had been published. Copies of those hypsometric tints could be found in the 1965 report of the IMW, which would be distributed at the current conference.

In the autumn of 1965, there had been held in Denmark a United Nations interregional seminar on the application of cartography for economic development, attended by participants from Latin America and Africa. The programme had covered most of the subjects related to cartography. Another such seminar would also take place in Denmark from 15 May to 10 June that year. All the developing countries of ECAFE had been invited to submit nominations for candidates to participate in that seminar. He hoped that many of the countries represented at the current conference which had received such invitations would be able to nominate officials from their surveying institutes to attend the seminar. In addition, it was expected that there would be a post-seminar study tour to visit cartographic institutes in both the Federal Republic of Germany and Switzerland.

At its thirty-ninth session, the Economic and Social Council had decided to convene a United Nations Conference on the Standardization of Geographical Names in Geneva from 4 to 22 September 1967. A resumed session of the 1960 group of experts had met at United Nations Headquarters from 21 March to 1 April 1966 on the subject and in its report had prepared helpful guide lines for the forthcoming conference. That report was being made available to each delegation. Whatever could be achieved by the Conference on the Standardization of Geographic Names would be aided by any work done in Canberra on the subject.

The United Nations had also been very active in extending technical assistance in cartography to the developing countries, especially in the ECAFE region, where United Nations technical assistance experts in surveying and mapping were currently operating in ten countries. Cartography had also become a field for preinvestment activities. To date four Special Fund projects had been approved, three of which are in the ECAFE region, two to help in the expansion of a governmental mapping institute and the other to complete the large-scale mapping of a sizeable area, in order to meet immediate area requirements.

Experience had shown that it was highly desirable, from both the technical and the economic point of view, that planners, administrators and engineers should be able to obtain easily and quickly existing crude data on surveying and mapping in whatever form or presentation they might be available. Information on the availability of such material was very helpful in reducing delay in policy-making decisions and avoiding an unrealistic approach to certain technical questions. There had been too many instances recently where failure to obtain at the outset even the simplest cartographic data available had led to the failure of important projects. In the ECAFE region, fortunately, much progress had been achieved in the dissemination and improvement of available data since the first conference.

The deliberations and accomplishments of the fifth conference might thus be expected to have an immediate bearing, not only on the improvement of cartographic work, but also on the economic and social development of the region.

On behalf of the Secretary-General, he expressed to the delegates his best wishes for the success of their work.

Vote of thanks to the Government of Australia

Mr. MARASHI (Iran) thanked the Australian Government for the hospitality it had shown and for the excellent facilities it had provided in Canberra.

Colonel HERNDON (United States of America), speaking on behalf of countries outside the ECAFE regional boundaries, said that such boundaries were administrative and had limited significance for an impact on cartographic endeavour, as was evidenced by the renewals of world-wide friendships and acquaintances which occurred at such conferences.

The solutions to many difficult tasks might stem from such meetings and he expressed the gratitude of the delegates to the Australian hosts and the United Nations staff for their efforts to make the conference a successful one.

Mr. KASHIN (Union of Soviet Socialist Republics) said that his country was conscious of the role of geodesy and cartography in the development of countries of the region, and hoped to be able to make some contribution to that development.

He thanked the Australian Government for its hospitality and excellent arrangements in Canberra.

Adoption of the rules of procedure

[Agenda item 1]

The TEMPORARY CHAIRMAN submitted to the Conference for adoption the draft rules of procedure, prepared on the basis of the rules of procedure used at previous conferences.[1]

The rules of procedure were adopted unanimously.

[1] *Fourth United Nations Regional Conference for Asia and the Far East*, vol. 1 (United Nations publications, Sales No.: 65.I.16), pp. 20–22.

Election of officers

[Agenda item 2]

The TEMPORARY CHAIRMAN called for nominations for the office of President.

Lieutenant-General SOMBOON (Thailand) nominated Mr. R. W. Boswell, Secretary of the Department of National Development, Australia.

Mr. MARASHI (Iran) seconded the nomination.

Mr. Boswell (Australia) was unanimously elected President and took the chair.

The PRESIDENT thanked the representatives of Thailand and Iran for their nomination. He drew attention to the fact that three-quarters of the nations in the ECAFE area were represented and expressed confidence in the success of the conference.

The meeting rose at 11.25 a.m.

SUMMARY RECORD OF THE SECOND PLENARY MEETING

Held at the Academy of Science, Canberra, Australia, on Wednesday, 8 March 1967, at 2 p.m.

CONTENTS

President: **Mr. R. W. Boswell (Australia)**

Election of officers (*concluded*)

[Agenda item 2]

The PRESIDENT called for nominations for the offices of First and Second Vice-President.

Mr. INOUE (Japan) nominated for the office of First Vice-President the representative of Iran, Mr. Badredin Marashi.

Major TEAO SUNTHAN (Cambodia) seconded the nomination.

Mr. Marashi (Iran) was unanimously elected First Vice-President.

Mr. LAMBERT (Australia) proposed Colonel Pranoto (Indonesia) for the office of Second Vice-President.

Mr. BOYES (New Zealand) seconded the nomination.

Colonel Pranoto (Indonesia) was unanimously elected Second Vice-President.

The PRESIDENT called for nominations for the office of Rapporteur.

Mr. AHMAD DAUD (Malaysia) nominated Commander Tabin (Philippines) for the office of Rapporteur.

Mr. TOMANE (Western Samoa) seconded the nomination.

Commander Tabin was unanimously elected Rapporteur.

It was agreed that Mr. Lines (Australia) should be requested to serve as Rapporteur pending Commander Tabin's arrival.

Adoption of the agenda

[Agenda item 3]

The PRESIDENT submitted the provisional agenda[1] for the approval of the conference.

The agenda was adopted unanimously.

The PRESIDENT announced that agenda item 4, report on credentials, would be made available at a later date. He asked representatives who had not submitted their credentials to endeavour to submit them within twenty-four hours.

[1] Issued as E/CONF.52/1 and E/CONF.52/2 and Add.1 and Corr.1.

Establishment of technical committees

[Agenda item 5]

The PRESIDENT asked for comment on the technical committees as listed in the annotated provisional agenda.[2]

Mr. LAMBERT (Australia) suggested that the names of the committees should be amended as follows: Committee I, Geodesy and control surveys; Committee II, Topographical cartography; Committee III, Topical cartography; Committee IV, General cartography; Committee V, Hydrography and oceanography.

The PRESIDENT suggested that an *ad hoc* steering committee should be formed consisting of the President, the First and Second Vice-Presidents and the representatives of Thailand, the USSR and the United States of America to confirm the names of the technical committees, classify the papers and prepare a work programme for each committee. He suggested further that Mr. Lambert (Australia) should act as secretary for the committee.

It was so agreed.

Progress reports by countries on their respective cartographic activities since the last conference

[Agenda item 6]

Major SUNTHAN (Cambodia) said that his country's geographic service had had initial difficulties in training personnel and securing modern equipment. The service was now well on the way to being firmly established, with the aid of foreign and local experts.

Many maps had been produced on scales varying between 1:5,000 and 1:2,000,000. They consisted of colour lithographic maps, both contoured and uncontoured, mono-colour maps, photo-mosaics, ozalid sheets and the like. The maps served many purposes; they included sheets for airports, townships and for economic, irrigation, tourist and administrative purposes.

Progress in astronomical and geodetic work had been slow owing to lack of funds. First- and second-order levelling of 850 km had been completed. Additional levelling of 550 km had been completed to aid in the general mapping programme.

Mr. TUTTLE (Canada) stated that his delegation had not submitted a detailed progress report but wished to draw attention to a number of points.

The Surveys and Mapping Branch was now a part of a newly formed Department of Energy, Mines and Resources. The Topographic Division of that branch was responsible for the topographic mapping, including reproduction of lithographic maps, of the total area of Canada.

[2] Issued as E/CONF.52/2 and Add.1 and Corr.1.

The need for aeronautical charts continued to increase. Work was continuing on the use of shaded relief and hypsometric tints for easy interpretation of charts.

He had no detailed report from the Hydrographic Charting Branch, but work was continuing to expand in charting areas round the coast. The charting of the northern ocean areas had been one of the major efforts. A new requirement for charts for inland waterways had assumed major proportions. Research continued in the development of more accurate and effective sounding methods and instruments.

In the topographical mapping field, the Department of Defence has recently withdrawn almost completely from the national mapping field and the Surveys and Mapping Branch had now full responsbility for the standard national topographic series at scales of 1:25,000, 1:50,000 and 1:250,000. Small-scale maps such as those at 1:500,000 and 1:1,000,000 were produced by compiling from the larger-scale maps. Effort had been concentrated for several years on completing coverage at 1:250,000 and the end of that programme was now in sight; it was expected to have full coverage by the end of 1967.

Requirements for more detailed maps at 1:50,000 had increased substantially as the country had awakened to the need for extended studies of resources of all forms. That had necessitated a considerable revision of the department's mapping techniques and improvement in instrumental holdings. It had also meant an extensive programme of new aerial photography, both for new plotting with closer contours and revision of all outdated maps. Production of new maps had been reasonably well maintained at about 200 sheets per year (15′ latitude × 30′ longitude), or roughly 70,000 square miles. No plans existed at the moment for complete national coverage at the 1:50,000 scale, but the department continued to concentrate on areas of economic importance. A recent map users' conference had been of great assistance in indicating the over-all requirement and the great need for strong expansion of the mapping effort.

In the 1:25,000 series, work continued in a programme to produce coverage of the urban, suburban and heavily populated areas and the department produced some thirty-five to forty sheets each year. Work had also continued in the populated areas in the establishment of second-order control traverses based on the geodetic first-order positions.

No detailed report of the geodetic survey programme had been provided for the conference, but continued progress had been maintained in the extension of geodetic first-order networks and levelling control. A major development in the field had been the introduction of Aerodist trilateration in first-order control. A paper entitled "Aerodist in geodetic surveying in Canada" would be presented to the Conference.[3]

Mr. KNORR (Federal Republic of Germany) stated that, since 1945, the organization of surveying and mapping in his country had been decentralized. Each of the eight German federal states had its own state survey office, equipped with modern installations, instruments, devices and machines. In addition, there were two federal institutions: the Institute for Applied Geodesy, mainly concerned with research work, and the German Hydrographic Institute, which was responsible for nautical and hydrographic charts. To co-ordinate the surveying and mapping work, the states had established a working committee representing all the state survey offices. The research work to be undertaken was determined by the German Geodetic Commission. Survey data and documents had existed in Germany for several decades. Current work consisted mainly in improving such data, revising documents and conducting scientific studies.

The existing primary triangulation network of Germany had been completed and extended. Several stations located on different islands in the North Sea had been reobserved. For those observations, a combination of angular measurements and electronic distance measurements had successfully been applied. Within the scope of the new adjustment of the European primary triangulation networks for scientific purposes, several geodetic base lines had been remeasured in western Germany by means of invar wires and electronic distance measuring equipment in order to check the scale.

Additional astronomical azimuths had been observed in order to improve the orientation of the triangulation net.

Astronomical deflections of the vertical had been observed and gravity measurements had been made to determine the position of the geoid in western Germany.

Numerous gravity measurements had made it possible to connect former measurements with the European milligal. On that basis, gravity maps of western Germany had been prepared.

The earth tide service had been continued. A considerable increase in the accuracy of the observations had been achieved by installing an electric spring in a gravimeter.

Practical photogrammetry had primarily been used for land consolidation, cadastral survey, for the preparation of the base map at 1:5,000 scale and for the revision of existing map series by the survey offices. However, the first of those tasks had also been carried out by automated terrestrial procedures using special theodolites, electronic computers and plotting instruments.

Research projects in the field of photogrammetry were performed mainly in connexion with the European Organization for Photogrammetric Experimental Studies (OEEPE) and the International Society for Photogrammetry (ISP). Here the recent studies made with the Orthoprojector were worthy of note.

With regard to the mapping activities of the official map series, the preparation of a base map at 1:5,000 scale was continuing. The topographical map at 1:25,000 (2,086 sheets) and the new topographical map at 1:50,000 (562 sheets) covered the whole country. A new topographical map at 1:100,000 (156 sheets) was being prepared and was in the first stages of completion. A new general topographical map at 1:200,000 (46 sheets) was also being prepared. When preparing the new sheets of the International Map of the World at 1:1,000,000 (IMW), the new specifications of the United Nations would be observed. Furthermore, the eight sheets of the World Aeronautical Chart (WAC) (ICAO) 1:500,000 of Germany had been revised. The four sheets of WAC at 1:1,000,000 covering the country had been completed.

In the cartographic research section of the Institute for Applied Geodesy, problems of generalization and representation of morphological small forms had been studied for the topographic general map at 1:200,000, using photogrammetric procedures.

In the field of map printing, tests had been made to reduce

[3] See part II of the present volume, under agenda item 8 (*a*).

the number of printing processes with multicoloured small-scale maps. Those tests had successfully been completed and the procedure had already been applied in practice.

The foregoing summary would clearly show that even a country which had long possessed excellent survey data would never be done with surveying and mapping if it was sufficiently interested in improving and revising its map material and participating in research work.

Colonel PRANOTO (Indonesia) said that his country's geodetic survey had been extended in the eastern part of Flores Island, and computations on the Bessel ellipsoid had been carried through the Bali, Lombok, Sumbawa and Flores islands. Computations were made on desk machines. The surveys had all been carried out by the geodetic department of the Army Topographical Service. Ten primary and twenty secondary points had been measured.

Control for large-scale and project mapping had been established in other areas.

Third-order levelling had been carried out in Java, Sumatra and Kalimantan, and six astronomical stations had been established in conjunction with Australian survey teams to help determine the border between West Irian and Papua-New Guinea.

A ten-year topographic mapping programme had been initiated on scales of 1:25,000, 1:50,000, 1:100,000 and 1:200,000, and some large-scale project mapping had been produced for developmental purposes.

A national atlas was in process of compilation; twenty-five sheets had been printed and forty compiled of the 100 or so required for the finished volume.

Four sheets of the World Aeronautical Series had been printed; also two sheets of the IMW.

Mr. MARASHI (Iran) said that first- and second-order geodetic surveys had been completed over 300,000 km^2, and a similar area had been covered by first- and second-order levelling.

70,000 km^2 had been mapped at 1:50,000 scale with 10 m contours, 650,000 hectares of irrigation land at 1:20,000 with 2 m contours, and 900,000 hectares of irrigation land at 1:5,000 scale with 1 or 0.5 m contours. The photography for that mapping had been flown at 1:10,000 and 1:7,000 scale.

Large-scale cadastral and road survey mapping ran to approximately 2 million hectares per year.

To maintain that progress, the cartographic organization had printed eight maps per day during the previous two years.

Mr. ELSTER (Israel) reported progress on the geodetic survey. The trigonometric network had been re-established in the densely populated central part of the country, where existing points had been largely destroyed. In the southern part, sixty-eight triangles had been observed, completing that major network.

Approximately 1,500 km of precise levelling had been completed. Two 10 km lines between fundamental points had been relevelled after two years, disclosing movements of up to 3 cm of intermediate marks in clay soils.

Magnetic observations at the field observatory and other field stations had continued.

Computer programmes for an IBM 360/50 computer were employed for most computations.

Premarked ground control points were utilized for all aerial photography, which was plotted by A7 and A8 autographs, coupled to co-ordinatographs and card punches.

Photo-compilation at 1:10,000 and 1:50,000 scales generally supplied the material for mapping at all the standard scales of 1:10,000, 1:20,000, 1:50,000, 1:100,000 and 1:250,000.

The large-scale Atlas of Israel had been completed in 1964.

The College of Land Surveying had been established under the auspices of the Survey of Israel. A three-year syllabus was designed to cover all aspects of land surveying and related fields.

Mr. INOUE (Japan) spoke of the revision survey of the 330 principal first-order geodetic stations in his country. Periodic re-surveys to detect crustal movements were considered a possible means of earthquake prediction. The first revision, commenced in 1947, would be completed in 1967.

A universal programme had been established for the adjustment of any triangulation and traverse network, and all computations were handled by an electronic computer, NEAC 2206, made in Japan.

A second revision of the 16,000 km first-order levelling network had been commenced in 1962; this was also a potential key to earthquake prediction.

Satellite observation stations would be set up at Saporo, Kanoya and at the Geodetic Observatory at Mt. Kanozan for observations of geodetic satellites. Connexions had been made to some outlying islands by satellite observation.

The Western Pacific calibration line for gravity surveys had been established, and a resurvey of the second-order gravity network was in progress.

The ninety-two first-order and 800 second-order magnetic stations were being reobserved in a continuing programme.

The ten-year project of producing the new national base map, reported at Manila, had been carried out as scheduled. The 1:25,000 base maps would be revised every three years in urban areas and every ten years in mountainous areas.

The photography of half of Japan's area was repeated at three- to five-year intervals; the remainder, being forest, was rephotographed by the bureau of forests as required.

Three sheets of the IMW covering the main islands of Japan had been completed and issued in 1966.

Thematic and geological mapping had proceeded at a rapid pace.

The Hydrographic Office had made astronomical observations, including lunar occultations and satellite observations. The Japanese Ephemeris, *Nautical Almanac*, and abridged *Nautical Almanac* were computed and published annually.

Japan was the oceanographic data centre for the United Nations oceanographic programme and was one of the most active nations in that sphere.

Mr. VAN DER WEELE (Netherlands) said that while his country was not engaged in mapping activities within the region, he hoped that its efforts in training students at the International Training College in Delft, acting as consultants on mapping techniques, and supplying staff for a photo-interpretation school would make some contribution to the development of the ECAFE countries.

Mr. BOYES (New Zealand) gave a general review of the development of the New Zealand survey system, as that was the first attendance by his country at a United Nations cartographic conference, and spoke of recent progress in the various fields.

Apart from cadastral surveys of private land, all control surveys and mapping activities were the responsibility of the Department of Lands and Survey.

Geological, gravity and magnetic surveys were carried out by the Department of Scientific and Industrial Research.

He traced the development of the survey system from the nine separate departments merging into one in 1876, and adopting the Torrens title system of land tenure, to the current situation of twenty-nine "meridional circuits". Those were areas of plane co-ordinate reference systems; their separate initial stations had been connected by the main geodetic triangulation by 1949. It was a reversal of the classic "whole" to the "part" system.

The international spheroid was used, as well as the transverse Mercator projection.

Some 2,200 miles of first-order levelling had been completed, with dynamic heights referred to latitude 45° and orthometric heights listed.

Photographic coverage was almost complete, although the "land of the long white cloud" lived up to its name, to hinder that programme.

Current topographic mapping policy was to complete the 1:63,360 scale coverage within five years. Sheet boundaries were unfortunately on yard grid lines, which would make the eventual change-over to metres a difficult one.

A specialist photogrammetric branch using Williamson wide-angle multiplex and Wild B8 instruments produced 1:25,000 and 1:63,360 mapping for national coverage, plotting on stable plastic materials at 1:15,840 and 1:47,520 scales respectively. Large-scale mapping for engineering purposes was produced using Wild A5, A7, A8 and Thompson-Watts plotters.

Aerial photography was carried out with a recently acquired Wild RC9 camera and an RC8 followed by aerial triangulation on A7 or A9, digitized with normal EK3 combination.

Early triangulation had been strengthened by tellurometer measurements.

Programmes were being progressively developed for the Elliott 503 electronic computer to cover geodetic and photogrammetric computations, tidal analyses and cadastral work.

First-order levelling only was carried out by the Department of Lands and Survey, totalling 2,200 miles to date, yielding information on the considerable range of earth movements which occurred.

His country had a direct interest in the cartography of the region in that New Zealand staff were supplied for the school of surveying at Kuching.

The meeting rose at 5.05 p.m.

SUMMARY RECORD OF THE THIRD PLENARY MEETING

Held at the Academy of Science, Canberra, Australia, on Thursday, 9 March 1967, at 9.30 a.m.

CONTENTS

President: Mr. R. W. BOSWELL (Australia)

Establishment of technical committees (*continued*)

[Agenda item 5]

The PRESIDENT advised members that the *ad hoc* steering committee recommended the establishment of five technical committees, as follows: Committee I: Geodesy and Control surveys (agenda item 8a); Committee II: Topographical cartography (agenda item 8b); Committee III: Topical cartography (agenda item 9 and first part of agenda item 10); Committee IV: General cartography (second half of agenda item 10, agenda items 11–15 inclusive); Committee V: Hydrography and oceanography (agenda item 16).

The recommendation was adopted.

The PRESIDENT noted that the steering committee had yet to allocate papers to each technical committee. He called for nominations for the chairmen of the five technical committees.

Mr. LAMBERT (Australia) nominated Major Sunthan (Cambodia) for the office of Chairman of Committee I.

Mr. TOMANE (Western Samoa) seconded the nomination.

Major Sunthan (Cambodia) was unanimously elected Chairman of Committee I.

Colonel SHARMA (India) nominated Mr. Boyes (New Zealand) for the office of Chairman of Committee II.

Lieutenant-General SOMBOON (Thailand) seconded the nomination.

Mr. Boyes (New Zealand) was unanimously elected Chairman of Committee II.

Mr. MARASHI (Iran) nominated Mr. Montrakun (Thailand) for the office of Chairman of Committee III.

Major NGUYEN VAU KHAI (Republic of Viet-Nam) seconded the nomination.

Mr. Montrakun (Thailand) was unanimously elected Chairman of Committee III.

Mr. BOYES (New Zealand) nominated Colonel Sharma (India) for the office of Chairman of Committee IV.

Professor TSAO MO (China) seconded the nomination.

Colonel Sharma (India) was unanimously elected Chairman of Committee IV.

Colonel PRANOTO (Indonesia) nominated Mr. Nagatani (Japan) for the office of Chairman of Committee V.

Mr. KASHIN (Union of Soviet Socialist Republics) seconded the nomination.

Mr. Nagatani (Japan) was unanimously elected Chairman of Committee V.

Progress reports by countries on their respective cartographic activities since the last conference (*continued*)

[Agenda item 6]

Mr. GLEDITSCH (Norway) stated that Norway's survey and mapping problems were so different from the problems of countries in the region that he would give only a brief résumé of its activities. However, the techniques used to overcome adverse natural conditions might be of some assistance to countries in the region.

Norway was 1,500 miles long and in parts as narrow as 3 miles, with a coastline so indented as to be of the same length as that of Australia. In the south, only five days were fit for aerial photography, and fewer in the north.

Modern techniques of electronic computing, trilateration, helicopter transport and photogrammetric scribing had enabled completion of the first-order triangulation and publication of seventy map sheets at 1:50,000 scale over the last ten years. Another fifty to be published in 1967 would complete one-third of the current programme.

Norway received help from the United States Army Map Service in map reproduction.

The country was fairly densely covered with nets of precise levelling, gravity and magnetic observations.

The Norwegian obligations for IMW and ICAO mapping had been fulfilled.

A 1:5,000 scale mapping programme had been functioning for two years, on the basis of a decentralized organization employing private firms under government supervision for some phases, the provinces bearing responsibility for their own areas.

Mr. SCHOLL (Switzerland) would only summarize his country's activities and progress in surveying and mapping in view of the different nature of the terrain of his country from that of most of the region.

The geodetic survey from first-order to third-order standards was now complete, with a density of one station to every 20 km^2.

The national levelling network had now been re-measured and movements of the earth's crust had been measured in many places.

Re-mapping at scales of 1:50,000, 1:100,000 and 1:500,000 had been completed in 1965. it was hoped to complete the 1:25,000 series by 1972. Mapping at scales of 1:5,000 and 1:10,000 was also partly completed.

A revision of the 1:25,000 national mapping series was in hand.

Aerial photography at scales of 1:25,000 and 1:30,000 was used for the revision of the national maps series on the scale of 1:25,000.

Colour aerial photography had an application in Switzerland to interpretation problems but was not likely to be useful in photogrammetrical plotting in the next few years.

Two volumes of the planned total of nine of the Atlas of Switzerland had already been published.

The Swiss Federal Topographic Service, within the framework of bilateral technical co-operation and also at the request of the United Nations, had delegated one expert each in cartography, reproduction techniques and photography for one or two years as instructors to developing countries.

He also referred briefly to the work of the Swiss Federal Directorate of Cadastral Surveys.

The next General Assembly of the International Union for Geodesy and Geophysics would take place in Switzerland from 25 September to 7 October 1967. For organizational reasons, the meetings of the associations making up the union must be divided as follows: Zurich: International Association for Vulcanology, International Association for Seismology; Bern: International Association for Hydrology, International Association for Oceanography; Lucerne: International Association for Geodesy, International Association for Meteorology; St. Gallen: International Association for Geomagnetism and Aeronomy.

Late in 1966, the Swiss school for photogrammetric operators had been established in St. Gallen. The school accepted students from all countries and gave them a thorough training as instrument operators in six-months' courses. On passing the examinations before a panel of internationally known experts, the graduates were awarded diplomas.

Mr. BOTELHO (Portugal) gave a brief summary of survey and mapping progress in Portuguese overseas provinces since the previous conference.

A geodetic connexion had been made from the island of Atauro to Timor by a Portuguese geographic mission. Geodetic and levelling surveys had been made in Timor. Gravity observations had been carried out in the Dili-Maubara area.

He said that 152 km^2 of contour mapping had been completed at a scale of 1:50,000. Existing maps had been improved by photogrammetric aerotriangulation over the whole of Portuguese Timor, using a Wild EK 5 co-ordinatograph and SL15 punched tape. Horizontal adjustments had been made by the van der Weele method with the aid of an electronic computer and vertical adjustments had been made graphically.

Nineteen sheets of the thirty-seven required to cover the area had been compiled, drawn and published in six colours. Eleven other sheets were in hand.

Hydrographic charts of the Port of Macao had been produced at 1:10,000.

Mr. KERZOM (Syria) said that, since 1964, 4,600 km^2 had been mapped, comprising eight sheets at 1:50,000. Most of the country was now covered, but some desert and frontier regions still required basic geodetic survey.

Adjustments would be made by the variation of co-ordinates method, using the electronic computer which was now being introduced. Programmes were being written for geodetic and levelling calculations.

Practically all the area covered to date by the base map had been precision levelled, the lines of levels totalling 3,300 km. One tide gauge was in operation and a second was in process of installation.

Aerial photography had been flown by an Ilyushin 14 aircraft equipped with a 210 mm focal-length camera. A recently acquired RC9 wide-angle camera would be installed in a new aircraft.

Some large-scale mapping for town planning purposes had been carried out, while 1:80,000 scale photography, almost completely covering the Syrian desert, had been used for 1:50,000 scale mapping.

The topographic programme was directed primarily to completion of the base map. In the matter of cartographic techniques, his Government was very interested in the adoption of engraving on glass.

His delegation would closely inspect the reports of other countries seeking technical information, such a conference being an excellent opportunity for exchange of scientific information on cartography.

Lieutenant-General SOMBOON (Thailand) said that considerable progress had been made in the matter of first-order geodetic survey and levelling for determination of map accuracy, there being already sufficient ground control of lower order for compilation of the base map of Thailand.

With the assistance of the United States Government, six electronic distance measuring instruments had been purchased and land gravity stations had been checked in accordance with the joint mapping agreement between the two countries.

Three photographic aircraft were in commission. It was hoped that the shortage of trained operating personnel would be overcome in the next few years with the assistance of the Netherlands Government, through the training of Thai officers under scholarship arrangements.

A map revision programme initiated in 1954 was 50 per cent complete.

The nautical charting of the Gulf of Thailand was complete except for some areas along the west coast of southern Thailand. The naval hydrographic department was also responsible for aeronautical charting, and the last of the eleven sheets provided for would be completed to ICAO specifications in 1967.

A National Map Information Centre had been set up in the Regional Map Information Office building.

Mr. KASHIN (Union of Soviet Socialist Republics) said that his country's programme over the previous two years had been concentrated on the development of techniques.

A programme of land reclamation had entailed extensive mapping at 1:10,000 scale, with 1 m contours. A comprehensive Atlas of Antarctica published in 1966 was the subject of a separate paper.

In the research field, progress had been made in the development of new types of tellurometers and of geodimeters using quantum generators of the laser type; new types of underwater and surface pendulum instruments had been devised.

A highly accurate stereo-comparator had been constructed, making possible co-ordinate measurements to an accuracy of 2 microns. Further details were to be found in the technical papers submitted by his country.

Mr. WIGGINS (United Kingdom) reviewed briefly the activities of the Directorate of Overseas Surveys and military survey parties in countries of the region, the British Solomon Islands Protectorate, the New Hebrides, Sabah, Sarawak and East Malaysia.

In the Solomons, a survey had almost been completed of all the major islands, and a 1:250,000 scale contoured map of Brunei had been published.

Maps of 1:250,000 scale had been published of the Yasawa and Kandavu groups and a revised edition of Vanua Levu in the Fiji Islands. Malaysian projects included 1:250,000 mapping of West Malaysia, completed south of latitude 4° north, rephotography and survey of Sabah and Sarawak, 28,000 square miles compiled for 1:50,000 mapping, and almost complete 1:250,000 cover of East Malaysia.

Hydrographic surveys in Far Eastern waters had been carried out by HMS *Dampier* under the direction of the Hydrographer of the Navy. Work had proceeded off Hong Kong, Sabah, Singapore, the British Solomon Islands Protectorate, the New Hebrides and Fiji and oceanographical observations had been made during passage.

Practical training in modern cartography, air and field survey and computing was being arranged in the United Kingdom under United Kingdom technical assistance schemes, as well as for holders of United Nations and Colombo Plan fellowships and for other officers nominated by their own Governments. Most of the countries concerned were represented at the conference.

A Land Resources Division had been established within the Directorate of Surveys to handle ecology, land use, soil science, hydrology and geomorphology.

Colonel HERNDON (United States of America) wished to confine his oral report to brief summaries of cartographic work that had taken place within the region, or were of interest to countries within the region. Thus others who were to embark upon similar projects would be aware of his country's activities.

The world geodetic satellite programme had been initiated with the launching of Pageos in June 1966. Observations involved co-operation with several nations in Asia and the Far East.

A quite extensive sea gravity programme was being pursued in the Pacific and the United States was contributing to the world gravity network.

Project Magnet, a world-wide airborne collection of magnetic information, was being continued, flying 124,000 miles to gather magnetic data in the area, while seismological activity included expansion of the Pacific Tsunami Warning Service and the world-wide earthquake location programme.

Major efforts had been made in the fields of hydrography and oceanography, with great numbers of new nautical charts and sailing directions being published.

Co-operative programmes continued with several countries in the area for topographic and geological mapping.

Good progress was being made with the 1:1,000,000 aeronautical charting of the world in a new presentation. 1:5,000,000 coverage of the world had been completed, and consideration was being given to a new 1:2,000,000 coverage south of the equator.

Since the previous conference, five gazetteers of countries in the region had been published, and a further three were in preparation.

Tribute to the memory of the Canadian Governor-General

The PRESIDENT extended the conference's condolences to the representative of Canada on the untimely death of the Canadian Governor-General.

One minute's silence was observed.

The meeting rose at 11.45 a.m.

SUMMARY RECORD OF THE FOURTH PLENARY MEETING

Held at the Academy of Science, Canberra, Australia, on Thursday, 9 March 1967, at 2.10 p.m.

CONTENTS

President: Mr. R. W. BOSWELL (Australia)

Progress reports by countries on their respective cartographic activities since the last conference (*continued*)

[Agenda item 6]

Major NGUYEN VAU KHAI (Republic of Viet-Nam) said that, during the period 1964–1967, the National Geographic Service of the Republic of Viet-Nam had conducted the following activities: completion of the basic cartographic coverage of 1:50,000; initiation of a cartographic programme of 1:25,000, and continuation of geodetic triangulation, traversing, gravimetry and precision levelling operations with a view to completing the existing geodetic network of the country. The National Geographic Service was also called upon to prepare, revise and publish plans of towns, special and topical maps, road maps, administrative maps, aeronautical charts, vegetation charts and general physical maps.

In the field of topographic mapping, the basic cartographic coverage of 1:50,000 had been completed in 1965 by the National Geographic Service of Viet-Nam in conjunction with the United States Army Map Service. It represented 428 sections, covering the whole of the territory of the Republic of Viet-Nam. In the same year, the National Geographic Service had undertaken the revision of forty sections in the region north of the Mekong Delta. That programme had been suspended by the re-establishment of basic coverage by the United States Army Map Service, using a new system which divided the territory into 300 sections only. The new cartographic coverage was being revised with the help of aerial photography.

The programme of topographical mapping of 1:25,000 had been undertaken at the end of 1965. A start had been made with the populated regions, where there existed a need for topographical maps for purposes of economic development and agricultural planning. Photogrammetric methods solely were used for the preparation of such maps, with the help of aerial photographs of 1:40,000 and 1:20,000, and second-order plotting equipment: Wild A8 and Poivilliers D4. Nineteen sections covering 2,000 km^2 had been plotted.

Four towns had been mapped, and the capital, Saigon, has been re-mapped on the scale of 1:10,000.

With regard to aerial photography for use in photogrammetric plotting, the Republic of Viet-Nam had available only French 1:40,000 coverage taken in 1952–1954 and United States coverage taken in 1958–1959. It was not possible to carry out further air photography missions in view of the current military operations.

The photogrammetric equipment available to the National Geographic Service was still very limited. Apart from the third-order instruments: Multiplex (7), Stereotopo (5) and Stereoflex (1), there existed only the following: 2 Autographs Wild A8; 1 Stereotopograph Poivilliers D4.

A request for the granting of aid from the United Nations Special Fund to provide the service with photogrammetric equipment in a three-year programme had been made through the representatives of the United Nations Development Fund in Saigon. The equipment requested comprised precision material for surveying and plotting.

The National Geographic Service was anxious to complete the existing network of triangulation and levelling of the country. Unfortunately, the current situation in Viet-Nam did not permit the service to make much progress in ground surveying. The teams could operate only in secured zones. Nevertheless, 400 km of first-order levelling by 120 bench-marks had been completed by ground surveying between 1965 and 1966. At the same time, supplementary control points had been set up over an area of more than 700 km^2 to facilitate aerial photography. Forty gravity stations had been established.

Mr TOMANE (Western Samoa) emphasized that the training of technicians for cartographic work was carried out in New Zealand and the country's mapping system was based on the months described in the New Zealand report.[1]

Mr. LAMBERT (Australia) asked representatives to refer to Australia's report on its cartographic activities and in particular drew attention to the maps annexed to the report.[2]

Professor TSAO MO (China) stated that it was hoped to complete the readjustment and recomputation to a single datum of about 8,000 triangulation stations on the mainland by 1967.

The total levelling of Taiwan was expected to be completed by the end of 1967.

Aerial photography at scales ranging from 1:10,000 to 1:120,000 were used for interpretation of agricultural and forestry resources as well as for photogrammetric compilation at scales of 1:20,000 to 1:120,000. Those compilations were then reduced to form the standard 1:50,000 topographic maps.

He described progress in topographic and general mapping at scales ranging from 1:50,000 to 1:4,000,000, as well as in the IMW. He also referrred to the facilities available at the survey college in his country.

Mr. KENGEBELE (Democratic Republic of the Congo) said that the Geographic Institute had completed aerial

[1] See part II of the present volume, agenda item 6.

[2] *Ibid.*

photography at 1:40,000 of 85 per cent of the country, the mountainous areas being difficult to photograph owing to excessive cloud coverage.

The institute had been reorganized in 1965 and the first surveys had commenced in June 1966 in industrial areas and areas selected for development. That survey had covered an area of 42,000 km^2.

Wild stereoplotting instruments had been used to plot from the available aerial photography. Compilations had been made, at air photography scale and then reduced to form the basis for the 1:200,000 map series.

Five-sixths of the territory had been covered with 1:1,000,000 scale maps; a 1:3,000,000 map had also been published as well as many special purpose maps.

It was planned to produce a new planemetric map series at 1:50,000, to be followed by a topographic map series at 1:50,000.

In 1966, three photogrammetric engineers and two technicians trained at the Delft college had been brought in to assist in the national mapping programme.

He described progress in the first, second and lower orders of triangulation and traverse and also in the basic levelling network in his country.

The Geographic Institute had recently acquired new printing presses and allied reproduction equipment, including a new Klimsch process camera.

Colonel SHARMA (India) said that India had not presented a formal report to the conference but would refer representatives to the annual report of the Survey of India, an organization which had now completed 200 years of service and had established one of the largest triangulation and levelling networks in the region.

The country was completely covered by the standard 1:250,000 series and a small area had been covered by a 1:50,000 series.

Various types of standard contoured topographic maps had been published, ranging in scale from 1:1,000 to 1:50,000.

His country was considering publication of special road maps for use by tourists and he suggested that representatives might consider a common specification for road maps.

A new training institute had been established with the aid of funds provided by the United Nations for the training of personnel in cartographic practices; it was engaged in pilot projects. The institute had received modern instruments such as geodimeters, tellurometers, automatic levels, photogrammetric plotters and reproduction equipment. It was hoped that in a couple of years the institute would be able to accept students from other countries in South East Asia.

Mr. URETA (Executive Secretary) observed that the provision of United Nations funds referred to by the previous speaker was a very important function of the United Nations. Other nations might also wish to apply for such a grant.

Major BITAR (Lebanon) said that the complete triangulation survey of the Lebanon had been revised since 1964, and first-order levels now covered almost the entire road network.

Twenty-seven map sheets had been produced at 1:50,000 within the period, six sheets at 1:100,000 and eighty-five of the total of 120 at 1:20,000 required for complete coverage. Urban and cadastral mapping had also been carried out at larger scales.

The existing aerial photographic coverage over certain areas would be revised every two years.

Topical and administrative maps had been produced. Geological maps at 1:20,000 and road and tourist maps were also available.

Mr. AHMAD DAUD (Malaysia) said that the Director of National Mapping (concurrently the Surveyor-General of West Malaysia) had been much assisted by the United Kingdom Government in the mapping of East Malaysia.

Six new primary and 129 lower order stations had been observed in Sarawak. However, the network had not yet been extended to the East Malaysia-Indonesia international boundary.

In West Malaysia, 155 miles of precise levelling, mostly along the east coast, completed a basic net of two lines running the whole length of the country, one on the east and one on the west coast, joined by an east-west line through the middle.

Discrepancies between the tide gauges at Port Swettenham and Singapore, and between Port Swettenham and Sungai Golok in Thailand had to be positively resolved before final determination of mean sea level. Two more gauges to be installed on the east and west coasts should achieve that end.

An extensive gravity programme in East Malaysia had been carried out by the United States Army Map Service and Directorate of Military Survey. The former had also published the results of a West Malaysian survey.

The whole of East Malaysia was now substantially covered by air photography.

In West Malaysia, 3,704 square miles had been photographed by the Directorate of National Mapping, and the coverage had been completed in February 1967 by a private contractor.

Of 340 map sheets in the 1:50,000 series, 108 had been published so far, with 100 ft contours.

The basic topographical series in West Malaysia was the 1:25,000 series with 50 ft contours, of which 187 sheets out of 708 had been published.

Eighty-eight sheets of the 151 in the 1:63,360 series for West Malaysia had been published, as well as town maps at large scales in both areas. The 1:250,000 series, comprising twenty sheets for East Malaysia, was 75 per cent complete, and six preliminary sheets had been published of the fourteen covering West Malaysia.

In the two-year period to January 1967, a total of 170 map sheets had been published at various scales by the Directorate of National Mapping and 118 sheets by United Kingdom Government bodies.

Mr. CHRISTIAN (UNESCO) extended greetings from UNESCO to the conference and read the following letter from Mr. Batisse, Director of the UNESCO Natural Resources Division:

> "I should explain that one of UNESCO's important programmes is the one concerned with natural resources. UNESCO believes that the stimulation of research and training related to the natural environment and its potential will provide a sound basis for the evaluation and development of natural resources, particularly in the developing countries.
>
> "The traditional disciplines such as geology, hydrology, soil science, geomorphology and ecology are all essential components of this programme, but there are many interactions among the various elements of the

natural environment such as rocks, soil, water, atmosphere, plants, animals and man. These interactions are of very real significance to the interpretation and achievement of the environment's potential. Accordingly, UNESCO has emphasized the inter-disciplinary approach to the study of natural resources, which is best exemplified in its promotion of integrated surveys. These are combined studies of the natural and human resources by teams of specialists under the guidance of a qualified team leader.

"Both the traditional disciplines and these integrated studies lead to the production of maps of many kinds. The quality and speed of such mapping have been significantly influenced by the use of aerial photographs. In 1964, UNESCO held an international conference in Toulouse, France, on this general subject of natural resources surveys by the use of aerial methods. The proceedings of that conference are being published and I am sure will be of interest to many member countries.

"UNESCO has supported a programme of improving the methodology of integrated surveys and stimulating their wider application. It has done this by supporting the establishment of the Centre for Integrated Survey Training associated with the International Training Centre for Aerial Surveys in Delft, Netherlands. Secondly, UNESCO has advised and encouraged the establishment of natural resource research and training centres in various countries and regions. An example is the Control and Zone Research Institute of Jodhpur in India.

"The training centre to which I have referred not only provides training for survey team leaders and additional training for specialists who are to participate in integrated surveys, but it also provides special training for administrators who may not be technicians but who are concerned with the planning and organization of resource surveys.

"This longer-term training is supplemented by short-term regional courses such as the one planned at Katmandu in Nepal in 1967. The regional institutes are particularly concerned with the practical study of natural resources appropriate to the particular regional environment in which they are situated.

"UNESCO is concerned with the preparation of scientific maps of many kinds, such as ecological and vegetation maps, world soil maps and hydrological and hydrogeological maps, geological, metallogenic and tectonic maps of various countries and regions. Much of this work is done by collaboration with other United Nations agencies, such as the Food and Agriculture Organization (FAO) and with non-governmental scientific agencies and national organizations.

"In co-operation with the International Geographical Union (IGU), UNESCO is attempting to stimulate and aid the preparation of modern national atlases for the developing countries.

"Finally, UNESCO has been concerned with the standardization of legends, nomenclatures and terminologies used in various kinds of maps, such as the international standard legend for vegetation and hydrogeological maps and multilingual dictionaries for hydrological terms, and the standard legend for the metallogenic map of Europe."

UNESCO would be very interested in the discussions which were to take place at the conference.

Mr. WIGGINS (United Kingdom) referred to the United Kingdom report[3] and recalled that the International Cartographic Association had set up a commission on standardization of cartographic terms.

A multilingual list of cartographic terms was being prepared in five main languages—German, English, French, Russian and Spanish—with single-term translations into twelve other languages.

Mr. SCHOLL (International Society of Photogrammetry) delivered a message from Mr. H. Harry, President of the Society, which read in part:

"The President of the International Society for Photogrammetry (ISP) wishes to take the opportunity offered by this meeting to convey the very best greetings of the ISP Council to the United Nations Regional Cartographic Conference for Asia and the Far East in Canberra.

"Surveying and mapping in Asia and the Far East is closely connected with photogrammetry and photo-interpretation. Natural resources inventories are inconceivable today without interpretation of aerial photos and restitution of such photographs. Science and technology have now reached a stage where photogrammetric methods, including aerial triangulation, have become indispensable for cadastral surveys, for the preparation of basic topographical maps and for the production of all kinds of topical maps. We therefore hope that photogrammetry and photo-interpretation will prove to be helpful in furthering the aims of the Canberra conference.

"Further progress in technical development is to be expected. At the Eleventh International Congress of Photogrammetry, which will take place in Lausanne, Switzerland, from 8 to 20 July 1968, new equipment and working procedures will be shown, permitting a considerable speeding-up and rationalization of cartographic production. We look forward to welcoming many specialists from Asia and the Far East in Lausanne next year."

The PRESIDENT thanked the previous speaker for the good wishes expressed by the president of ISP.

The meeting rose at 4.15 p.m.

[3] See part II of the present volume, agenda item 6.

SUMMARY RECORD OF THE FIFTH PLENARY MEETING

Held at the Academy of Science, Canberra, Australia, on Tuesday, 14 March 1967, at 9.40 a.m.

CONTENTS

Acting President: Mr. MARASHI (Iran)

Progress reports by countries on their respective activities since the last conference (*concluded*)

[Agenda item 6]

General LACLAVÉRE (France) said that French surveying and mapping activities were spread over several organizations, as follows: Institut géographique national (IGN), mapping; Cadastral Service, land titles; universities, national atlases; Naval Hydrographic Service, hydrographic charting.

All overseas mapping was handled by IGN.

Mapping of New Caledonia at 1:50,000 (forty-six sheets) and 1:100,000 mapping of the New Hebrides had been completed. Maps covering the Society Islands in the Tuamotu group would be completed in 1967.

A 1:100,000 map of Kerguelen Island would be completed in 1967, using somewhat unorthodox methods because of the severe climate.

Scientific and research programmes were being actively pursued by IGN.

All scribing was done directly from machines except in very flat country, and photographically reduced to 1:50,000. A satisfactory solution had yet to be found for the changing of contour intervals for compilations at different scales.

In the field of satellite geodesy, connexions had been made from the Azores to Africa, by observations to satellites Echo 1 and Echo 2. Other islands had been connected to the Azores by flare triangulation with an accuracy of 20 m, instead of the previous 400 m.

It was planned by 1969 to establish connexions between Europe, Africa and South America.

The national atlas, now out of date, was being revised by the universities and IGN would finance its publication.

A research group within IGN was furthering progress in aerotriangulation over very large areas, development of lasers for distance measuring and airborne profile recording, orthophotography and development of photographic equipment on entirely new principles.

In conclusion, he stated that IGN had been a financially autonomous body as of 1 January 1967, and operated as an agency having its own budget and income.

Mr. PULLICINO (Malta) said that, since Malta had obtained independence in September 1964, this was the first time a delegation from Malta had attended a United Nations regional cartographic conference.

He traced the development of mapping in Malta, from the earliest triangulation survey in 1880, to the revision of the 25-inch and 6-inch series of the islands undertaken after the Second World War by the Directorate of Overseas Surveys and the Public Works Department. A completely new edition was at present being compiled.

Being of small area—120 square miles—it was uneconomical for his country to invest in photogrammetric equipment.

Commander TABIN (Philippines) said that responsibilities for all types of mapping, surveying and associated activities were spread over thirty-one government agencies involving about 6,500 personnel.

The coverage of primary control, reported at 15 per cent of the area at the last conference, had been steadily extended. To date about 10 per cent of the country had been rephotographed at 1:15,000, primarily for land capability survey.

Tidal, geomagnetic and other geophysical observations were continuing activities.

There was now complete coverage of 1:50,000 topographical maps (969 sheets), 1:250,000 (55 sheets), and 1:1,000,000 (six sheets).

Nautical charts had been updated on a continuing basis, and various economic map series had been started.

In view of the wide dispersion of mapping activities, the standardization of technical practices was aimed at. A Philippine plane co-ordinate system based on the transverse Mercator system had been adopted, and a nation-wide training programme implemented for surveyors and cartographic engineers.

A calibration base line for electronic distance measuring equipment had recently been established.

Reports on progress in matters which formed the basis of resolutions or recommendations at the last conference

[Agenda item 7]

Mr. KULKASEM (Thailand) summarized the progress made in Thailand as set out in the papers submitted by his delegation.[1] He mentioned that the economic atlases mostly produced so far by the Royal Thai Survey Department, were on display at the Conference.

Mr. LAMBERT (Australia) referring to the Australian report E/CONF.52/L.78[2] said that Australia had now reached the stage of wanting to acquire more knowledge rather than

[1] See part II of the present volume, agenda item 7.

[2] *Ibid.*

only to disseminate it. Progress on the IMW was reported in another paper (E/CONF.52/L.75).[3]

Views on the use of the metric system in navigation charts had been revised since the writing of the report. The steps to be taken for the conversion of Australian hydrographic charts to metric measurements were now being considered. The change would not take place, however, for some years.

[3] See part II of the present volume, agenda item 11.

Mr. KHAMASUNDARA (Thailand) expressed his country's appreciation of the 361 map sheets received so far from Australia for the Map Information Office.

Professor TSAO MO (China) read his country's report (E/CONF.52/L.110).[4]

The meeting rose at 10.23 a.m.

[4] See part II of the present volume, agenda item 7.

SUMMARY RECORD OF THE SIXTH PLENARY MEETING

Held at the Academy of Science, Canberra, Australia, on Wednesday, 15 March 1967, at 9.30 a.m.

CONTENTS

President: **Mr. R. W. BOSWELL (Australia)**

Report on credentials

[Agenda item 4]

The PRESIDENT reported that the credentials of all representatives had been submitted and found in order. Agenda item 4 was thus completed.

Mr. Marashi (Iran), First Vice-President, took the Chair.

Reports on progress in matters which formed the basis of resolutions or recommendations at the last conference (*concluded*)

[Agenda item 7]

RESOLUTION 3. MAP INFORMATION OFFICE

Mr. INOUE (Japan) reported that the Geographical Survey Institute and other government agencies of Japan had sent or were sending various materials, including maps, charts and reports, to the Map Information Office in Thailand.

Mr. KHAMASUNDARA (Thailand) said that only 5 per cent of the total documentation received was from countries other than Thailand, and requested a greater degree of international co-operation to make possible the provision of services to other countries in the region.

Colonel HERNDON (United States of America) complimented Thailand on the energy which had been applied to action on the resolution, and said that the United States would supply any items outstanding from its contribution.

He recommended that a resolution be drafted recognizing the efforts which Thailand had undertaken and drawing attention to the needs of Thailand in the creation and operation of the service on behalf of the international community.

Mr. URETA (Executive Secretary), referring to the suggestion by Thailand that the United Nations should give assistance in the staffing and equipment of the office (E/CONF.52/L.10 paragraph 7),[1] pointed out that, since there would be financial implications, the matter should be dealt with by ECAFE. A resolution should therefore be adopted asking ECAFE to sponsor the office.

[1] See part II of the present volume, agenda item 7.

Mr. KHAMASUNDARA (Thailand) welcomed the suggestion and said that he would approach ECAFE on the matter.

RESOLUTION 4. ESTABLISHMENT OF BASE LINES FOR CALIBRATING ELECTRONIC AND ELECTRO-OPTICAL INSTRUMENTS

Mr. TABIN (Philippines) recalled that a calibration base line 1.6 km long had been established in Quezon city.

Mr. LAMBERT (Australia) said that frequencies had been carefully checked before and after each year's operation and particular lines check-measured with a great variety of instruments. That procedure provided a means of calibration while analyses of the many results obtained indicated that it also provided a standard base line of considerable accuracy.

It was Australia's view that standards of time were being calibrated, rather than standards of distance.

Mr. INOUE (Japan) reported that it was difficult to find a place wide enough to establish a long base line over 10 km for calibrating electronic and electro-optical instruments in flat areas in Japan. It was possible, however, to establish a short base line and extend it by triangulation. If two or more base lines could be established at suitable locations from a base line network, a long calibration base and test observation area would be provided. As the first step to that end, a base line about 1 km in length had been established at Akita, a western suburb of Tokyo. Its length had been observed with a mean square error of less than 1 mm with four invar wires. That was accurate enough for calibrating the instruments used for second-order traverse survey. Observations with several kinds of electronic distance measuring instruments were also made.

RESOLUTION 5. CALIBRATION OF CRYSTAL FREQUENCIES IN ELECTRONIC DISTANCE MEASURING INSTRUMENTS

Mr. INOUE (Japan) reported that the final accuracy of the observed length with electronic distance measuring instruments often depended on the modulating frequency of the crystal installed in the instrument and on its stability. Several kinds of such instruments such as Geodimeter (models II and IV), Tellurometer (models 1, 2 and 3) and Electrotape were used for field work in Japan. The geodimeter was used mainly for determining the length of sides in the first-order triangulation network. Its standard modulating frequency was checked several times during field observations by comparing it with that of the carrier of the standard wave, JJY, which was transmitted continuously throughout the day.

Regarding other such instruments, no legal regulation on the checking of frequency existed. However, with regard to instruments belonging to the Geographical Survey Institute, the frequency check with a highly stable frequency standard was usually made once a year. For instruments of private companies, the institute suggested periodical frequency checks.

Mr. LAMBERT (Australia) reported that adequate facilities were available and regular frequency checks were carried out as standard procedure.

RESOLUTION 6. ESTABLISHMENT OF ADDITIONAL WORLD GRAVITY BASE STATIONS IN THE REGION

Mr. INOUE (Japan) reported that the International Gravity Commission and the International Association of Geodesy, had designated five international first-order gravity stations in the region, namely, Kyoto, Singapore, New Dehli, Melbourne and Christchurch. The western Pacific calibration line project was in progress with a view to establishing a world-wide gravimetric network, as reported in the technical report presented to the Conference.[2]

Mr. LAMBERT (Australia) reported that gravity bases on the western Pacific calibration lines had been established at Darwin, Mt. Isa, Cairns, Townsville, Mackay, Rockhampton, Maryborough, Brisbane, Grafton, Kempsey, Sydney, Canberra, Albury and Melbourne. Together with those already established by pendulum surveys they formed bases from east to west across the continent. The stations were tied to the world gravity base net through the national gravity base in Melbourne.

RESOLUTION 7. ESTABLISHMENT OF A REGIONAL MAGNETIC OBSERVATORY FOR CALIBRATION OF MAGNETIC SURVEYING INSTRUMENTS

Mr. INOUE (Japan) reported that five magnetic observatories were making continuous magnetic observations with absolute value. They were Kakioka, Memambetsu, and Kanoya, belonging to the Meteorological Bureau, Shimosato to the Hydrographic Office, and Kanozan to the Geographical Survey Institute. At the Geodetic Observatory of Kanozan, for example, a set of magnetic variometers had been installed for continuous observation of declination, horizontal component and vertical component. Furthermore, a set of proton precision magnetometers was used to obtain the absolute values of total force and horizontal component; the results would give the base lines values of the continuous observations. Similar observations were made at the other observatories. Those continuous observations were employed for reducing field observation values.

Mr. LAMBERT (Australia) reported that the geophysical observatories at Port Moresby, Papua; Mundaring, Western Australia, and Toolangi, Victoria, maintained calibration equipment for the adequate control of continuously recording magnetic variometers. The same equipment could be used to calibrate field magnetic survey equipment.

RESOLUTION 8. AN INTERNATIONAL TSUNAMI WARNING SYSTEM

Mr. INOUE (Japan) said that, while no international tsunami warning system as yet existed, the Japanese National Meteorological Agency operated a tsunami warning service for Japan with the co-operation of the United States and the USSR. When a severe earthquake occurred near Japan, the agency announced a tsunami warning by JMG teletype transmission to the coastal areas concerned. At the same time, the warning was directly communicated by AFCS through a special line to the Honolulu centre, which was the central organization for the tsunami warning system in the United States. It was also broadcast by meteorological radio teletype transmission and might be received by the USSR and other countries. The agency also utilized any warnings given by other countries for their own services. The systems described were recognized and supported by the World Meteorological Organization (WMO). The agency had participated in the tsunami meeting in Honolulu in 1965.

Mr. TABIN (Philippines) said that continuous tidal observations were being taken in the city of Quezon.

RESOLUTION 9. ECONOMY OF AERIAL SURVEY AND MAPPING

Mr. INOUE (Japan) reported that the cost of aerial survey and mapping was one of Japan's main concerns, but that it was hardly possible to derive any reliable figures from the available data, since so many factors influenced the cost of photogrammetric production, such as type of terrain, area, weather and condition of air. Nevertheless, great attention was paid to the problem, and it was hoped that a scientific form of management might successfully be introduced into map production. An experiment was being conducted with a view to including the problem in the activities of the Japanese Society of Photogrammetry.

Mr. LAMBERT (Australia) reported that those matters were currently under consideration in connexion with Australia's proposed ten-year 1:100,000 scale topographic mapping programme; no definite information, however, was available for dissemination at that stage. It was planned to recommence a national mapping bulletin that would serve a useful purpose in the dissemination of details of the technical processes that were found most suitable and productive for Australian conditions.

RESOLUTION 10. STANDARD SCALES FOR BASE MAP

Mr. INOUE (Japan) reported that the Geographic Survey Institute had issued topographical maps at scales of 1:25,000 and 1:50,000 and compiled maps at the scales of 1:200,000, 1:500,000, 1:1,000,000 (IMW) and 1:2,500,000. The maps were available to foreign nations at specific prices without any limitation.

Mr. LAMBERT (Australia) reported that decimal scales were gradually being introduced for maps at 1:50,000 and larger scales.

The bulk of Australia would be mapped at a basic scale of 1:100,000; that was not a scale recommended at the fourth conference, but was considered best suited to Australian conditions. Other standard scales were 1:250,000 and 1:1,000,000.

RESOLUTION 11. EXCHANGE OF MAP DESIGN

Mr. INOUE (Japan) reported that the Geographical Survey Institute had sent technical information on its newly designed map specifications for the 1:25,000 topographical map series and the newly prepared sheets of IMW for Japan, with copies of sheets to the Map Information Office in Bangkok, Thailand.

Mr. LAMBERT (Australia) reported that no action had yet been taken in the matter, as the Australian 1:100,000 1:250,000 and 1:1,000,000 map specifications were being completely revised. When that revision was complete, details would be distributed.

[2] *Ibid.*

Resolution 12. Super-wide-angle photography

Mr. INOUE (Japan) reported that the super-wide-angle camera was not used in Japan, for the following reasons: Japan was a mountainous country and gradients often exceeded 30 degrees, preventing effective use of the camera; Japan already possessed sufficient numbers of wide-angle and normal-angle cameras, and most plotting instruments were fitted only for wide- and normal-angle cameras; those instruments were sufficient for aerial survey needs.

Mr. LAMBERT (Australia) reported that the Wild R.C. 9 camera was being used extensively throughout Australia. Six such cameras were already in use and several commercial companies had others on order.

Resolution 13. Aerial photo-interpretation

Mr. INOUE (Japan) said that the Geographical Survey Institute, the Geological Survey and the Forestry Agency held courses each year in that field as one of the international training courses in surveying and mapping under the Colombo Plan and ECAFE.

Commander TABIN (Philippines) recalled that a photo-interpretation centre had been established at the University of Quezon. Other countries were invited to use the centre.

Colonel SHARMA (India), replying to a question from Mr. KHAMASUNDARA (Thailand), said that a photo-interpretation centre had been established at Dehra Dun in India, with the assistance of the Netherlands Government. He would find out whether overseas students could be enrolled. The centre comprised four sections: forest resources; geology; soil survey and photogrammetry. Another pilot project and training centre was being set up in Hyderabad with United Nations assistance. In two years or so that centre might be able to accept overseas students.

Resolution 14. Topical maps and national atlases

Mr. INOUE (Japan) drew attention to the reports submitted by his country on the many kinds of topical maps which had been prepared by government or administrative agencies for their own purposes.[3]

Mr. URETA (Executive Secretary) stressed the desirability of implementing the resolution. A working group should be appointed within the region, but, as there would be financial implications, support would have to be requested from ECAFE.

Commander TABIN (Philippines) thought that the intention had been to set up a separate committee at the current conference, and that that had been accomplished by the establishment of Committee III.

Mr. LAMBERT (Australia) said that his country's understanding was that a committee functioning by correspondence should be formed to exchange information and submit a resolution to the next conference. If that were the case, Australia would be happy to participate.

Professor TSAO MO (China) reported that his Government was working on the subject and that material would be forwarded to Bangkok when available.

The PRESIDENT suggested that discussion on the matter should be continued in conjunction with the discussion of resolution 15.

It was so agreed.

[3] See part II of the present volume, agenda items 6, 9(*b*) and 13.

Resolution 15. Regional economic atlas for Asia and the Far East

Mr. LAMBERT (Australia) moved a draft resolution on the following lines:

"*The Conference,*

"*Noting* resolution 14 of the Fourth United Nations Regional Cartographic Conference for Asia and the Far East,

"*Recommends* that a committee on topical maps and national atlases be established consisting of corresponding members from the following countries: Australia, Federal Republic of Germany, Israel, Japan, Philippines, Thailand, Union of Soviet Socialist Republics, United States of America;

"*Further recommends* that this committee be required to consider and suggest standard specifications for these types of maps and to report thereon at the sixth conference."

Mr. KASHIN (Union of Soviet Socialist Republics) agreed to his country's membership of the committee on the understanding that discussions and work would be carried out by correspondence between the current conference and the next.

Colonel HERNDON (United States of America) suggested that some initial committee work might be carried out at the current conference. For example, the projections to be used in the atlases might well be discussed at that time.

Mr. LAMBERT (Australia) stated that it would also be necessary to nominate a country to act as convenor for the committee.

Proffessor TSAO MO (China) recalled that, in compliance with the relevant resolution of the third conference, a national atlas had been compiled and exhibited at the fourth conference in Manila.

Resolution 16. International Map of the World on the Millionth Scale (IMW)

Resolution 17. Geographical names

Colonel SHARMA (India) suggested that the discussion on these resolutions should be postponed until after they had been discussed in committees III and IV.

It was so decided.

Resolution 18. Hydrographic training centres

The ACTING PRESIDENT asked the representatives of India and Japan to indicate whether any progress had been made in their countries on the establishment of hydrographic training centres.

Colonel SHARMA (India) said that he had no information on the subject but suggested that the Executive Secretary might be able to advise on the position.

Mr. INOUE (Japan) said that a hydrographic training centre had not yet been established in Japan, but that the Japanese Hydrographic Office in Tokyo had accepted the applications for hydrographic training so far received from countries. The training had taken the form of "on the job" work at the Hydrographic Office.

Admiral VIGLIERI (International Hydrographic Bureau) said that the bureau was directly concerned in the setting up of the training centres. It would be interested to receive detailed statements from member countries clearly setting out their needs. Funds to assist in setting up such training centres should be available through the United Nations Development Programme.

Some member nations of the International Hydrographic Bureau had already established their own training courses in hydrography and in some cases those had been adopted by other member nations. The International Hydrographic Bureau would be pleased to circulate details of the training courses to interested nations. He pointed out that the establishment of training centres could be quite expensive.

Captain HASLAM (Australia) stated that a hydrographic school had been established in Sydney in 1966 and students from the Philippines and Malaysia had attended. The school facilities could be made available to students from member countries.

Resolution 19. Use of the metric system in navigation charts

Mr. INOUE (Japan) stated that, in 1920, the Japanese Hydrographic Office had decided to adopt the metric system for use in its original charts in accordance with the recommendation of the International Hydrographic Conference. That system was now used in all the original charts issued by the Hydrographic Office. It was to be hoped that the system would be used internationally, and as soon as possible, not only in navigation charts but also in all types of maps and charts.

He recalled that, in the recent North Sea Fisheries Chart series published under joint agreements by the six participating countries of the North Sea Hydrographic Commission, one country which had not yet adopted the metric system in its navigation charts was compiling the chart series using that system.

Captain HASLAM (Australia) said that his country was considering changing to the metric system in consultation with the United Kingdom. Both countries felt that it was desirable to make the change-over on a "block" basis (i.e., all scales of charts in a stated area) rather than make the conversion of individual charts at the various scales.

Admiral VIGLIERI (International Hydrographic Bureau) recalled that the bureau at its first conference in Monaco in 1921 had directed members to encourage the adoption of the metric system in navigation charts.

Resolution 20. The co-operative study of the Kuroshio (Japan current)

Mr. INOUE (Japan) stated that the subject had been fully dealt with by Committee V (Hydrography and Oceanography).

Resolution 21. Regional oceanographic survey of a portion of the South China Sea

Mr. LAMBERT (Australia) discussed the report on Indonesian and Australian activities in connexion with the survey of the border between West Irian and the Territories of Papua and New Guinea[4] and was pleased to join with the representative of Indonesia in submitting the report. The work had been carried out in the spirit of resolution 22 of the second conference on co-operation in mapping boundary areas.

Colonel PRANOTO (Indonesia) quoted from the joint report and said that the undertaking had been carried out with complete accord and was an excellent example of international co-operation.

The meeting rose at 12 noon.

[4] See part II of the present volume, agenda item 7.

SUMMARY RECORD OF THE SEVENTH PLENARY MEETING

Held at the Academy of Science, Canberra, Australia, on Tuesday, 21 March 1967, at 9.40 a.m.

CONTENTS

President: **Mr. R. W. BOSWELL (Australia)**

Question of convening a Sixth United Nations Regional Cartographic Conference for Asia and the Far East

The PRESIDENT informed the Conference that the representative of Iran had invited it to hold the Sixth United Nations Regional Cartographic Conference for Asia and the Far East in Teheran in October 1970. The secretariat would prepare an appropriate draft resolution on the subject.

The meeting rose at 9.45 a.m.

SUMMARY RECORD OF THE EIGHTH PLENARY MEETING

Held at the Academy of Science, Canberra, Australia, on Wednesday, 22 March 1967, at 9.30 a.m.

CONTENTS

President: **Mr. R. W. BOSWELL (Australia)**

Adoption of the report of the Conference

[Agenda Item 17]

Commander TABIN (Philippines), Rapporteur, presented the draft report of the conference (E/CONF.52/3 and Add.1), suggesting one minor correction.

The draft report, as amended, was adopted unanimously.

Commander TABIN (Philippines) said that the Philippines was prepared to act as host country to the second seminar on aerial survey methods and equipment. His Government would appreciate the co-operation of countries in the region in sending representatives to the seminar, particularly of those countries which were more advanced in the field.

The PRESIDENT thanked the Philippine representative for the kind offer he had made on his Government's behalf.

Closure of the Fifth United Nations Regional Cartographic Conference for Asia and the Far East

The PRESIDENT said that it had been a privilege and a most heartening experience to preside over the conference, which had provided a venue for the creation of much goodwill among the thirty nations and the seven international associations represented.

He noted the advent of electronic computers and satellite geodesy, the possibility of automated mapping and the increasing supersession of angular measurement by measurement of distance and hence of time.

The more technically advanced nations could do much to help in the assessment of the natural resources of countries within the region. Map-making was the foundation for efficiency in the management of those resources.

He thanked the representatives for the honour done to Australia by their coming and wished them success in their future work.

The representatives of CANADA, INDIA, INDONESIA, ISRAEL, JAPAN, MALAYSIA, MALTA, NEW ZEALAND, NORWAY, THAILAND, the UNION OF SOVIET SOCIALIST REPUBLICS, the UNITED KINGDOM and the UNITED STATES OF AMERICA and the representative of the International Hydrographic Bureau expressed thanks to the Australian Government for its hospitality, to the President for his conduct of the proceedings, and to the United Nations for the services it had provided to the conference.

The Fifth United Nations Regional Cartographic Conference for Asia and the Far East was formally closed at 11.20 a.m.

Part II

TECHNICAL PAPERS PRESENTED TO THE CONFERENCE

AGENDA ITEM 6

Progress reports by countries on their respective cartographic activities since the last conference

AIR PHOTOGRAPHY AND TOPOGRAPHIC MAPPING IN AUSTRALIA

Paper presented by Australia[1]

INTRODUCTION

Responsibility for the government of Australia is divided between the Commonwealth (Federal) Government and the six state governments.

Under the Constitution setting up the Federation, only certain specific powers were given to the Commonwealth Government and in all other respects the state governments have sovereign powers.

No specific mandate was given to the Commonwealth in respect of mapping, but the Commonwealth may and does undertake topographic mapping as an activity necessary for the good government of the nation, for defence purposes, for civil aviation and to assist in national development.

The states also undertake general topographic mapping for the good government of their territories and for specific administrative and developmental projects. The work is carried out by the lands and survey departments under the respective state surveyors general.

A large amount of topographic mapping, at varying scales (mostly large scale) is undertaken by photogrammetric mapping companies working on contracts from engineering and mineral prospecting agencies and from governmental and semi-governmental authorities.

GOVERNMENTAL ORGANIZATION FOR MAPPING

By direction of the Commonwealth Government, the Department of National Development has full responsibility for all geodetic surveys and topographic mapping required for Commonwealth purposes and for the co-ordination of these activities with those of the states. The Division of National Mapping is the organization within the department that is charged with these responsibilities.

Certain of the resources of the Royal Australian Army Survey Corps are applied to portions of the Commonwealth geodetic surveys and topographic mapping programme which are allotted to it by the Department of National Development.

In 1945, the Prime Minister of the Commonwealth and the state premiers agreed to set up a National Mapping Council which would advise on the standardization and co-ordination of Commonwealth and state mapping activities.

The Director of National Mapping is chairman of this Council and the following Commonwealth officers are members: the Hydrographer of the Royal Australian Navy, the Director of Military Survey and the Commonwealth Surveyor General (Department of the Interior).

Each state surveyor general is a member.

It was agreed, at the same time, that the Director of National Mapping would be responsible for the co-ordination of the activities of Commonwealth and state authorities in planning and carrying out the national mapping of Australia, with full regard to the recommendations of the National Mapping Council.

The Council meets once each year. It has a technical sub-committee consisting of technical officers who meet six months before each meeting, discuss their work in detail and report on technical matters specifically referred to them by the Council.

No formal dividing line has been agreed upon, or even suggested, between the Commonwealth and the states, but in practice the states concentrate mainly on medium-scale and large-scale mapping (1:31,680 and larger) while the Commonwealth concentrates on small-scale and medium-scale mapping (mainly 1:1,000,000, 1:100,000 and occasionally 1:50,000 and 1:25,000).

The Commonwealth Department of the Interior is responsible for Commonwealth land boundary and engineering surveys, and in this capacity undertakes large-scale topographic surveys, particularly in connexion with the development of Canberra as the national capital.

Some states have mapping advisory or co-ordinating committees and some have survey co-ordination acts.

The Commonwealth has its own Advisory Committee on Commonwealth Mapping which usually meets on one half day each year to review generally and advise on the Commonwealth's programme. It consists of the administrative heads of the departments of National Development (Chairman), Navy, Army and Interior, and a representative of the Institution of Surveyors. It reviews departmental proposals and gives general advice to the Minister for National Development on Commonwealth mapping activities.

The Division of National Mapping provides the secretariat for the National Mapping Council and the Advisory Committee on Commonwealth Mapping.

TYPES OF MAPS PRODUCED

In general, both Commonwealth and state mapping programmes have been directed towards air photography followed by early production of photomaps, and the earliest availability of these photographs and photomaps has been of the utmost value in Australian national development.

[1] The original text of this paper, prepared by Mr. B. P. Lambert, Director of National Mapping, Department of National Development, Canberra, and submitted under agenda items 6 and 8 (*b*), appeared as document E/CONF.52/L.1.

In respect of New Guinea, where photomaps have little value because of extreme height distortions, the Commonwealth has produced independent planimetric strip plots and experimented with the publication of block coverage of individual photographs so arranged as to permit examination in the field with small hand stereoscopes.

The processes after this preliminary approach have varied as between different agencies.

The Commonwealth has accepted as its first objective the need for a nation-wide planimetric map coverage at 1:250,000 scale and has been assisted in achieving this objective by some states.

A considerable amount of medium-scale contoured mapping has been produced by the Royal Australian Army Survey Corps for military training purposes.

All states have found it necessary to give priority to large-scale project work, but they have also devoted some time to standard mapping at scales of 1:31,680 to 1:50,000.

Now that the 1:250,000 preliminary basic mapping phase is nearing completion, the Commonwealth is starting a mapping programme aimed at covering the whole of Australia and the Territories of Papua and New Guinea with 1:100,000 scale contoured mapping in the next ten years. The normal contour interval will be 20 m but will be varied appropriately to suit extreme terrain conditions.

This programme was drawn up by the Director of National Mapping in consultation with the Director of Military Survey and with the support of the National Mapping Council.

After review and endorsement by the Advisory Committee on Commonwealth Mapping, it was approved by the Government towards the end of 1965 and a start has now been made.

The bulk of the work will be done by the Division of National Mapping and the Royal Australian Survey Corps. The states are for the most part adapting their programmes to help expedite the Commonwealth programme.

Private enterprise will assist with air photography and mapping contracts.

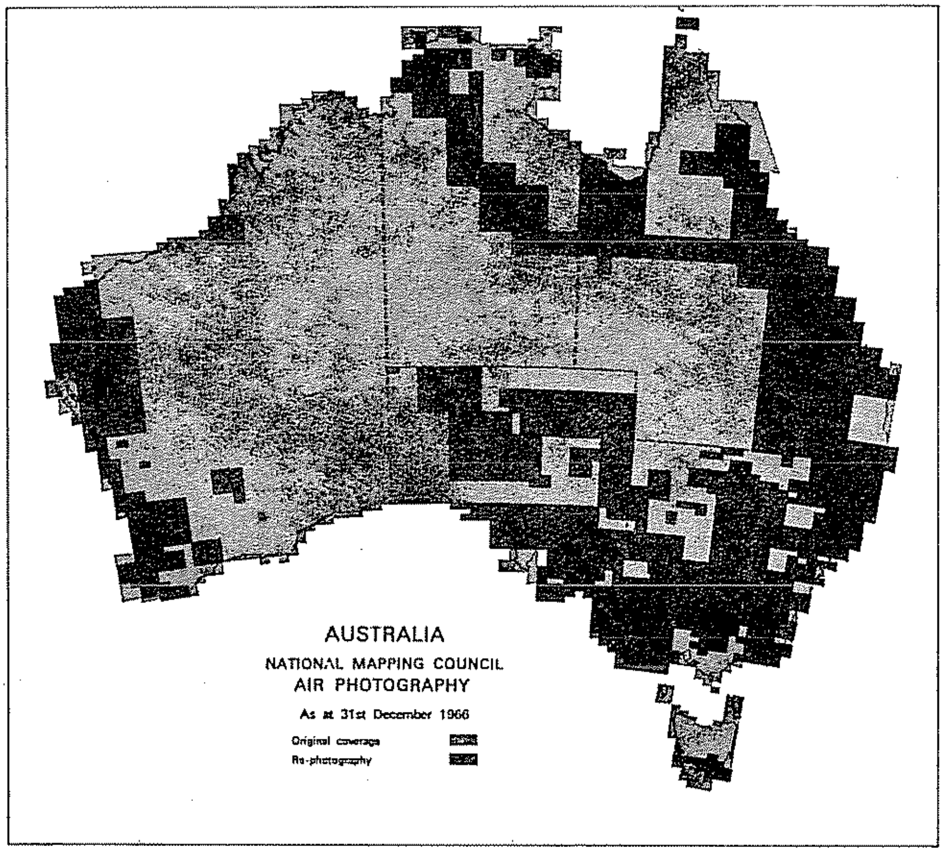

Fig. I—Australia: Air photography

The coastal portions of the continent will be published at 1:100,000 scale. The central area will be compiled at 1:100,000 scale but published only at 1:250,000 scale.

The proposed programme in respect of Australia is illustrated in the schedule below (p. 31).

TECHNIQUES AND EQUIPMENT

Air photography

The basic photography for Commonwealth purposes in Australia is now taken with super-wide-angle cameras from an altitude of approximately 25,000 feet with east-west flight lines normally spaced between the 1° intervals of latitude and covering $1\frac{1}{2}°$ of longitude. The work is done by private contractors.

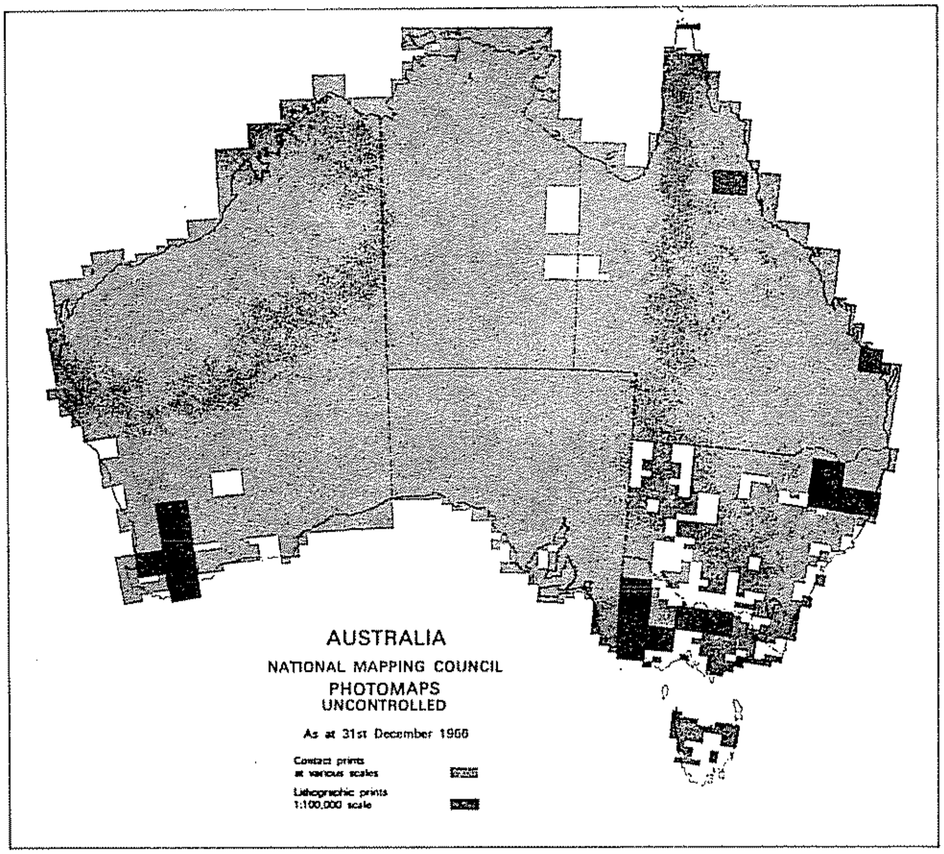

Fig. II—Australia: Uncontrolled photomaps

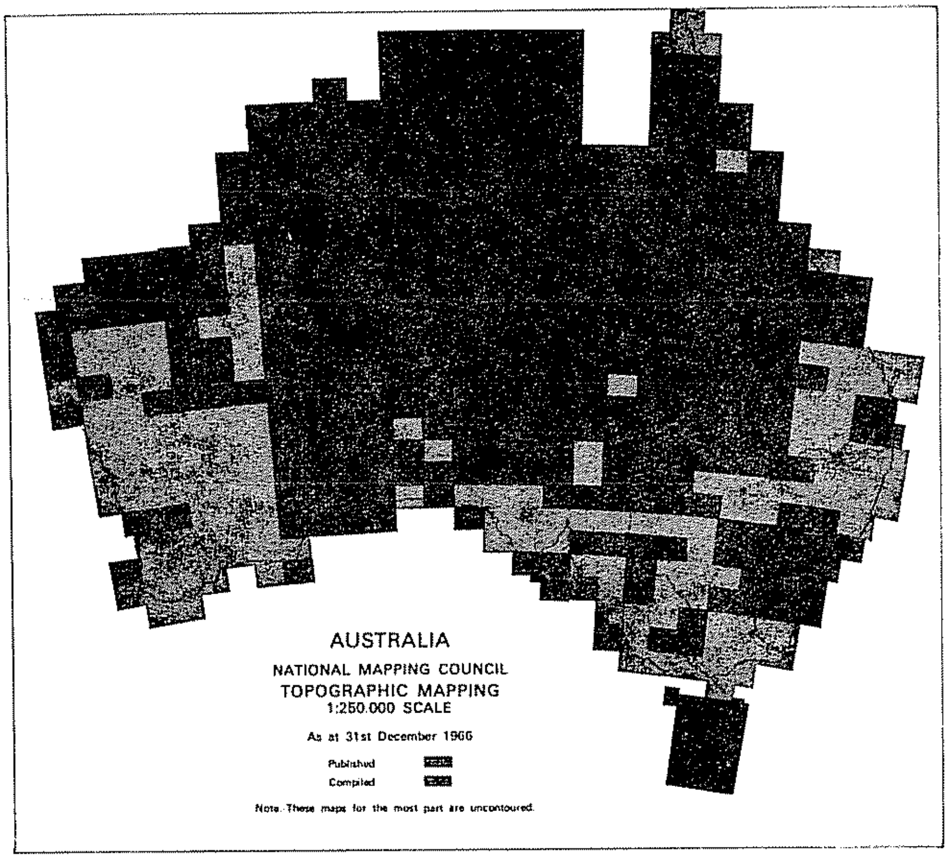

Fig. III—Australia: Topographic mapping at 1: 250,000 scale

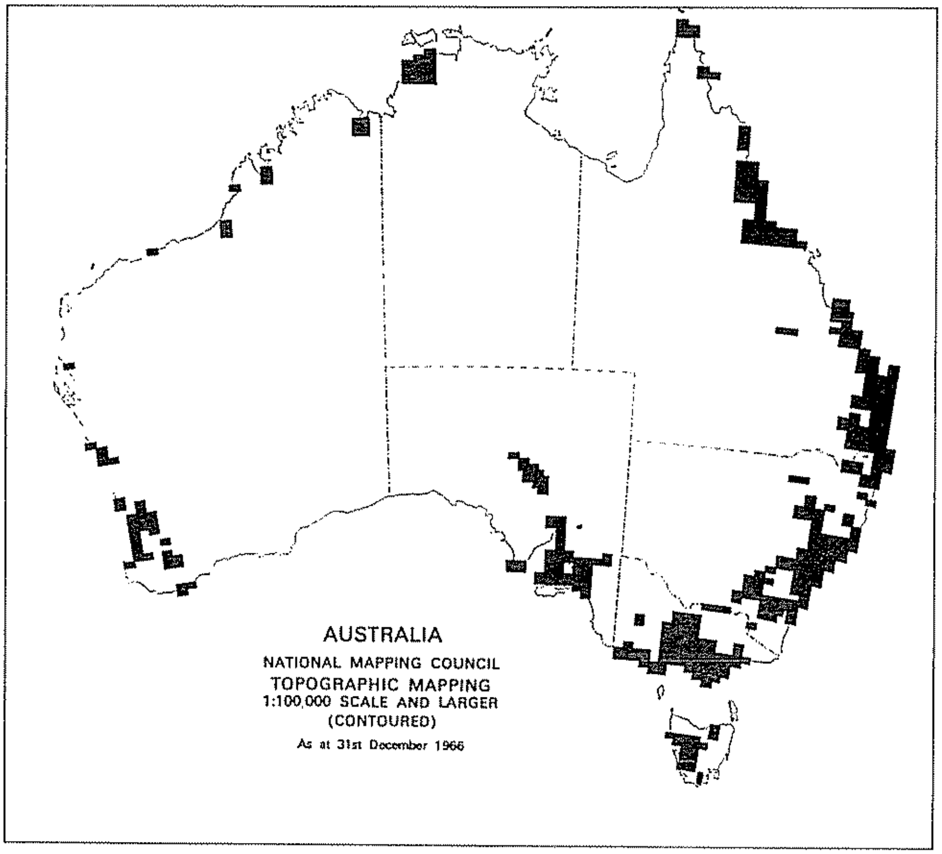

Fig. IV—Australia: Topographic mapping at 1:100,000 scale and larger

State photography is usually taken with modern wide-angle cameras at scales appropriate to the project. In some cases the complete work is done by contractors, in other cases the state lands departments charter aircraft and undertake their own photography.

Owing to excessive cloud conditions, great difficulty is being experienced in obtaining air-photo coverage of New Guinea and photography is being accepted from the contractor at any usable scale.

The most effective procedure for this area seems to be that of stationing an aircraft on stand-by in the north from about April to November and in the south for the remainder of the time. Most successful periods of photography occur when a nearby typhoon "sucks up" the local clouds.

Compilation

The basic 1:250,000 planimetric coverage was prepared using slotted template assemblies, initially laid to astro-control; as the geodetic survey progressed, the two forms of control were combined. Simple processes were used to transfer topographic detail.

For medium-scale standard mapping, the Army Survey Corps and the state lands departments have used various makes of analogue-type stereoscopic plotting equipment.

The Bervoets method is popular for planimetric block adjustment and the Jerie analogue equipment is used for height adjustment.

The state of Tasmania uses analytical aero-triangulation techniques based on the procedures developed by the United Kingdom Ordnance Survey.

For large-scale project work, it is customary to obtain survey control for individual stereoscopic models.

For the 1:100,000 scale programme, the Royal Australian Survey Corps intends to continue with the Bervoets and Jerie adjustment techniques for position and height, respectively. Airborne equipment will be used to provide survey control and normal stereo-plotting equipment for compilation.

In New Guinea, it has been necessary to intensify the amount of such control in order to cope with the heterogeneous pattern of air photography.

The Division of National Mapping has been concentrating on provision of early airborne control for the 1:100,000 scale programme. Aerodist is being used for horizontal control and radar APR (air profile recorder) for vertical control. The Department of Supply has been asked to develop a laser profile recorder.

Investigations are in hand to ascertain the best control patterns and mode of stereo-triangulation suitable for 1:100,000 scale mapping. These are being developed with full regard to the fact that 67 per cent of the Australian terrain has a slope of less than 5 per cent.

Test diapositives were submitted for processing on automatic and semi-automatic stereo-plotting machines and, the results having proved satisfactory, steps are in hand for the procurement of a machine capable of ortho-photo, contour and digital output.

When received, this will be assessed to ascertain how many more will be required for the division's part of the ten-year programme.

SCHEDULE OF SURVEY ACTIVITIES OF GOVERNMENT MAPPING AGENCIES FOR THREE-YEAR PERIOD 1 JANUARY 1963 TO 31 DECEMBER 1965

Activity	*Division of National Mapping*	*Royal Australian Survey Corps*	*Department of the Interior*	*Northern Territory Administration*	*Western Australia*	*South Australia*	*Victoria*	*New South Wales*	*Queensland*	*Tasmania*	*Total*
Aerial photography (sq. miles)	332,300	3,300	16,100	33,900	100,000	168,250	6,320	88,700	43,768	5,100	798,138
Levelling—precision (miles)	—	—	—	—	422[a]	—	366[a]	513[a]	16[a]	—	1,317[a]
	16,561[b]	—	14,730[b]	—	3,229[b]	1,331[b]	1,504[b]	507[b]	65[b]	—	37,927[b]
Geodetic survey, first order (miles)	7,404	4,197	320	1,528	1,968	1,310	441	1,741	150	85	19,144
Laplace astro-stations (number of)	279	38	—	—	18	10	—	—	—	—	345
1:250,000 manuscript map compilations (map = 6,000 sq. miles)	103	110	—	—	23	—	—	—	3	—	239
1:250,000 published maps (map = 6,000 sq. miles)	103	125	—	—	13	—	—	—	—	—	241
1:25,000 to 1:100,000 Larger scale map manuscript compilations (sq. miles)	19,150	91,170	—	—	—	5,460	4,804	11,600	3,170	3,425	138,779
1:25,000 to 1:100,000 Larger scale maps published (sq. miles)	20,580	50,540	—	—	580	2,605	2,800	10,630	1,190	3,880	92,805
Aerodist stations occupied (number of)	46	59	—	—	—	—	—	—	—	—	105
Aerodist line measurements (number of)	207	117	—	—	—	—	—	—	—	—	324

[a] Precision. [b] Third order.

Conclusion

The organizational arrangements that have evolved are found in practice to be those best suited to current local conditions. Their success depends to a large extent on the goodwill and good intent of those participating. As long as good co-operation continues, the existence of separate organizations will stimulate the evolution, testing and comparison of various techniques (some of which could possibly be stifled in one large organization) and thereby benefit national mapping as a whole.

It is expected that the production of topographic data in successive stages of air photographs, uncontrolled photomaps, planimetric maps and, finally, contoured maps will not cause much delay in the production of the final over-all contoured maps.

This early topographic information has been put to immediate use in resources surveys and developmental planning and has been particularly used to give greater efficiency in the planning and direction of current and future geodetic survey, air photography and topographic mapping activities.

It will be particularly interesting to ascertain what effect the automatic stereo-compiling machines will eventually have on future techniques of map production and presentation.

CARTOGRAPHIC ACTIVITIES IN NEW ZEALAND

Paper presented by New Zealand[1]

Introduction

As this is the first time that New Zealand has been represented at a United Nations cartographic conference, the purpose of this report is to present a general review of the progress in survey and mapping activities with some background information on the development of the New Zealand survey system

The Survey Division of the Department of Lands and Survey, as the principal survey and mapping organization in the country, has the following responsibilities: control surveys; cadastral surveys of all lands administered by the Crown; cadastral mapping; topographic mapping; special and general mapping; Aeronautical charting.

Cadastral surveys of private land are carried out by private practising surveyors, who also do some Crown cadastral surveys under contract.

Hydrographic surveys and charting are carried out by the Royal New Zealand Navy, using shore control supplied by Lands and Survey.

Geological surveys and mapping are carried out by the Geological Survey Division of the Department of Scientific and Industrial Research. Mapping is largely based on material supplied by Lands and Survey.

Gravity and magnetic surveys are carried out by the Geophysics Division of the Department of Scientific and Industrial Research.

New Zealand survey system

The topography of the country and the early history of European settlement are the two factors which have had most influence on the survey system which operates today. New Zealand lies between 34° and 48° south and between 166° and 179° east and consists of three major islands: North, South and Stewart. North Island (44,280 square miles) is largely hilly, with a major mountain chain varying from 3,000 to 6,000 ft and isolated mountain masses rising to over 9,000 ft. South Island (58,090 square miles) is largely mountainous, with a major backbone range in which there are seventeen peaks over 10,000 ft high and a high peak of 12,349 ft. Stewart Island (670 square miles) is hilly, rising to 3,200 ft. At the time of settlement, much of the country was covered with forest. From 1840, settlements were established at various places round the coast and gradually spread to the more accessible interior.

Until the abolition of the provincial system of government in 1876, the surveys of New Zealand were conducted by nine survey departments, each independent of the other, and working on no common system, except that all showed measurements in chains and links, and areas in acres, roods and perches. In 1876, the amalgamation of these into one Department of Lands and Survey was accomplished. Several of the provinces had conducted their surveys on a trigonometrical framework basis, but, as the others were building one survey on another by traverse on magnetic or other azimuthal bearings, without any reference to true meridian or any independent check of triangulation, a state of considerable confusion and uncertainty had arisen in the survey records.

With the adoption of the Torrens system of land title registration, it was necessary to devise a system that would rapidly bring the surveys under control and record, so that settlers might be placed in secure possession of their land and the Crown be safe to issue titles on reliable plans and descriptions. On that basis, it was necessary to provide a system of survey control whereby permanent monuments would serve as a reference for all land title surveys.

The plan adopted was to divide the country into twenty-nine districts designated "meridional circuits", each with a limited extent in longitude. The boundaries of each circuit were as far as possible made coincident with natural features such as rivers or mountain ranges. At the initial or main station of each, generally about mid-longitude where possible, the latitude, longitude and meridian were accurately determined. Lines of bearings on the true astronomical meridian of the initial station were extended throughout its circuit to the plains and valleys where surveys were in progress. Within three years, those standard bearings had been so extended as to enable all surveys to be conducted on the true meridian of their respective circuits. In conjunction with that operation, base lines were measured and minor triangulations of 2 to 3 mile sides were extended through the circuits wherever most required for the check and connexion of the settlement surveys. Any isolated triangulations previously carried out were connected and in this way the country was placed very quickly under a system of correct recordable survey, readily

[1] The original text of this paper, prepared by W. S. Boyes, Assistant Surveyor General, Department of Lands and Survey, appeared as document E/CONF.52/L.2.

adjustable to the requirements of a population rapidly spreading over areas widely apart.

It was realized in 1876 that the establishment of a minor triangulation with stations spaced only a few miles apart could not await the carrying out of an overall geodetic triangulation and consequently the ideal of proceeding from the "whole" to the "part" had essentially to be reversed. In fact, the geodetic triangulation was not completed until 1949. In spite of this, the survey system adopted in 1876 has, for land survey purposes, proved to be most practical and efficient.

Trigonometrical stations and all other survey marks were referenced by plane co-ordinates, the origin being the circuit initial station, or, until all the minor triangulations in a circuit were joined together, the main station of a particular survey district. The bearings of all surveys within a circuit were in terms of the true meridian of the circuit initial station.

GEODETIC SURVEY

Between 1910 and 1913, a start was made on the first-order geodetic triangulation of the whole country by measuring five base lines in North Island. However, owing to economic and other reasons the work progressed only spasmodically and observations and computations were not finally completed until 1949. The international (Hayford) spheroid was adopted for computations. The first-order work has been partly and still is being divided into second- and third-order control, using as far as possible old stations of the early meridional circuit minor triangulations. Much of this early work was of very good quality and in these cases it is being readjusted to respect the geodetic framework and classified as fourth order. Increasing use is being made of tellurometer traversing to establish new control and to make possible the adjustment of the early minor triangulations to the geodetic net. The present position with regard to first-order, second-order, third-order and fourth-order triangulations as well as the main tellurometer traverses is shown in figures I and II and some details of the adjustment of the first-order work are shown in the annex.

National yard grid co-ordinates on the transverse Mercator projection, with one origin in each of the two main islands, are computed for all stations. Trigonometrical record maps in production list geographical, national yard grid and meridional circuit link co-ordinates as well as elevations in feet. For cadastral survey purposes, the meridional circuits and their initial stations have been retained, but stations are now co-ordinated on the TM projection, a separate one for each circuit, with the old initial station being the origin of co-ordinates as before.

Precise levelling to international geodetic standards was first commenced in 1938 and some 2,200 miles of first-order levelling has now been completed, mainly for hydroelectric investigations. The extent of this work is shown in figure III. In the central North Island thermal regions, annual relevelling has been carried out to determine the extent of subsidence associated with geothermal power development operations. A considerable extension of this levelling will be required in the future, not only to complete the national network but also to check on possible movements across fault lines.

Published bench-mark lists give orthometric and dynamic heights, descriptions and locality diagrams of the permanent marks. Dynamic heights are referred to standard latitude 45° and are computed from a theoretical value of the acceleration due to gravity, with constants determined from New Zealand measurements.

AERIAL PHOTOGRAPHY

Figure IV shows graphically the existing aerial photographic coverage. A private company, under agreement with the Crown, carries out all aerial photography and produces mosaic maps required for government purposes. In general, the basic aerial photographic cover of New Zealand, started in 1939, was with Eagle IV cameras with 8.25-inch focal length at 1:15,840 negative scale. From 1956, photography was mainly with Wild RC5a camera, basic interpretation cover with 8.25 inch focal length at 1:15,840 negative scale and mapping coverage with 4.5 inch focal length at 1:44,000 negative scale. The 16,500 ft operational ceiling of the Beechcraft plane, then in operation, dictated the scale of photography. In 1963, an Aero Commander plane, with an operational ceiling of 25,000 ft, became available, and with Wild RC8 camera mapping photography for 1:25,000 and 1:63,360 mapping was produced at 1:66,000 scale. Basic cover for mosaic and interpretation purposes was at either 1:15,840 or 1:24,000 negative scale. A Wild RC9 super-wide-angle camera has recently been acquired and photography from a flying height of 25,000 ft is now being used for 1:25,000 and 1:63,360 topographic mapping. A considerable amount of special photography, mainly for large-scale photogrammetric engineering mapping required for government purposes, is also supplied by this company. Semi-controlled mosaic maps produced for the department by this company are available over about half the country. These conform to the same sheet lines as the 1:25,000 topographic maps but are at 1:15,840 scale. Generally scale errors do not exceed 5 per cent in flat country or 10 per cent in hilly country. A recent development, to obviate the compilation of conventional mosaics in certain areas, is the use of enlargements from 1:66,000 negatives, each photograph covering a 10,000 yard square. These are available at 1:15,840 scale. The flight pattern is based on the topographic map sheet layout, with a spacing of 5,000 yards between photocentres and 10,000 yards between flight lines.

CADASTRAL MAPPING

For survey and land administration purposes, the country is divided into twelve land districts, and for record purposes these are further subdivided into survey districts, of 12.5 miles or 1,000 chains square. For land appellation purposes, each of these is further subdivided into sixteen blocks, each 250 chains square. Generally all subdivisions of land, excepting those within towns or cities, refer to a section number of a block of a survey district. Accurately plotted record maps, at 1:7,920 or 1:15,840 scales for rural areas and 1:792 or 1:1,584 scales for urban areas, are maintained in each land district office. Every land survey carried out, whether by private or government surveyors, is plotted and recorded on these maps, which provide the basis for the production of published cadastral maps. Since about 1880, these have been produced by districts and published at 1:63,360 scale in both the survey district and county series. These are now virtually superseded by a new series, at the same scale and showing the same information, but adopting the sheet lines of the 1:63,360 topographic maps. Original drawings are on stable plastics and some use is made of stick-up lettering. Every subdivision of land is shown and these maps have been of inestimable value to the development of the country, and form the basis for most land administration functions, showing not only the boundaries but also areas and descriptions of all parcels of land.

Topographic mapping

Figure V shows the present position as regards topographic map coverage at 1:63,360 scale. In conjunction with the early triangulations carried out some eighty years ago, reconnaissance topographic maps at 1:31,680 scale were produced by surveyors. These showed the main rivers, lakes, streams, mountain ranges, bush, etc., with some spot heights but no contours, and were generally adequate for the requirements of that time.

The outbreak of the Second World War revealed the paucity of topographic map coverage for modern needs and in a few years more than one-third of the country had been mapped at 1:63,360 scale by field parties using plane tables and such other equipment as was available. Mapping was confined mainly to the coastal areas, using the cadastral maps as a basis. Over most of the country there was no aerial photographic coverage, but during that period a small photogrammetric unit which had been established was engaged mainly in the production of 1:25,000 maps of important defence areas. Following the Second World War, there was an increasing demand for topographic maps, with emphasis on large-scale information for hydro-electric engineering investigations and land development projects. The aim at that time was to complete the national topographic coverage at 1:25,000 scale, from which the smaller scale 1:63,360 and 1:250,000 maps would be compiled. It was soon realized that that aim was not realistic and the present policy is to complete the 1:63,360 coverage within the next five years.

To assist in obtaining some form of 1:63,360 coverage as quickly as possible, some sheets are published as an interim series. These normally show stream and ridge patterns with cultural detail and are produced in the district offices using aerial photographs, slotted template laydown and radial line plotters. The 1:250,000 topographic mapping coverage is shown in figure VI. These are compiled from available larger scale topographic information. The 1:25,000 topographic mapping is at present limited to areas where there is a specific requirement for this information. In many cases, prints from the instrument plots suffice and, as will be seen in figure VII, not all the 1:25,000 information available has been produced as published maps. The topographic map sheet lines are based on the north and south national yard grids, the 1:63,360 maps covering 45,000 yards in an east-west direction, and 30,000 yards in a north-south direction. These are subdivided for the 1:25,000 sheet layout into nine sheets, each covering 15,000 yards east-west by 10,000 yards north-south. It will be noted that the sheet layout is based on a yard grid and not on a graticule system. This is perhaps unfortunate, for undoubtedly there will eventually be a change to metres. It is recommended that countries which are commencing mapping, or where mapping is not too far advanced, should adopt a graticule system for their sheet layout whether or not they are working in metres.

The Department of Lands and Survey produces all topographic mapping to meet both the civil and the military requirements of the Government. Except for some small projects where other methods are best applicable, photogrammetric methods are used. A specialist Photogrammetric Branch of Head Office produces 1:25,000 and 1:63,360 mapping for national coverage with 50-feet and 100-feet contour intervals with Wild B8 instruments, which can be adapted for super-wide-angle photography, or with Williamson wide-angle multiplex. Mapping is plotted on stable plastic materials at 1:15,840 and 1:47,520 scales for the 1:25,000 and 1:63,360 maps, which are drawn either in district offices or in the Cartographic Branch at Head Office. Those drawn in districts are processed through the Cartographic Branch for editing and relief shading of the 1:63,360 series. Field checks are carried out by district office survey staff before final drawing stage, using compilation prints.

Special and general mapping

Large-scale engineering topographic mapping produced by the Photogrammetric Branch with Wild A5, A6, A7, A8 and Thompson-Watts plotters includes work required for highways, railways, housing, hydro-electric investigations, forestry utilization and land development projects. Scales are generally between 1:500 and 1:5,000, with contour intervals ranging from 2 to 20 ft.

The Cartographic Branch draws the following types of maps for publication: reconnaissance topographic maps of the Antarctic Ross Dependency; street maps at scales from 1:7,920 to 1:20,000; general maps of New Zealand at scales from 1:250,000 to 1:4,000,000; maps of national parks; tourist and trampers' maps; land inventory maps; maps of the Pacific area; maps for encyclopaedias and so on.

Aeronautical charting

Aeronautical charts produced by the Lands and Survey Department for the Department of Civil Aviation and the Royal New Zealand Air Force include: approach and landing charts; service charts; radio navigational and terminal charts; flip charts; aeronautical charts at 1:500,000 and 1:1,000,000; plotting charts at 1:1,000,000; 1:2,000,000; 1:2,500,000; 1:3,000,000 and 1:6,000,000.

Technical developments

Field survey

MRA1, MRA2 and MRA3 tellurometer equipment has been used by the Lands and Survey Department for some years for extending geodetic control and for connexions through early triangulations to enable these to be adjusted to the geodetic network. Traversing, as opposed to trilateration, has been used throughout and closures between fixed geodetic stations are generally better than 1:50,000. To date, 6,500 miles of tellurometer control traverses have been completed. More use is being made of helicopters on this work in mountainous areas. Tellurometers are also used extensively to establish ground control for all scales of topographic mapping as well as for cadastral survey control. Wild N3 levels, with Wild and Watts staves, are in use for first-order levelling, and 2,200 miles have now been completed. Premarking of ground survey control for all scales of photogrammetric mapping is now being extensively used.

Computing

An Elliott 503 electronic computer is available for use by government departments. A number of geodetic computations as well as aerial triangulation have been analysed and programmes produced for use on this com-

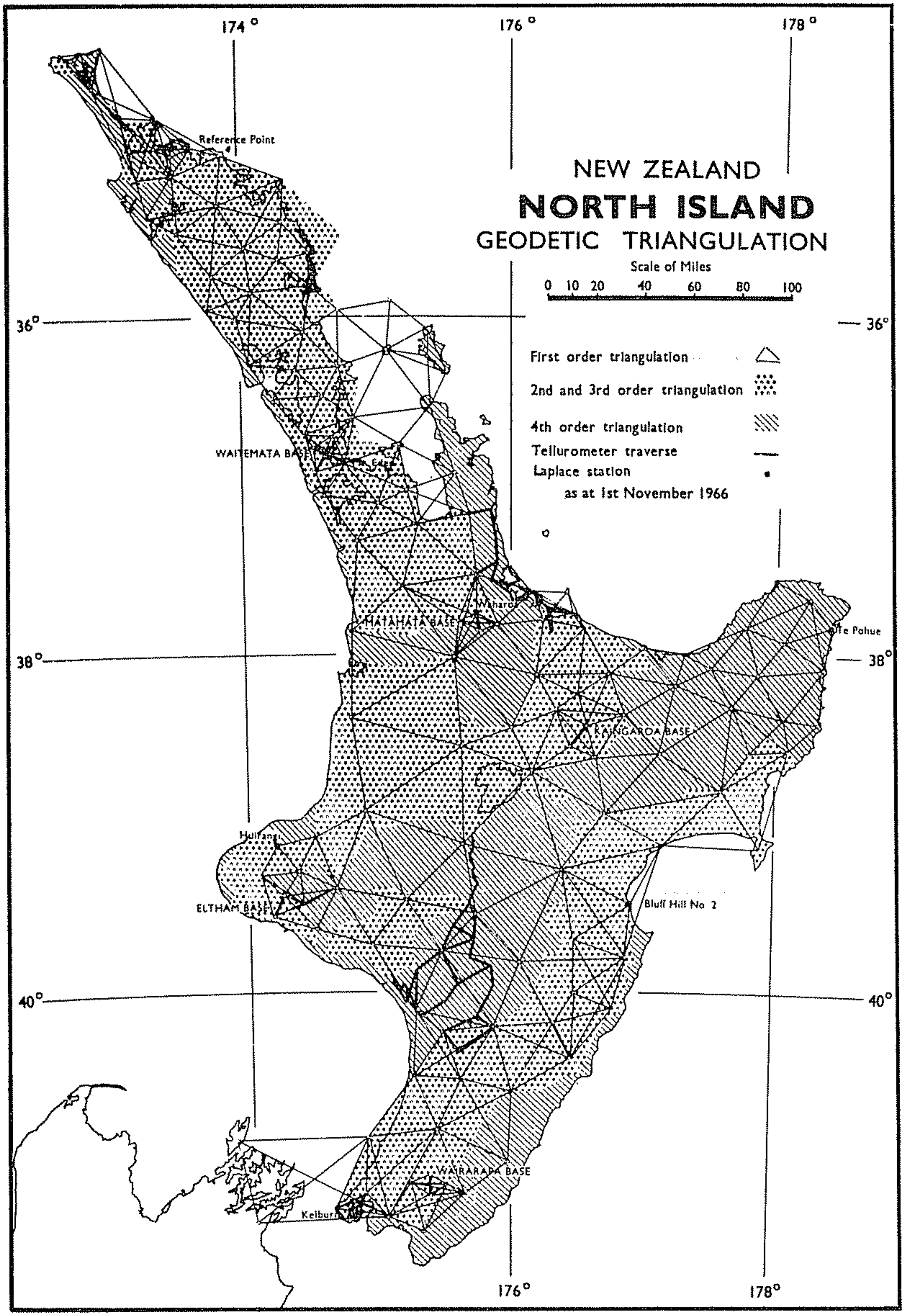

Fig. I—New Zealand: North Island, geodetic triangulation

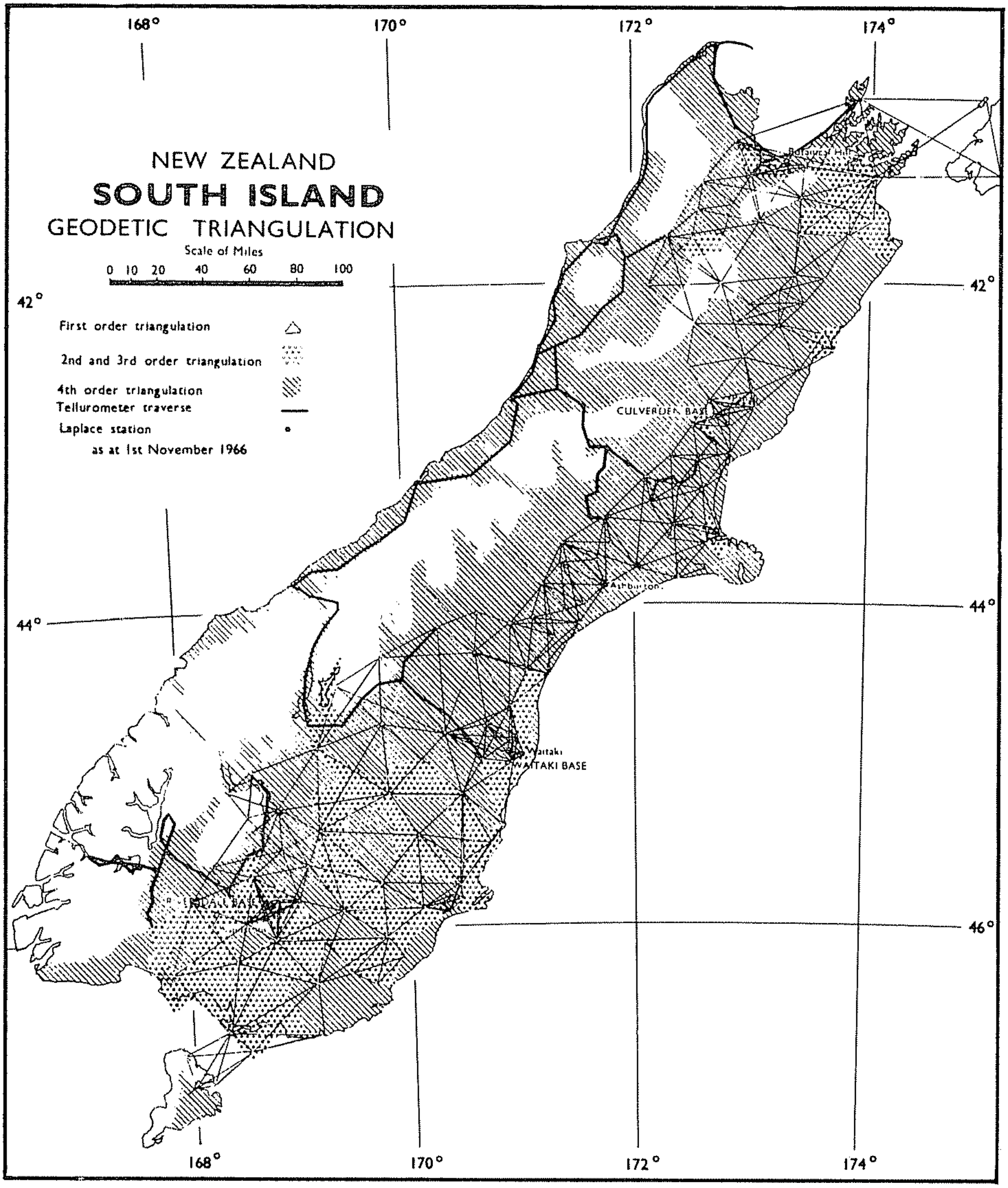

Fig. II—New Zealand: South Island, geodetic triangulation

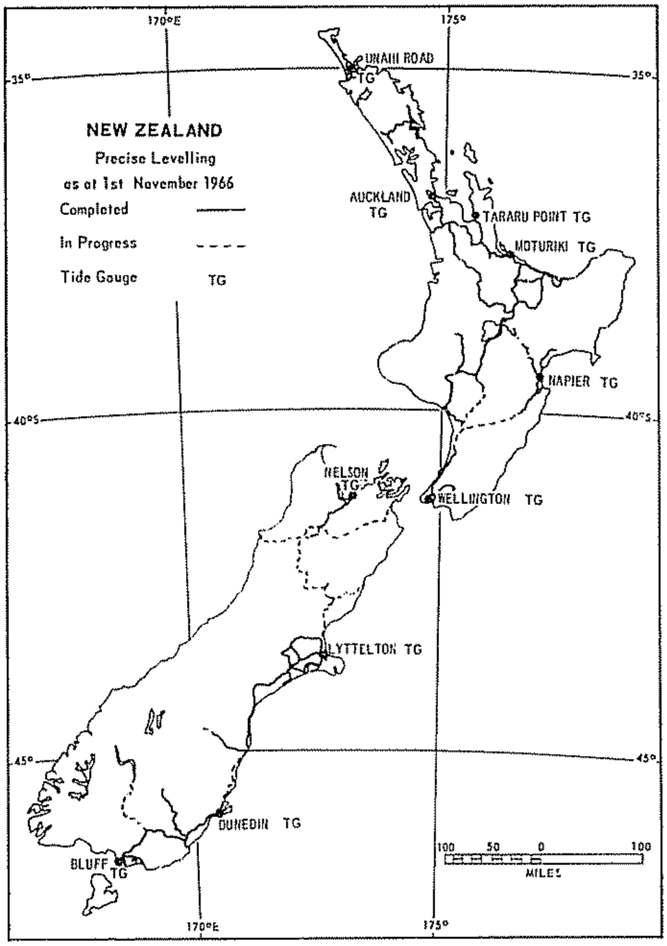

Fig. III—New Zealand: Precise levelling as at 1 November 1966

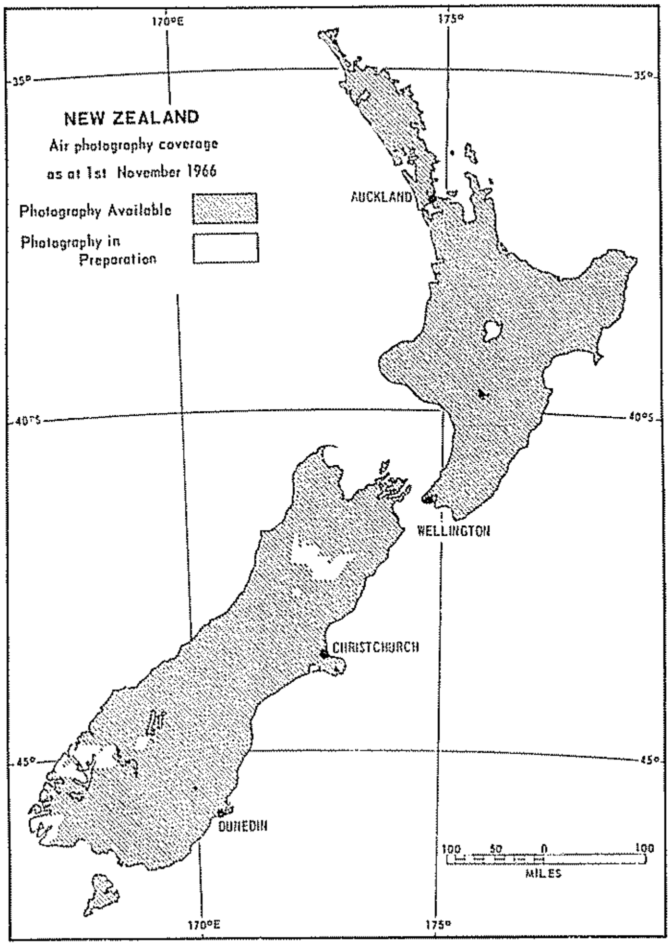

Fig. IV—New Zealand: Air photography coverage as at 1 November 1966

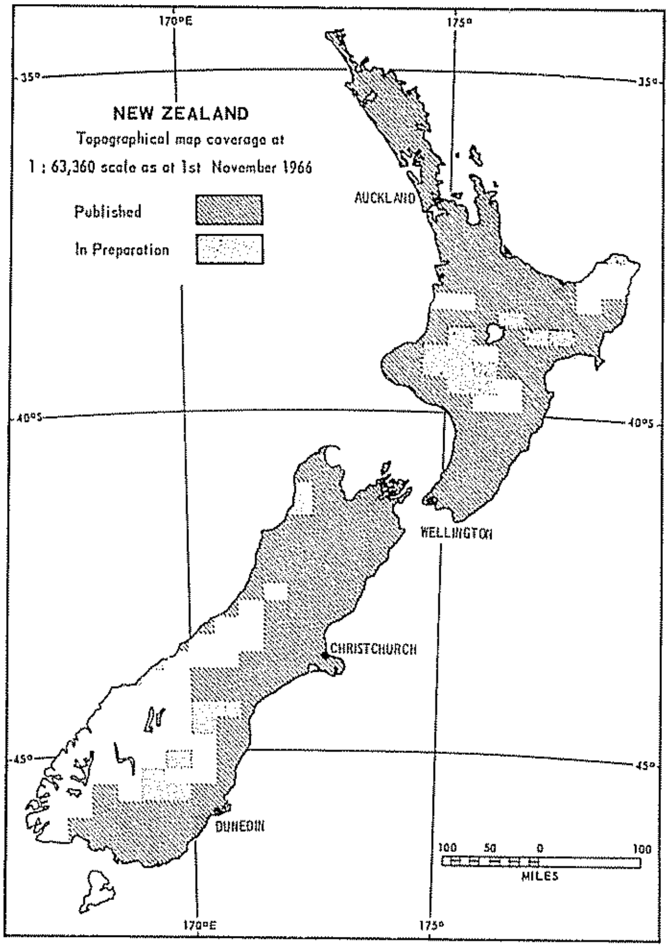

Fig. V—New Zealand: Topographic map coverage at 1:63,360 scale as at 1 November 1966

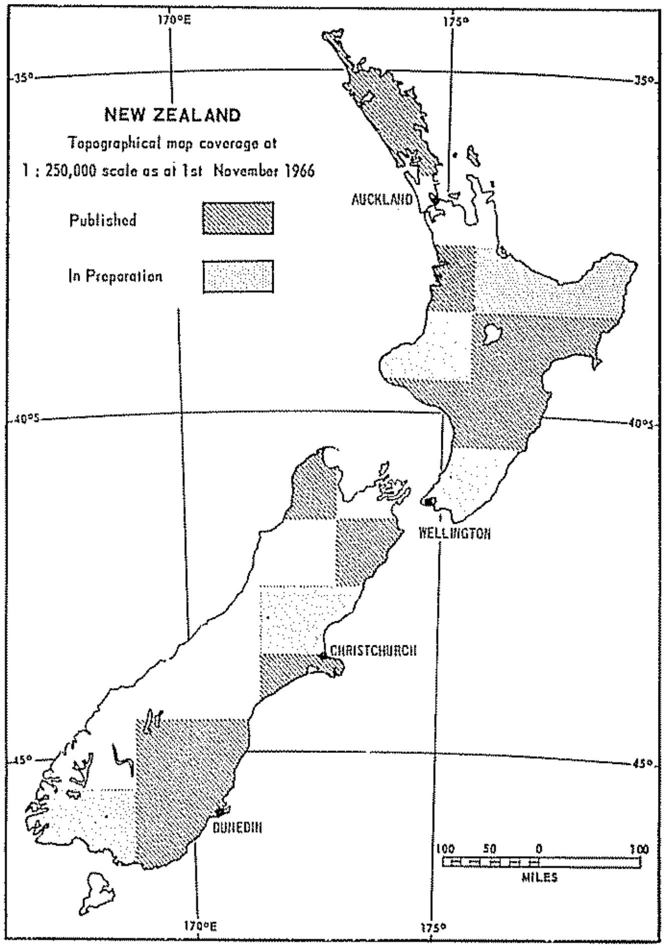

Fig. VI—New Zealand: Topographic map coverage at 1:250,000 scale as at 1 November 1966

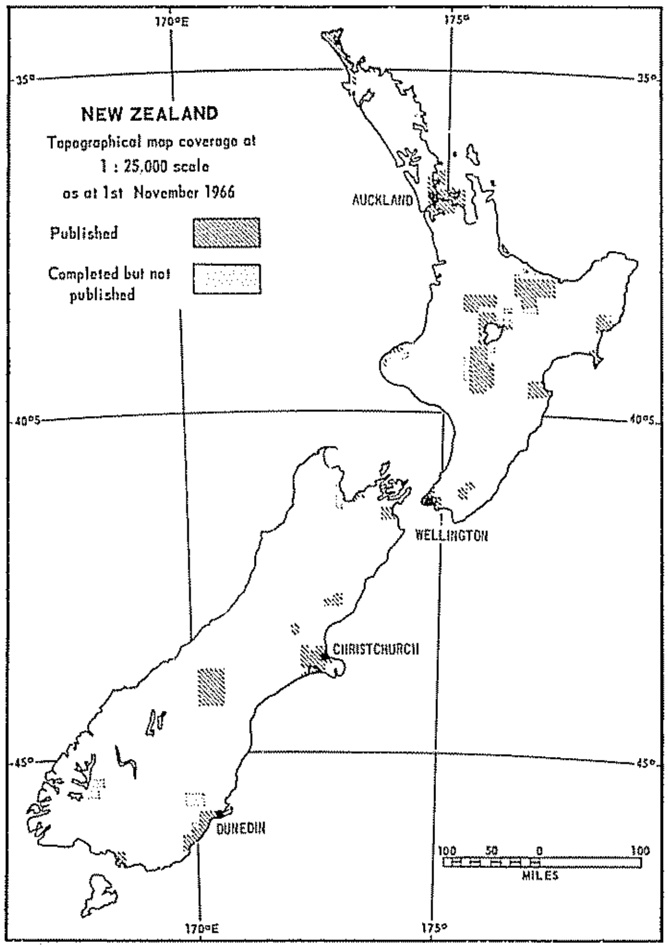

Fig. VII—New Zealand: Topographic map coverage at 1:25,000 scale as at 1 November 1966

puter. Programmes to convert other geodetic computations, including tidal analyses and predictions, to electronic methods, are being developed and it is expected that this work will extend into the cadastral survey field. Flexowriter and Veripunch units are shortly to be installed in Head Office Computing Branch to assist in this work.

Cartography

For a number of years, the department produced most of its maps for same-scale reproduction, using positive-to-positive reversal on vinyl materials. With the advent of stable polyester-based negative-to-positive photographic emulsions, a change was made to negative processing, including drawing for reduction where necessary. More recently, polyester wash-off drafting films have been introduced for converting drawings of the earlier editions, on less stable or less suitable bases, to modern stable bases for map revision purposes. All map names are reproduced on stripping film by Monophoto or Photonymograph equipment. The adhesive used is Flexowax. Earlier scribing operations were for positive conversion by dyeing the line work and removal of the coating. Negative scribing is now used, the scribed line work being either combined with letter-type from a type overlay at an intermediate or printing plate stage, or being contacted to positive on presensitized polyester materials for finishing and lettering.

Relief shading is executed at reproduction scale on translucent white astrofoil, coated with grey printer's ink which includes cobalt driers. The work is done, with the aid of aerial photographs, on light tables over a translucent colour proof of the combined culture, hydrography and contour drawings. Special black grease lead pencils are used to intensify the grey tone for shadows and various erasers used to produce the highlights. The drawings are not susceptible to smudging and can be easily altered, and the technique can be readily learnt by juniors with a minimum of training.

Reproduction of relief shading is through half-tone photography. The opaqued half-tone negative, together with the road fill-in overlay and the water area overlay for use as drop-out masks, are registered together in the projection copy holder of the camera and reprojected through the camera to produce a reverse positive for plate making. This reprojection reduces the dot size of highlight and flat-land tones, thus overcoming many of the objections to the dark-plate method. Where possible, colour masks and overlays are produced by peel-coat methods.

All printing plates are of ungrained presensitized aluminium. All maps are printed on 100 per cent rag-fibre chart paper or on 50 per cent rag-fibre high wet-strength chart paper and inks are premixed in quantity by the manufacturers to ensure uniform colour standards.

The printing of all maps produced by Lands and Survey is carried out by the Government Printer.

Aerial photography and photogrammetry

A Wild RC9 super-wide-angle camera has recently been acquired to provide photography from 25,000 ft for basic mapping at 1:25,000 and 1:63,360 scales. A Wild RC8 camera, focal length 4.5 inches and 8.25 inches, is also available. Aerial triangulation is carried out on either an A7 or an A9, each of which is digitized with the normal EK3 combination. It is intended to use eight-channel punch tape as well in the future.

Individual strip adjustment is carried out over most readily accessible parts of the country where ground control presents no great problems. Consequently, for 1:63,360 mapping, the density of control requires only alternate runs to be bridged. In the more mountainous areas, ground control is more difficult and costly to obtain, and tie-runs, spaced about 35 miles apart, are located to enable the best use to be made of available control. These tie-runs average about 60 miles in length across terrain ranging from sea level to over 10,000 ft in some areas. Every mapping run is bridged in these circumstances.

The A7 is used for providing the supplementary control for all scales of mapping from the RC8 photography, both wide angle and normal angle, while the A9 is restricted, at present, to wide-angle photography from the RC8 and super-wide-angle from the RC9 for basic mapping. So far, only a relatively small amount of RC9 photography has been obtained. Although all this photography will be taken with 80 per cent longitudinal overlap, only the 60 per cent models will be used for bridging, and mapping will be done on adapted Wild B8 instruments, of which the department holds three. The A7 is also used for terrestrial photogrammetry, very large-scale mapping of small areas and obtaining cross-section data for highway location computer programmes. This work is likely to increase in future.

Annex

ADJUSTMENT TO FIRST-ORDER TRIANGULATIONS
(*in seconds*)

	Total number of triangles	*Average triangle closure*	*Maximum triangle closure*	*Mean error of an angle*	*Probable error observed direction*
North Island					
Main figure	163	0.913	3.888	0.562	0.479
East Cape figure	35	1.462	5.489	0.864	0.678
Subsidiary figures	88	1.162	4.660	0.627	0.505
South Island					
Northern figure	77	0.987	3.143	0.704	0.473
Southern figure	154	0.973	2.862	0.692	0.511
Subsidiary figures	137	1.210	4.869	0.775	0.671

The East Cape figure contains the earliest work when observations were made in daylight to beacons, using 8 inch micrometer theodolites. Later observations were made at night to beacon lamps, using Wild T3 theodolites.

Base lines

The probable errors of the base line measurements are:

Base	*Length (links)*	*Probable error*
Matamata	54,799.085	1:6,765,000
Waitemata	41,790.479	1:5,290,000
Wairarapa*	64,776.063	1:2,958,000
Eltham*	79,604,347	1:6,219 000
Kaingaroa*	91,198.176	1:6,204,000
Riversdale	56,541.119	1:8,567,000
Waitaki	59,997.557	1:9,230,000
Culverden	55,003.495	1:8,209,000

The first five bases listed are those in the North Island that were measured between 1910 and 1913. Those marked (*) were not remeasured with the MACCA equipment in 1947, but corrections derived from the remeasurement of the other two bases were applied.

The error of closure of length between base nets, as computed from the unadjusted observations used in forming the length equations, are as follows:

	Number of triangles in chain	*Error of closure of length*
Waitemata to Matamata	6	1:270,000
Matamata to Kaingaroa	4	1:29,000
Matamata to Eltham	9	1:90,000
Eltham to Wairarapa	11	1:24,000
North Island to Culverden	12	1:82,000
Culverden to Waitaki	15	1:47,000
Waitaki to Riversdale	9	1:58,000

ACTIVITIES OF THE UNITED KINGDOM DIRECTORATE OF OVERSEAS SURVEYS

Paper presented by the United Kingdom[1]

INTRODUCTION

This report is an account of the contribution to the surveying, mapping and charting of the countries and seas of Asia and the Far East made by United Kingdom government agencies between August 1964 and the end of September 1966.

Land survey work has been carried out continuously by the surveyors of the Directorate of Overseas Surveys in co-operation with the survey departments of the British Solomon Islands Protectorate, the New Hebrides, Sabah and Sarawak. Military survey parties have also worked extensively in East Malaysia.

Hydrographic surveys in Far Eastern waters have been carried out by HMS *Dampier* under the direction of the Hydrographer of the Navy. Work has proceeded off Hong Kong, Sabah, Singapore, the British Solomon Islands Protectorate, the New Hebrides and Fiji, and oceanographic observations have been made on passage.

Air photography of East Malaysia has been flown both by the Royal Air Force and by a commercial firm under contract.

Contoured topographic maps at scale 1:50,000 have been published of Malaysia and of Fiji and the first sheets of the new planimetric series of the Solomon Islands have been completed. These are printed in five colours.

Practical training in modern cartography, air and field survey and computing has been arranged in the United Kingdom under United Kingdom technical assistance schemes and for holders of United Nations and Colombo Plan fellowships and for other officers nominated by their own Governments. Visits and courses have lasted from a few weeks to a year or more and have been arranged for officers from the British Solomon Islands Protectorate, Burma, Ceylon, Hong Kong, India, New Zealand, Pakistan, the Republic of Viet-Nam, Sarawak and West Malaysia. Practical survey training under local field conditions has been provided in the New Hebrides and in Sabah and Sarawak by the attachment of members of the local survey department to overseas surveys' field parties.

TOPOGRAPHICAL SURVEY, AIR PHOTOGRAPHY AND MAPPING

British Solomon Islands Protectorate

The field survey programme to provide control for 1:50,000 form-lined mapping of the whole group was almost completed by the end of the period. Primary perimeter traverses, measured by tellurometer, were completed along the northern shores of Santa Isabel and Choiseul and in the Santa Cruz group and were partially measured on San Cristobal. In addition, tertiary control was established on all those islands and on Malaita. When the current programme of heighting has been carried out, survey work will have been completed on all the major islands and work will then proceed on the outlying islands of Rennell and Bellona, Stewart Island and Lord Howe Atoll.

Fourteen planimetric and two partially form-lined 1:50,000 sheets of the New Georgia and Shortlands islands were published and work is currently in hand on six form-lined 1:50,000 sheets of Shortlands and Vella Lavella. All are based on the air photography flown by the Royal Air Force in 1962–1963 (see also under "Pacific" below).

[1] The original text of this paper appeared as document E/CONF.52/L.4.

Brunei

A contoured map at 1:250,000 of the whole State has been published. Relief is depicted by both layer tints and hill shading.

Fiji

Work continues on 1:50,000 contoured mapping. Three revised sheets were published of Vanua Levu and one of Viti Levu and also new sheets of both Lomaiviti and Viti Levu.

Contoured layer-coloured sheets at 1:250,000 were published of the Yasawa and Kandavu groups and a revised edition of Vanua Levu was printed (see also "Aeronautical charts" below).

Hong Kong

A new series of contoured maps at scales 1:10,000 and 1:25,000 is being prepared; work has so far been taken up on twenty-seven 1:10,000 sheets.

Malaysia

West Malaysia—Malaya

Military survey assistance to Malaysia has included work on a project to replace the $\frac{1}{4}$ inch to 1 mile mapping by a new series of maps at 1:250,000 scale which have a $1° \times 1\frac{1}{2}°$ format and are to be constructed on the Rectified Skew Orthomorphic (RSO) projection. The area south of 4° N has been completed and the 1:1,000,000 sheets of the same area have been revised and published with the RSO grid.

East Malaysia—Sabah and Sarawak

The Royal Air Force has continued to fly new survey photography of Sabah and Sarawak. During the period under review, about 200 successful sorties have been obtained. This photography is being used in the current 1:50,000 mapping programme.

During parts of 1964 and 1965, one military field survey party from the United Kingdom joined the two parties from Singapore which worked from 1964 to 1966 assisting Malaysia by making control surveys in unmapped parts of East Malaysia. Methods used were tellurometer traversing, astronomical fixation and heighting by vertical angles and altimeter (see also under "Sabah" and "Sarawak" separately below).

As a result of the progress of all field work in both Sabah and Sarawak, it has been possible to complete the photogrammetric compilation of 28,000 square miles of territory for 1:50,000 mapping.

Except for the extreme north of Sabah, complete map cover at 1:250,000 scale has been published for East Malaysia. The first editions were essentially planimetric sheets; as relief information became available, subsequent editions have variously shown hill shading, contours, contours with layer tints and latterly contours, layer tints and hill shading.

Sabah

Directorate of Overseas Surveys (DOS) field parties, assisted by members of the Lands and Surveys Department, have worked in Sabah throughout the period to provide control for 1:50,000 contoured mapping. They have worked mainly in the extreme north and east of the country measuring coastal traverses by tellurometer and penetrating inland up the rivers. They have collaborated closely with the military survey parties whose aircraft and helicopter support has greatly facilitated the reconnaissance and establishment of survey stations in country that is very inaccessible on the ground.

Contoured maps at 1:50,000 and at 1:25,000 have been completed and published of the Labuk Valley area and at 1:50,000 of the Semporna Peninsula and work is in hand on a further six sheets. A revised town plan of Sandakan at 1:5,000 has been published in nine sheets.

Sarawak

DOS field parties, assisted by members of the Lands and Survey Department, have continued to carry out tellurometer traversing and heighting in Sarawak to provide the basis of new 1:50,000 contoured maps; existing survey schemes have been incorporated in the over-all framework. Work has been completed in the coastal half of the country east of 111° 45′ E between 2° and 4° N as far as existing photography allows. At the end of the period the surveyors were concentrating on completing the coastal traverses in the Lower Rajang delta.

During the period June to August 1966, a block of 7,900 square miles of air photography was flown under contract of the Lower Rajang area extending southwards into the Second Division.

Contoured 1:50,000 sheets were published of the whole of the First Division. Work was taken up on 103 sheets of a contoured town plan of Kuching at 1:1,250 scale; thirty sheets had been published by September 1966.

New Hebrides

The programme of the DOS field party is to run tellurometer traverses to connect and supplement the triangulation chains and tertiary network established previously by the French Institut géographique national and by the Condominium Survey Department. Work commenced in 1964. Reconnaissance has been carried out and observations completed on Efate and in the south and east of Espiritu Santo; the party will then move to Ambrym and Pentecost.

Pacific

Satellite geodesy

One United Kingdom team has taken part, since 1964, in the United States Army Map Service SECOR project. The team has made observations from Guam (Mariana Isles) and Gizo (British Solomon Islands Protectorate).

HYDROGRAPHIC SURVEYS

During the period under review, hydrographic surveying was carried out in Far Eastern waters by HMS *Dampier* and detached units working from the ship.

In November 1964, work was resumed on the survey of the southern approaches to Hong Kong, which had been started earlier in the year. On completion of the survey, the ship sailed for Darvel Bay, Sabah, occupying oceanographical stations en route. The Darvel Bay surveys, part of an extensive programme for resurveying Sabah waters, was completed in April 1965 when the ship left for Singapore, again carrying out oceanographical observations on passage. On arrival, a hydrographic survey of Singapore Roads was undertaken.

In October, on completion of its annual refit, HMS *Dampier* sailed, having embarked a United States scientific team, to carry out a coarse-grained geophysical survey of the waters round the Solomon Islands, during which gravity and magnetic (total force) profiles were obtained over a sea-path of some 15,000 miles, in addition to valuable bathymetric data. Meanwhile a detached party was left at Thousand Ships Bay in Santa Ysabel Island to carry out a large-scale survey of the area.

During the first half of 1966, surveys were carried out on the east coast of the island of Malekula in the New Hebrides, at Port Sandwich, Norsup Bay and Port Stanley and Banan Bay. Moving to the island of Erromango in the same group, anchorages at Dillon Bay and Port Narevin were surveyed, the latter in conjunction with the French coastal minesweeper *Dunkerquoise*.

The ship then sailed for Fiji to carry out, during June and July, a survey on the north coast of Vanua Levu, from Mali Passage to Nathula Point. During the same period, the Vatu Ira channel was surveyed and a detached party worked on the coast of Viti Levu.

Aeronautical charts

Scale 1:1,000,000. Production of the Royal Air Force Topographic Navigation Chart (TNC) series is continuing, replacing series GSGS 4695. Some twenty-eight sheets have now been published, covering continental South-East Asia, West Pakistan, most of India and East Pakistan (two sheets to complete the cover of India and East Pakistan are expected to be available in 1967), Ceylon, East Malaysia, Brunei, Indonesia, the Philippines and New Guinea and Papua north of 6° S.

Scale 1:500,000. Progress is also continuing in the production of the Royal Air Force 1:500,000 Topographic Tactical Chart (TTC) series. Twenty sheets have been published, covering Malaysia, parts of continental South-East Asia, Indonesia and the Philippines.

In the *ICAO 1:1,000,000 chart series*, covering Asia, the Far East and the South Pacific, twenty-seven sheets have been published by the United Kingdom to complete its commitment in the area. Other sheets in the area are being completed by Australia and New Zealand.

Specialist (topical) maps

The Directorate of Overseas Surveys publishes specialist maps of different types; they are generally drawn and prepared for colour printing from draft material prepared by the specialist himself. In addition, a number of maps are in preparation to illustrate investigations undertaken by the DOS Land Resources Division.

Geological maps

A fully coloured geological map of Fiji compiled and drawn by the Geological Survey Department was colour-masked and published in 1966.

Work is in hand on five geological maps at scale 1:50,000.

Land resource maps

A number of specialist maps at scales of 1:50,000 and 1:25,000 are being prepared to illustrate the investigation of the coconut-growing potential of Christmas Island, in the Gilbert and Ellice islands, which was undertaken in 1965–1966 by the Land Resources Division.

Annex I

NEW BRITISH ADMIRALTY CHARTS PUBLISHED BETWEEN AUGUST 1964 AND SEPTEMBER 1966

Chart No.	*Title*	*Scale*	*Date*
	Malacca Strait		
3929	Plans in East Sumatra:		May 1965
	S.E. Entrance to Selat Rupat, Pelabuhan Dumai	1:35,000	
	Sungai Siak, Pelabuhan Sungai Pakning	1:50,000	
3933	Selat Bengkalis and Selat Rupat	1:75,000	May 1965
3944	Pulau Penang to Sembilan Islands	1:200,000	Dec. 1965
	Singapore and approaches		
2587	Western portion of Johore Strait	1:25,000	Apr. 1966
2586	Johore Strait, Pulau Ubin to the Causeway	1:25,000	Feb. 1966
2015	Singapore harbour—Western Roads	1:12,000	Apr. 1966
2014	Eastern approaches to Selat Jurong	1:12,000	Apr. 1966
2023	Keppel harbour	1:6,000	Aug. 1966
	East coast of Malaya		
3543	Singapore to Pulau Redang	1:500,000	Apr. 1965
	Eastern archipelago		
3031	Plans on the east coast of Kalimantan:		Oct. 1964
	Approaches to Sungai Berau, Sangkalirang Bay	1:100,000	
	Klumpang Bay, Pamukan Bay, Balik Papan	1:100,000	
	Pelabuhan Balik Papan	1:20,000	
3827	Mantanani Islands to Banggi Island	1:100,000	Oct. 1964
921	Approaches to Surabaja	1:100,000	Jan. 1965
	Pelabuhan Surabaja	1:12,000	
	Siam		
1046	Bangkok Bar to Ko Chuang	1:120,000	June 1966
	China		
1761	Wu-ch'iu hsu to Tung-yin-shan	1:300,000	Sept. 1964
1124	Southern approach to Ch'ang Chiang	1:150,000	Oct. 1964

Annex I

NEW BRITISH ADMIRALTY CHARTS PUBLISHED BETWEEN AUGUST 1964 AND SEPTEMBER 1966 (*continued*)

Chart No.	Title	Scale	Date
	Japan		
3436	Plans on the north-west coast of Honshu:		Oct. 1964
	Togiko, Wajima ko, Funakawa ko	1:25,000	
	Nanao Nan-wan	1:37,500	
	Fushiki, Sakata ko, Toyama	1:18,000	
	Akita	1:15,000	
1578	Shimonoseki Kaikyo	1:20,000	July 1966
2265	Kob ko	1:18,000	Jan. 1966
2279	Osaka ko	1:18,000	Jan. 1966
3109	Yokohama ko	1:20,000	Aug. 1966
	India—West coast		
242	Approaches to Karwar	1:30,000	Apr. 1965
1486	Approaches to Gulf of Cambay	1:300,000	Dec. 1964
1487	Approaches to Bombay	1:300,000	Oct. 1964
	East Pakistan		
732	Pussur River	1:100,000	May 1965
	Philippine Islands		
972	Plans in the Philippines	Various	March 1965
989	Plans in the Philippines	Various	Aug. 1964
1622	Plans in the Philippines	Various	Apr. 1965
2914	Plans in the Philippines	Various	Dec. 1964
3193	Cebu Harbour and approaches	1:35,000 and 1:15,000	Sept. 1966
	Fiji Islands		
495	Sau Sau Passage to Ringgold Channel	1:100,000	Nov. 1964
801	Approaches to Ellington Wharf	1:25,000	Feb. 1966
	Solomon Islands		
2893	Sealark Channel to Lunga Roads	1:75,000 (with plans)	Sept. 1964
3259	Plans in the Solomon Islands	Various	March 1966
	Gilbert Islands		
731	Gilbert Islands	1:800,000	May 1965
767	Tabiteuea South Lagoon	1:50,000	Jan. 1966
	New Caledonia		
480	Port Noumea	1:15,000	Aug. 1965

In the period under review, fifty-two charts of these areas have undergone major revision, in addition to the new charts above.

Annex II

SUMMARY OF MAPS PUBLISHED BY THE DIRECTORATE OF OVERSEAS SURVEYS BETWEEN AUGUST 1964 AND SEPTEMBER 1966

	British Solomon Islands Protectorate			
1:50,000	New Georgia group	Part contoured	2 sheets	Total: 16 sheets
		Planimetric	10 sheets	
	Shortlands group	Planimetric	4 sheets	
	Fiji			
1:500,000	Fiji	Geological	1 sheet	Total: 10 sheets
1:250,000	Yasawa group	Contoured/layered	1 sheet	
	Kandavu group	Contoured/layered	1 sheet	
	Viti Levu	Contoured/layered	1 sheet	
1:50,000	Lomaiviti	Contoured	1 sheet	
	Viti Levu	Contoured	2 sheets	
	Vanua Levu	Contoured	3 sheets	
	Malaysia			
1:50,000	Sabah	Contoured	28 sheets	Total: 107 sheets
		Planimetric	5 sheets	
	Sarawak	Contoured	21 sheets	
1:25,000	Sabah	Contoured	14 sheets	
1:5,000	Sabah (Sandakan)	Contoured	9 sheets	
1:1,250	Sarawak (Kuching)	Contoured	30 sheets	

CARTOGRAPHIC ACTIVITIES IN THAILAND

Paper presented by Thailand[1]

Generally speaking, cartographic activities in Thailand are the responsibility of the Royal Thai Survey Department, Supreme Command, Ministry of Defence. This department is responsible for conducting the ground and air surveys needed for the preparation of the land maps of the kingdom, training cartographic personnel and conducting geodetic and geophysical research work.

Aerial photography

With the procurement of two photographic aircraft, Beechcraft Queen Air A-80, equipped with two Wild R C-8 aerial cameras, aerial photography has been used in twelve national development projects, including a feasibility survey for the construction site of a dam, for railroad construction and for a cadastral survey. The total area covered by aerial photography is about 74,336 sq. km. The application of aerial photographs in civil engineering projects is in very great demand and from past experience Thailand has been faced with many difficulties, especially a shortage of pilots, survey navigators and camera operators. With the assistance of the Netherlands Government, which is offering scholarships to Thai personnel to further their studies in those fields, it is hoped that most of these difficulties may be overcome in the next few years.

The aerial photography effort began in early September 1966 in accordance with the joint Thai-United States mapping agreement. The total length of the flight lines is about 17,000 miles, covering areas from the Thai-Malay border up to latitude 12° north and part of the north-east region of the country. The purpose of these operations is to serve as a basis for the map compilation and map revision programme of Thailand.

Geodetic survey

Another paper, "Geodetic survey of Thailand"[2] shows the progress made on the connexion of the triangulation networks between the western and eastern parts of Thailand and also the co-operation between Thailand and Malaysia in connecting their first-order levelling.

During the preparation of the base map of Thailand using photogrammetric methods, most of the geodetic survey operations were carried out for the purpose of producing that base map, but during the past few years considerable progress has been made on the first-order triangulation and the first-order levelling nets. The programme to increase the density of these types of ground controls for the determination of map accuracy and for study and research will be expanded in the near future. The procurement of six units of the electronic microwave surveying instrument, model M8, has been made with the assistance of the United States Government. The purchase of more Wild T3's has been planned and will be made after October 1966.

Astronomical observations

First-order astronomical observations have been conducted with the aid of the Wild T-4. Observations were made at Khao Ko Lanta station (No. 66) and at Khao Kantang station (No. 65). These two stations are located at both ends of a first-order triangulation leg. It has been resolved to make observations for the establishment of another such station after 1 October 1966. Only one Wild T4 is available at present.

1:50,000 scale mapping

The entire area to be covered by the base map at 1:50,000 scale is about 511,936.58 sq. km. The compilation of the map was begun towards the end of 1952 under the joint mapping agreement between the United States of America and Thailand, using photogrammetric methods. At the time of writing, 94 per cent of the projected area has been completely mapped. The area not mapped at this scale lies between the Thai-Malay border south of latitude 7° north. The difficulty of completing the latter section lies in the unfavourable weather conditions which hamper aerial photography operations, thus retarding the schedule of the programme. The aerial photography operations have been undertaken by the United States Government as part of the assistance and contribution to the joint mapping programme. The total length of the flight line is estimated to be 1,600 miles. It is earnestly hoped that the operation will turn out air photos of a quality which could be used as source materials for photogrammetric compilation; then the entire kingdom of Thailand would be covered by the 1:50,000 scale map. However, some remaining areas along the international boundary between Thailand and neighbouring countries are unmapped or are not released. This is due to lack of agreement on mapping exchange between the countries concerned.

The procurement of three Belfort plotters, with the assistance of the United States Government, and the purchase after October 1966 of a Wild A7, with a co-ordinate printer EK 5A and a Wild A8, with profiloscope PR1, would reinforce the efforts of supporting national development projects with large-scale maps.

1:12,500 scale mapping

The mapping of such important areas as city precincts and urban districts on the scale of 1:12,500 has been planned. The maps when completed will contribute to national development projects.

The 1:12,500 mapping remains a long-range programme of the Royal Thai Survey Department, extending over five years. The compilation of these maps has been carried out by means of plane-table surveys, based on aerial photographs, and so far the completion of thirty-seven areas has been reported. Photogrammetric compilation has been scheduled to replace the plane-table surveys in the very near future.

1:250,000 scale mapping

The compilation of 1:250,000 scale maps has been classified as medium-scale mapping; the first compilation was made prior to the completion of the 1:50,000 scale maps and the compilation was done by employing all available source materials, including aerial photographs. These maps have been intended for interim use

[1] The original text of this paper appeared as document E/CONF.52/L.5.

[2] See p. 46 below.

during the beginning phase of 1:50,000 scale map compilation.

The second compilation was carried out after the compilation of 1:50,000 scale maps of certain areas; 1:50,000 map sheets and the latest aerial photographs were used as source materials. The compilation of this series on major sections of the country has now been completed and the current programme is to standardize and revise all sheets of this series for the benefit of users. The remaining coverage, that is, the area between the Thai-Malay border and latitude 7° north will be completed in the near future.

Map revision programme

The ten-year map revision programme was started in October 1954, the objective being to keep the base map of Thailand at 1:50,000 up to date. The sources for map revision have been obtained through field-reclassification surveys accompanied by aerial photography operations of the projected areas.

The progress made in the collection of data from the field reclassification surveys has been achieved satisfactorily and, at the time of writing, the field work completed covers 50 per cent of the designated area.

Topical maps

The Royal Thai Survey Department was reorganized in 1963 and by then the Special Purpose Mapping Division had been established. The functions of the new division are to conduct geographical studies and research, to compile topical maps, including various types of geographical maps, and to compile and prepare listings of geographical names. In addition, it has the responsibility of compiling the regional topical maps for Asia and the Far East and of organizing the Map Information Office in accordance with the resolution of the third United Nations Regional Cartographic Conference for Asia and the Far East.[3]

These activities, since the last conference, deal chiefly with the preliminary phase, but further progress in the activities of the division can be stated as follows:

It has begun to organize the Map Information Office of Thailand, laying a framework for future expansion under the resolution of the third cartographic conference;

It has been revising maps for the compilation of topical maps required (samples are exhibited at this conference);

It has made preparations for the compilation of regional topical maps, based on source materials so far available and obtained from the interested countries of the region;

It has begun collecting all data and material needed for preparing geographical names listings to serve as the framework for the National Board of Geographical Names.

Map reproduction

Approximately 7.8 million copies of maps have been printed, most of which are on large and medium scales. The quantity to be produced to meet the needs of various government units and even the general public has been considered too large in proportion to the capacity of the printing presses currently owned by the Royal Thai Survey Department. The only solution to this problem is to increase the number of presses to cope with the ever-increasing demand. The allotment for the purchase of such high-priced machines has to be placed in a long-range budgetary programme. During the period of this report, the Royal Thai Survey Department has been able to add one two-colour offset press, Roland RZK III, together with many items of printing equipment, to its printing plant.

Gravity survey

During this period, the Royal Thai Survey Department sent the Cambridge pendulum apparatus to Japan for modification from the conventional method recorder to the high-speed recorder with crystal clock. One La Coste and Romberg gravimeter was purchased in September 1966 and now the procurement of another La Coste and Romberg gravimeter, or the Askania GS-11 or GS-12, including the tide-recording system, is under consideration.

There is no progress in the field observation operations of the Royal Thai Survey Department, the reason being lack of funds and the need for proper instruments for this type of survey, while the density of the gravity survey stations in the Thai territory has been increased with the assistance of the United States Government in accordance with the joint mapping agreement between the United States and Thailand. A total of 567 gravity survey stations have been established and distributed as follows:

Central Thailand	85
North-eastern Thailand	141
Northern Thailand	211
Southern Thailand	130
Total:	567

The observations for this survey have been completed and the final computations will be finished in the near future. The Royal Thai Survey Department has had assistance from the United States Government experts to advise Thai personnel. The work accomplished will help lay the foundation for progress in the field of surveying expected to take place in the near future.

Geomagnetism

There is still no magnetic observatory in Thailand, although the establishment of such an observatory has been added to the future programme of the Royal Thai Survey Department. Owing to budgetary limitations, the department is unable to purchase new instruments for a magnetic survey operation, but it has already conducted magnetic observations for forty-seven stations, which are distributed in thirty-two locations. An increase in the density of such stations has been planned.

Hydrographic surveys

Hydrographic surveys in Thailand, in recent years, have been carried out mostly in coastal areas and harbours for military purposes and harbour improvement. During the last three years, a total area of 4,438.9 square miles has been surveyed, and with this result two new charts have been compiled and six new publications completed. In addition symbols and abbreviations formerly used in nautical charts have been revised in accordance with the resolutions of the International Hydrographic Bureau. The borders of nautical charts on the scale of 1:75,000 and larger are

[3] *Third United Nations Regional Cartographic Conference for Asia and the Far East*, Vol. 1 (United Nations publications, Sales No.: 62.I.14), p. 9.

provided with grid ticks of the Universal Transverse Mercator (UTM) system.

Oceanographic surveys

Thailand's last oceanographic survey was carried out in 1964, while participating in the International Indian Ocean Expedition programme, on the west coast of the Malay Peninsula from Ko Tarutao to Ko Surin at depths of from 22 to 175 m. Since oceanographic surveying is one of the vital functions in supporting economic development and military activities, the Hydrographic Department has set a five-year plan for further oceanographic surveying in both inshore and offshore areas in the Gulf of Thailand, including waters on the west coast of the Malay Peninsula at 200 m depths. The work will be initiated in early 1967. Results of the survey will also be sent to the World Data Centre and the various countries concerned.

Aeronautical chart production

Aeronautical charts have been produced by the Thai Hydrographic Department since 1952, with financial support from the Department of Aviation, Ministry of Communication. The charts have been constructed in accordance with the agreements of the International Civil Aviation Organization (ICAO). Eleven World Aeronautical Charts (ICAO) at 1:1,000,000 have been planned; ten have been completed. In addition, three aerodrome charts, one Air Traffic Service System and two obstruction charts have been drawn up. The final chart No. 2920, together with seven Instrument Approach Charts of airports and charts on the scale of 1:500,000, will be prepared and published in the next programme.

Training of cartographic personnel

The Survey School, functioning under the direction of the Royal Thai Survey Department, provides an educational programme in mapping and surveying. This institution has been assigned to train cartographic personnel to meet the demands of all government units. A two-year course of study is provided; short refresher courses have also been organized from time to time to acquaint personnel with new techniques. It is also planned to add a sub-regional training centre for photo-interpretation at this institution.

During the period of this report, twenty-two persons were enrolled in the two-year course of study; a refresher course was given to twenty-six junior cartographic personnel, and a refresher course was given to forty senior cartographic personnel.

In addition to the educational facilities furnished by the Survey School, assistance in the form of scholarships has been contributed by various Governments, including the Federal Republic of Germany, Japan, the Netherlands and the United States of America.

GEODETIC SURVEY OF THAILAND: TRIANGULATION OPERATIONS FROM 1964 TO 1966

Paper presented by Thailand[1]

During the period covered by the present report, the Division of Geodesy, Royal Thai Survey Department, sent its field survey parties out to establish first-order triangulation stations connecting the first-order triangulation networks of the eastern and western regions of Thailand. The new network covers the central part of the kingdom from latitude 13° to 14° north and from longitude 99° to 102° east. The total area covered is about 3,432 km^2. The work on angle measurements and light signalling was done with the aid of Bilby steel towers, since the terrain is flat, consisting mainly of rice fields and orchards. The work was very successful and contributed to the engineering and development projects already in progress in the region.

Bilby steel towers have been used extensively throughout the period of operations, but our personnel have noted that the towers vibrate in strong winds and could not be stabilized in spite of many attempts. These vibrations caused inaccuracy in many angle measurements. The closure yield of certain triangles was as high as 2.8 seconds. In computing the discrepancy of the checked base by means of the Indian datum, the figure became better than 1:60,000. It should be noted that, if the South Asia datum had been applied in place of the Indian datum, the result would have been better.

The Royal Thai Survey Department is expanding its levelling programme each year, realizing that the number of vertical bench-marks for development and engineering projects is inadequate. So far, levelling operations have been performed to support the irrigation project of central Thailand.

[1] The original text of this paper, submitted under agenda items 6 and 8 (*a*), appeared as document E/CONF.52/L.6.

The connexion of the first-order levelling between Thailand and Malaysia is worth mentioning here. This levelling connexion was performed in 1934. The Royal Thai Survey Department did a levelling survey close to the SBM 724 of Malaysia at the railroad station of Padang Besar to the west of the Malay Peninsula. The levelling instrument used was made by Gurley of the United States of America.

The difference was as follows: SBM 724, elevation (Thai Ko Lak datum), 63.6870 m; elevation (Malay datum) 63.9770 m. The difference between the Thai and Malay datum was 0.2900 m (1934).

In 1966, a survey party of the Royal Thai Survey Department for the second time conducted a levelling survey together with a survey party from Malaysia. Both survey parties met at the same time at the TBM 1116 of Malaysia by the railroad bridge spanning the Kolok River between the Thai-Malay border in the vicinity of the eastern seaboard of the Malay Peninsula; the Thai team used a Wild N3 to close the triangle.

The difference was as follows: TBM 1116, elevation (Thai Ko Lak datum), 11.0703 m; elevation (Malay datum) 11.3534 m. The difference between the Thai and Malay datum was 0.2831 m (1966).

The difference between both connexions after a period of thirty-two years was 0.0069 m; the results are considered satisfactory.

A new determination of the datum for levelling surveys is hereby proposed to enable the use of a common datum in connecting operations with neighbouring countries. Thailand is willing to co-operate in such an effort.

CARTOGRAPHIC ACTIVITIES IN ISRAEL

Paper presented by Israel[1]

GEODESY

Triangulation

During the period covered by this report, a trigonometric network was re-established and observed in the densely populated central part of the country, where the existing points had been to a large extent destroyed by development and agricultural projects. Forty-nine new points were established and seventy-eight triangles observed. The new part of the network was connected to five sides of the old one. The major network in the southern part of the country was completed; twenty-eight new points were established and sixty-eight triangles observed. This part of the network was also connected to five sides of the old one. A re-observation was undertaken at several points of the existing network, where the original observations did not conform to the tolerances set for major triangulation.

All the field observations were carried out with Wild T3 theodolites in six sets, with the maximum difference of 5 inches permitted between sets. The triangle closures permitted up to 3 inches.

A programme was prepared for computation of the results and adjustment by electronic computer, which included formation of condition equations and computation of geographical co-ordinates and also Cassini Soldner local co-ordinates. The adjustment was that of the least-square solution of weighted condition equations.

In addition to the above-mentioned major triangulation work, approximately 300 lower-order trigonometric points were established.

Astronomy

Additional observations connected with the establishment of Laplace points and Laplace azimuths were continued during the period covered by this report. The instrument used was the Wild T4 theodolite. The following mean square errors were obtained: latitude, $\pm 0.2''$; longitude, $\pm 0.25''$; azimuth, $\pm 0.25''$.

Geodetic (precise) levelling

Following the decision in 1962 to establish a precise levelling network in the country, this work generally proceeded along all the main roads. Fundamental benchmarks were established at approximately 50 km intervals by sinking marks to the depth of 8 m in ordinary soils or by rock drilling. Intermediate permanent stations were established every 3–4 km and densified to approximately 2 km intervals. All lines were levelled in both directions.

Since 1962, approximately 1,500 km have been levelled. The instrument used is the Wild N3.

The network will be adjusted in four parts in accordance with geographical divisions. Up to the present, approximately 1,050 km have been adjusted.

The probable accidental error for one loop was within ± 0.52 mm and the probable systematic error within ± 0.20 mm. In the northern part of the country, which includes sixteen loops each about 75 km in length, the mean weighted closure of a loop was 11 mm. The mean square error of a loop after adjustment was ± 0.68 mm. In the southern part, which includes thirteen loops of approximately 30 km each, the mean weighted closure was 3 mm per loop and the mean square error after adjustment ± 0.32 mm.

In addition to the above, two levelling lines, each about 10 km long, were relevelled after an interval of two years. The two lines, which have fundamental points at their terminals, run across clay soils which change their density considerably between summer and winter. The relevelling shows discrepancies at the intermediate points up to 3 cm. This matter will be the subject of further checks.

The new precise levelling network is referred to the mean sea level value obtained from three and a half years of regular mareograph observations at the port of Jaffa. It differs from the 1933 value by about 10 cm.

Magnetometry

The observations of the variations of magnetic field components (D,H,Z) were continued at our field observatory and at a number of points spread out throughout the country.

Special projects

Precise geodetic measurements were carried out in connexion with engineering construction. This consisted of the determination of the position and inclination of the construction with the accuracy ± 0.1 mm.

Geodetic computations

The period covered by this report saw a gradual transition from manual to high-speed electronic computations. The computer programmes are routinely employed on computation of traverses, precise levelling, astronomical data, aerial triangulations and road planning surveys based on field and photogrammetric data. The computer utilized is the IBM 360.[2]

PHOTOGRAMMETRY

Mapping at different scales

An extensive programme of photogrammetric mapping at medium and small scales is being carried out by the Survey of Israel. Densely populated areas are mapped on the scale 1:10,000.

These maps, printed as a topo-cadastral series, contain the basic material for development projects, agricultural and urban planning and other topical maps.

Large-scale maps from 1:500 to 1:5,000, mainly for engineering purposes, are produced by the department.

Methods and instruments

Control points are signalized on the ground before photography is used for all scales. Aerial triangulations, adjusted either in strips or in blocks, are used. Scribing contour lines in the stereoscopic plotter is standard procedure with the Survey of Israel. An integrated system for road and highway planning is in operation in the Survey of Israel.

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[1] The original text of this paper appeared as document E/CONF. 52/L.13.

[2] For more details, see "Some aspects of electronic computing and plotting", under agenda item 14.

The system employed consists of A7 and A8 autographs coupled with co-ordinate registration devices, including a card-punch. The transformation of the national co-ordinate system is carried out in an electronic computer, IBM/360, which also produces the cards controlling an electronic co-ordinatograph plotting the cross-sections.

Cadastral mapping

A comprehensive research project on the adaptability of photogrammetry for cadastral mapping is now being executed at the Survey of Israel.

Cartography

Topographical mapping

During the period under review, mapping work was continued at the standard scales, which in Israel are: 1:10,000 (topo-cadastral series), 1:20,000, 1:50,000, 1:100,000 and 1:250,000. In general, the 1:10,000 and 1:50,000 scale series are compiled from photogrammetric manuscripts at the same scale, while the other series are compiled from reduced and generalized manuscripts.

Revision

The extensive development projects, both agricultural and urban, make it necessary to carry out, parallel with mapping, various revision tasks. Revision priorities are fixed according to the degree of obsolescence of the various maps. Usually for maps which have good quality altimetry only a partial revision of detail is made, concentrating on roads, newly built-up areas and plantations. The revision is done almost exclusively by photogrammetric methods.

Town plans

The Survey of Israel prepares and revises plans on the scale 1:10,000 of the main towns in the country. These are compiled from existing photogrammetric mapping and municipal information pertaining to street names and places of public importance.

Thematic and special maps

Various administrative, statistical and historical maps of the country are compiled and processed, as well as special-purpose maps in such fields as geology, meteorology, hydrography, drainage and agricultural and urban planning.

Atlas of Israel

This large-scale national atlas was completed in 1964. Owing to the rapid progress of human geography in Israel, the atlas is based on time-sequence.

An approach to the problem of revision of the atlas is under consideration, taking into account a critical evaluation of the first edition by the editors, advisers and users.

An English edition of the Atlas of Israel, which will include some revisions and modifications, is now in preparation and is expected to be completed in 1968.

Cartographic methods

Scribing methods are now standard, using plastics such as Astroscribe Scribalon, which are considered the most suitable from the point of view of efficiency in scribing work and stability under adverse climatic conditions (warm and humid).

Reproduction

No major changes occurred during the period covered by this report.

Cadastre

The area to be mapped for cadastral purposes is approximately 10,000 km^2, representing about 40 per cent of the country's total area.

The rapid economic development of the country necessitates extensive revisions of the existing maps and reparcellations. Consolidation of lands, aimed at rational agricultural exploitation, is carried out in certain cases.

Education

The College of Land Surveying

This institution of higher learning is operated under the auspices of the Survey of Israel. The three-year syllabus, which includes theoretical and practical training in all aspects of land surveying and related fields, is designed to provide a cadre of professional surveyors in the country. Graduates are eligible after a prescribed period of practical experience to sit for a licensed surveyor's examination.

The syllabus of the college has been revised recently to include instruction in new subjects and aspects of the profession such as electronic surveying, automation, astronomical methods, etc. These revisions are not regarded as final and further modifications aimed at updating the instruction are now under consideration.

WORK OF THE INSTITUT GÉOGRAPHIQUE NATIONAL (IGN) FROM 1 JANUARY 1965 TO 31 DECEMBER 1966

Paper presented by France[1]

New Caledonia

Mapping at 1:50,000. Publication of a 46-sheet map, covering the whole of New Caledonia and the Loyalty Islands, was completed in 1964.

Mapping at 1:200,000. It was decided in 1964 to prepare a map of the archipelago at 1:200,000. The map has now been completed and is available in five sheets, with the following specifications: UTM projection; Geographical grid of 30′ × 30′; relief indicated by contours at intervals of 100 and 50 m printed in eight colours: black, two shades of blue, sepia, green, red, yellow, shading.

Map at 1:500,000. A 1:500,000 map covering the whole of New Caledonia on a single large sheet is in course of preparation.

The sheet is based on the 1:200,000 map referred to above and follows the style and projection of the IMW (Lambert, 20° × 24° strip). Relief is indicated by contours at 100 m intervals, emphasized by shading. Eight colours are used. This map will serve as the basis for the eventual preparation of a sheet of the IMW.

[1] The original text of this paper, submitted in French, appeared as document E/CONF.52/L.24.

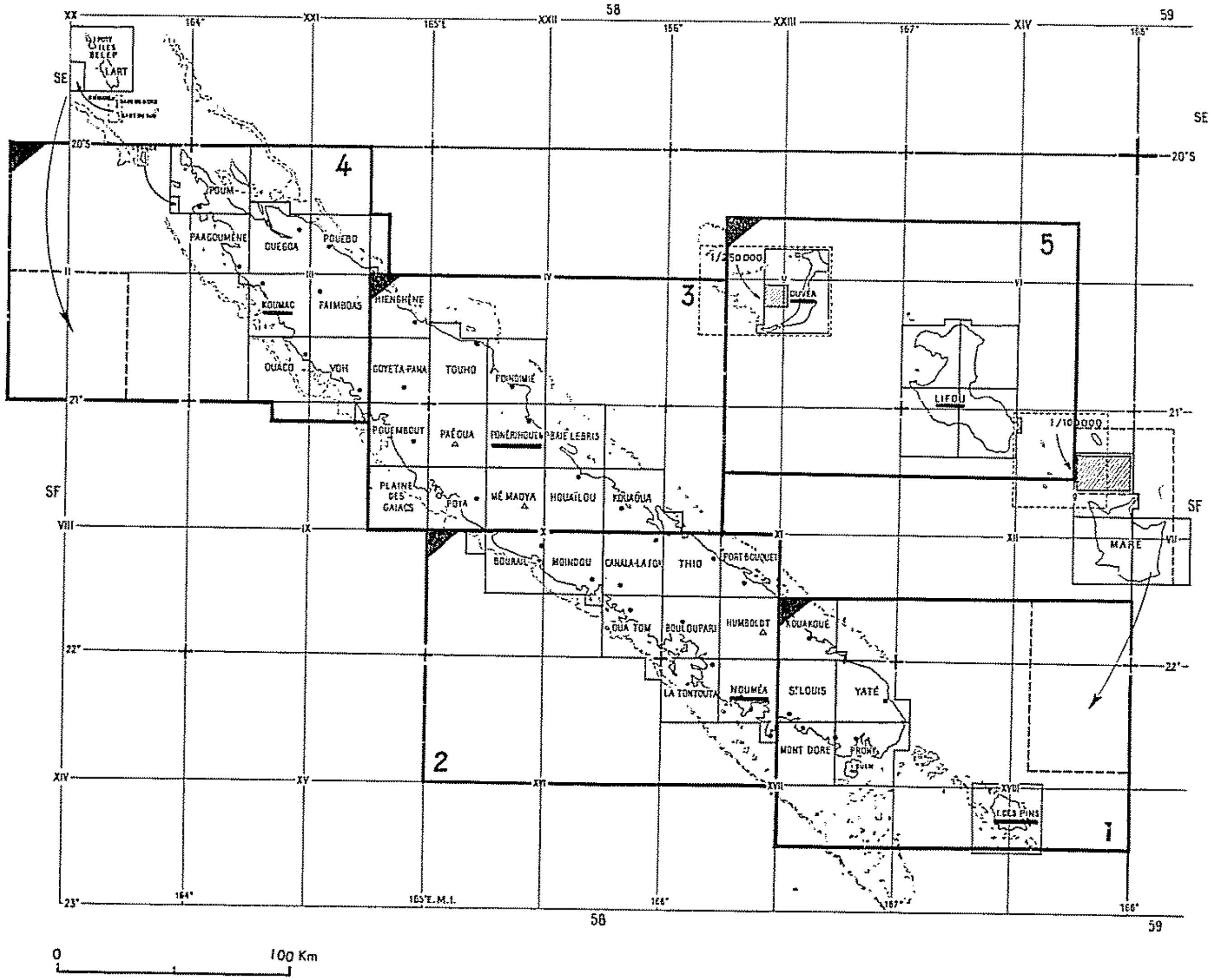


TABLEAU D'ASSEMBLAGE
DE LA

CARTE DE LA NOUVELLE CALÉDONIE au 1/200 000

Feuilles en cours
Feuilles publiées } au 31 Décembre 1966

DESCRIPTION

TYPE : Carte topographique - 8 couleurs.
FORMAT : Dimensions (1°30' en longitude, 1° en latitude) - Projection Mercator Transverse Universelle, avec réseau géographique de 30' en 30'.
SYMBOLE : I. G. N. F.
ORIGINE : Levés stéréotopographiques aériens.
CARACTÉRISTIQUES : Agglomérations et constructions représentées par signes conventionnels - Routes classées suivant leur importance - Relief en courbes de niveau ; équidistance 100 mètres, intercalaires 50 mètres ; altitudes en mètres ; estompage - Teintes vertes sur la végétation.
EXACTITUDE : Très bonne.

Tableau d'assemblage publié par I. G. N. F.

INDEX TO MAPS OF

NEW CALEDONIA 1/200,000

Sheets in progress
Sheets available } as at 31 December 1966

SERIES DESCRIPTION

TYPE : Topographic maps - 8 colours.
SIZE : Sheet sizes (1°30' in longitude, 1° in latitude). UTM projection, with geographical grid of 30' to 30'.
SYMBOLE : I.G.N.F.
ORIGINE : Photogrammetric compilation.
CHARACTERISTICS : Populated areas and buildings shown by symbols - Roads classified according to their importance - Relief indicated by contours at 100 and 50 meters intervals ; elevations in meters ; hill-shading - Vegetation symbolized by green overprint.
RELIABILITY : Very good.

Index published by I.G.N.F.

Fig. I—France: Index to maps of New Caledonia

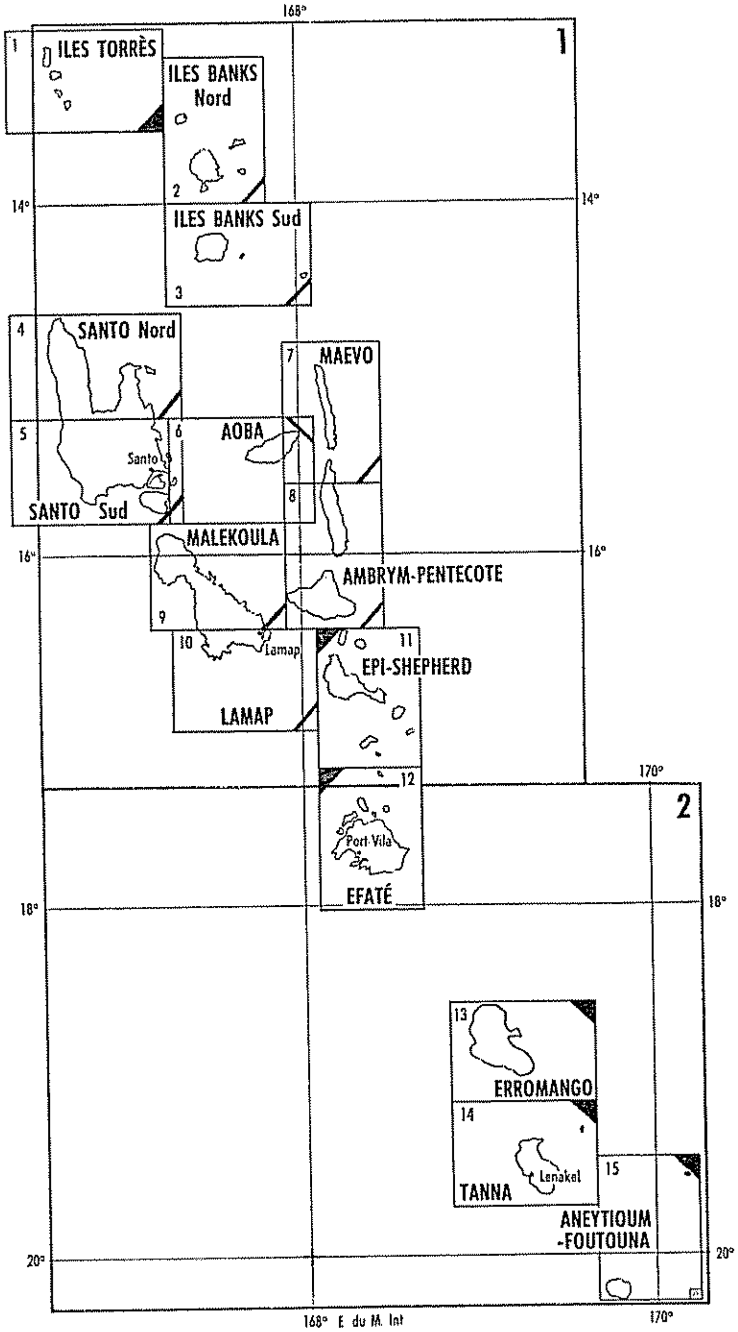


TABLEAU D'ASSEMBLAGE
DE LA

CARTE
DES NOUVELLES HÉBRIDES
au 1/100 000

SÉRIE X 621

Feuilles en cours } au 31 Décembre 1966
Feuilles publiées }

DESCRIPTION

TYPE : Carte topographique - 6 couleurs.

FORMAT : 66 × 90 cm (50' × 30' sex.). Projection Mercator Transverse Universelle avec quadrillage kilométrique.

SYMBOLE : I. G. N. F.

ORIGINE : Levés stéréotopographiques aériens.

CARACTÉRISTIQUES : Agglomérations et constructions représentées par signes conventionnels. Routes classées suivant leur importance. Relief en courbes de niveau - équidistance 20 mètres - altitudes en mètres - estompage - Teintes vertes sur la végétation.

EXACTITUDE : Très bonne.

Tableau d'assemblage publié par I. G. N. F.

INDEX TO MAPS OF

NEW HEBRIDES
1/100,000

SERIES X 621

Sheets in progress } *as at 31 December 1966*
Sheets available }

SERIES DESCRIPTION

TYPE : Topographic - 6 colours.

SIZE : 66 × 90 cm (50' × 30' sex.). U.T.M. projection with 1000 m grid.

SYMBOLE : I. G. N. F.

SOURCE : Aerostereotopographic surveys.

CHARACTERISTICS : Populated places and buildings shown by symbols. Roads classified according to their importance. Relief indicated by contours at 20 meters intervals - Elevations in meters - hill-shading - Vegetation symbolized by green overprint.

RELIABILITY : Very good.

Index published by I. G. N. F.

Fig. II—France: Index to maps of New Hebrides

New Hebrides

The plotting of the archipelago at the scale 1:50,000 was completed in 1965 with the plotting of 3,959 km^2 of Oba, Espíritu Santo, Pentecost, Malekula and the Banks Islands.

As a result of this work, a 1:100,000 map of the archipelago in fifteen sheets has been prepared. Six sheets are available, and a further five will be published in the first half of 1967. The map uses the UTM projection and is printed in six colours: black, two shades of blue, sepia, green and shading.

Oceania

Tahiti

Field surveys. In 1966, an IGN survey mission carried out 160 km of precise levelling on the road encircling the island, on the coastal road of the Taiarapu peninsula and on the Taranao plateau.

Office work. An eight-colour, 1:100,000 road and tourist map of Tahiti, using the UTM projection, has been published. On the basis of this map, 1:100,000 relief map of Tahiti has been prepared, comprising the island itself, the Taiarapu peninsula and, in an inset, Moorea Island.

Society Islands

A sheet of the IMW (ICAO specification) covering the archipelago at the scale 1:1,000,000 was published in 1965.

Tuamotu Archipelago

Photo-mosaics at the scale 1:20,000 have been made of the following atolls: Anaa, Hikueru, Haraiki, Farakava, Rangiroa, Tikehau and Makemo.

On the basis of these mosaics, the following sheets are at present in course of preparation and publication: four 1:20,000 sheets covering the small atolls of Anaa, Hikueru and Haraiki; thirteen 1:50,000 sheets covering the large atolls of Tikehay, Rangiroa, Farakava and Makemo.

In 1965 and 1966, the Ecole nationale des sciences géographiques (National School of Geographic Sciences) provided training for twenty-one students and trainees from States and Territories of Asia and the Far East, as follows:

Students attending one of the school's four regular two-year courses: three Cambodians; two Laotians; one Tahitian.

Engineers and technicians attending one of the shorter courses arranged by the school: four Cambodians; one Indian; one Japanese; five Laotians; one Malay; one Singaporean; one Viet-Namese; one Frenchman from New Caledonia.

In addition, three engineers of the IGN were seconded as technical co-operation experts, for periods ranging from three months to two years, to the following countries: two to Laos; one to the Republic of Viet-Nam.

A geographer has been permanently attached to the Polynesian Topographical Service in Tahiti.

CARTOGRAPHIC ACTIVITIES IN THE FEDERAL REPUBLIC OF GERMANY

Paper presented by the Federal Republic of Germany[1]

Since 1945, surveying and mapping in the Federal Republic of Germany has been decentralized. Each of the eight federal states has its own survey office, equipped with modern installations, instruments, devices and machines. There are also two federal institutions: the Institute for Applied Geodesy, mainly performing research work, and the German Hydrographic Institute, which is responsible for nautical and hydrographic charts. To co-ordinate the surveying and mapping work, the federal states have established a working committee of government survey offices. The research work to be executed is determined by the German Geodetic Commission. Survey data and documents have existed in Germany for several decades. The present work mainly consists in improving these data, revising documents and carrying out scientific studies.

The existing primary triangulation network of Germany has been completed and extended by re-observing several stations located on different islands in the North Sea. For these observations, a combination of angular measurements and electronic distance measurements has successfully been applied. Within the new adjustment of the European primary triangulation networks, several geodetic base-lines have been remeasured in western Germany by means of invar wires and electronic distance meters to check the scale. The results provide interesting information about the accuracy of these measuring procedures.

Some additional measurements made to improve the net configuration in the primary network have resulted in further information about scale and accuracy. Additional astronomical azimuths have been observed in order to improve the orientation of the triangulation net.

Astronomical deflections of the vertical have been observed and gravity measurements have been made to determine the position of the geoid in western Germany.

Numerous gravity measurements have made it possible to join former measurements with the European milligal. On this basis we have prepared gravity maps of western Germany.

The earth tide service has been continued. A considerable increase in the accuracy of the observations has been achieved by installing an electric spring in a gravimeter.

Practical photogrammetry has primarily been used for land consolidation, cadastral survey, for the preparation of German base map at 1:5,000 scale and for the revision of existing map series by the survey offices. However, the first of these tasks have also been executed by means of automated terrestrial procedures using special theodolites, electronic computers and plotting instruments.

Research projects in the field of photogrammetry are mainly performed in connexion with the European Organization for Photogrammetric Experimental Studies (OEEPE) and the International Society for Photogrammetry (SIP). Here the recent studies made with the Orthoprojector are worth mentioning.

In connexion with mapping activities for the official German map series, the preparation of the German base map at 1:5,000 scale has been continued. About 85 per cent of this map series has been completed in respect of

[1] The original text of this paper appeared as document E/CONF.52/L.86.

planimetry, and 58 per cent in respect of planimetry and contours. The topographic map at 1:25,000 (a total of 2,086 sheets) and the new topographic map at 1:50,000 (a total of 562 sheets) are available for the entire territory of the Federal Republic. A new topographic map at 1:100,000 (a total of 156 sheets) is being prepared and in the first stage of completion. A new general topographic map at 1:200,000 (a total of 46 sheets) is also being prepared. So far, twenty-two sheets have been completed. Several sample sheets have been prepared for a new general map at 1:500,000, the publication of which has not yet been definitely decided upon. In preparing the new German sheets of the IMW, the new United Nations specifications will be observed. In this connexion, it should be mentioned that the official large-scale map series, up to the scale of 1:100,000, are prepared by the state survey offices, while the small-scale map series of 1:200,000 and smaller are prepared by the Institute for Applied Geodesy. Furthermore, the eight sheets of the WAC (ICAO) 1:500,000 of Germany have been revised. The four sheets of the WCA (ICAO) 1:1,000,000 covering Germany have been completed.

In the cartographic research section of the Institute for Applied Geodesy, problems of generalization and representation of morphological small-forms have been studied for the topographic general map at 1:200,000 with the aid of photogrammetric procedures.

In the field of map printing, tests have been made to reduce the number of printing processes with multicoloured small-scale maps. These tests have been successfully completed and the procedure has already been applied in practice.

Topical maps are also in preparation at scales extending from 1:2,000 to 1:100,000 (soil, soil quality, geological maps etc.) for agricultural purposes, forestry, regional planning and administration, geography, geology and hydrography.

This summary clearly shows that even a country which has long possessed excellent survey data will always find room for more surveying and mapping if it is interested in improving and revising its map material and participating in research work.

CARTOGRAPHIC ACTIVITIES IN JAPAN (HYDROGRAPHY)

Paper presented by Japan[1]

This report outlines the hydrographic aspect of cartographic activities in Japan during the period 1964 through 1966, and is a continuation of the report on cartographic and hydrographic activities in Japan, 1961–1964, submitted to the Fourth United Nations Regional Cartographic Conference for Asia and the Far East.[2]

Geodesy

Astronomy

Photo-electric and visual observations of occultation of stars by the moon are being conducted at the Hydrographic Office in Tokyo and three hydrographic observatories in this country. The reduction of data gave the following values of the difference ΔT = Ephemeris time − Universal time (for stars in Robertson's catalogue):

Period	ΔT
1962-1965	$33^{s}.21 + 0^{s}.09$
1963-1965	$32.99 + 0.12$
1964-1965	$33.91 + 0.11$
1965-1965	$38.86 + 0.13$

Astronomical surveys with an astrolabe were photo-electrically made at Nii Sima (island), Miyake Sima, Awa Sima and O Sima, 1965 through 1966.

On the occasion of the total solar eclipse on 30 May 1965, an observation team was dispatched to Hervey Islands, southern Pacific, under the project of the Solar Eclipse Committee of the Science Council of Japan.

Space research for geodetic and navigational purposes is being carried out. Successful observations of the satellite balloons Echo I and Echo II were made at Tori Sima in September 1965, at Amami-O Sima in March 1966 and at Ao-ga-Sima in July 1966.

The Japanese ephemeris, nautical almanac and abridged nautical almanac are computed and published annually. Sight reduction tables are also compiled and published continuously.

Geomagnetism

On the basis of newly obtained magnetic data referred to 1965.0, the following three magnetic charts have been revised:

Chart No. 6024: Curves of equal magnetic variation and equal annual change of the adjacent seas of Nippon;

Chart No. 6043: Curves of equal magnetic dip and equal annual change of the adjacent seas of Nippon;

Chart No. 6044: Curves of equal horizontal magnetic intensity and equal annual change of the adjacent seas of Nippon.

The data obtained from the world magnetic survey around Japan and from the magnetic survey of Japan, both conducted 1961 through 1964, were used in the compilation of these charts.

At the Simosato Hydrographic Observatory located about 130 km south-east of Osaka, continuous magnetic observations are carried out with an ordinary magnetometer (for H, D and Z) and an inductive magnetometer (for dH/dt, dD/dt and dZ/dt).

[1] The original text of this paper, submitted under agenda items 6 and 16, appeared as document E/CONF.52/L.87.

[2] See *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 2 (United Nations publication, Sales No.: 66.I.3), p. 46.

At the Hatizyo Sima Magnetic Observatory, south of Izu Syoto (islands), magnetic observations of three elements are being conducted with a sight magnetometer, forming a part of the world-wide magnetic observations for IQSY (International Year of the Quiet Sun) since 1964.

Magnetic observations on the sea were carried out with a shipborn precision proton magnetometer aboard the survey ship *Takuyo* along the Japan trench, east of Honsyu, and around Yamato Tai (bank) in the Japan Sea, in 1965. Distribution charts of the total intensity of geomagnetism in these areas could thus be compiled.

Aerial magnetic observations were also carried out, in 1964, over Hokkaido and its vicinity and over Kagosima Wan (bay) in Kyusyu, with an airborne proton magnetometer.

The World Magnetic Survey (WMS) project was formed in accordance with the resolution and recommendation adopted by the Special Committee on the International Geographic Year (CSAGI) and the International Union of Geodesy and Geophysics (IUGG) Committee on WMS. To co-operate in this international work, the Science Council of Japan established the National Committee on WMS, which then formed a project for the aerial magnetic survey of Japan and its vicinity. Under that project, the Hydrographic Office carried out aerial magnetic observations in the adjacent seas of Japan from 1961 to 1964. From the results of those observations, seven kinds of magnetic charts on the scale of 1:2,500,000 will be published as appendices to a bulletin to be issued at Kyoto University in March 1967, referring to the year 1965.

Oceanography

Oceanographic observations

Joint oceanographic observations in the sea around Japan are carried out regularly by the Hydrographic Office, the Meteorological Agency, the Fisheries Agency and other authorities concerned. These observations consist of the current observation with GEK, measurement of water temperature with BT and the conventional serial observations with Nansen bottles. Salinometers are used widely for salinity determination.

Airborne radiation thermometers have been put into practical use successfully since 1963, to determine the route of the Kuroshio, particularly in winter. Figure I shows the stream axis of the Kuroshio in the adjacent seas of Japan from 1963 to 1966.

The results of these observations are made public. The charts entitled "State of the adjacent seas of Nippon", compiled from observation data obtained by various organizations, are published quarterly by the Hydrographic Office.

Observation of sea ice is carried out every winter along the coast of Hokkaido at fixed points on land as well as by patrol boats and aircraft. In particular, the icebreaker *Soya*, which formerly participated in the Japanese Antarctic Research Expedition, conducts extensive ice and oceanographic observations in the Okhotsk Sea every winter.

For the investigation of sea-water pollution by radioactive substances, chemical analyses of the radioactivity of sea water and bottom sediments have been made of samples collected from surface and deep layers in the sea around Japan, in the western part of the Pacific and in the Antarctic Ocean, as well as of samples from harbours where atomic-powered submarines enter occasionally.

In 1964, a recommendation for the Co-operative Study of the Kuroshio and adjacent regions (CSK) was approved by the Inter-governmental Oceanographic Commission at its third session. The programme started in the summer of 1965. Japan is one of the most active countries in the programme. The Hydrographic Office is participating in various phases of the programme; in particular, it sent the survey ship *Takuyo* in the summers of 1965 and 1966 to the southern area off the Philippines and Taiwan, where the Kuroshio begins.

Figure II shows the CSK stations observed in 1965 and 1966, respectively.

The Japanese Antarctic Research Expedition was resumed in 1965. Two members of the office are participating in the expedition to make oceanographic observations in the Antarctic waters.

Tide and tidal current observations

There are about 100 tide stations along the coast of Japan maintained by the Hydrographic Office, the Geographical Survey Institute and the Meteorological Agency, of which 26 belong to the Hydrographic Office. These stations are carrying out continuous observations to provide tidal data to maintain the accuracy of tide predictions and the chart datum, as well as to study storm surges, tsunamis, ground changes and sea-level variations.

As a part of the earthquake prediction investigation programme, the data of mean sea level is collected by the Geographical Survey Institute, and levelling surveys are conducted more frequently.

In order to use the mean sea level variation for the study of the variation of the Kuroshio, the Hydrographic Office established new tide stations on the islands south of the Japanese mainland in previous years. The records have revealed many interesting phenomena of the variation of the Kuroshio.

Tidal current observations are being carried out in near-shore waters of Japan, especially in harbours and straits, using self-recording current meters.

The charts of tidal currents showing the tidal currents of the Seto Naikai (Inland Sea), where tidal currents are most complicated, are published by the office from 1964 to 1967.

Experiments to study the mixing and exchange of sea water in bays and harbours, using dye such as Rhodamin B, have been conducted at several places.

Survey

Ordinary hydrographic survey

The number of operations of various hydrographic surveys carried out during the period are shown in table 1. Among them are included surveys for up-dating charts in line with the rapid changes in harbour facilities and passages resulting from construction and repair works in fast developing coastal industrial districts, as well as from the reinforcement of major open ports with the economic development of the country.

Table 1. Number of hydrographic surveys

Type of survey	*1964*	*1965*	*1966 (projected)*
Harbour surveys	11	12	7
Review and check surveys	218	217	122
Passage surveys	3	4	4
Coastal surveys	2	5	3
Oceanic surveys	3	1	1

Photogrammetry

Needless to say, the utilization of photogrammetry, both aerial and terrestrial, is of great value in the construction process of charts. Since 1965, the Hydrographic Office has exerted itself to improve the whole process of such utilization, from photography to plotting work.

The main work of photogrammetry is aerial triangulation. The office successfully put the analytical method into practical use with a medium-sized computer and, since 1965, the method has become routine in hydrographic survey work conducted by the office.

Now that the plotting of shore controls required for sounding lines can be made in the course of analytical aerial triangulation, all such controls are determined by this method exclusively for harbour surveys, replacing the conventional ground triangulation. The positional error is within 0.2 mm on the sheet of control points.

The information included in an aerial photograph varies to a great extent. In particular, the image of the sea bottom provides indispensable data to the hydrographic survey. Since 1965, the study of the interpretation and drawing of the sea bottom using colour photographs has been practised at the office. It is expected that this will greatly contribute to the solution of the problem by locating charted dangers and shoals.

Furthermore, studies of the application of terrestrial photogrammetry to hydrographic surveying are being made at the office. One such study is to observe the rise of the water surface in narrow straits where the tidal stream is very strong. It is tentatively concluded from this study that in such areas it is necessary to take the time element into consideration as well as local elements in resolving the problem of the variation in the chart datum.

Another study is that which measures the height of overhead cables across navigable waters. With terrestrial photogrammetry it is possible to determine exactly the vertical clearance of the cable as well as the height of every point of the cable above sea level.

Investigation of crustal movement

In order to make clear the datum level in harbours where ground sinking is considerable as well as to study the sinking mechanism of the ground, levelling, precise sounding of a fixed point and investigation of the character of the bottom are being carried out.

Investigation of the character of the bottom, using sonic layer detector

A sonic layer detector is able to emit sonic waves of 3 kc and 8 kc, and receives the echo bounced back from the discontinuous layer of the bottom, thus detecting vertical status of the bottom sediment layers, which are comparatively soft. Therefore this device has a capacity which is to be ranked between the echo-sounder and Sparker. With this device it becomes possible to detect the location and condition of objects below the bottom sediment layers, such as shoals, rocks, wrecks, buried submarine cables and submerged timbers, as well as to investigate the status of various sediment layers of floating mud, sand, clay etc.

Some examples of the investigations carried out with this device are mentioned below.

(a) *Research into a submerged aircraft*

On 4 February 1966, a jet airliner with 133 passengers and crew crashed into Tokyo Wan, and the wreckage scattered on the bottom of the sea. The Hydrographic Office at once dispatched its survey boats equipped with the sonic layer detector for rescue and searching operations. The survey boats found most of the wreckage buried in the soft mud layer of the bottom.

(b) *Investigation of the ground*

Following the Niigata earthquake of 16 June 1964, the sea bottom around Awa Sima rose about 5 m at the maximum. To discover the relation between the layers below the bottom sediment layers and the rise, the sonic layer detector was used for geological investigation together with the echo-sounder and proton magnetometer.

(c) *Study of formation of sediments and their movements*

In areas where tidal currents are strong and the movements of bottom sediments very complex it is noted that harbours, passages and roadsteads face the serious problem of being silted or damaged. To deal with this situation, the Hydrographic Office conducted at Bisan Seto, in Seto Naikai, an investigation of the structure of sediment layers and their actual condition and movement, using a sonic layer detector.

(d) *Investigation of anchor-hold*

With the increase in the size of vessels, it has become insufficient to provide larger sized vessels with information concerning the characteristics of the surface of the bottom only. It has also become necessary to investigate the sediment layers under the surface layer of the bottom. Investigation of the vertical distribution of bottom layers is currently conducted in Osaka Wan, using the detector together with the core sampler.

General Bathymetric Charts of the Oceans (GEBCO)

The Japanese Hydrographic Office has almost completed compilation of twenty-nine GEBCO sheet A III plotting sheets. It is also responsible for co-ordinating the A III plotting sheets prepared by the hydrographic offices of Australia, India, Indonesia, the Netherlands and the United Kingdom. In this connexion, the following points should be noted: where soundings on plotting sheets were shown in fathoms, they had to be converted into metres; echo-sounded depths were reduced to absolute depths; since the co-ordinating agency is responsible for checking the continuity of depth contours at the joins of plotting sheets, 1,000 m depth curves and, where necessary, 500 m depth curves were drawn in accordance with IHB (International Hydrographic Bureau) procedure; some plotting sheets reached the office in damaged condition (the damage might have occurred in transit).

Measurement of thickness of bottom sediment layers

The Hydrographic Office has developed a device to measure the thickness of sediment layers of the bottom by emitting supersonic pulses from a transducer buried below the layers of the bottom. The object is to conduct a long-term and regular observation of coastal sedimentation and erosion. Experiments with this device are being carried out in the vicinity of the mouth of Sagami Kawa (river).

Use of infra-red theodolite to carry out hydrographic surveys in foggy or smoggy weather

In most harbour surveys of coastal industrial districts, sounding is conducted by the straight-line leading method with a theodolite fixed on land. Efficiency in this work, however, has recently been impaired considerably by the foggy or smoggy atmosphere often occurring in industrial districts. To overcome this difficulty, the office has developed an infra-red theodolite for practical use, applying the principle that in foggy or smoggy weather the degree of absorption and decrement of rays of longer wave is much less than that of rays of shorter wave. This device contains an image-tube for near infra-red rays with which it is expected to offset the reduction in efficiency in surveying resulting from low visibility.

Upper Mantle Project (UMP)

As a part of the project of the Geological Structure Section of the UMP, the Hydrographic Office carried out the first-year programme (1964) in the area along the 39°N parallel in the vicinity east of Honsyu (zone A), the second-year programme (1965) in the Japan Sea (zone C) and the third-year programme (1966) in the northern part of the Izu-Marianas island arc (zone B). As the fourth-year programme (1967), the office will again conduct the survey in zone B.

These investigations were carried out with precise echo-sounder, Sparker, bottom sampler, etc. The data obtained will eventually be analysed together with the results of the measurements of earthquakes, geomagnetism and gravity.

The results obtained thus far have been adopted in the compilation of Bathymetric Charts of the Adjacent Seas of Nippon, published in 1966.

Hydrographic survey by private enterprises

The number of private companies conducting hydrographic surveys has been increased year after year and now reaches ten. Those enterprises mainly carry out surveys for the purpose of providing basic data for the planning of harbour construction. Some of the operations conducted by the private companies are: survey for calculation of amount of soil for dredging operations, investigation of bottom sediments, basic survey for route of submarine cables, survey for chart correction and investigations for prevention of natural disasters and those of sea-bottom resources. The instruments used include the Hydrodist, Tellurometer, Sparker Geosonar and current meters of the latest type.

As to private hydrographic surveys conducted for chart correction, their results are subjected to close inspection by the Hydrographic Office. Accepted data are published as correction chartlets accompanying Notices to Mariners.

CHART PUBLICATION

General

Construction of new harbours and the launching of huge vessels, as reported in the previous report, have steadily increased during this period. These factors have necessitated more frequent and timely publication of new charts and new editions of charts for coastal areas and harbours.

LORAN charts have been revised now that certain LORAN stations formerly owned by the United States Forces have been moved and transferred to the Japanese Government.

Since DECCA stations will open in April 1967 in Hokkaido districts, the office is eager to publish nine different DECCA charts covering the area. Six of them have already been published.

The work under the new publication programme of coastal charts of 1:200,000 to 1:250,000 is also in progress.

The Hydrographic Office has published Bathymetric Charts of the Adjacent Seas of Nippon based on the latest data available. They were displayed at the eleventh Pacific Science Congress and received considerable praise.

Two charts of the Antarctic area have been newly published for the eighth Japanese Antarctic Research Expedition.

Scope of publication

The number of charts published by the Hydrographic Office during the period is as shown in table 2 (by year):

Table 2. Number of charts published

Type of chart	*1964*	*1965*	*1966 (Jan.-Oct.)*
New charts:			
Nautical	8	8	10
Miscellaneous	2	2	8
Aeronautical	1	0	0
New editions:			
Nautical	28	26	23
Miscellaneous	2	12	4
Aeronautical	0	2	2
Reprints	27	3	7
TOTAL	68	53	54

The number of notices which appeared in Notices to Mariners and the number of chartlets for correction of portions of charts issued to bring charts up to date are shown in table 3.

Table 3. Number of notices and chartlets

Year	*Notices*	*Chartlets*
1964	1,688	251
1965	1,763	348
1966 (Jan.-Oct.)	1,613	268

Total number of charts available in October 1966 is shown in table 4.

Table 4. Charts available in October 1966

Types of charts	*Sheets*
Nautical charts including LORAN charts	1,445
Miscellaneous charts (186)	
Bathymetric charts	2
Depth curve charts	18
Bottom sediment charts	10
Fisheries charts	18
Magnetic charts	6
Others	132
Aeronautical charts (13)	
(ICAO)	9
Route charts	2
1:500,000 charts	2
TOTAL	1,644

Chart reproduction and printing

Total number of plates (new charts, new edition of charts and reprinting of existing charts) and number of copies printed each year of the period are shown in table 5.

Table 5. **Plates and copies printed**

Year	Total number of plates	Number of copies
1964	1,180	358,075
1965	1,142	334,873
1966 (Jan.-Oct.)	934	318,155

Japanese Oceanographic Data Centre

In order generally to promote the scientific techniques in oceanography of the country as well as to provide oceanographic data to interested parties throughout the world, the Japanese Oceanographic Data Centre inaugurated its service on 1 April 1965, as recommended in the International Oceanographic Commission resolution I-9 of 1961. The Data Centre is an administrative component of the Japanese Hydrographic Office. The following functions are carried out at the Data Centre in accordance with the directives given in the *Manual on International Oceanographic Data Exchange* (IOC [International Oceanographic Commission] Technical Series 1):

Acquisition of data: the Data Centre obtains oceanographic data from reports, exchanges, contributions and purchases from various sources, both at home and abroad;

Evaluation of data: the data obtained is evaluated and classified according to its degree of accuracy;

Data processing: the data is processed by coding, punching, accounting and by other methods as required;

Depositing and cataloguing: processed data is deposited at the Data Centre in forms such as punch cards, magnetic tapes, printouts and microfilm; on request, the data will be exchanged; a catalogue of data holdings is published;

Publication of data: fundamental data of high utility will be collectively issued as a publication;

Tabulation and atlases showing oceanographic conditions: tabulation and atlases showing annual and seasonal oceanographic conditions will be prepared for general use.

In addition, the Data Centre receives various data and information sent from countries participating in the Co-operative Study of the Kuroshio (CSK). The catalogues of data and information are published bi-monthly in the *CSK News Letters*, of which Nos. 1 to 8 inclusive have been published to date. The data will be processed at the Data Centre, classified and printed and distributed as preliminary data reports of CSK.

The Data Centre is now preparing to publish a CSK provisional atlas based on CSK data.

Organization of the Japanese Hydrographic Office

Headquarters organization is as follows:

Maritime Safety Agency

Hydrographic Office
(Chief Hydrographer: Takuichi Matsuzaki)

Counsellor
(Sigeo Sano)

Administrative Section
(Chief: Yoshiyuki Nakajima)

Surveying Section
(Chief: Kiyoshi Kawakami)

Oceanographic Section
(Chief: Daitaro Shoji)

Astronomical Section
(Chief: Akira M. Sinzi)

Chart Section
(Chief: Minoru Nagatani)

Publication Section
(Chief: Kageyoshi Kutsuna)

Printing Section
(Chief: Satoshi Shigehiro)

Japanese Oceanographic Data Centre
(Director: Daitaro Shoji)

Maritime Research Laboratory
(Chief: Naoaki Owaki)

Regional organization is as follows:

Maritime Safety Agency

Regional Maritime Safety Headquarters

Hydrographic Division

Hydrographic Observatory

Administrative Section
Hydrographic Section

Training organization is as follows:

Maritime Safety Agency

Maritime Safety Academy
Hydrographic course
Maritime Safety Training School
Hydrographic course

Survey ships

Table 6. List of survey ships belonging to the Hydrographic Office

Name	Tonnage (GT)	Speed (kt)	Range (M)	Year launched	Main instruments: For surveying	Main instruments: For oceanography
Takuyo	771	14	9,600	1957	Precise echo-sounder for extreme deep sea Precise echo-sounder for deep sea Precise echo-sounder for shallow water Dredger Piston core sampler Taperod wire (12,000 m) and winch (120 HP) Snapping sampler LORAN, 2 DECCA navigator system	Wire and winch (8,000 m, 15 HP, for serial water sampling) Wire and winch (3,000 m, 5 HP, for serial water sampling) Wire and winch (1,500 m, 3 HP, 2 sets, for serial water sampling and BT) GEK Recording thermometer Inductive salinometer Photoelectric colorimeter
Meiyo	360	12	5,280	1963	Precise echo-sounder for extreme deep sea Precise echo-sounder for shallow water Wire and winch (6,000 m, 7 HP, for core sampling) LORAN	Wire and winch (8,000 m, 77 HP, for serial water sampling) Wire and winch (2,000 m, 3 HP, for serial water sampling) Wire and winch (1,000 m, 3 HP, for BT) GEK Photo-electric colorimeter Scintillation counter
Kaiyo	308	12	6,100	1964	Precise echo-sounder for deep sea Precise echo-sounder for shallow water LORAN	Wire and winch (3,000 m, 7.5 HP, for serial water sampling) Wire and winch (2,000 m, 5 HP, for serial water sampling) Wire and winch (1,000 m, 3 HP, for BT) GEK
Tenyo	121	10	3,160	1961	Precise echo-sounder for deep sea Precise echo-sounder for shallow water LORAN	Wire and winch (1,000 m, 2 HP, for serial water sampling and BT) GEK
Heiyo	51	9	670	1955	Precise echo-sounder for shallow water	Wire and winch (1,500 m, 3 HP, for serial water sampling and BT) GEK

Study

Study of production management and stock control of nautical charts

To keep charts up to date, chart correction must be as simple and speedy as possible. It is therefore necessary to examine the whole process of chart production and representation with a view to improving it. At the same time, ways should be sought of rationalizing production management and the stock control of charts in connexion with the issue of supplementary prints on the basis of plates that have been corrected and brought up to date. The reason is that, in the case of charts covering areas where rapid changes occur in charted information, there is likely to be a waste of time and labour in overproduction; at the same time, the effective use of the requisite data is impeded.

As coverages and scales of charts vary according to their usage, so the degree and frequency of changes in charted information and the numbers of copies required will vary. At present, the decision as to the quantity of supplementary prints to be printed tends to be based on somewhat empirical considerations. To improve this situation, the research laboratory of the Hydrographic Office is carrying out a study of production management and stock control of charts using an electronic data-processing system.

Study of automation of hydrographic work

Owing to recent changes in marine transport, including harbour development and the extension of work in associated disciplines, especially in the oceanographic and geophysical fields, the volume and variety of hydrographic data have enormously increased. It is therefore a matter of urgency that the product of hydrographic work should be furnished rapidly, in greater detail and with higher accuracy. To this end, the automation of survey, observation and analysis, or data-processing, should be developed; this applies both to individual instruments and types of equipment and to the entire system of hydrographic work, taking into consideration whatever information is requested by navigators and scientists.

The Hydrographic Office has recently begun research on the automation of hydrographic work; as a first step, the digitalizing of echo-sounding, including three-dimensional sounding.

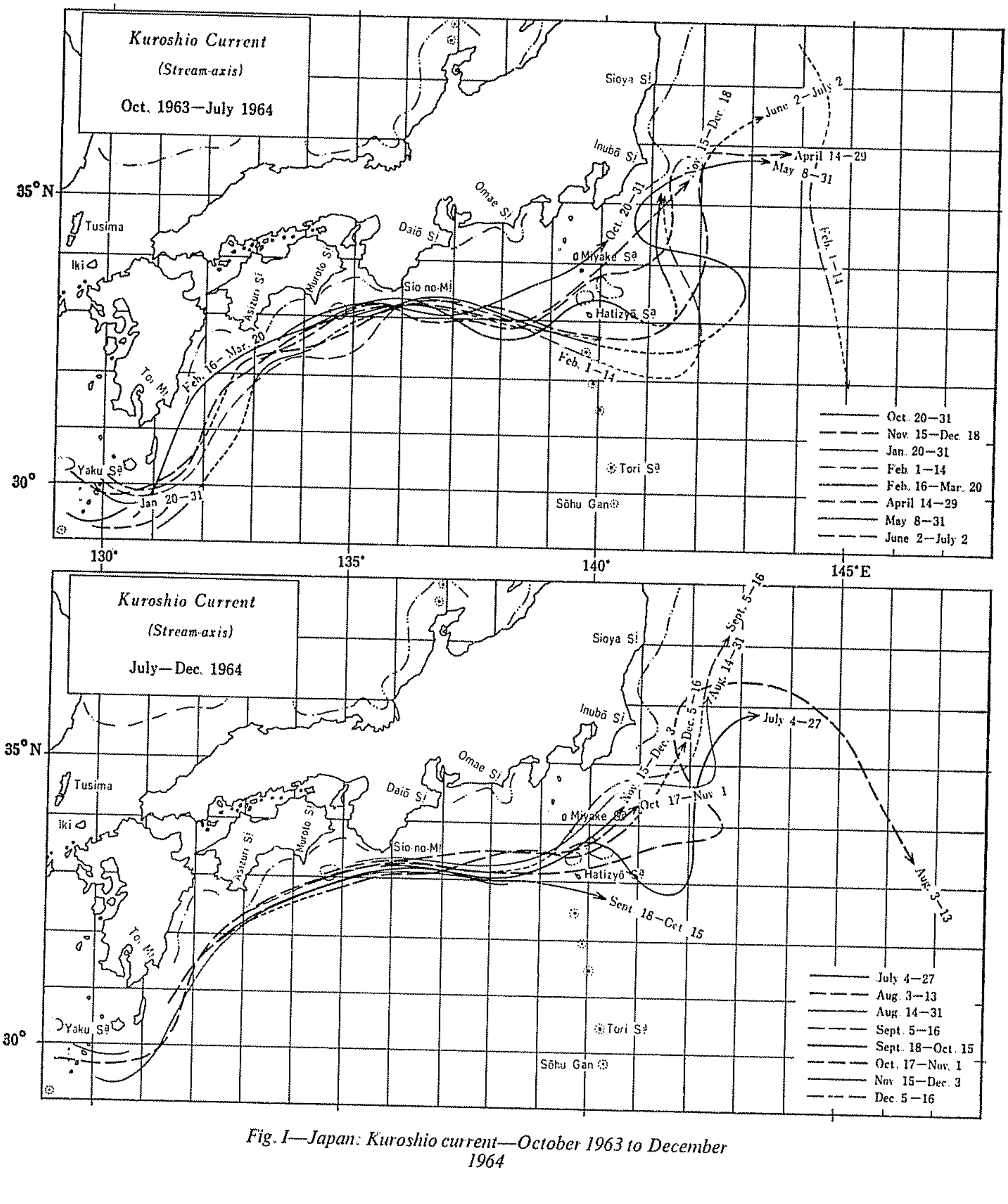
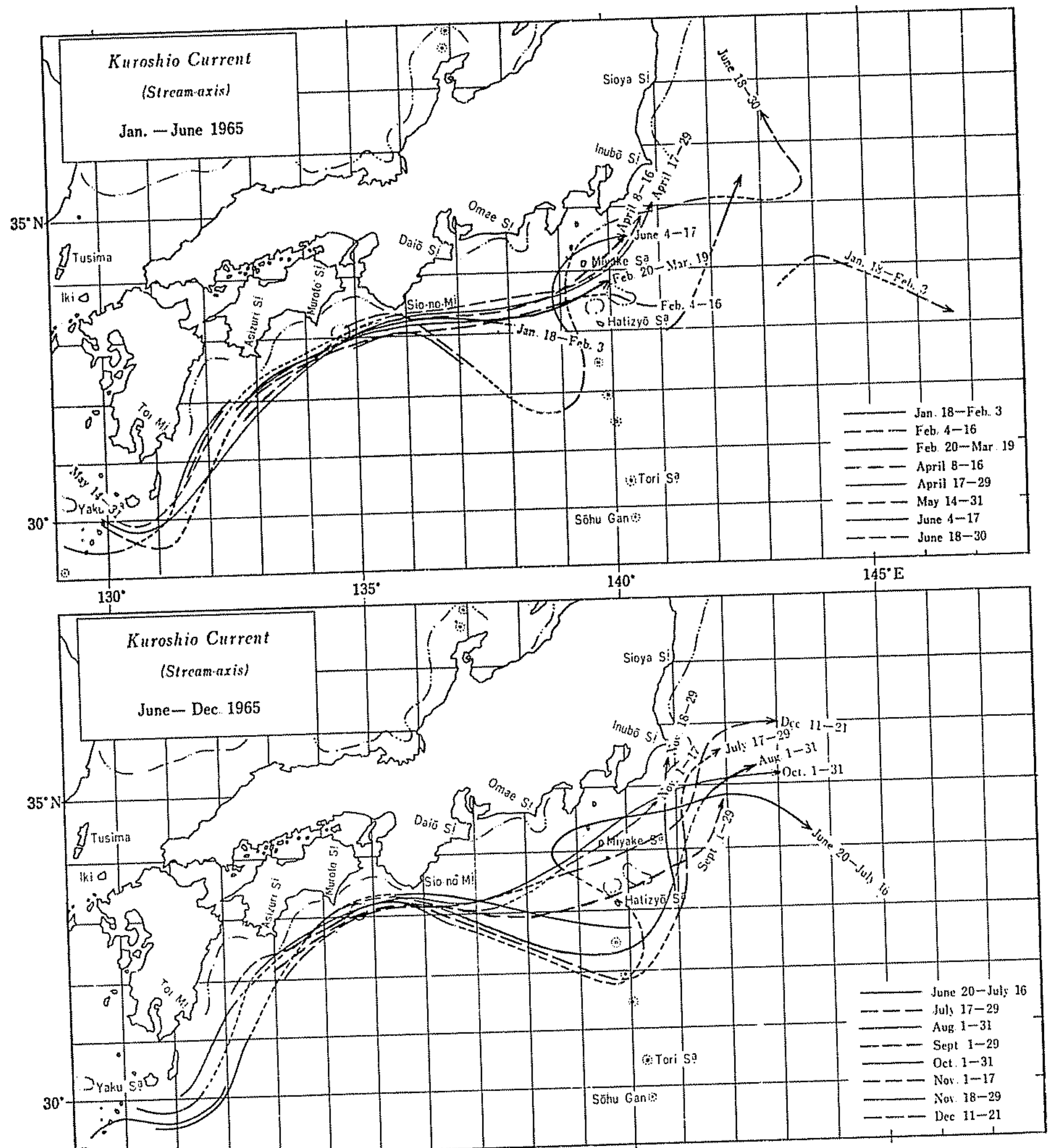
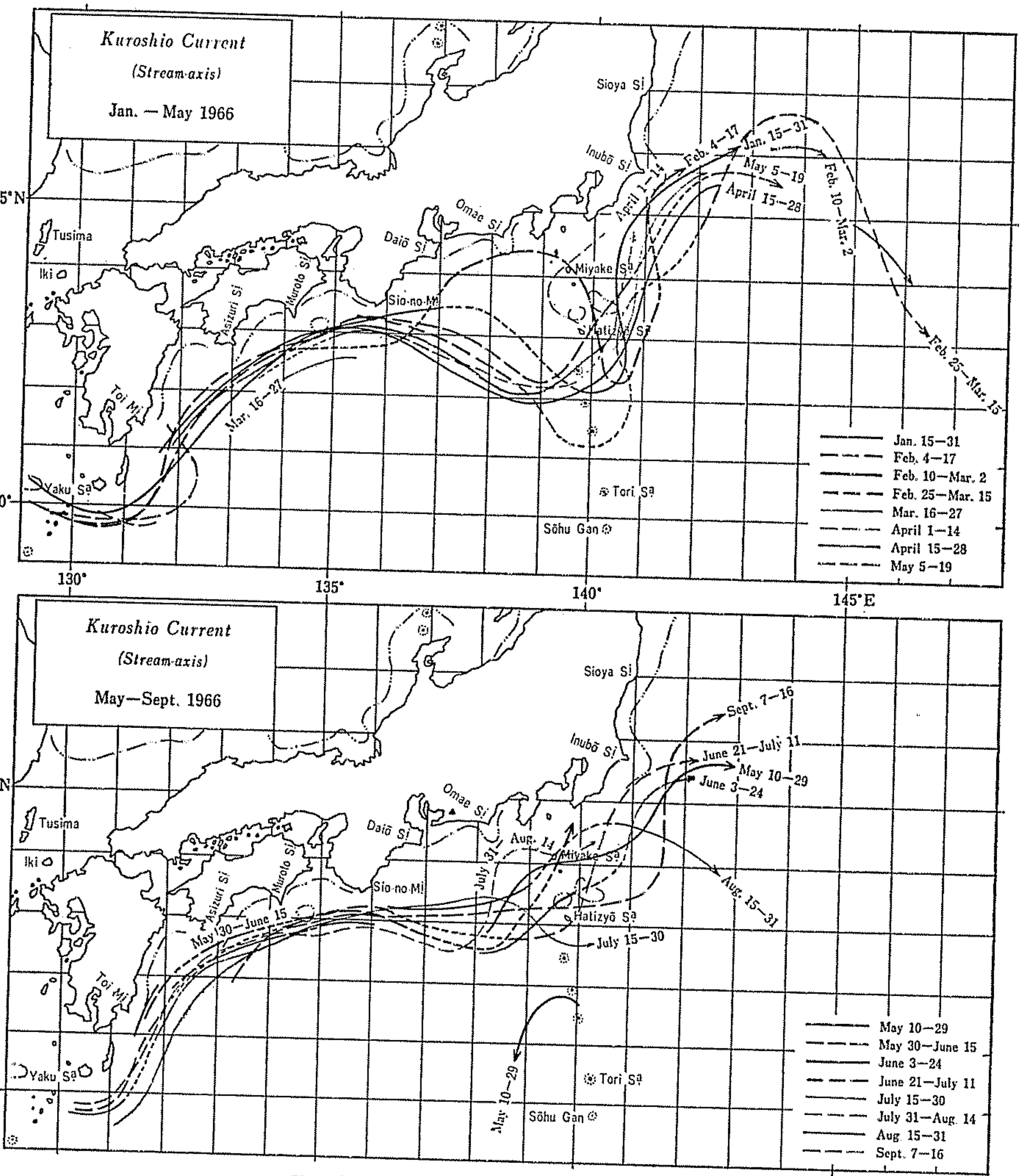


Fig. I—Japan: Kuroshio current—October 1963 to December 1964



(Fig 1 continued on next page)

Kuroshio current—January to December 1965



Kuroshio current—January to September 1966

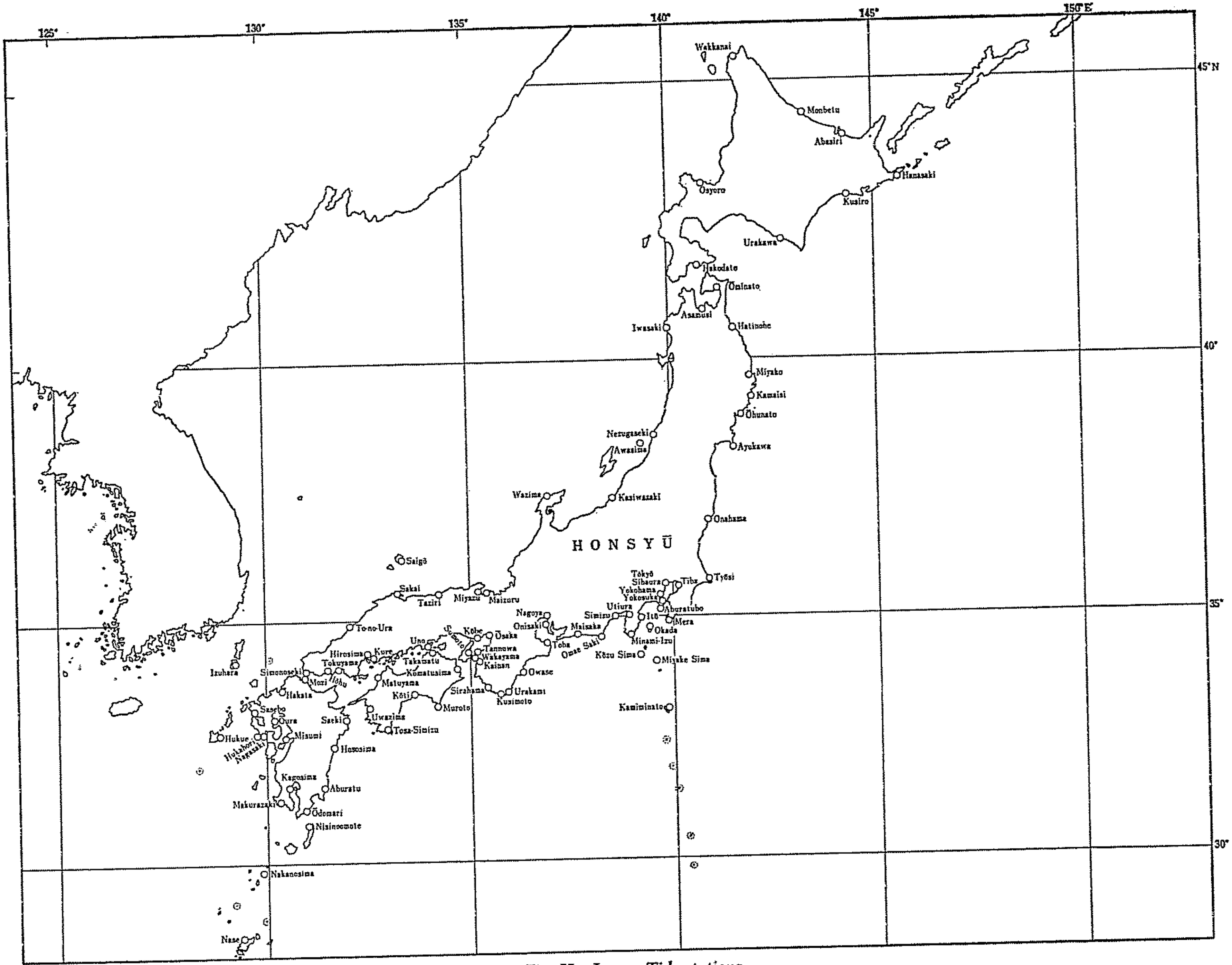


Fig. II—Japan: Tide stations

CARTOGRAPHIC ACTIVITIES OF THE NATIONAL GEOGRAPHIC SERVICE

Paper presented by the Republic of Viet-Nam[1]

Introduction

During the period 1964–1967, the cartographic activities of the National Geographic Service of the Republic of Viet-Nam have comprised the following: completion of the basic cartographic coverage of 1:50,000; initiation of a cartographic programme of 1:25,000; continuation of geodetic operations triangulation, traversing, gravimetry and precision levelling with a view to completing the existing geodetic network of the country.

For national requirements, the National Geographic Service is also called upon to prepare, revise and publish plans of towns, special and topical maps, road maps, administrative maps, aeronautical charts, vegetation charts and general physical maps.

Topographic mapping

The basic cartographic coverage of 1:50,000 was completed in 1965 by the National Geographic Service in conjunction with the United States Army Map Service. It represents 428 sections covering the whole of the territory of the Republic of Viet-Nam. In the same year, the National Geographic Service undertook the revision of forty sections in the region north of the Mekong Delta. That programme was suspended by the re-establishment of the basic coverage by the United States Army Map Service using a new system, which divides the territory into 300 sections only. The new cartographic coverage is being revised with the help of aerial photography.

The programme of topographical mapping at 1:25,000 was undertaken at the end of 1965. A start was made with the populated regions, where a need exists for topographical maps in order to obtain details for economic development and agricultural planning. Photogrammetric methods alone are used for the preparation of these maps, with the help of aerial photographs at 1:40,000 and 1:20,000 and second-order plotting equipment: Wild A8 and Poivilliers D4. Nineteen sections covering 2,200 km² have been plotted.

Four towns have been mapped, and the capital, Saigon, has been remapped at 1:10,000.

Aerial coverage and photogrammetric equipment

The Republic of Viet-Nam has been covered by two aerial missions working to the scale of 1:40,000: a French Aquilor 13 × 18 cm mission made during the period 1952–1954, and a United States Metrogon 24 × 24 cm mission made during the period 1958–1959. These missions, made with third-order equipment (Multiplex, Stereotop, Stereoflex) were used in the preparation of the map of 1:50,000. Some of these missions, using Autograph Wild A8 and Stereotopograph Poivilliers D4 equipment, contributed to the preparation of topographical maps at 1:25,000. This equipment is sufficiently precise from both the planimetrical and the altimetrical points of view. However, these missions took place some time ago, and the planimetrical aspect, especially in populated areas, is continually changing. A new aerial mission for cartography at 1:25,000 would be desirable, but unfortunately the National Geographic Service has no means of taking aerial photographs, and is therefore obliged to make do with military missions of 1:40,000 and 1:20,000 to complete its surveys. The use of such missions presents certain difficulties, as they do not possess all the technical characteristics of a cartographic mission. The town plans are prepared solely with the help of military large-scale aerial photographs, going from 1:10,000 to 1:8,000.

The photogrammetric equipment available to the National Geographic Service is still very limited. Apart from the third-order instruments (Multiplex (7), Stereotop (5) and Stereoflex (1)), there exist only the following: 2 Autographs Wild A8; 1 Stereotopograph Poivilliers D4.

These instruments are used to full capacity (fourteen hours daily, with two teams of plotters) for plotting at 1:25,000 and 1:10,000.

A request for aid from the United Nations Special Fund to provide the service with photogrammetric equipment for a three-year programme has been made through the United Nations Development Programme representative in Saigon. The equipment requested comprises precision material for surveying and plotting.

Ground surveying

The National Geographic Service is anxious to complete the existing network of triangulation and levelling of the country. Unfortunately, the present situation in Viet-Nam does not enable the service to make much progress in ground surveying. The teams can operate only in secured zones. Nevertheless, 400 km of first-order levelling by means of 120 bench-marks were completed by ground surveying between 1965 and 1966. At the same time, supplementary control points were set up over an area of more than 700 km² to assist aerial photography. Forty gravity stations were established.

[1] The original text of this paper, submitted in French, appeared as document E/CONF.52/L.89.

UNITED STATES CARTOGRAPHIC ACTIVITIES

Paper presented by the United States of America[1]

Geodesy

The basic horizontal control in the United States has been extended mainly as area networks between existing arcs of triangulation. This has been done for general use in mapping and various types of engineering programmes, such as highway construction, water diversion and reclamation projects, and the development of urban and suburban areas. Continued use has been made of electronic measuring equipment, particularly in connexion with the extension of the transcontinental geodimeter traverse surveys used to strengthen the basic horizontal control

[1] The original text of this paper appeared as document E/CONF.52/L.98.

network in the country and to provide scale for the geodetic satellite triangulation, which has been partially accomplished over the North American datum. About 5,000 km of these traverse surveys had been completed at the end of calendar year 1966.

During that period, the world geodetic satellite project commenced operations with the launching of PAGEOS in June 1966. At present there are thirteen camera stations deployed through the northern hemisphere, from Japan east to Iran, observing on the basic world-wide net. In addition to the basic net, which employs BC-4 cameras, the United States is using Doppler, PC-1000 and SECOR systems in the geodetic satellite effort.

Resurveys for the detection of earth movement have been continued, particularly in California. Geodetic surveys for this purpose have been completed in the Anchorage and Prince William Sound areas of Alaska and reports on earth movement in this area have been, or will be, made available in publications of the Environmental Science Services Administration (ESSA). In the case of the Alaska work, the purpose is not only to detect earth movement, but also to strengthen the basic network and bring it up to date.

Relevelling has continued in the United States over the basic network to update elevations which have changed for various reasons. Astronomical observations for latitude, longitude and azimuth are being continued in connexion with orientation control of the horizontal network, with particular emphasis on the transcontinental traverse surveys at intervals of from 20 to 30 km.

Extensive geodetic operations were carried out by the United States Navy Oceanographic Office for the support of hydrographic surveys in South-East Asia. Thirty-two Raydist transmitter sites and numerous visual landmarks were positioned and tied to existing control points. Considerable support was also given positioning mobile monitor stations engaged in calibrating the numerous LORAN nets in the western Pacific.

Gravimetry

Present-day science and technology requires accurate knowledge of the earth's gravity field. Fuel and mineral deposits are located by intensive field surveys. Regional surveys on land and sea bring out broad patterns of crustal structure and are used in calculating improved absolute datum values for triangulation networks. Space vehicles and inertial navigation systems require precise calibration values and knowledge of the external gravity environment.

A major activity has been the extension of gravity traverses over primary level lines throughout the United States. These surveys provide gravity base values at close intervals and also make possible computation of dynamic elevation differences along the various loops of spirit levelling. Approximately 1,300 new stations were established along a traverse distance of 5,200 miles. Early in 1966, a project was begun to concentrate gravity measurements in the vicinity of six mid-western astronomical stations to determine an improved datum value for the North American triangulation.

Special gravity measurements were accomplished in Alaska in 1964 in the course of investigations following the March 1964 earthquake. To detect possible changes in crustal structure during the post-earthquake period, many of the gravity measurements were repeated in 1965. No significant changes were found in the immediate area of the epicentre, but a rise of about 2 feet was detected at one offshore island during the year following the earthquake.

Sea gravity measurements were accomplished by the oceanographic ships *Pioneer* and *Surveyor* on north-south tracklines in the Pacific Ocean, off the west coast of the United States for the Upper Mantle project, and in the Prince William Sound, Alaska, region in connexion with the earthquake investigations. A new evaluation range for shipborne gravity meters was established off the east coast of the United States by the use of underwater meters, and a laboratory was established near Washington, D.C. for testing the ship meters on moving platforms.

The United States Government, working in conjunction with other nations as well as universities and geophysical institutions, has nearly completed the first-order world gravity network. This project is being accomplished in conjunction with special study group No. 5 of the International Association of Geodesy. The plan provides for an integrated network of base stations, with gravity at each station observed by pendulums or spring type gravimeters to an accuracy of 0.3 mgals. Stations in Asia and the Pacific area are located in New Delhi, Singapore, Tokyo, Melbourne, Christchurch and Honolulu.

The three primary calibration lines which have been established are the Euro-African, American and west Pacific. In addition, three secondary calibration lines have been established. These lines were established in accordance with the agreements reached at the fourth assembly of the International Gravity Commission, in September 1962. The observations were conducted by various government organizations, universities, and other institutions under the direction of special study group No. 5.

United States Government organizations and oceanographic institutions, including those operated by universities, are presently involved in observing ocean gravity using both submarines and surface vessels. Gravity surveys in the Indian Ocean have been completed. Other projects include surveys off the Australian continental shelf south of the tropic of Capricorn, around the Maldine and Laccadine Islands in the Arabian basin, and the continuation of the work in the Andaman Sea.

As a result of a co-operative survey by the University of Hawaii, the United States Army Map Service, the United States Air Force 1381st Geodetic Survey Squadron, and the United States Coast and Geodetic Survey, a national gravity base net for the United States has been established. Gravity bases were established at auxiliary sites (airports) in fifty-four cities throughout the United States. Measurements, which had been corrected for the effects of nonlinear dial response, circular error and earth tides, were used in a least-squares adjustment to determine preliminary gravity values for the bases observed on the survey. This network will provide a basis for all future gravity surveys conducted in the United States. Plans are being formulated to relate this network to existing networks and to establish permanent base stations at monumented points.

The United States Army Map Service, the United States Coast and Geodetic Service and the United States Air Force 1381st Geodetic Survey Squadron have performed land gravity surveys in various parts of the world to establish the national base nets and increase the density and distribution of gravity stations. The study of the Upper Mantle, which is centred along the 37th parallel within the United States, is scheduled to be completed in time for the next meeting of the International Union of Geodesy and Geophysics. This project is being conducted under the auspices of the Geophysics Research Board of the United States National Academy of Sciences. The project is known as the transcontinental geophysical survey and includes geological, seismic, and magnetic mapping in addition to gravimetric surveys.

Geomagnetism

The United States Coast and Geodetic Survey compiled and published the 1965 series of magnetic charts of the United States. In collaboration with the United States Naval Oceanographic Office, and in consultation with the Royal Greenwich Observatory of the United Kingdom, the Survey also compiled the 1965 series of world magnetic charts which were then published by the Navy.

Significantly new procedures were used in preparing both series of charts. The employment of analytical methods, briefly described below, has achieved greater objectivity with respect to the basic data and thus has reduced dependence on the personal judgement and experience of the cartographer in plotting isolines. Continued development and refinement of these procedures is planned for future editions of the charts.

Each new chart is compiled from the basic data rather than by applying secular changes to the preceding chart. To correct the data to epoch 1965, the same procedures that were developed some years ago were used, the corrections being derived from magnetic observatory records and from repeat magnetic survey operations. The analysis and construction of the world charts then consisted essentially of four steps:

A pre-analysis, whereby the distribution of the magnetic field was mathematically described by a two-dimensional polynomial expression in each of about 600 overlapping 30° by 30° quadrangles; from these coefficients were computed the values of the field at equally spaced grid points 10° apart in latitude and longitude;

A spherical harmonic analysis of the entire earth's field, to degree and order 12 (168 coefficients), using the equally spaced grid values as input;

The computation, from the spherical harmonic coefficients, of the loci of the required isolines;

The automatic plotting, on a Concord co-ordinatograph at the Naval Oceanographic Office, of the isomagnetic lines in a form suitable for direct reproduction and printing.

The 1965 series of world magnetic charts includes an isogonic chart (declination), and isoclinic chart (inclination) and isodynamic charts of horizontal intensity, vertical intensity and total intensity. Each magnetic element is presented on a Mercator projection extending from 84° north to 70° south at a scale of 1:39,000,000 at the equator, and two polar stereographic projections extending from the poles to latitude 55° at a scale of 1:10,000,000 at latitude 71°. The construction of the magnetic charts of the United States follows similar procedures, but without the spherical harmonic analysis. The charts, plotted from the coefficients of the polynomial expressions, show somewhat more magnetic detail than the world charts, being comparable in that respect with earlier editions of the United States charts.

Shipboard geophysical surveys conducted by the Naval Oceanographic Office in the western Pacific were limited to the operations of the USNS *Sgt Shoup* between January and October 1965. During that period, over 10,450 gravity observations were made, and continuous total magnetic intensity profiles were obtained for approximately 40,000 nautical miles of track.

The Naval Oceanographic Office project MAGNET, a continuing world-wide airborne vector magnetic survey, gathered approximately 124,000 miles of magnetic data in the area. Figure I shows the tracks flown. Land gravity measurements were made each time the aircraft landed, and it is standard procedure to forward these as well as the magnetic data to countries granting permission to overfly or land. All airborne magnetic data are available in the *Naval Oceanographic Office Special Publication* No. 66 and its supplement and track profiles of various selected areas are stored on microfilm and are available at a nominal cost.

Seismology

The world-wide earthquake locating programme continues to expand, issuing approximately 6,500 epicentres annually during the past two years. The growth has been due essentially to the improved data and reporting from the world-wide network of standard seismographs and other co-operative stations and vastly improved electronic computer facilities. Accuracy of epicentre locations, focal depths and magnitude determinations have increased. The epicentre and focal depth data have provided for advancement of studies of the discontinuities and significant layers in the crust and upper mantle. There was a noticeable increase in requests for seismic estimates of maximum earthquake motions for use by structural engineers, particularly in connexion with nuclear reactor site selections.

The Pacific Tsunami Warning Service was continued with expansion in the seismic and tidal detection network and improvements to communications in the Alaskan-Aleutian areas. The establishment of a seismic quadripartite net in Oahu, Hawaii, was completed in April 1965. Its purpose is to provide early seismic data to approximate the position of the earthquake epicentres required for the tsunami watch. Similar systems with one to three seismometers have been established at Adak, Sitka and Palmer, Alaska. Seismic data from these stations and College will be telemetered to Palmer for early detection of seismic disturbances. In addition, tidal data from Shemya, Adak, Unalaska, Cold Bay, Kodiak, Seward and Sitka will be telemetered to Palmer for evaluation of tsunami wave heights and to provide immediate source data for announcing tsunami warnings. A similar system of seismic and tidal stations is being proposed for the west coast of the United States. The data will be evaluated at a centre, from which tsunami warnings will be issued for the west coast. All data from Palmer and the west coast centre will be furnished by Honolulu for use in the Pacific Tsunami Warning Service.

An *Annotated Bibliography on Tsunamis* was completed by the United States Coast and Geodetic Survey, ESSA, printed by the International Union of Geodesy and Geophysics and distributed free of charge to the Tsunami Warning participants. Work is now progressing on the first supplement to the bibliography, covering articles published in 1963 and 1964 and those missed or not abstracted in the original publication. Numerous changes to the *Communication Plan for the Tsunami Warning System* were issued to keep the plan up to date.

Considerable efforts to prepare public educational material were undertaken during the period under review. A colour film, *Tsunami*, was produced and also a 46-page colour brochure entitled, *Tsunami: The Story of the Seismic*

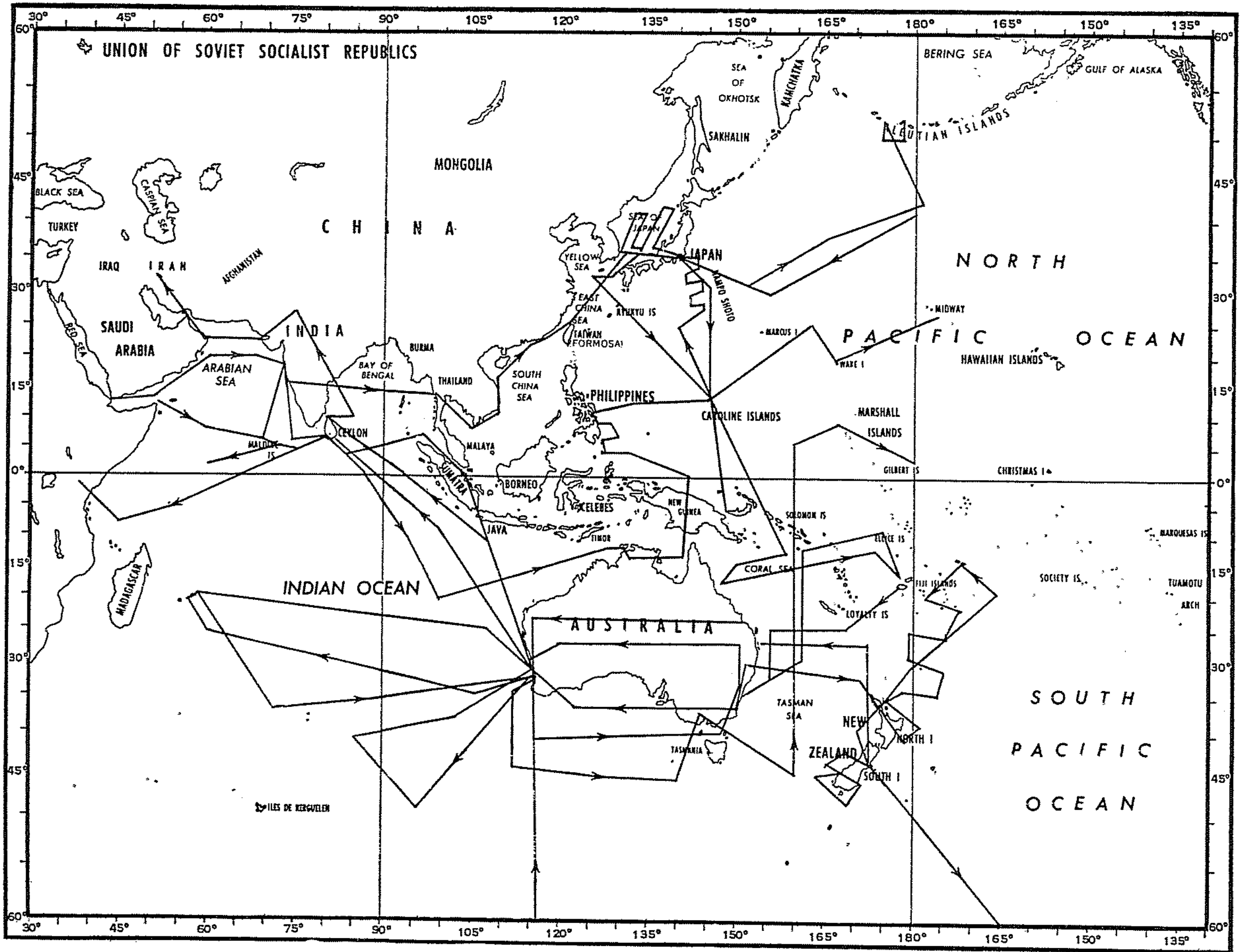


Fig. I—United States of America: Project Magnet; tracks flown since 1964

Sea Wave Warning System. Two small pamphlets entitled *Notes on the Seismic Sea Wave Warning System* and *Tsunami Notes* were prepared for public use.

A conference on the international aspects of the tsunami warning system in the Pacific was held at Honolulu under the sponsorship of the United States Coast and Geodetic Survey, ESSA, on behalf of the Inter-governmental Oceanographic Commission. Representatives from the United States of America, the Soviet Union, the Philippines, Japan, Peru, Canada, Chile, French Polynesia, New Zealand, Mexico, Republic of China and Western Samoa were in attendance. Means of furthering co-operation between national warning systems and the Tsunami Warning System were explored.

The United States Coast and Geodetic Survey has greatly expanded its network of accelerographs in the western United States and Alaska, so that the present total is 145 and in addition there are 309 seismoscopes. Present plans call for expansion in other seismic areas of the United States, including Colorado, Missouri and the St. Lawrence valley. The teleseismic station network has been increased by the addition of new observatories at Adak, Newport, Washington and Palmer, Alaska. In addition, the Survey has acquired the Blue Mountain Seismological Observatory at Baker, Oregon, which has an advanced seismic array system with magnetic tape and photographic recording.

A National Earthquake Information Centre was established in the Rockville, Maryland, office of the Survey on 16 August 1966. Earthquake data are promptly received by telephone and telegraph from Guam, Tucson, Honolulu, College and Newport, and the epicentre for earthquakes of magnitude 6½ and greater are determined within an hour or two. Information on earthquake locations, depth of foci, magnitude and felt or damage effects are released directly to the Press and placed on the ESSA teletype system for dissemination across the United States.

The seismological investigation of the Prince William Sound earthquake of 28 March 1964, conducted by the Geophysics Research Group and the Seismology Division of the United States Coast and Geodetic Survey will be published soon in volume 2B of the earthquake report. Briefly, the results of this investigation show that about twenty tremors occurred in the area from 1 January 1964 to the time of the main shock, the largest being a magnitude $m_b = 5.6$ shock on 6 February 1964. By December 1965, 2,060 aftershocks had been located and many thousands more recorded. Of these aftershocks, 912 were recorded at teleseismic distances and located using the teleseismic hypocentre determination programme, and 1,148 additional earthquakes were located using P arrival data from a local network of stations and a local hypocentre determination programme. These located earthquakes ranged in magnitude from 8.3 to 2.7. Magnitude determinations of a number of events recorded by only the local network of stations could not be determined because of insufficient data.

Focal mechanism studies of ten earthquakes occurring in the area have been completed. These include P-wave solutions for one large tremor (6 February 1964), the main shock, and eight aftershocks, and S-wave solutions for the same tremor, the main shock, and one aftershock.

Maps indicating the strain release in the normalized form of the equivalent number of magnitude 3 earthquakes are being prepared for a time period of fourteen years prior to 1964, and for the aftershock time period to December 1965 inclusive.

Hydrography and oceanography

A new *United States Coast and Geodetic Survey Nautical Chart Catalogue*, in three volumes, is now being issued. Each volume is accordion-folded, similar in format to road maps, and covers entire coasts. Volume I covers the Atlantic and Gulf coasts, including Puerto Rico and the Virgin Islands; volume II covers the Pacific Coast, including Hawaii, Guam, and Samoa; volume III covers Alaska. The catalogue includes chart numbers, areas, prices, scales and information on related publications, miscellaneous charts and other data. First editions of fifteen small-craft charts have been published in the past two years. Fifty-two of these specially designed nautical charts are now available to meet the rapidly expanding needs of recreational boating in the United States.

Under an agreement reached at the eighth International Hydrographic Conference, held in Monaco in May 1962, most maritime nations are participating to produce bathymetric plotting sheets of the world's oceans. These plotting sheets are forwarded to International Hydrographic Bureau headquarters in Monaco for compilation of the General Bathymetric Charts of the Oceans (GEBCO). The United States commitment, being fulfilled by the United States Coast and Geodetic Survey and Naval Oceanographic Office, includes the north Pacific Ocean, the Arctic Ocean and the western half of the Atlantic Ocean. Ten of these plotting sheets have been completed and forwarded to the International Hydrographic Bureau.

Six bathymetric maps of the Aleutians arc are available to the public. Other bathymetric maps scheduled for publication in the near future are a series of fifteen maps of the middle Atlantic continental shelf and a series of five maps of the California shelf area.

Prototype machine graphic displays have been made for the development of a compatible automated system of nautical chart production. The automated system begins with the collection of field data; it proceeds through the various processing steps to the final presentation of a nautical chart.

In the United States, basic hydrographic surveys were accomplished along the east coast off Cape Hatteras, the Carolinas and in the Strait of Florida. Basic surveys were continued in the northern Pacific Ocean between the Hawaiian Islands and the Aleutians, Alaska. Revision hydrographic surveys were conducted along the Atlantic coast and Gulf of Mexico in various areas from Massachusetts to Texas; along the Pacific coast, in Puget Sound area as well as in various inside waters of south-east Alaska, and in Prince William Sound and Cook Inlet, Alaska. Revision surveys were also continued in the Hawaiian archipelago, in the vicinity of Molokai, Lanai, and the Maui Islands. Wiredrag investigations of reported obstructions, shoals and wrecks were completed in a number of coastal and harbour areas. In conjunction with the hydrographic operations, oceanographic investigations were made along coastal and offshore areas.

During this period, various federal agencies and private institutions participated in the Atlantic and Pacific Coasts International Upper Mantle Project, which extended from 35° to 39° north and offshore approximately 500 miles; the Gulf Stream investigation, which included following the stream along the 15° isotherm from Cape Hatteras to a point south of Nova Scotia, and observing standard sections of oceanographic stations normal to the axis of the stream; and the scientific observations on the total solar eclipse of 12

November 1966 off the coast of Uruguay. The objectives of these co-operative projects were to carry out physical, chemical, geological, biological and current studies.

Since the Fourth United Nations Regional Cartographic Conference, in Manila, most of the United States Navy's hydrographic efforts in the Far East have been in the South-East Asia area. Four survey ships have gathered over 20,000 nautical miles of controlled soundings and produced much needed nautical charts of the eastern and south-eastern coasts.

In regard to hydrographic surveying in general, the United States Navy's harbour survey assistance programme should also be mentioned. This is a programme started in late 1964 and designed to develop a hydrographic surveying and mapping capability in developing countries. United States hydrographic engineers are sent into the field to assist and train host country personnel in carrying out hydrographic surveys of their ports and harbours; those countries can then maintain accurate charts and thus stimulate foreign trade and hopefully improve their general economic conditions. Efforts to date have been quite successful, and it is believed that three of the small countries now have this capability. Although the programme has been limited to Latin America, a similar programme for Asia and the Far East supported by the United Nations or one of the leading maritime nations is worthy of consideration by this group.

Since July 1964, the Naval Oceanographic Office has published 109 new nautical charts or new editions of nautical charts for the Indian Ocean and the Pacific Ocean (excluding North and South America and Hawaii), bringing the number in the area now on issue to 1,340. Facsimile reproductions of sixty-four foreign charts of the area were also made available. For this report, new chart coverage is described under the following three categories: small-scale general ocean and sailing charts (smaller than 1:600,000); medium-scale coastal charts (1:75,000 to 1:600,000); large-scale harbour approach and port coverage (larger than 1:75,000).

Since the last meeting, the following sixty-three new nautical charts or new editions have been produced: (*a*) eight small-scale charts for the Japanese islands, the southern sea of Okhotsk, the southern part of the South China Sea, the Bay of Bengal and the Arabian Sea; (*b*) twenty-three medium-scale charts for the approaches to Bushehr in the Persian Gulf, the south-east coast of the Malay Peninsula, Formosa Strait, and portions of the east and south coasts of Africa, the east coast of India, the east coast of Borneo, the Philippines and the Fiji Islands; (*c*) thirty-two large-scale charts for numerous ports and harbours, including Hong Kong, Sandakan, Auckland, Geelong, Brisbane, Karachi, Kuwait, Nagoya, Yokohama, Osaka and Saipan.

In addition to this nautical chart coverage, the Naval Oceanographic Office produces and maintains many special-purpose charts, weekly Notices to Mariners, sailing directions, pilot charts, light lists and radio aids. New products in these categories are the 1965–1966 *Sailing Directions for the Red Sea and the Bay of Bengal* (Nos. 61 and 64), three small-scale gnomonic charts (5405-31M, 5405-32M, and 5405-33M) for plotting great circle routes, and two small-scale bathymetric charts (BC-2203N and BC-2204N) for echo-sounding and LORAN-A navigation in the vicinity of the Marianas.

To facilitate the problem of providing global chart coverage to its mariners, the United States has entered into bilateral agreements with other nations whereby each may issue for sale to the general public modified facsimile reproductions of the other's nautical charts. As of November 1966, the United States has agreements with the Philippines and the Republic of Korea in the Far East as well as Brazil, Canada, the Federal Republic of Germany, Italy, Japan, Mexico and the United Kingdom. Similar agreements are pending with the Republic of Viet-Nam and Australia. These agreements are in accordance with resolutions of the International Hydrographic Bureau.

Topographic maps and aerophotogrammetry

During the reporting period, the United States has continued its co-operative mapping and charting programmes with several Asian and Far Eastern countries. Very satisfactory progress has been made, and will be individually reported by the nations concerned. These co-operative programmes achieve a significant benefit in the adoption of standardized symbols, methods, formats, colours and materials.

A recent development of the United States Geological Survey is the Stereo-Image Alternator (SIA), a system that eliminates the need for anaglyphic filtering and permits direct viewing of stereoscopic models in projection-type stereoplotting instruments. The SIA system operates with three synchronized rotating shutters, two in the projection field and one in the viewing field (with segments for both eyes), to interrupt and pass the cones of light alternately from the left and right projectors so that each eye sees only the image from the corresponding projector. Powering the three shutters are miniature stepping motors driven by pulse and logic circuitry which controls the rotor positions of the motors. The motors can be run fast enough to eliminate perceptible flicker in each projector image.

Elimination of the anaglyphic filters increases the stereo-model resolution and the amount of light reaching the eyes of the stereoplotter operator. Furthermore, colour photographs can now be used in projection-type stereoplotting instruments.

Operational tests of the SIA system are complete, and several units have been put into regular production use in the Geological Survey. A complete report on this system is contained in a paper presented at this conference.[2]

An off-line automatic co-ordinate-plotting system is being developed in the United States Geological Survey for the preparation of base sheets for topographic maps. The basic mechanism for the prototype model, now in the final engineering stage, was adapted from a standard Haag-Streit co-ordinatograph. To this basic instrument was added incremental electronic-control logic consisting of a punched-paper-tape reader, translating logic, stepping-motor control, and plotting-head control. Servomechanisms mounted on the rails of the plotter carry out the commands of the logic unit. An electronic computer programme, in preparation, will process the basic input data and generate the paper tape (or magnetic tape) for activating the plotter. Plotting error over the 48 × 48 inch table does not exceed 0.0015 inch, and plotting resolution is 0.0005 inch. Plotting time for a $7\frac{1}{2}$-minute quadrangle base sheet, containing projection lines, grid intersections, control points, pass points and labels, is expected to be about 15 minutes.

The general interest in photo-image maps as an effective

[2] "The Stereo-Image Alternator, potential successor to anaglyphic writing", see below, agenda item 8(*b*).

means of portraying terrain detail has been confirmed and intensified by the production and circulation of experimental maps covering a wide variety of ground conditions. Research is continuing in an effort to improve the production techniques and colour rendition of photomaps and to determine types of areas for which photo-image representation is most effective. Other experimental photomaps are being prepared at 1:24,000 scale for average areas and 1:12,000 scale for densely populated areas. Most of the selected areas have enough terrain relief to require the use of orthophotographs.

The United States Antarctic Research Programme (USARP), administered and financed by the National Science Foundation (NSF), is the mechanism by which the United States participates with eleven other countries in a co-operative scientific effort to learn more about a little-known area that covers almost 7 per cent of the globe. The Geological Survey receives funds from NSF for mapping operations in support of USARP activities. This activity, which began in 1957 on a smaller scale, requires five to ten men to spend approximately five months in New Zealand and Antarctica each year establishing mapping control and inspecting aerial photography for mapping. (Six men went in 1966 and five will go in 1967.) NSF bears all costs associated with the programme. Thirty-four Antarctica topographic maps at 1:250,000 scale have been published and 38 more are in progress. Revision of the two-layer, multi-coloured plastic relief model of the Antarctica area is in hand and it should be ready for sales distribution in 1967 or early 1968. The revised model will be at a scale of 1:10,000,000 with a vertical exaggeration of 25:1, as in the original. Shaded relief sketch maps at a scale of 1:500,000 have been published for northern Victoria Land and portions of the coast of Byrd Land. In addition to the continuing mapping programme, United States Geological Survey scientists are sometimes involved in geological, glaciological, gravimetric, seismic and aeromagnetic investigations in Antarctica. In 1966, ten men went to Antarctica for approximately four months each, in connexion with these latter investigations; only one will go in 1967. All costs are reimbursable from NSF funds.

Development of a computational analytical system of aerotriangulation was completed and is in operation at the United States Coast and Geodetic Survey. The system includes the use of both monocular and stereo-comparators for the measurement of aerial photographs, the metric calibration of wide-angle aerial photogrammetric cameras through stellar exposures and the compensation of aerial film distortion through the use of 8 camera fiducial marks. The entire data reduction is accomplished through the use of electronic computers and all programming has been done in Fortran language and is adequately documented for dissemination.

The computer programmes allow for the compensation of lens distortion, film deformation, atmospheric refraction and camera calibration. They accomplish strip aerotriangulation using either the two-photograph or the three-photograph method of relative orientation and linear or non-linear strip adjustment to accomplish a least-squares fit to any number of horizontal and vertical ground control points. They also accomplish the adjustment of blocks of overlapping strips containing up to 200 aerial photographs by the simultaneous orientation of all photographs to fit a small or large number of ground control points through the minimization of plate image residual errors in accordance with the method of least squares.

Provision was also made for varying the relative weight of photograph images as a function of radius, the relative weight of the photograph images of photogrammetric passpoints and ground control points and the relative weight of the photogrammetrically and geodetically determined ground positions.

Photogrammetric measurement of floating targets has been successfully used to determine current velocities in harbour areas. This technique has been applied to the study of the movement of ocean currents. Floating targets placed by ship determined the velocity of the western edge of the Gulf Stream to an accuracy within 0.5 knot. A complete technical report on this test is contained in a paper distributed at this conference.[3]

Geology and geological mapping

United States technical co-operation in geology and geological mapping is supported by the United States Agency for International Development, the United Nations, and other agencies through the United States Department of State. Over the past decade, the central theme of United States Geological Survey assistance to developing nations has been the strengthening of counterpart central government geological, hydrologic and topographic institutions to enable them better to assess and appraise indigenous natural resources and thus effect their orderly use in advancing their own national economies. Methods utilized include: training of earth science specialists, by assigning students to field parties and laboratories in the United States or by extending to them in-service training in their home countries; furnishing advisory services in the establishment or improvement of appropriate local earth science institutions; jointly engaging in broad programmes designed to explore, investigate, assess and appraise indigenous mineral and water resources; offering advice, support and encouragement to local educational institutions and professional societies for the development of a broader earth-science community; encouraging the free exchange of scientific information between American institutions and specialists and their counterparts in the developing nations.

As of 1 July 1966, sixty-four United States Geological Survey specialists were at work in twelve countries at the request of host Governments. Academic and/or in-service training in the United States was being extended to thirty-nine young scientists and technicians from abroad. In Asia and the Far East, assistance programmes have been completed or are in progress in Afghanistan, India, Indonesia, Nepal, Pakistan, the Philippines, the Republic of Korea and Thailand.

National resources inventory

At the Fourth United Nations Regional Cartographic Conference in Manila, the prototype General Inventory on the Dominican Republic was displayed and described. Since then, considerable progress has been made in refining the techniques and producing studies on a number of Latin American countries.

More recently, the concept has been extended to the Far East, where the Mekong Resources Atlas is being produced. The project is sponsored by the Mekong River Committee of the United Nations Economic Commission for Asia and the Far East (ECAFE), in collaboration with the Govern-

[3] "Photogrammetric research work on the Gulf Stream", see below, agenda item 8 (*a*) and (*b*).

ments of Cambodia, Laos, the Republic of Viet-Nam and Thailand and the United States Tennessee Valley Authority. It is financed by the United States Agency for International Development.

Aeronautical charts

The increase in international air operations, with its resulting congestion and limitation of controlled air-space, has resulted in major problems in the control of today's air traffic. Changes in air traffic control procedures, the introduction of new air navigation systems and increased emphasis on air safety has brought about an extensive review and redevelopment of aeronautical charts and flight information publications. The Aeronautical Chart and Information Centre (ACIC) produces world-wide aeronautical charts and flight information publications. These products are made available to commercial and governmental organizations as well as to private individuals who may purchase them from the United States Coast and Geodetic Survey. They are also made available to many countries and organizations through mutual exchange agreements.

At the present time, flight information for the Asian and Far Eastern areas is provided jointly by the Pacific South-East Asia series of Flight Information Publications (FLIPs) and the Australia, New Zealand and Antarctica FLIPs. These FLIPs consist of planning documents, *en route* charts (with supplements), terminal publications and standard instrument departure charts, designed to provide the air crew with all aeronautical information necessary to flight operations. The Pacific South-East Asia publications are issued each month, while the Australia, New Zealand and Antarctica publications are issued every two months. A continuing programme is conducted to improve, expand or modify the content of these publications to satisfy changes to air traffic control procedures and navigation systems.

Production of the large size Operational Navigation Charts (ONC's) is being continued, with the coverage of Australia planned for completion during 1968 and that of New Zealand in 1969.

As a follow-on to the ONC programme, a new series of Pilotage Charts (PC) at 1:500,000 scale is also being produced. This new PC series is similar in design to the ONC, with sheet-lines based on a quadrant division of the ONC series. At the present time, only limited coverage of this new PC series is available. Coverage of South-East Asia, Japan and the Philippines has been completed. Future production is planned for the Indonesian area.

For general navigation and planning purposes, the Aeronautical Chart and Information Centre has produced the 1:5,000,000 scale (United States Air Force) Global Navigation and Planning Chart (GNC) series. This series of charts is designed to satisfy long-range air navigation requirements as well as provide for preflight planning. Complete coverage of Asia and the Far East is available.

The Aircraft Position Chart series, produced by the United States Coast and Geodetic Survey, has been extended by providing coverage from California and Hawaii to Tahiti, Fiji, Samoa, New Zealand and Australia. Other charts in this series providing Pacific coverage of Japan, the Philippines and Viet-Nam have been revised since the last conference. These charts are on the Lambert conformal conic projection at a scale of 1:6,250,000 and the Mercator conformal projection at 1:5,000,000. Full aeronautical data are furnished, including LORAN and navigation grid.

The Controller Charts, first reported at the Manila conference in 1964, are specialized aeronautical charts developed by the Federal Aviation Agency for use with display consoles in the Air Route Traffic Control Centres. The original United States coverage in thirty-six sheets at scale 1:500,000 has been expanded by the addition of seventeen charts at scale 1:250,000 to accommodate highly congested terminal areas. Four charts at scale 1:1,000,000 have been produced for special coverage of sparse traffic areas. This series of charts is designed to fit the unique environment of the air traffic controller and ensures that the information used by the controller agrees with the information available to the pilot.

Low altitude *en route* (radio-navigation) charts of the United States have been revised to meet requirements for both civil and military use and are published by the United States Coast and Geodetic Survey. The revised charts replace two separate series previously produced for civil and military use respectively.

Specifications have also been approved for the preparation of compilation bases at 1:500,000 scale of Alaska and the conterminous United States from which both civil and military editions of visual flight charts will be produced. Both editions will feature relief shadings. Production of the compilation base and the initial issue of the civil edition is being funded over a four-year period by the Federal Aviation Agency. The civil edition of each chart will be printed in two halves (back to back), and include a full aeronautical information overprint; whereas the military edition will be printed in the Pilotage Chart (PC) format (full sheet, printed on one side) and include a stable limited aeronautical overprint.

The Federal Aviation Agency, in support of United States commitments to the International Civil Aviation Organization (ICAO), has continued its aerodrome obstruction surveying programme in accordance with the obligatory requirements set forth in annex 4 of the ICAO convention. Obstruction charts are available on all aerodromes regularly used by international commercial air transport. Obstruction surveys have also been accomplished on 600 aerodromes used by domestic commercial air transport.

National atlas

In accordance with a recommendation of the National Academy of Sciences, the United States Geological Survey undertook in 1962 the preparation of the national atlas of the United States. Work on it was suspended in fiscal year 1964 due to lack of funds, but completion of the bound volume for sale in 1968 now seems probable. Meanwhile, selected maps will be published for separate sale as they are printed, beginning with the geological map which is now in press. About twenty atlas pages are ready for platemaking, fifty-four pages have been scribed, and about 150 pages are in various stages of completion.

The national atlas is intended to serve primarily as a reference and research tool for government agencies, executives in business and industry and large research libraries. It will be 19 × 14 inches with many maps on double-page spreads that open to 19 × 28 inches. Some 350 pages of special subject maps will deal with such characteristics of the United States as its physical features, history, economy, social conditions, boundaries and administrative units, indexes of coverage by the principal sets and series of maps and charts, and the position of the United States in world affairs.

Geographical names

The United States programme of geographical names standardization had produced some years ago for each country or area of the world at least a minimum file of names officially designated as standard for use by the United States Government. These files have been and are being revised and enlarged as circumstances and resources warrant.

Since the previous cartographic conference, gazetteers in this area have been issued on: Burma, 52,000 entries, superseding the 1955 edition with 6,800 entries; Mainland China administrative divisions, 16,600 entries; North Viet-Nam, 22,250 entries; the Republic of Korea, 26,500 entries; Thailand, 45,500 entries.

Additional gazetteers are in press or in preparation on: Mainland China, some 100,000 entries; Indonesia, some 60,000 entries; Malaysia, some 50,000 entries.

For more than two decades, the emphasis in United States standardization of names outside its own territory has been on usage of the country of origin of the named entities, and on systematic romanization from non-Roman writing systems. This emphasis has continually been strengthened as more and more countries have undertaken programmes to standardize their own names. The Board on Geographic Names gazetteers of Kenya and Tanzania were actually produced by programmes of co-operation between the United States and those countries, and active co-operation is proceeding with several countries in the Americas. The secretary of the Commission de toponymie of the Institut géographique national in Paris spent six months in Washington working with the Board on Geographic Names on new gazetteers of former French colonies in Africa, and a variety of co-operative activities have been carried on with other individual countries. At the same time, every possible assistance has been rendered to the United Nations in its programme directed towards world-wide standardization, including participation in the preparatory meeting for the forthcoming United Nations Conference on the Standardization of Geographical Names, and the preparation of papers for both this meeting and the Second United Nations Regional Cartographic Conference for Africa.

International map of the world

The world-wide series of topographic quadrangle maps at 1:1,000,000 (IMW) is sponsored by the United Nations. There are fifty-three maps covering the conterminous United States. Eight maps remain to be published and operations are in hand on five of these. Sheet NL-16 Lake Superior is scheduled for publication in July of this year. Understandings have been arrived at between the United States and Canada as to the responsibility for preparing maps along the boundary between the two countries and for the interchange of source data. All maps are being prepared in accordance with the recommendations of the United Nations Technical Conference in Bonn, 1962, and the meeting of the United Nations working group on hypsometric tints held in Edinburgh in 1964.

GEODETIC AND TOPOGRAPHIC INVESTIGATION IN THE USSR, 1964–1966

Paper presented by the Union of Soviet Socialist Republics[1]

Geodesy

In 1965, a national standard for theodolites was introduced, determining their types, dimensions and principal characteristics as well as the technical requirements to be met. The classification is based on the mean error of a horizontal angle measured in one set. The standard makes provision for manufacturing eight types of theodolites which provide mean errors of measuring horizontal angles in a set within $\pm 0''.5$ to $\pm 30''$. A number of theodolities meeting the requirements of the standard have been elaborated and are now in serial production.

The optical precision theodolite T05 for measuring horizontal angles with an accuracy of $\pm 0''.5$ has been developed. This theodolite consists of two detachable parts, namely, the telescope with microscope and the three-screw base. The instrument has demonstrated the precision needed for measuring horizontal angles during field investigations.

New types of theodolites—T2, T5 and T10—have also been elaborated, all of the same design. Comprehensive tests have proved their reliability in operation and the required precision in measuring horizontal and vertical angles.

In 1965, a higher standard for levelling instruments was also introduced, covering the manufacture of levelling instruments of five types.

Since 1967, standards for optical double-image range-finders have been introduced. The classification of range-finders is based on the mean error of measuring a 100 m distance. Provision is made for the manufacture of range-finders with which distances can be measured with an error of from ± 4 cm to ± 20 cm. Before 1967, some optical double-image range-finders had already been designed both as individual instruments and as attachments for conventional theodolites.

Recently certain electro-optical instruments have been designed for determining distances in daylight under 1.5 to 2.0 km and under 3 to 5 km in the dark. All these instruments are of relatively small dimensions and do not require much power. The electro-optical distance-measurer "CT-62" uses two synchronous Kerr cells. The modulation frequency is variable; it is about 20 megacycles. This frequency is read on the dial at the moment of line-measuring; the dial is simultaneously calibrated at separate points by means of a special calibrating device.

The electro-optical distance-measurer "Crystal" uses the variable modulation frequency; and the method of determination is similar to that of "CT-62". A special feature of this instrument is the use of a bipolar device which separates the modulated light beam transmitted to the reflector and received back in different planes of polarization. This makes it possible to use one optical system and one Kerr cell both for transmitting the light beam and receiving it as well as for increasing the modulation frequency to 30 mc.

[1] The original text of this paper appeared as document E/CONF.52/L.102.

The electro-optical distameter "Quant" uses fixed modulation frequencies and has a semi-conducting optical gallium arsenide generator with a wavelength of approximately 0.83 μ as a light source. The display unit is photoelectronic. The measuring range of the distameter is about 1.5 to 2.0 km both in daylight and in the dark.

A model of a microwave instrument has been designed that has separate antennas which can be raised on a mast to a height of about 26 m above the ground, without markedly shortening the measuring range or decreasing accuracy, as was revealed by tests.

In recent years, comprehensive investigations have been carried out to study the extent to which external conditions affect the accuracy of distance measuring by microwave instruments. These studies have shown that the accuracy of distance measurements attained by microwave instruments may be in many areas not worse than 1:50,000 (tundra zones, timbered plain and hilly areas, steppe). For lines along which considerable reflections occur during measurements, special methods of computations are developed to avoid or reduce "swing".

To determine gravity differences at stations far distant from each other, a special pendular apparatus has been elaborated which makes it possible to obtain an accuracy of gravity difference observation under 0.2 mgal. This apparatus uses special combined pendulums made of quartz and tungsten and keeps a constant temperature and pressure of about 1 mm.

A pendular apparatus for gravity observations at sea has also been designed providing accuracy of ± 7–10 mgal, and pendulums of the instrument eliminating the effect of lateral accelerations.

Topography

In recent years, the designs of photogrammetric universal instruments have been considerably improved. Two plotting instruments such as stereograph SD-3 and stereoprojector SPR-2 have been developed. These instruments make it possible to compile maps of every scale with great precision and productivity, from aerial photographs of a considerably smaller scale than that of the map.

The application of the analytical method for constructing three-dimensional photogrammetric networks has played a substantial part in aerotopography investigations. An automatic stereocomparator has been designed to measure image co-ordinates with an instrument error of about ± 1.5 to 2μ. The data may be printed or recorded on punched cards. To ensure the identity of transfer points in the adjacent flight strips, there is a special photo-device for obtaining photo-sketches of the image points.

To compute and adjust the co-ordinates of the points of photogrammetric networks, some algorithms have been elaborated which make it possible to adjust not only the networks on one flight strip but also the nets on the photographs of many flight strips. The construction of photogrammetric networks by the analytical method involves considerable decrease in the density of the control points, which should be determined by routine surveying methods.

Much research work has been carried out to improve the technique of compilation of 1:25,000 topographical maps. These investigations have made it possible to produce a map from aerial photography on a smaller scale and reduce the number of needed control points whose position and elevation are to be measured using conventional ground control. This technique applies to relief drawing by stereophotogrammetric methods only.

Well elaborated methods of photo-interpretation in the office have made it possible to decrease the amount of photo-interpretation to be done in the field.

AUSTRALIAN CARTOGRAPHIC ACTIVITIES AS AT 31 DECEMBER 1966

Paper presented by Australia[1]

Introduction

The purpose of this report is to present a brief review of cartographic progress in Australia.

The progress shown is a consolidation of the work carried out by Commonwealth and state agencies, the chief contributors being: the Commonwealth Department of National Development; the Commonwealth Department of the Army; the mapping agencies of the various state surveyors-general; the Commonwealth Scientific and Industrial Research Organization; the Commonwealth Department of the Navy; the Commonwealth Department of the Interior; the state departments of mines and forests.

The text is brief, as it is believed that the attached maps will provide the reader with a reference which is more amenable to rapid review by cartographers than a voluminous text.

Brief comments are made under the headings of national geodetic survey, national levelling survey, aerial photography and topographic map coverage. These activities are carried out under the guidance of the National Mapping Council of Australia. Further information may be obtained from: "Pictorial Index of Activities", prepared annually by, and obtainable from, Director of National Mapping, Department of National Development, Canberra, ACT, Australia.

A brief report is presented by the Hydrographic Service, Royal Australian Navy. Catalogues of Australian charts are available from the Hydrographic Office, IBM Building, Kent Street, Sydney.

Additional headings are: geological surveys, land system and soil surveys, forestry and timber surveys and thematic mapping. The Commonwealth Bureau of Mineral Resources, Geology and Geophysics (Department of National Development) publishes periodically a Pictorial Index of Activities. Inquiries should be directed to: The Director, Bureau of Mineral Resources, Geology and Geophysics, P.O. Box 378, Canberra City. A.C.T.

In 1966, the Department of National Development published a 250-page *Index to Australian Resources Maps: Supplement for 1960–64*. Reference should also be made to the conference paper, "Review of recent Australian thematic mapping".[2]

[1] The original text of this paper appeared as document E/CONF.52/L.104.

[2] See below, under agenda item 10.

National geodetic survey

The geodetic survey of Australia at the end of the 1965 field season is shown on Annexure 1.* There are 2,506 stations, including 533 Laplace stations, and 33,100 miles of tellurometer traverse.

Together with a further 135 stations on the geodetic survey of New Guinea and on the United States HIRAN survey, this work was adjusted on the new Australian geodetic datum during the first half of 1966. The values chosen for the Australian national spheroid were those adopted by the International Astronomical Union: a=6,378, 160 m; 1/f=298.25.

Co-ordinates for the Johnston origin in the middle of Australia were chosen from an analysis of 275 astro-geodetic stations distributed evenly over the whole of the Australian continent.

The new Australian map grid is the universal transverse Mercator system applied to co-ordinates on the Australian geodetic datum. The new grid has been adopted for the whole of Australia and New Guinea, Norfolk, Cocos, Christmas and Macquarie Islands, but not for Nauru, Heard Island or the Australian Antarctic territory, for which the international spheroid remains in use.

The areas enclosed between the geodetic traverses are now being filled in for map control. Much of the work is being done by Aerodist, some by second-order tellurometer traversing.

Thirty-six satellite tracking stations have been co-ordinated on the Australian geodetic datum. For ten Tranet stations, near Adelaide, Darwin, Perth, Townsville, Woomera, Canberra, Narrabri (NSW) and Manus, Thursday and Cocos Islands, co-ordinates have been determined by Doppler observations to satellites. These Doppler co-ordinates are in good agreement with the co-ordinates obtained from satellites for the Baker Nunn camera at Woomera.

It is intended to start the observation of some trans-continental geoid sections in February 1967.

No continental adjustment of trigonometric heights on the national geodetic survey has yet been made, pending the completion of the national levelling survey in 1970.

National levelling survey

Good progress has been made in covering the Australian continent with a network of levelling traverses forming loops of up to 1,000 miles in circumference.

Most of the levelling is now observed to third-order standards. Automatic levels are used almost exclusively. A great deal of levelling is done by private surveyors on a contract basis under the supervision of the state surveyors-general.

The total amount of control levelling of first- to third-order standards had reached 76,000 miles at the end of 1966.

The National Mapping Council of Australia is arranging a programme of simultaneous recordings at some thirty tidal gauging stations on a continuous basis. These stations are located at about 500-mile intervals around the continental coastline. It is planned to extend this programme up to three years. A suitable period of twelve months is to be selected during which all or most of the participating gauges have produced acceptable records. Mean sea level for this particular period will then be computed for all tide gauges.

A national height adjustment will be undertaken in 1970. Selected loops of levelling will be adjusted in relation to mean sea level at the above-mentioned tide gauges.

It is expected that about 100,000 miles of control levelling will be completed at the time of the adjustment. Annexure 2* shows the completed and planned national levelling survey.

Aerial photography

Annexure 3* shows graphically the existing photography of Australia and Papua/New Guinea.

It will be noted that the initial coverage of Australia has been completed, while only approximately 50 per cent of the New Guinea mainland is covered. The delay in completing the coverage of New Guinea is due to the prevailing poor photographic conditions in that Territory.

Most of this photography is at an approximate scale of 1:50,000, but recent photography and future planned work is at a scale of approximately 1:86,000.

Two distinct photography scales are used: for use in preparing the national 1:250,000 and 1:100,000 topographic series, 1:86,000; for use in larger-scale mapping carried out by state authorities in the more intensely developed areas of the state, 1:30,000.

The introduction of the Wild RC9 super-wide-angle camera has proved very successful on the Australian mainland and, from a flying height of 25,000 feet, the resulting small-scale photography (1:86,000) has speeded up the production of the national series maps.

In Papua/New Guinea the RC9 camera has been used only to photograph the flat terrain of south-western Papua. Use of this super-wide-angle camera is unsuitable in the remainder of the Territory because of the high and rugged terrain, rising to a maximum of 14,000 feet. In such areas, the 6-inch wide-angle camera has been used.

The rephotographing of the Australian mainland with the Wild RC9 super-wide-angle camera (scale 1:86,000) is now approximately 30 per cent complete. The complete rephotographing at this scale will probably take a further four to five years.

The commencement of phase 2 will not await the completion of phase 1; phase 2 has already commenced and will gather momentum as phase 1 draws near completion.

In Papua/New Guinea, the aerial photography is being processed to produce compilations at 1:50,000 scale. Action has commenced on a series of maps to be published at a scale of 1:100,000 which will provide the initial over-all coverage of the Territories.

1:1,000,000 series

In addition to the national topographic series, other series at the scale of 1:1,000,000 such as the world aeronautical series are compiled and published, and a regular programme of revision and publication of new editions ensures that all new mapping work is incorporated in the charts of such series. A start has been made on the production of a new format WAC series and production of the IMW has been recommenced.

* See pocket at end of volume.

Topographic map coverage

Annexure 4* shows the present position as regards topographic map coverage. This figure refers specifically to maps intended to provide systematic national coverage and produced from aerial photographs by the usual photogrammetric processes based on field survey control.

The national topographic series is primarily being undertaken by the Department of National Development with considerable assistance from the Department of the Army and making use of larger scale work produced by the state lands departments.

The latter maps are intended for local state use but are prepared in a form suitable for incorporation in the national series. The whole project is proceeding under the general guidance of the National Mapping Council on which the Commonwealth and states are represented.

The maps of the national topographic series are produced in two main phases.

In the first phase, a planimetric series at 1:250,000 is produced, printed in colour, with relief shown by hill-shading in brown. Production of this series is at the rate of sixty sheets ($1° \times 1\frac{1}{2}°$) each year. The whole series has now been compiled and at present progress all maps of the series should be published by the end of 1967.

The second phase contemplates the production of map compilations at a scale of 1:100,000 over the continent, contoured, and based on geodetic control.

From these compilations, maps will be published in two general groupings: in the more closely settled areas, contoured maps in colour will be published at a scale of 1:100,000; in the dry interior of the continent, contoured maps in colour will be published at a scale of 1:250,000.

Hydrographic Service, Royal Australian Navy, 1957–1966

Faced with the problem of surveying, mostly for the first time, over 12,000 miles of Australian coast and some 4,500 miles of the coast of the Territories of Papua and New Guinea, the Royal Australian Navy Hydrographic Service has concentrated on the principal shipping routes and approaches to the main established and many fast developing ports.

The attached chartlet (see Annexure 5*) shows the progress which has been made to date with areas planned for the period 1966–1970. In many cases, these surveys have been a compromise between an exhaustive search of the area and a survey at the minimum acceptable scale, and the inshore waters have generally not been examined, so that eventually more work will be required even in areas shown as having been completed.

As a result of the rapid progress made with modern land maps in the area, it is now possible to revise the existing charts with, at least, the coastline and topography accurately charted. The immediate aim is to produce over-all coverage of the area on a series of charts at a scale of 1:300,000, using this land detail and accepting whatever hydrographic detail is available. In areas of more difficult navigation, charts at a scale of 1:150,000 will be produced, with additional harbour charts as required. For planning purposes, a series of thirty charts at a scale of 1:1,000,000 is projected.

At present, charts of Australia are a mixture of British and Australian but the intention is to withdraw the British ones gradually as they are replaced by the new Australian charts.

The surveying ships HMAS *Warrego* and *Barcoo*, built in wartime, were withdrawn from surveying in 1963–64 when the new ship HMAS *Moresby* was commissioned. This 18-knot vessel, especially designed for surveying, was built at the New South Wales state dockyard, Newcastle, and is proving very satisfactory. The only other ship at present engaged in the task is HMAS *Paluma*, a stores lighter converted for the task in 1958, which has performed very useful work in the Great Barrier Reef and New Guinea waters. Both ships rely mostly on the electronic fixing aids—Lambda or Hifix.

After several moves, the Royal Australian Navy Hydrographic Office transferred in April 1964 to the modern IBM building near Sydney Harbour Bridge, with the chart depot and agency in the adjacent old Observatory Hill building. A small photographic section has been built up and some printing can now be undertaken, although the majority of charts are printed by the Royal Australian Survey Corps at Bendigo or by commercial firms in Sydney.

Geological surveys

The geological surveys of the Commonwealth and Papua/New Guinea, shown on Annexure 6*, include mapping carried out by Commonwealth and state authorities, based on systematic geological surveys with the aid of aerial photographs and compiled on adequately controlled planimetric base maps.

Geophysical surveys have proceeded at the same time and large areas have been covered by gravity, airborne magnetometer and seismic surveys by government authorities and oil exploration companies.

Land system surveys and soil surveys

The surveys carried out by various Commonwealth and state authorities may be broadly divided in these three main categories: regional land system surveys at reconnaissance level; soil surveys; Atlas of Australian Soils at reconnaissance level (1:2,000,000).

These surveys (Annexures 7 and 7A*) are designed to facilitate the planned development of various parts of the continent.

Forestry and timber surveys

The task of carrying out forestry and timber surveys is largely borne by the individual state forestry authorities. The Commonwealth Government is involved with activities in its territories.

Surveys are carried out at varying levels of intensity depending on the projected end use. Some of the areas previously shown as having been covered by surveys were reassessed or remapped at a more intensive level during the period 1964–66. (See Annexure 8.*)

Annex

Thematic maps

The following notes briefly summarize progress in selected topics. Further information appears in several conference papers, principally in the review of recent Australian thematic mapping prepared by the Geographic Section, Department of National Development.

Geology (see Annexure 6). Geological maps at smaller scales include new geological sheet maps for the states of Victoria (scale 1:1,000,000) and Western Australia (1:2,500,000), the four sheets

* See pocket at end of volume.

of the Geological Map of the World (1:5,000,000) which together cover Australia and Papua/New Guinea, and the map-sheet "Geology", 2nd edition (1:6,000,000) of the Atlas of Australian Resources.

Soils. Much of the mapping effort of the Division of Soils, Commonwealth Scientific and Industrial Research Organization (CSIRO) in the last three years has been spent on the ten-sheet Atlas of Australian Soils. Progress in the field mapping of smaller areas is shown on Annexure 7A. Recent small-scale maps include "Soils" 2nd edition (1:6,000,000), of the Atlas of Australian Resources.

Water resources. The mapping of water resources, both surface and underground, is receiving increasing attention. Maps produced include summaries prepared for the first national review of water resources (prepared for the Australian Water Resources Council). More detailed mapping of underground water, in particular, is currently proceeding in the various states and the Northern Territory.

Forestry. "Forest Resources", 2nd edition (in preparation), of the Atlas of Australian Resources, will summarize at 1:4,500,000 much forestry mapping, including unpublished material. Other maps include one of Australia at 1:6,000,000 showing Crown forestry reserves and administrative areas, and a map of forest types and Crown forestry reserves in the south-west of Western Australia (1:633,600).

Land classification. Most recent mapping in terms of land systems has been done by the Division of Land Research, CSIRO.

Regional and national atlases. Two major developments have been the publication by the Tasmanian Department of Lands and Surveys of the Atlas of Tasmania and by the Commonwealth Department of National Development of the first four sheets of the twelve-sheet Fitzroy Region, Queensland, Resources Series. The latter department has also published another four sheets in the second series of the Atlas of Australian Resources. Conference papers deal with each of these subjects.

CARTOGRAPHIC ACTIVITIES IN SWITZERLAND

Paper presented by Switzerland[1]

Private survey companies

There are approximately 250 private survey companies in Switzerland, fourteen of which are equipped with photogrammetric plotters; one operates an aerial photography service. These companies not only handle private contracts, but they also participate to a great extent in the official surveys under the direction of the appropriate federal or cantonal authorities, against payment according to an established schedule of fixed rates. This applies especially to cadastral surveys, many of which are entrusted to private cadastral surveyors.

Swiss Federal Topographic Service

The duties of this office include: national triangulation from first- to third-order; national first-order levelling; publication of topographic maps at 1:25,000, 1:50,000, 1:100,000 and smaller; checking general maps at 1:5,000 and 1:10,000, which are prepared photogrammetrically by private survey offices; control surveys on a number of power dams.

The triangulation network of first- to third-order was completed approximately forty years ago and has a density of 1 point per 20 km^2. To maintain the network in perfect condition, the triangulation points are checked every ten to fifteen years and any deficiencies in the points themselves or their reference monumentation are immediately corrected. On the occasion of such checks, it could be ascertained that strict adherence to the practice of referencing each and every triangulation point by several eccentric reference marks has proved its worth and contributed greatly to the preservation of the triangulation network.

The triangulation of fourth-order, with a mean density of about 2 points per km^2 and a total of more than 70,000 points, can now be considered as practically concluded. It has been established mainly by private cadastral surveyors.

Crustal movements over larger areas could not be observed so far by means of the triangulation. In this field, periodical measurements of hillside shifts are increasingly gaining in importance, especially where the protection of large structures is concerned.

The existing national levelling network is about to be successively remeasured under the present arrangement, after a lapse of approximately fifty years. In addition, every fifteen years inspections are made to check the groups of bench-marks.

The crustal movements determined from the remeasurement of the national levelling net have remained within the limits of measuring accuracy, even over the very long period of forty to fifty years. While along the Jura no movement could be determined with certainty, the north-south lines along the Rhone and Rhine rivers are showing a tendency to rise in the southern areas by 2 to 3 cm per 30 km in forty years.

Local subsidences in alluvial areas, by contrast, reach magnitudes of up to 50 cm for the same period of time.

The Swiss Federal Topographic Service also participates in the geodetic supervision of dams. While in the case of newly constructed barrages measurements are made in rapid succession, the intervals are later extended to five and more years. Corresponding measurements are also carried out on other large structures, especially bridges.

In the field of aerial photogrammetry, comprehensive investigations with colour photography have been carried out. The first results of the investigations of plotting techniques for 1964 and 1965 are set out in a report on photogrammetric mapping of contours from aerial colour photographs (Denzler). For photographic and phototechnical reasons, colour photography for photogrammetric mapping will not be used to any great extent in the next few years. On the other hand, colour photographs are already in very great demand for interpretation purposes, for example in forestry, in the soils sciences and for vegetational and glaciological investigations.

The remapping project at 1:50,000, 1:100,000 and 1:500,000 was concluded in 1965. Of the new national map at 1:25,000, totalling 245 sheets, 195 sheets have been published. This map will be completed in 1972. In the near future, a national map at 1:200,000 will also be published.

General maps at 1:5,000 and 1:10,000 are available for 66.5 per cent of the country's area; for a further 28.5 per cent they are presently in preparation.

As a matter of principle, the revision of the national map is based on the scale 1:25,000 and is carried out in photogrammetric plotters from aerial photographs of

[1] The original text of this paper appeared as document E/CONF.52/L.106.

picture scales of 1:25,000 to 1:30,000. In map revision, the reproduction process calls for the greatest work expenditure. Orthophotography would not bring any relief here; on the contrary, it would increase the amount of photographic work.

For glaciological investigations, the Aletsch glacier has been mapped at 1:10,000. Every year, two test areas are photographed, and it is planned to map the entire glaciered region anew in some two to three years.

Two instalments of a planned total of nine of the Atlas of Switzerland have already been published. A detailed description of this new geographic-cartographical standard work is given in the paper, "Atlas of Switzerland", by E. Imhof.[2]

The Swiss Federal Topographic Service, within the framework of bilateral technical co-operation and also at the request of the United Nations, has delegated one expert each in cartography, reproduction techniques and photography for one or two years as instructors to developing countries.

Swiss Federal Directorate of Cadastral Surveys

The Directorate of Cadastral Surveys is a supervisory authority which, in co-operation with the cantonal survey authorities, commissions private licensed surveyors to carry out cadastral surveys. These surveyors are nevertheless given a very free hand in the choice of survey methods. In general, only the map scale and the required accuracy are specified. The scale varies between 1:500 and 1:10,000 according to land values and parcel areas.

Of the total area of 38,800 km^2 to be surveyed, 21,170 km^2, or 54.6 per cent, have already been surveyed. The cadastral surveys presently in execution comprise 4,280 km^2 or 11 per cent. In many places, property reallotment must be carried out; since for reasons of economy these operations as a rule take place prior to the cadastral surveys, they tend to delay such surveys. It is therefore estimated that the completion of the entire survey project will require some thirty years.

In photogrammetric property surveys, the stereo-models are fitted into the field of control points by means of a Helmert transformation with a subsequent adjustment onto the actual co-ordinate by interpolation. The standard deviation determined through terrestrial control surveys amounts to 3 to 7 cm for the horizontal co-ordinates, and 2 to 5 cm for distances.

Presently the suitability of spatial block adjustments for the intensification of the control network in regions of low land values is tested by means of practical work (cf. the paper "Topometer data-processing systems for photogrammetry and geodesy" by P. Vetterli).[3]

Where the land registry surveys can be carried out only at a future date, the photocadastre as an interim solution has proved its value. It consists of an unrectified enlargement of an aerial photograph at the approximate scale of 1:1,000 or 1:2,000, wherein property boundaries, agricultural limits and buildings are identified, and of the corresponding property and proprietors' registers. A photocadastre has been established in fifty communities of the mountain cantons of Valais and Grisons.

Detailed regulations for the application of automatic data-processing in cadastral surveys and a new schedule of rates are in preparation.

[2] See below, under agenda item 10.

[3] See below, under agenda item 8(*a*).

Swiss Geodetic Commission

The Swiss Geodetic Commission is a branch of the Swiss Society for Nature Research and concerns itself mostly with fundamental geodetic problems.

The gravimetric net of Switzerland is an area net. It comprises a basic net with large loops, which have been intensified by a first-order net. The average distance between gravimetric points is 20 to 25 km on level land and 15 km in the mountains. The project is close to completion.

The determination of the geoidal undulations has been continued. The method of measuring reciprocal zenith distances has proved very successful in the Alps. Plumb-line deviations determined by this method are adjusted into the deviations determined by astronomic levelling. The geoid warps about 1 m above the reference ellipsoid under the Jura mountain range, sinks about 1 m below it in the midlands, rises 2 to 2.5 m above it under the Alps, and in the south falls to about 3 m below the reference ellipsoid.

The Swiss magnetic net is out of date. For this reason a systematic magnetic resurvey of the entire country is planned for 1968 or 1969.

International Union for Geodesy and Geophysics (IUGG)

The next General Assembly of the IUGG will take place this year in Switzerland from 25 September to 7 October. For organizational reasons, the meetings of the associations making up the union must be divided as follows:

Zurich: International Association for Vulcanology. International Association for Seismology;

Bern: International Association for Hydrology. International Association for Oceanography;

Lucerne: International Association for Geodesy. International Association for Meteorology;

St. Gallen: International Association for Geomagnetism and Aeronomy.

United Nations Conference on the Standardization of Geographical Names

Switzerland will be host to the conference, which will take place in Geneva from 4 to 22 September 1967.

Swiss School for Photogrammetric Operators (SSPO)

Late in 1966, the Swiss School for Photogrammetric Operators was founded in St. Gallen. It accepts students from every part of the world and offers them a thorough training as instrument operators in six-month courses. After passing the examinations before a panel of internationally known experts, graduates are awarded diplomas.

Fellowships

Since 1964, a small number of fellowships have again been granted by the Department of the Interior and the Bureau for Technical Co-operation to students from developing countries. The fellowships are granted for a full course of studies up to diploma level, or for post-graduate courses of at least one year at the Departments of Geodesy and Photogrammetry of the Swiss Federal Institute of Technology in Zurich or of the University of Lausanne. Fellowships are also granted for on-the-job training in private survey offices and in industry.

MAPPING IN MALAYSIA

Paper presented by Malaysia[1]

INTRODUCTION

Malaysia, which was formed on 16 September 1963, is geographically divided by the South China Sea into two parts. The western part, comprising the states of Johor, Kedah, Kelantan, Melaka, Negeri Sembilan, Pahang, Penang, Perak, Perlis, Selangor and Terengganu, is now known as West Malaysia, and the eastern part, comprising the states of Sabah, and Sarawak, is now known as East Malaysia.

The Director of National Mapping, Malaysia (concurrently the Surveyor-General of West Malaysia) who is responsible for topographical and geodetic surveys of the whole country, has the duty to produce and maintain topographical and town maps of Malaysia. This heavy responsibility has however been much relieved by the generous assistance of the United Kingdom Government in the mapping of East Malaysia. This assistance is provided by two United Kingdom survey organizations: the Directorate of Overseas Surveys (DOS), whose assistance is provided under the United Kingdom technical aid programme of the Ministry of Overseas Development, and the Directorate of Military Survey of the Ministry of Defence, whose assistance through the Assistant Director of Survey, Far East Land Forces, has been mainly in connexion with military operations by United Kingdom and Commonwealth Forces under defence treaty obligations.

TRIANGULATION

In East Malaysia, the triangulation network of Sarawak has been further extended and subdivided, partly to provide ground control for mapping and partly to extend survey control for cadastral purposes. The rapid completion of this work owes much to the availability of helicopter support, since some of the points would prove almost inaccessible on foot. The two United Kingdom aid organizations and the Land and Survey Department, Sarawak, between them, have surveyed twelve new primary triangulation stations, six new secondary, and 123 new tertiary stations. The new primary stations form an extension to the original traingulation chain and are mainly in the mountainous interior of Sarawak. The extension has not, however, reached the main watershed which forms the international boundary between East Malaysia and Indonesia. In West Malaysia, no new primary or secondary triangulation stations have been established, but three tertiary points were fixed during the period and twenty old points reobserved. In the same period seventeen topographical flags were fixed and observed. A topographical flag (half white and half red) is normally attached to a long stout pole and fixed to a suitably situated tall jungle tree and intersected by theodolite rays from three or more trigonometrical stations. The position of the flag is transferred to the ground by plumb-bob and the actual ground point is normally marked by a pipe.

TELLUROMETER TRAVERSES

The nature of the country does not make it easy or economical to break down the primary triangulation network into subsidiary networks of second- or third-order of accuracy for the control of both mapping and cadastral surveys. Precise traverses along roads, railways, rivers and habited areas are more convenient and expeditious and these are often resorted to. In the period under review, in East Malaysia a total of 428 control points of second-order and 409 points of third-order of accuracy were fixed mainly by tellurometer traverses and, since 1966, also by geodimeter. These traverses were carried out mainly by survey parties under the control of the two United Kingdom aid organizations mentioned above.

In West Malaysia, no tellurometer traverses were undertaken.

LEVELLING

High-order level networks have been completed for the towns of Jesselton and Sandakan in East Malaysia. These are intended to provide the basic level framework for mapping, engineering and other purposes. The datums (mean sea level) at these two places have not, however, been observed to geodetic standards.

In West Malaysia, a total of 155.2 miles of precise levelling was completed during the period December 1964 to January 1967, of which 139.6 miles were along the east coast of the peninsula. With the completion of the east coast levelling, West Malaysia now has two lines of precise levels running the whole length of the country: one on the west coast and the other on the east coast, joined by an east-west line through the middle of the country. From Johor Baharu, at the southern end of the peninsula, there is a line of precise levels joining the West Malaysian level network to the automatic tide gauge at Tanjong Pagar in Singapore.

All the levelling in West Malaysia is based on a datum bench-mark at Port Swettenham on the west coast whose mean sea level value was fixed by the British Admiralty in 1912. This datum has been considered unsatisfactory because Port Swettenham is situated in the estuary of a river and, when the level network was connected to the tide gauge in Singapore, it was found that the Port Swettenham datum was about 0.9 ft too high. In September 1966, with the kind co-operation of the Royal Thai Survey Department, a connexion was made to the Thai level network at Sungai Golok on the east coast and a difference of 0.957 ft was found, the Malaysian one being higher. Again, in January 1967, another connexion was made to the Thai level network on the west coast at Padang Besar, and a difference of about 1.3 ft was found, again the Malaysian one being higher. These differences have strengthened the suspicion that the value of the Port Swettenham datum is in error by about 1 ft; but although they are very persuasive, they provide no conclusive proof to that effect. The point will not be determined until Malaysia observes its own value of mean sea level. The Directorate of National Mapping has now obtained two automatic tide gauges for determining mean sea level and it is proposed to establish one tide gauge station at Lumut on the west coast and the other at Kuantan on the east coast.

GRAVITY, MAGNETOMETER, AND SEISMIC SURVEYS

In East Malaysia, further gravity surveys have been undertaken by detachments from the United States Army

[1] The original text of this paper appeared as document E/CONF.52/L.108.

Map Service and the Directorate of Military Survey. Hundreds of gravity stations have been established, many of which are trigonometrical points. The programme was discontinued at the end of 1966.

Seismic and airborne magnetometer surveys off the shores of East Malaysia have been undertaken by major oil companies, but no details are available.

The results of the gravity survey of a number of points in West Malaysia have been published by the United States Army Map Service.

AIR PHOTOGRAPHY

The whole of East Malaysia is now substantially covered by air photography at various scales. The photography was done by the British Royal Air Force, Huntings Aero Survey of England under contract to the Director of Overseas Surveys, and also by the directors of lands and surveys of the states of Sabah and Sarawak, using their own Wild RC8 cameras fixed to chartered aircraft. Some air photography in Sabah was also taken by timber extraction companies.

In West Malaysia, 3,704 square miles of air photography was taken by the Directorate of National Mapping, using its own Wild RC8 cameras fixed to a Royal Malaysian Air Force aircraft. Some photography was also taken by the Royal Air Force of the United Kingdom. Colombo Plan aid was also obtained from the Government of Canada for the complete photo cover of West Malaysia at the photo scale of 1:25,000, and for some areas at the photo scale of 1:50,000. The contractors, Messrs. Lockwood Co. of Canada, completed this photography in the period February 1966 to February 1967. Air photographs of Malaysia are also used by other departments and agencies of the Government such as the agricultural, forestry or geological, the National Electricity Board, the university and so on, and also by rubber plantations, mines and other groups engaged in searching for minerals.

MAP COMPILATION

In Malaysia, the basic scales and projections of topographical maps are as follows:

East Malaysia, 1:50,000, and West Malaysia, 1:25,000 and 1:63,360; Rectified Skew Orthomorphic (RSO) Projection.

The 1:50,000 and 1:63,360 topographical maps have been designed as the basic map to serve both the armed forces and civilian users, and the 1:25,000 maps of West Malaysia have been produced to meet the needs of the country's rural development and other special civilian purposes.

Series T.735, 1:50,000

This is the map series covering East Malaysia. There are 340 map sheets in this series and the old uncontoured and unsatisfactory preliminary sheets have steadily been replaced by fully coloured and contoured editions. So far, 108 fully coloured and contoured sheets have been published. The contour interval for this series is 100 ft, with provision for 50 ft supplementary contours for certain areas. However, for certain sheets covering the high mountains of the interior adjacent to the border, the contours have been shown to 250 ft. The sheet lines follow graticules and each degree square is divided into sixteen map sheets such that each sheet covers 15′ in latitude and 15′ in longitude. The sixteen sheets in each degree square are numbered serially, beginning from the top left-hand corner, but each number must be preceded by the value of the latitude and longitude lines at the south-west corner of each degree square. For example, the degree square between the parallels 3° and 4° N, and meridians 114° and 115° E, will have the generating number "3/114", and each one of the sixteen sheets in the square will have its serial number preceded by that number. The sixth sheet in that degree square will therefore be numbered "3/114/6" and the twelfth sheet, "3/114/12" and so on.

Series L.8010, 1:25,000

This series has been designed to serve the needs of rural development and other civilian special purposes in West Malaysia. Although the 1:63,360 is considered as the standard map series in West Malaysia, the 1:25,000 series actually forms the basic topographical mapping of West Malaysia. All basic topographical maps of West Malaysia are compiled at that scale but not all the sheets, especially not those covering the mountainous regions, are published. This 1:25,000 series has a total of 708 map sheets, but so far only 187 sheets have been published. The contour interval for this series is 50 ft. The standard size of the map (within the neat lines) on each sheet is approximately 21 × 24 inches, but a few sheets have different size maps. These sizes have been chosen so that six maps of this series will fit exactly into the sheet lines of one map of the 1:63,360 series from which the sheet numbers of this series are derived.

In the period December 1964 to January 1967, the Topographical Division of the Directorate of National Mapping completed the compilation of 13,288.7 square miles of the country at the scale of 1:25,000.

Series L.7010, 1:63,360

This series is derived from the 1:25,000 compilation sheets and is considered the standard series for West Malaysia. It is fully coloured and fully contoured at 50 ft vertical intervals. This series has been designed to serve the purposes of both the armed forces and civilians, and will replace the older series, L.707, drawn on the Cassini projection. There are 151 map sheets in the new series, and of these 88 map sheets have been published. One map sheet in this series covers the whole of the island Republic of Singapore. The standard size of the map (within the neat lines) on each sheet is 18.7 × 25 inches, but a few maps in the series have dimensions different from the standard. The sheet lines follow RSO grid lines and the sheets are numbered serially from 1 to 153 (sheet Nos. 27 and 51 not used).

Town maps

Town maps of Malaysia are divided into the following series: for East Malaysia, T.931; for West Malaysia, L. 905; at various scales.

Maps of forty-three towns in West Malaysia and ten in East Malaysia are in the programme for publication. Of these, the maps of six towns in West Malaysia and eight in East Malaysia have been published in the period under review. The others are in various stages of preparation. These town maps have been designed primarily to serve the needs of internal security.

During the period under review, the Topographical Division of the directorate completed the compilation of 194.3 square miles at various scales for town maps.

Series L.5010 and T.503, 1:250,000

Series T.503 covers East Malaysia and L.5010 West Malaysia. Series T.503 is derived from the 1:50,000 maps of East Malaysia and its production is therefore dependent on the completion of the contoured 1:50,000 maps of series T.735. There are twenty sheets in this series and so far sixteen have been published, but not all these have contours.

Series L.5010 has been designed to replace the old L.501–1:253,440 series covering the Malay peninsula. This series will be derived from series L.7010–1:63,360 of West Malaysia. A systematic compilation of series L.5010 has not been started, but preliminary sheets have been prepared by up-dating the communication details on the old 1:253,440 sheets and changing the scale to 1:250,000. Six of these preliminary sheets have been published of a total of fourteen in the series.

State maps

State maps of the thirteen states in Malaysia have been published at various dates, and many of them are more than ten years old. These maps were compiled by the survey department in each state from cadastral surveys and generally show details of communications, drainage patterns, administrative boundaries, alienated land, forest and other reserves, and other details that may be of use to the general map user. Contours are not shown, but trigonometrical stations are shown. The state maps are fully coloured but the scale of publication varies from state to state. In 1966, the state map of Sabah was partially revised and reprinted by the Director of National Mapping. The maps of the other states are now in various stages of revision and a couple of these are almost ready for publication.

Miscellaneous maps

This heading includes the seven sheets of series L.802, 1:25,000, covering the Republic of Singapore, which are fully coloured and contoured and were published recently. Various other types of maps, such as geological, soils, tourist, meteorological, roads and general have also been prepared. Small areas selected for development have often been mapped at a scale of 1:10,000 or larger, but the maps have always been in black and white and not normally released to the public. A total of 62.6 square miles of this type of maps was compiled during the period under review in West Malaysia and 43.9 square miles in Sabah (East Malaysia).

MAP PRODUCTION

The map production component of the Directorate of National Mapping consists of the Central Drawing Office, and the Photo-Lithographic Section. Assembly, scribing or fair drawing, colour separation, annotating and masking are done in the Central Drawing Office, while all camera work and printing are done in the Photo-Lithographic Section.

Table 1. Map sheets produced by the Central Drawing Office and the Photo-Lithographic Section, December 1964–January 1967

Name of map or series	*Central Drawing Office*		*Photo-Lithographic Section*			
	Number of new map sheets completed	*Number of map sheets revised*	*Number of new map sheets printed*	*Number of revised map sheets printed*	*Number of map sheets reprinted without revision*	*Total number of copies printed*
Series L.7010 and L.707—1:63,360	39	18	34	17	65	1,238,550
Series L.8010—1:25,000	53	4	48	3	—	74,625
Series T.735—1:50,000	—	—	16	—	26	460,450
Series L.5010 and T.503—1:250,000	2	—	2	—	—	20,500
Series L.905 and T.931—Town maps various scales	3	—	—	—	2	14,650
Miscellaneous maps and charts	70	—	70	—	3	585,915
TOTAL	167	22	170	20	96	2,394,690

Table 2. Map sheets produced by the Directorate of Military Surveys and the Directorate of Overseas Surveys, December 1964–January 1967

Name of mapping agency	*Number of map sheets of:*					*No. of map sheets reprinted*
	T.735	*T.503*	*T.931 & L.905*	*L.5010*	*Misc. Maps*	
Directorate of Military Surveys	37	14	3	6	7	35
Directorate of Overseas Surveys	51	—	—	—	—	—
TOTAL	88	14	3	6	7	35

Table 3. Photogrammetric equipment available in Malaysia

Name of equipment	*With Directorate of National Mapping*	*With Lands and Surveys Department, Sarawak*	*With Lands and Surveys Department, Sabah*	*Total*
Wild A7	1	1	—	2
Wild A8	2	—	1	3
Wild B8	2	2	3	7
Multiplex	4	—	2	6
EK5A or EK3D	1 (5A)	—	1 (3D)	2
PUG Point transfer	—	1	1	2
SEG V Zeiss rectifier	1	—	—	1
EMI Logetronic printer	1	1	—	2
Contact printer	1 (Zeiss)	1	1 (Zeiss)	3
Film processor	2 (Wild)	1	1 (Zeiss)	4
Enlarging camera	1 (De Vere)	2 (Klimsh super) (Omega)	—	3
Wild RC8 air camera	2	1	1	4
Santoni (stereo micrometer)	—	1	—	1
Zeiss film viewer	1	—	—	1

The equipment in the possession of the Directorate of National Mapping has been used entirely for the production of maps, whereas that in the possession of the Lands and Surveys Department, Sabah, has been primarily used for cadastral work. Some mapping work has been done with the equipment in the Lands and Surveys Department, Sarawak.

Map-printing equipment

The Photo-Lithographic Section, which is the map-printing section of the Directorate of National Mapping, is fairly well equipped for the printing of maps and charts. This section possesses the following equipment:

Equipment	*Size (in inches)*
3 Roland offset printing machines (single colour)	18 × 24, 24 × 36 and 30 × 40
2 Roland offset printing machines (double colour)	30 × 42 (RZU. IV)
1 Quad Demy Crabtree offset machine (single colour)	35 × 45
1 platten printing machine (letterpress)	10 × 14
4 proving presses (one is automatic)	24 × 36, 30 × 40, 35 × 50 (automatic)
3 plate-coating machines	47 × 55, 38 × 30, 54 × 43
3 printing-down frames (for plates)	54 × 43, 38 × 30, 47 × 55
2 Vacuum printing cabinets (for film)	35 × 45
3 Hunter Penrose Cameras	24 × 36, 30 × 40, 12 × 12
1 pictorial process camera	36 × 46
1 photostat camera	18 × 24
1 paper-seasoning machine	
1 rotary perforating machine	
1 numbering machine	
1 wire-stitching machine	
1 Martini book-sewing machine	
2 ink machines	
2 plate-graining machines	90 × 60 and 46 × 40
1 waxing machine	
1 rotary print drier	
2 guillotines (Polar and Ace)	52 and 42
1 micro-file camera	35 mm

SUMMARY OF CARTOGRAPHIC ACTIVITIES IN THE REPUBLIC OF CHINA

Paper presented by the Republic of China[1]

Geodesy

Compilation and reproduction of geographical co-ordinates of triangulation points in China (mainland)

Geographic co-ordinates of all triangulation stations in mainland China were readjusted and recomputed to a single geodetic datum. During the past two years, the geographic co-ordinates of about 8,000 triangulation stations have been prepared in card system and composed separately in accordance with 1:250,000 scale series. It will be completed at the end of 1967.

Precise levelling

There is a total of 1,600 km bench-marks in Taiwan. During 1962–1967, 1,022 km levelling were completed. The whole levelling project is to be finished in 1967.

The levelling was carried out by Wild N-3 level with invar bars. Its error does not exceed $4\text{mm}\sqrt{K}$ (K for km). The adjustment of the levelling net was referred to the Keelung datum.

Triangulation station mark recovery and re-establishment

In Taiwan, there are 1,069 trigonometrical stations of different orders of less than 500 metres height above mean

[1] The original text of this paper appeared as document E/CONF.52/L.109.

sea level. One-third of these stations was damaged by natural and human causes. The tellurometer was used for this station recovery and re-establishment.

Photogrammetry

Various scales of air photos ranging from 1:10,000 to 1:120,000 are used for photo-interpretation, agricultural and forest inventory, topographic map revision and production.

Multiplex

In multiplex compilation, where aerial photographs and existing control are required, the manuscripts are first compiled at 1:20,000 or 1:40,000, and then reduced to 1:50,000 scale of standard topographic maps.

The different instruments used in photogrammetry in Taiwan are as follows:

4 A3 air cameras
4 K17 air cameras
2 Automatic photo developing machines
1 A7 autograph
1 C8 stereoplanigraph
13 Multiplexes
2 Zeiss SEG-V rectifiers
2 Wild rectifiers
9 Sketchmasters

Topical maps

Engineering construction survey

An alignment is made at 1:1,000 scale for the installation of a natural gas pipeline. The pipeline runs south to north of Taiwan 400 km in length. The survey has now been completed on 20 km^2. The maps are used for the planning of natural gas development with the aim of meeting the needs of industrial and economic construction.

Civil airport survey

Two kinds of topographic maps at 1:2,000 and 1:5,000 were made. The maps are designed for use in planning the expansion of the civil airport for the development of airlines.

Shen-au topographic maps

Topographic maps at 1:2,000 scale of the harbour area, and hydrographic charts of the sea bottom of its adjacent area were prepared for the planning and development of this area.

Survey for city development

For the development of Taipei city, map sheets at 1:1,200 scale were made of the south-western part of Taipei, covering 3,500 hectares and 1,350 hectares at stake points. These maps will be used as basic data in city construction and rehabilitation engineering projects.

Topographic maps at 1:600 scale were made of new community areas in Taipei city.

Map compilation and reproduction

To meet various requirements, the China Topographic Service has compiled and reproduced the following map sheets: topographic maps at 1:50,000 and 1:100,000; terrain studies at 1:250,000; plastic relief maps at 1:250,000; general maps at 1:500,000, 1:1,000,000, 1:2,500,000 and 1:4,000,000.

The number of map sheets completed during the past three years is as follows:

Scale	*1964*	*1965*	*1966*
1:25,000	—	—	30
1:50,000	450	450	36
1:100,000	—	—	100
1:250,000	58	58	58
1:500,000	—	12	12
1:1,000,000	2	2	2
Smaller than 1:1,000,000	6	5	2

International Map of the World on the Millionth Scale (IMW)

The IMW series of China consists of seventy-three sheets. Thirty-eight sheets have been published to date, or approximately 52.1 per cent of the total coverage. The maps were compiled according to the specifications of the international format and domestic requirement. The specifications reached at the 1963 United Nations Conference in Bonn were adopted for the compilation of the map.

Standardization of geographical names

The Chinese Government accepts the United Nations recommendation for the standardization of geographical names. In view of the differences in pronunciation of names, a geographical name pronunciation guide has been compiled in accordance with the national standard phonetic system. The guide will be used for domestic and foreign names.

Topical maps

A topical map, including data on population, communication, climate, products and geology has been published for Taiwan province. The information shown on that map has changed and does not reflect the actual situation. The Government plans in five years to compile topical maps for national economic development. This source material will be sent to the Information Office in Bangkok as soon as possible.

Training

A Survey College established sixty-three years ago is responsible for the training of surveying and mapping personnel. The college consists of five departments, namely geodesy, photogrammetry, topographic survey, cartography and instrument manufacturing. High-school graduates are admitted to the college, and are awarded a bachelor's degree after being given specialized training for four years and four months. Survey College graduates in the past years have undertaken many types of topographic engineering and mapping projects. Photo-interpretation is one of the subjects taught at the college.

CARTOGRAPHIC ACTIVITIES IN JAPAN (GEODESY, PHOTOGRAMMETRY, PHOTO-INTERPRETATION, CADASTRE AND CIVIL ENGINEERING)

Paper presented by Japan[1]

Most cartographic work in Japan is controlled by government agencies and falls into two categories: the national fundamental survey executed by the Geographical Survey Institute of Japan, and the public survey, carried out by other public organizations such as the Hydrographic Office, the Bureau of Forests, the Economic Planning Agency, the National Railway Office, highway construction or local government agencies.

Cartographic work in Japan is still more active owing to rapid increases in economic, industrial and social activities such as reconstruction of urban areas, highway construction and prevention of disasters.

National fundamental survey

The national fundamental survey has been carried out under the new ten-year project mentioned in the national report of Japan at the fourth United Nations Regional Cartographic Conference for Asia and the Far East in Manila.[2]

The national fundamental survey in Japan is roughly divided as follows: geodetic work, topographic work, geographical work and other. Details of each category will be explained below.

Geodetic work

The Geographical Survey Institute is responsible for the fundamental geodetic land survey of Japan. This work is divided into two categories. One is the establishment of new minor control points, such as fourth-order triangulation stations, second-order traverse stations, and second- or third-order bench-marks, which will serve for large-scale mapping, cadastral survey, and other public surveys. The other is the revision survey of the existing geodetic network, such as first-order triangulation and first-order levelling. This resurvey is intended to detect crustal deformations as well as to maintain the results of existing control points. The study of crustal movements is considered one of the most powerful means of investigating the problem of earthquake prediction. Astronomical, geodetic satellite, gravimetric and geomagnetic observations are also made.

Triangulation

The revision survey of 330 principal first-order triangulation stations which form the fundamental framework of the Japanese triangulation nets was commenced in 1947 and already covers most of the country except for a part of the Hokkaido district. After finishing the remained area in 1967, a second revision will take place under the new geodetic project and the earthquake prediction project. In the present survey, many base lines have been established with geodimeter and many first-order stations have been planned as Laplace stations, whereas only one-third of the base lines and no Laplace stations existed in the former surveys. Consequently, higher accuracy of the geodetic networks than before will be expected even though the method of angle observations will be simplified. Second- and third-order triangulations are made only for areas where revision surveys are required owing to earthquakes or other causes.

Minor horizontal control points are established by fourth-order triangulation and second-order traverse survey mainly in flat areas where cadastral survey or large-scale mapping is planned. Using electronic distance-measuring instruments, the traverse survey has become a quicker and more economical method than triangulation in flat areas.

Some fourth-order triangulation and second-order traverse surveys are made by private surveying companies under contract with the Geographical Survey Institute.

An electronic computer, NEAC 2206, made in Japan, was introduced in the office of the Geographical Survey Institute and has been used not only for most kinds of computation of geodetic data but also for data-processing in map-making. In this connexion, a universal programme adjustable to any triangulation and traverse network has been developed and used.

In order to calibrate and standardize electronic distance-measuring instruments, a comparison base line was established at Akita near Tokyo in 1965 and was observed with invar wires, geodimeters, tellurometers and electrotapes. Since the region is a cultivated one, it is very difficult to find a place wide enough to settle a long base line and measure it with invar wires, so that this base line is only 1 km in length. Extension by triangulation is, however, planned and a net will be made for use in many kinds of test observations.

Table 1. Geodetic work performed, 1947-1963

	Revised 1st-order triangulation station	*2nd- and 3rd-order triangulation stations*	*Base lines observed with geodimeters*	*Laplace stations established*
1947–1963	250		16	45
1964	22	68	2	13
1965	17	9	2	8
TOTAL	289	77	20	66

	4th-order triangulation stations	*2nd-order traverse stations*	*Total*
1947–1963	17,819	5,545	23,364
1964	1,678	1,057	2,735
1965	2,123	882	3,005
TOTAL	21,620	7,484	29,104

Levelling

A revision survey of the first-order levelling network was also commenced in 1947. About 16,000 km, or most of the existing lines, had been completed by 1961. The next phase of revision began in 1962. The result of this work is the basic material for studying the crustal movements and

[1] The original text of this paper, prepared by the Geographical Survey Institute, Tokyo, appeared as document E/CONF.52/L.121. Additional papers bearing the same symbol were submitted under agenda items 7, 8, 9, 10, 12 and 13.

[2] *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 2 (United Nations publication, Sales No.: 66.I.3), p. 46.

is considered one of the most effective means for the prediction of earthquakes. The progress of this work was accelerated by the Upper Mantle project.

Precise levellings had been repeated many times over several years in the Niigata district, because a severe ground subsidence was in progress, caused perhaps by the mining of natural gas near Niigata city. Fortunately the surveys covered wide areas of the Niigata plain, including the coast near the epicentre of the 1964 Niigata earthquake. An analysis of the results of this survey showed a characteristic land deformation in this area prior to the earthquake. This deformation might be a key to earthquake prediction. Since the summer of 1965, a group of numerous earthquakes has occurred in a small region near Matsushiro, in central Japan. Precise levelling has been worked out again and again in this area. Some second-order bench-marks have been established in regions such as those mentioned above, in order to gain detailed information on the vertical movements of the earth's crust.

Second-order bench-marks are established along national or local roads other than the first-order levelling routes as a supplement to first-order nets.

In order to distribute the tidal observation records obtained at sixty-two tidal stations belonging to the Geographical Survey Institute, the Hydrographic Office and the Japanese Meteorological Agency, the Coastal Movements Data Centre was established in the Geographical Survey Institute in 1965. These data will be used for the study of crustal movements and the prediction of earthquakes.

Table 2. Levelling work, 1962-1965

	Revised first-order levelling	*Established second-order bench-marks*
1962–1963	2,208 km	
1964	2,405 km	
1965	2,976 km	517 (1,136 km)

Astronomical and satellite observations

Astronomical latitude, longitude and azimuth are observed at about two-thirds of the principal first-order triangulation stations for the purpose of establishing Laplace stations. Observations are made with astrolabes equipped with the electronic transit detector developed by the Geographical Survey Institute.

Satellite geodesy has been put to practical use. Some solitary islands around the mainland of Japan were connected geodetically with the mainland with the co-operation of the Tokyo Astronomical Observatory, the Hydrographic Office and the Geographical Survey Institute. Observation stations were constructed by the Geographical Survey Institute at Sapporo in Hokkaido and Kanoya in Kyushu as the basis of the satellite observing network, together with the Geodetic Observatory at Mt. Kanozan. Precise satellite tracking cameras with photo-electric timing devices will be set up at these stations and observations of satellites such as *Echo* or *Pageos* are planned to connect the geodetic net of Japan with those of other nations and also to detect the land deformation and drift of the Japanese islands as a whole.

Gravity survey

In order to establish the Western Pacific calibration line, three series of international pendulum observations, Japan—Hawaii—United States, Japan—Alaska and Japan—Philippines—Singapore were carried out with the modified GSI pendulum apparatus in 1965 and 1966.

For the domestic survey, the pendulum apparatus is used for observations at fundamental gravity stations. The first- and second-order gravity surveys are made with LaCoste and Romberg gravity meters. The first-order gravity station will serve as the control point in the second-order gravimetric network, which consists mainly of bench-marks. The second-order survey had covered the whole land by 1960. Since then, resurvey has been in progress.

A sea gravity survey was made with two kinds of surface ship gravity meters by the Ocean Research Institute, the University of Tokyo and the Geographical Survey Institute in the Pacific Ocean and the Sea of Japan.

Magnetic survey

Ninety first-order and about 800 second-order magnetic stations have been established. Twenty of the first-order are revised every other year and the rest at intervals of five years. It is planned to revise the second-order survey every ten years. Results of these surveys are summarized and magnetic charts are compiled.

After the Niigata earthquake, resurvey of the disturbed area showed an anomalous feature in the secular change of the local magnetic field which might be helpful in the prediction of earthquakes. A repeat survey at a shorter interval is requested by the earthquake prediction project.

Under the world magnetic survey programme, an aero-magnetic survey observing the three geomagnetic components was carried out by the Geographical Survey Institute and the Hydrographic Office. The main land and adjacent Sea of Japan had been covered by the survey by 1965.

National base map

The ten-year project of producing the new base maps, reported at the Manila conference, has been carried out as scheduled. The third-order instruments, however, have no longer played an important role in the production. The place of the third-order instruments has been taken by second-order instruments, that is, precision plotters and topographic plotters. Two-thirds of the total production is now executed by private enterprise under the supervision of GSI.

Revision survey of the old base maps at 1:50,000 is also being carried out. However, 1:50,000 maps will be compiled from the 1:25,000 maps after the completion of the new base maps at 1:25,000.

According to the project, 1:25,000 base maps will be revised every three years in urban areas and every ten years in mountainous areas.

National large-scale mapping

With regard to the national large-scale map, the initial project has been modified since 1964 in order to unify the map scale at 1:5,000, except in special cases where the scale is 1:2,500.

The progress of the project since 1964 is shown in table 4; the work in the period 1960–1963 was reported in the national report presented at the Manila conference.

The project is administered by the Geographical Survey Institute and most of the practical work is carried out by private firms.

Table 3. Topographic activities since 1964

	1964	1965	1966
1:25,000:			
New edition	133 sheets (12,000 km²)	236 sheets (19,000 km²)	275 sheets (23,000 km²)
Revision	—	34 sheets (3,300 km²)	101 sheets (8,000 km²)
1:50,000:			
Revision	27 sheets (8,400 km²)	23 sheets (8,500 km²)	22 sheets (9,000 km²)
Partial revision	50 sheets (17,000 km²)	49 sheets (15,500 km²)	42 sheets (17,000 km²)
AMS style edition	85 sheets (30,000 km²)	—	—

Table 4. National large-scale mapping project

	Scale	1964	1965	1966	Total since 1960
Photography (km²)	1:10,000	—	1,119	804	60,923
	1:20,000	39,681	35,285	36,040	171,906
Mapping (km²)	1:2,500	281	251	0	3,444
	1:5,000	2,678	2,198	3,635	11,619
Photo-contour map (km²)	1:5,000	474	348	607	1,429
Photo-map (km²)	1:5,000	6,171	6,108	3,640	15,919

Photography

Aerial photographs are taken by the GSI covering half the country, about 190,000 km^2, at intervals of three to five years, at the scale of 1:20,000, except in some city areas, for which the scale is 1:10,000; the other half of the country, which is mostly forest, is photographed by the Bureau of Forestry.

Signals are established in all areas for which mapping work is carried out or will be carried out in the near future. The work is being carried out in accordance with the project, and the prescribed area has been almost covered.

Control survey

The large-scale mapping project also calls for the establishment of fourth-order triangulation points (side length about 1.5 km) which serve for large-scale mapping works and cadastral surveys. The control survey is also going well, and about 95,000 km^2 of Japan will be covered by the end of the project.

Mapping

With regard to mapping, the execution of the project is not yet satisfactory. The mapping of some 2,500 to 3,000 km^2 has been carried out each year since 1963; however, the project calls for the mapping of about 9,500 km^2 each year. The position will be corrected in the near future.

The maps are copied in response to the requirements of users.

Photo-map

Requirements for the photo-map have gradually increased for recognition purposes as well as for photo-interpretation.

Since 1964, photo-maps have also been made for the national large-scale map in the Geographical Survey Institute. They are made by the control mosaic method for flat areas and by the orthophotographic method for mountainous regions.

Maintenance of the map

New 1:25,000 base maps are to be kept up to date by regular revision surveys, made as a rule every three years or so for urban areas and every five or ten years for the other parts. Revision surveys are carried out with the aid of aerial photographs, field checking and other data. Small-scale maps will be revised as well, using the 1:25,000 maps mentioned above.

Compilation of maps

Medium and small-scale maps compiled by GSI are described below.

To improve the style and to modernize the 1:50,000 map, some sheets that were prepared by the plane-table method are to be replaced by photogrammetrically prepared sheets, using compilations from the 1:25,000 map. The work started in 1965 and eighty sheets have been compiled.

Recompilation of the 1:200,000 regional map, which began in 1955, was completed in 1964 and totals 119 sheets. Since 1965, revision of the sheets has been undertaken. About ten sheets are revised each year.

Recompilation of all seven sheets of the 1:500,000 district map started in 1966 and will be completed in three years.

Compilation of the IMW was initiated in 1964. Three sheets, covering the main islands of Japan, were completed and issued in 1966.

REPRODUCTION OF MAPS AND AERIAL PHOTOGRAPHS

GSI supplies to users annually 5 to 6 million copies of approximately 3,500 kinds of maps and 80,000 to 100,000 copies of aerial photographs. Recent activities are described below.

Drafting

The traditional pen and ink drawing has been replaced, for the most part, by new methods: scribing on synthesized plastic film, stick-up of photo-composed lettering, and masking by peel-coat. A punch system on colour separation sheets was introduced in 1966.

Plate-making

Since 1961, master plates for making printing plate have been replaced by process film from copper or zinc plate. Films for all sheets of the 1:50,000 topographical map, the 1:200,000 regional map, and 80 per cent of the 1:25,000 topographical map have been completed.

Printing

The quantity of maps to be printed is determined by the demand for copies of maps. GSI adopted a policy of printing from a half-year supply to a four-year supply depending upon the annual demand and the number of colours used for one sheet. Because of the small demand for large-scale maps and lake charts, blueprints are prepared only on request. Contact prints and enlargements of aerial photographs are also made on specific request.

Supply

The annual supply of maps and aerial photographs is tabulated in tables 5 and 6. In addition, approximately 1 million copies of maps are printed for other governmental agencies based on specific requests and 20,000 copies of aerial photographs are printed for GSI use.

Cadastral survey

The cadastral survey in Japan is carried out by the Economic Planning Agency on the basis of the law of land research. The principal purposes of the land research are cadastral survey, establishment of control points for the cadastral survey, land classification research and water research.

Field work is undertaken for the cadastral map survey, but recently photogrammetry has also been adopted in many cases.

Table 7 shows the cadastral work done in the period 1964–1965.

Table 5. Annual supply of maps

Scale and type	*Number of colours*	*Number of sheets*	*Annual supply of copies* 1963	1964	1965
1:10,000 topo. map	1–5	242	28,000	4,000	25,000
1:25,000 topo. map	1–3	1,839	225,000	270,000	438,000
1:50,000 topo. map	1–4	1,259	6,093,000	4,938,000	4,541,000
1:200,000 regional map	6	119	277,000	266,000	239,000
Others	1–16	116	47,000	62,000	52,000
	TOTAL	3,575	6,670,000	5,540,000	5,295,000

Table 6. Annual supply of aerial photographs

Type of aerial photography	*Annual supply of copies* 1963	1964	1965
Contact prints	81,800	61,900	63,500
Enlargements	15,100	19,900	17,000
Plates or films for plotting instruments	3,900	4,500	200
TOTAL	100,800	86,300	80,700

Table 7. Cadastral survey, 1964-1965

	1964	*1965*	*Total since 1951*
Control point survey (in points)	998	1,050	22,760
Cadastral survey (in km²)	2,222	2,495	14,044

Public survey

In Japan, the public survey makes up the larger part of the cartographic work and large numbers of the maps have been made for public purposes, usually at scales 1:1,000 to 1:5,000. These surveys have usually been carried out by private firms in compliance with the orders of various public organizations.

The Bureau of Forestry has taken photographs of the mountainous areas of Japan, which principally correspond to forest areas, in co-operation with the Geographical Survey Institute. Their project is to cover about 190,000 km² of Japan. The scale of the photographs is 1:20,000.

The total areas of photography and mapping in 1964–1966 are also shown in tables 10 and 11 respectively.

Recently, very large photographs have been taken using the helicopter for purposes of very large-scale mapping, research of snow damage, study of flow such as tidal current, traffic circulation, etc.

Table 8. Private firms and their personnel

	1964	*1965*	*1966*
Private firms	946 (51)*	986 (54)*	992 (56)*
Personnel:			
Total	25,051	25,551	26,118
Registered surveyors	4,317	4,517	4,730
Registered assistant surveyors	2,201	2,501	2,855

* Number of firms which can carry out photogrammetric work.

Table 9. Photogrammetric equipment in Japan

	1964	*1965*	*1966*
Aircraft for photography:			
Government	1	1	1
Private	27	39	39
Cameras:			
Government	5	7	8
Private	47	51	51
First-order instruments:			
Government	4	4	4
Private	19	22	22
Second-order instruments:			
Government	6	6	13
Private	123	123	126
Third-order instruments:			
Government	38	31	31
Private	34	30	31
Comparators:			
Stereo:			
Government	1	1	1
Private	0	0	1
Mono:			
Government	0	0	0
Private	3	4	4

Table 10. Areas photographed in 1964-1966 for public survey

Year	Photo scale	Forestry survey (km²)	Other public surveys (km²)
1964	1:10,000	0	2,334
	1:20,000	31,880	17,910
	1:30,000	0	10,530
1965	1:10,000	0	4,312
	1:20,000	38,460	27,680
	1:30,000	0	4,150

Table 11. Areas mapped for public survey (in km²)

Type of map	1964	1965
Forestry contour map	13,400	13,500
City planning map	2,855	2,440
Highway planning map	3,747	2,224
Railway planning map	1,289	623
River improvement map	1,077	2,448
Land improvement map	1,435	482
Combination development maps	2,377	2,908
TOTAL	26,180	24,625

THEMATIC MAPS

As reported previously, various kinds of thematic maps have been prepared for many purposes by governmental organizations. Principal maps issued during this period are listed below.

Land classification map series

This series consists of three thematic maps: landform classification, surface geology and soil maps. The Economic Planning Agency co-ordinates the preparation of the 1:50,000 map series. Ten sets have been prepared by government agencies and universities. The agency has also been preparing the 1:500,000 map series covering the main part of the country in six sheets. These sheets will be issued in the near future.

Land-use maps

Two sheets of the 1:10,000, four sheets of the 1:25,000 and fifteen sheets of the 1:50,000 maps have been prepared by GSI and local governments. Since 1961, GSI and the Hokkaido Development Agency have been co-operating in covering the Hokkaido district (79,000 km²) with the 1:200,000 map. Work on all twelve sheets will have been completed by the end of this period.

Land-condition maps

The 1:25,000 map for disaster prevention and land development has been issued for the Kyoto-Osaka-Kobe area (eight sheets) by GSI. The map for Nagoya and its environs is currently in preparation.

For practical application, a map for the master planning of the cross-country highway has been made on a trial basis by GSI and the Road Bureau. The map presents information on landforms, surface geology and land use. In addition, several sheets include information, when necessary, on snow depth and avalanches along planned routes.

1:10,000 lake chart

Charts for seven lakes (236 km²) have been completed by GSI.

1:50,000 water-use map

The Economic Planning Agency started preparation of the water-use map in co-operation with GSI in 1965 and has so far completed the map for the Kiso river, one of the most important river systems in Japan.

GEOLOGICAL MAPS

Basic geological maps

The Geological Survey of Japan prepares basic geological maps. For the Hokkaido district, the Hokkaido Development Agency and the Geological Survey of Hokkaido also take part in the preparation of these maps. Eighty-three sheets of the 1:75,000 map and ten sheets of the 1:100,000 map (Hokkaido district) have been published as the basic geological maps. However, in 1952, the 1:50,000 map replaced these maps. Approximately thirty sheets of the 1:50,000 map are surveyed each year. 293 sheets were published by 1965, covering almost 55 per cent of the country, primarily to show mineralized areas, geologically unclear districts, and regions for national exploitation projects.

In the preparation of these maps, not only field survey but also photo-interpretation techniques have been widely utilized. Based on these maps, two map series at scales 1:200,000 and 1:500,000 have been compiled. Twenty-one sheets of the former and thirteen sheets of the latter had been published by 1965. A few of the 1:500,000 map sheets have been revised: Kyoto in 1954, Kochi in 1961, Fukuoka in 1962 and Tokyo in 1966.

General and special geological maps

Besides the preparation of the basic maps, many types of geological maps have been prepared. Maps prepared in 1964 and 1965 are as follows: geological map of Japan, 1:2,000,000, 1964 (revised edition); hydrogeological map of Japan, 1:2,000,000, 1964; hydrogeological map with explanatory text of the Kinsei, Kano, Nakayama and Shigenobu river basins, Ehime prefecture, 1:100,000, 1964; hydrogeological map of the western part of Chiba prefecture, 1:100,000, 1964; metallic and non-metallic mineral deposits of Hokkaido IV, geological map of Hokkaido, 1:800,000, 1965.

International co-operation

The Geological Survey of Japan has been co-operating with ECAFE in preparing several types of geological maps of Asia and the Far East at 1:5,000,000 as an inner regional organization in compliance with the ECAFE project of the working party of senior geologists.

Maps already published in line with the ECAFE project are a geological map in 1960, an oil and natural gas map in 1962, and a mineral distribution map in 1964. Maps currently being compiled and scheduled to be completed in 1968 are a tectonic map and a metallogenic map. Maps for future consideration are a gravity map and a hydrogeological map.

Survey and reproduction

With the increasing need for survey work, the Geological Survey has contracted with private concerns to perform the surveys. Private contractors, under the supervision of the Geological Survey, have been reproducing all the Geological Survey maps. The Geological Survey controls the colour design with the standardized colour scheme chart especially prepared several years ago following the scheme used by the Australian Geological Survey.

Recent cartographic activities

Plotting instrument

A new medium-scale plotting instrument with a simple mechanical analogue computer is currently being made in Japan and an experimental model was completed in 1966. This instrument was made by the Nihon Kogaku Co., Ltd. under the direction of GSI.

Text for photo-interpretation

To utilize photo-maps more effectively, a photo-interpretation text is being prepared by using the punch-card system. The cards will serve not only for photo-reading but also for other geographical surveys, such as land use and land classification.

Geographical names on maps and charts

GSI and the Hydrographic Office have been co-operating to unify representation of geographical names on their topographic maps and nautical and aeronautical charts.

During this period, geographical names for the IMW for Japan were established. Discussions are now being conducted to determine the geographic names for the new 1:500,000 district map and the 1:200,000 coastal chart.

Masking

GSI has developed a new method for masking by dyeing film. This new method is very effective for complicated patterns and has been applied to the reproduction of some thematic maps.

Other activities

A symposium of Commission V of the International Society for Photogrammetry was held in Japan in 1966. Approximately 280 persons from thirty-five countries attended the symposium at the Toshi Centre Hall in Tokyo and discussed the problems of the application of photogrammetry.

Another meeting, the Pacific Science Congress, was also held in Tokyo in 1966. One of the major topics was cartographic problems.

Technical co-operation between Japan and foreign countries under the Colombo Plan has been increasing since 1963. To date, GSI has accepted many individuals from various countries for training in surveying and mapping. Table 12 shows the number of participants since 1963.

Table 12. Number of participants

Year	*1963*	*1964*	*1965*	*1966*
Number of participants	9	15	11	15

Under the same plan, the Forest Experiment Station has accepted, since 1957, some half-dozen candidates for training in the application of photogrammetry to forestry.

ACTIVITIES OF THE KHMER GEOGRAPHICAL SERVICE

Paper presented by Cambodia[1]

The Khmer Geographical Service was created in 1955, under the Ministry for National Economy, after the dissolution at Dalat (Republic of Viet-Nam) of the Indochina Graphical Service, 30 per cent of whose outdated equipment it inherited. In 1956, it became a part of the National Defence Department.

The early days of the service were difficult because it lacked qualified leaders and technical specialists. Such personnel was trained in the period up to the end of 1965. During that period, the service acquired more modern equipment in order to be able to meet modern needs. Equipment is still being acquired.

However, with the help of foreign experts, local technicians trained at home and others continuously returning from overseas, the service has managed to complete important projects, a list of which follows.

Economic cartography

1961

Sketch of the Samboc rapids at 1:40,000, monochrome, with contour interval at 5 m, covering 57 km^2.

Sketch of Kompong Sala at 1:10,000, monochrome, with contour interval at 5 m, covering 25 km^2.

1962

Plan of the Prek dam at 1:10,000, monochrome, with contour interval at 5 m, covering 50 km^2.

Master plan of the Prek Thnot irrigable zone and dam at 1:20,000, polychrome; 23 sheets covering 1,500 km^2.

Plan of Phnom Koulen at 1:10,000, monochrome; 2 sheets, with contour interval at 10 m, covering 62 km^2.

Sketch of Tamyong at 1:2,500, with contour interval at 5 m, covering 2 km^2.

Sketch of Krapeu Py at 1:2,500, with contour interval at 5 m, covering 2 km^2.

Master plan of the Tonlé Sap dam at 1:20,000, monochrome, with contour interval at 10 m, covering 250 km^2.

Approach map of Pochentong airport at 1:10,000 covering 5 km^2, on ozalid paper.

Plan of Pointe de Départ Island (Sihanoukville) at 1:5,000 on ozalid paper, with contour interval at 10 m, covering 25 km^2.

Master plan of Kirirom dam, O'Chral, at 1:10,000, on ozalid paper, with contour interval at 10 m, covering 50 km^2.

Plan of Kirirom III at 1:10,000, on ozalid paper, with contour interval at 10 m, covering 50 km^2.

1964

Approach map of Siemreap-Angkor airport at 1:10,000, on ozalid paper, covering 10 km^2.

Plan of Sihanoukville at 1:5,000, on ozalid paper, with contour interval at 10 m, covering 25 km^2.

1965

Plan of Sihanoukville peninsula at 1:20,000, polychrome; 23 sheets, with interval at 10 m, covering 2,760 km^2.

[1] The original text of this paper, submitted in French, appeared as document E/CONF.52/L.123.

1966

Plan of Kirirom at 1:20,000, monochrome, with contour interval at 10 m, covering 1,440 km^2.

Plan of Sen Monorom dam at 1:20,000, with contour interval at 5 m, covering 40 km^2.

1966–1967

Master plan of the irrigable zone of Sambor, polychrome, at 1:20,000, with contour intervals at 1 m and 5 m, covering 3,120 km^2.

1967

Plan of Noreay dam at 1:10,000, on ozalid paper, covering 40 km^2.

Photo-mosaic of the northern and western regions of Cambodia for the study and construction of roads.

General cartography

1966–1967

Coverage of Cambodia at 1:50,000, polychrome and monochrome, covering 144,800 km^2.

1966

Tourist map at 1:2,000,000 polychrome.

Administrative map at 1:2,000,000, polychrome.

Administrative (and road) map at 1:1,000,000, polychrome.

1967

Administrative and road map at 1:500,000, polychrome.

Economic and physical map at 1:500,000 (current project).

1966

Plan of the town of Phnom-Penh at 1:10,000.

Astronomy and geodesy

Through lack of funds, the service has not been able to undertake important triangulation projects.

Levelling

The service has completed about 850 km of first- and second-order levelling and 550 km of complementary levelling which serves as a basis for master plans.

Miscellaneous

At the present time the service is participating actively in road-building projects for the economic development of the country, and is assisting foreign missions in mineral prospecting and the preparation of geological maps of Cambodia.

ACTIVITIES OF THE GEOGRAPHICAL INSTITUTE OF THE CONGO

Paper presented by the Democratic Republic of the Congo[1]

Introduction

As the reorganization of the Airborne Surveys Service was undertaken during 1965, the first mission was set up in June 1965. The purpose of the mission was to survey a region which is intensely active from an industrial point of view and which has undergone significant modifications since the last survey in 1954. The survey covers an area of 42,000 km^2.

Ultimately, it is planned to organize regular flights for aerial photography during meteorologically favourable periods of the year, so as to cover the 15 per cent of the territory yet to be surveyed. This 15 per cent is entirely situated in the equatorial zone, where the vegetation is dense and the cloud coverage constant.

The service has one C47 aircraft. The aerial photography equipment of the Congolese Geographical Institute is made up of five Wild RCTA cameras and one Wild RC8 camera. Aerial survey missions will very shortly be using a Wild RST2 statoscope.

Cartographic application of aerial photographs

Three stages are foreseen in the cartographic application of the aerial coverage, depending on the density and the precision of the control points which have been set up.

Stage 1

Compilation tracings at photo-scale: 20,340 km^2;

Compilation manuscripts at 1:200,000 scale: 96,636 km^2;

Compilation manuscripts at 1:1,000,000 scale covering five-sixths of the territory;

Compilation manuscripts at 1:3,000,000 scale for the whole of the territory;

Many special projects as requested.

Stage 2

Planimetric plotting (radial triangulation);

Planimetric manuscripts at 1:50,000 scale: 128,050 km^2.

Stage 3

Manuscripts finalized at 1:25,000 scale: 9,562 km^2.

During 1966, three photogrammetric engineers and two technicians joined the staff. They are all from the International Training Centre in Delft.

Geodesy and topography

Ground surveying

To permit plotting for the preparation of planimetric sheets at 1:200,000 scale, a party for the surveying of control points determined by vertical contour has been put into operation. Two experimental points were set up in 1966. The mission will begin operations in 1967.

To permit plotting for the preparation of topographical sheets at 1:50,000, sixteen frameworks were demarcated and numbered; twenty-four triangulated or polygonated framework stations and sixteen non-demarcated polygonated stations were established; twenty-nine telluro-metrical measures were effected amounting to 56 km, and forty-one points were plotted on photographs.

[1] The original text of this paper, submitted in French, appeared as document E/CONF.52/L.124.

To permit plotting for the preparation of topographical sheets at 1:50,000, 108 points were localized and plotted on photographs.

The continuation of the great loop crossing the Congo in a curve from Bangui to Brazzaville and having its base on the levelling of Central West Africa is in progress.

Levelling of the Katanga area has also been started and a link with the Zambian levelling at Bancroft is planned.

Unfortunately, the necessary authorization to complete this connexion on Zambian soil has not yet been received. During the period in question, sixty-five reference points were set up and 203 km measured.

A tellurometric polygon was measured in a section of the Katanga triangulation.

Computations

The major computation operation was the general re-adjustment of the planimetric framework in the continental system of the 30th meridian arc. After compensation of the Sixth South Parallel Arc (published in 1962), the adjustment of the following major regional network was completed during the period in question: Kivu–Maniema; North-East; Kwilu–Kasai; Mayumbe.

The adjustment of the loop known as Popokabaka, which adjoins the 6th south parallel and takes in an important section of the Angolese chain of the 6th south parallel, was undertaken and completed.

The detailed planimetric networks have not been neglected, and mention should be made of the advancement of the detailed network adjustment in the Mayumbe and Bas-Fleuve regions, also of the completion of the compensations of the local Gowa framework on the one hand, and of the network of geometric levelling of Kinshasa on the other.

Finally, the co-ordinates of 312 cartographic control points have been established.

Publications are being prepared and will shortly appear on the following: the Mariema–Kivu framework; the geometric levelling of the Kinshasa region framework.

Design and printing

Design

The Design Bureau has produced numerous sheets for purposes of revision as well as for the preparation of selections for new editions on different scales. Details are as follows: at the scale of 1:200,000, 15 sheets completed, 9 sheets under way; at medium scale, 19 sheets completed, 29 sheets under way; road and administrative maps, 8 sheets completed.

This is without taking into consideration the collating operations and numerous special projects undertaken at the request of public or private services.

Photo-engraving and printing

The printing shop received a new press in September 1966. This press will soon go into operation and will make it possible to increase the shop's production capacity.

During the period in question, production rose to 160 documents, which necessitated 179,378 machine runs; 633 zinc plates were mulled and 165 m² of documents were laminated. These undertakings necessitated the preparation of 2,925 copies on astralon and 365 copies on zinc plates.

Photographic laboratory

A new Klimsch-Commodore reproduction apparatus has been installed and put into use. This new equipment has increased quantitative production and at the same time ensures greater accuracy.

This section's activities will be greatly increased through the recommencement of aerial photography.

INTERNATIONAL CO-OPERATION IN SURVEYING AND MAPPING IN INDONESIA

Paper presented by Indonesia[1]

Introduction

The population problem in Indonesia has two important characteristics: fast growth and uneven distribution. The annual population increase is estimated at 2.5 million, creating social and economic problems. Sixty per cent of the total population of 105 million live in Java, an island comprising not more than 8 per cent of the total land area. The nation's economy is basically agrarian. As a direct result, food shortages have been felt in this country which not long ago had been able to feed itself. Another problem arising from this situation is the gradual increase in unemployment, disguised or not, while vast natural resources await exploitation.

Transmigration and industrialization have been considered as solutions to the problem. This means opening up new land and developing new resources. A good and well co-ordinated plan is needed to achieve such an end. Surveying and mapping is a prerequisite in providing planners with the data and information they need to design an effective, rational and well co-ordinated plan, which the nation still lacks.

[1] The original text of this paper, prepared by Soewarno Martojoewono, Secretary of the Board of National Survey and Mapping, Djakarta, appeared as document E/CONF.53/L.126.

This paper proposes to sketch Indonesia's most pressing problem in the field of surveying and mapping. Indonesia believes that this problem can be solved, at least in part, through international co-operation.

Present situation

The problem is more financial than technical in character. Mapping agencies have always been handicapped by lack of funds, especially foreign exchange, to procure additional equipment and maintain existing equipment as well as to procure supplies and materials. Procurement of additional equipment is necessary, since present capacity is far too inadequate. According to a recent estimate, a period of at least twenty years is needed to complete the mapping of the whole archipelago. This estimate does not take into account the time needed to conduct a national resources survey and map revisions. Indonesia could not afford to wait so long.

Only 41 per cent of the total land area has been mapped. Half of this is covered by topographic maps with standard accuracy; however, most of these maps need revision. The other half is covered by maps with unreliable accuracy prepared by quick surveying, as well as by terrestrial or photogrammetric sketch mapping. The remaining 59 per cent of the area is unmapped. Although geodetic and topographic surveys as well as map revisions are continuously undertaken, such efforts lag far behind the need, owing to budgetary limitations.

On the other hand, hydrographic and oceanographic work shows somewhat better results. Almost all Indonesian waters have been mapped. There nevertheless remains a vast amount of work to be done to uncover the sea's natural resources. No less important economically is the revision of hydrographic maps for safe inter-insular and inland navigation.

A national inventory of natural resources remains an enormous task to be undertaken. For instance, not more than 20 per cent of the land has been geologically surveyed. A national forest inventory as such has not been started. The main activity in this field has been feasibility surveys in relation to particular projects, covering relatively small areas, which were to be developed immediately.

Facing such an enormous task, the Government, through Presidential Act No. 263/1965, established the Board of National Surveys and Maps as a co-ordinating body of some thirty agencies, under the jurisdiction of various departments, in an attempt to rationalize the effort.

Possibilities of international co-operation

International co-operation may take various forms or combinations of forms and may include the provision of experts, equipment, supplies and services, as well as the establishment of institutes, training centres and other means such as fellowships and scholarships. Bilateral arrangements should be beneficial to both parties concerned and may cover exchange of information, joint boundaries, control surveys, oceanographic expeditions etc.

Some of the main areas of interest are listed below.

National mapping and resources surveys

If natural resources are to be utilized rationally and economically, they must be known. The United Nations Special Fund exists to meet such a need, and it is suggested that this conference should adopt a resolution to the effect that Indonesia should be given the necessary assistance. In addition, offers have recently been made in this connexion by various individual governments; these are still under consideration.

Surveys and mapping for regional development

Another possibility is joint surveys for integrated regional development, such as the Lampung project (South Sumatra), by member countries in capital investment in such development. Application for United Nations assistance has been forwarded to the regional representatives of the Food and Agriculture Organization and the United Nations Educational, Scientific and Cultural Organization. Further arrangements are being made to achieve this aim.

Feasibility studies.

This type of survey is especially important in creating conditions which will not only attract foreign capital investment, but will also make such investment feasible and more effective. One proposal by a foreign private company is under negotiation. Some co-operation in this area has been achieved. Indonesia also hopes to receive this type of assistance from the United Nations under the Expanded Programme of Technical Assistance.

Conclusion

Economic development must be accelerated not only in order to overcome pressing present problems but also to create better living conditions for the future. A basic knowledge of natural resources and their capacity for development is a prerequisite for creating conditions for capital investment. Considering the present economic condition in general and budget limitation in particular, it will be more practical to look for outside assistance to enable Indonesia to embark rapidly on this enormous and important task.

CARTOGRAPHIC ACTIVITIES IN LEBANON

Paper presented by Lebanon[1]

The major cartographic achievements of the Lebanese Geographical Affairs Service since 1964 are listed below.

The service has completed revision of the first-, second- and third-order triangulation of the Lebanon, the preparatory work for which was completed before 1964. The general first-order levelling survey covers most of the Lebanese road network.

Maps at 1:50,000 (twenty-seven sheets, the format of which conforms to that of the IMW) were used in the preparation of the map at 1:100,000 (six sheets) using a format adequate for Lebanon. An agreement was recently reached with the Syrian Arab Republic with a view to drawing up a new map at 1:100,000 following the format specified for the IMW; this is under way.

Eighty-five of the 120 sheets covering the whole of the country at 1:20,000 have been completed. These maps are prepared in relation to economic development. The remaining thirty-five sheets are in preparation and will be ready by the end of 1968. They cover the mountainous regions, whose economic development is not foreseen in the near future.

Several localized aerial photographic coverages have been completed and will be renewed every two years to meet cartographic and cadastral requirements arising out of the programme of road building and economic development.

Maps have been drawn at 1:500 of large towns and at 1:2,000 of villages, with a view to planning and developing these towns and villages in a rational manner in accordance with the principles of modern town planning.

Maps are in preparation at 1:1,000 for regions determined by the Cadastral Survey Department at the average annual rate of 40,000 hectares.

Administrative maps have been prepared at 1:200,000; road and tourist maps at 1:200,000; geological maps at 1:20,000, and an approach map for Beirut International Airport.

[1] The original text of this paper, submitted in French, appeared as document E/CONF.52/L.127.

CARTOGRAPHIC WORK IN INDONESIA, 1964–1966

Paper presented by Indonesia[1]

Geodetic work

Triangulation/trilateration

First- and second-order triangulation is still being carried out in Indonesia in order to extend the general triangulation network to all parts of the country.

In the period under review, ten primary and two secondary triangulation points were measured in the eastern part of Flores Island.

An adjustment has been carried out of the triangulation net of Bali, Lombok and Sumbawa Island; the co-ordinates of these triangulation points have now been definitely computed. The co-ordinates of twenty other primary points of the Sumbawa-Flores triangulation have been provisionally computed.

The "Bessel" ellipsoid is used: $a = 6{,}577{,}397$ m; $1/f = 299$; $b = 6{,}356{,}079$ m.

Tellurometers were used for this geodetic work. All computations are made using regular or old-fashioned computing machines, such as desk computers.

The fundamental geodetic surveys mentioned above are carried out by the Geodetic Department of the Army Topographical Service.

In some parts of the country, a few fourth-order triangulation points were measured and second-order traverses were carried out; they are used as control points for large-scale mapping and technical maps.

Levelling

Third-order levellings were carried out in some parts of the country (Java, Sumatra and Kalimantan) for technical purposes.

Astronomical surveys

At the border between West Irian and the Territories of Papua and New Guinea, six second-order astronomical points were measured and their co-ordinates computed; this survey is done for a better determination of the above-mentioned borderline. Field work was carried out under a survey programme agreed upon by the two Governments concerned. These first-stage astronomical surveys were finished in time, thanks to the good co-operation between the Indonesian and Australian survey teams.

Gravity surveys

Owing to lack of experts and adequate material for this special geodetic work, no gravity surveys have so far been carried out in Indonesia. Steps will be taken in this direction as soon as one or more gravimeters are available; in particular, gravity surveys of Java will be undertaken.

Topographic mapping

Systematic topographic mapping in Indonesia is still in progress and is the concern of the Army Topographic Service.

Under the new ten-year national mapping programme, this systematic mapping will be carried out in four phases, according to priority. Top priority is given to the economically most important parts of the country (phase 1). Phase 2 will comprise the mapping of previously unmapped territories, including and starting with state border areas. Phase 3 will comprise the new mapping of areas not yet covered by topographic maps on the standard scale as already adopted. Phase 4 will comprise the revision of the old topographic maps at 1:50,000 and 1:100,000.

Owing to shortage of funds and skilled manpower, progress in the period 1964–1966 has been very slow.

For special reasons, some areas were mapped at 1:25,000 and a few maps at that scale and at 1:200,000 were revised.

The topographic mapping activities of the last three years are summarized in table 1.

Table 1. Topographic mapping, 1964-1966

		1964	*1965*	*1966*
1:25,000	New edition	9 sheets (765 km²)	—	—
	Revision	—	—	6 sheets (486 km²)
1:50,000	New edition	6 sheets (1,950 km²)	—	—
	Revision	12 sheets (3,900 km²)	10 sheets (3,250 km²)	25 sheets (8,125 km²)
1:100,000	New edition	2 sheets (2,600 km²)	—	—
	Revision	—	—	35 sheets (45,500 km²)
1:200,000	New edition	—	—	—
	Revision	—	—	3 sheets (15,600 km²)

Large-scale mapping

Large-scale maps are normally needed for the various national development projects. Large-scale mapping of such project areas was carried out, using the classical terrestrial method, as well as photogrammetric techniques.

Mapping activities in the period 1964–1966, using large scales varying from 1:1,000 to 1:10,000 for these development projects, are shown in table 2.

Table 2. Large-scale mapping, 1964-1966 (in hectares)

	1964	*1965*	*1966*
Terrestrial method—map scale: varying from 1:1,000 to 1:10,000	25,775	13,470	17,333
Photogrammetric method—Photo scale: 1:20,000; map scale: 1:10,000	119,253	23,625	44,520

[1] The original text of this paper, submitted under agenda items 6, 10, 11 and 12, appeared as document E/CONF.52/L.129.

MAP PRODUCTION OTHER THAN TOPOGRAPHIC

National atlas

At this stage, general maps at 1:5,000,000 and 1:10,000,000 are produced, depicting the physical and economic aspects of the country, especially with regard to their distribution. At a later stage, regional maps at a larger scale are planned.

Some 100 different sheets are planned. Twenty-five sheets have been printed and are available for purchase. Forty other sheets have been drafted. Some ten sheets are outdated and accordingly must be revised before they come to press. All are provisional plates.

The technical staff is drawn predominantly from the Topographical Department.

World Aeronautical Chart (ICAO)

In co-operation with the Air Force, twenty-four sheets have been compiled and drafted. The base date is 1961. Four sheets have been printed; five are at the proof stage.

International Map of the World

Indonesia is responsible for twenty-six sheets. The latest revision printed was in 1957, and consisted of two sheets. A total of nine sheets were revised; but they are all delayed at the printing shop.

Master copies of all maps are still drawn on paper, not on shrinkproof material, resulting in registration hazards and an immense slowing down of the printing process.

CARTOGRAPHIC ACTIVITIES IN PORTUGUESE OVERSEAS PROVINCES SINCE DECEMBER 1964

Paper presented by Portugal[1]

Timor province

The Portuguese province of Timor is composed of the eastern part of the island of the same name, the island of Atauro and the enclave of Oe-Cussi. Surveying and mapping are carried out in this province by a geographical mission.

GEODESY

Triangulation

The geodetic connexion of Atauro island was made to the Timor triangulation net.

The observations were carried out by means of a Wild T3 theodolite at geodetic stations, using the horizon method, with ten basic points.

Levelling

For the precision levelling of the province, a general reconnaissance of the net was undertaken, covering 1,200 km; also signalling, using cemented bench-marks and levelling lines over a distance of 400 km.

Gravimetry

The reconnaissance of the lines Dili–Maubara and Dili–Aileu was undertaken. Observation was undertaken of the line Dili–Maubara. Connexion was made between Dili airport station and the Dili soil-tide station. A Worden gravimeter of the type used in surveying was used for the gravity observations.

CARTOGRAPHY

Work achieved for the map of Timor at 1:50,000 was made up of field work (completion) and office work (aero-triangulation, plotting, drafting and printing).

Completion

This consisted of a mapping survey, using classical methods of four photographic breaks along the boundary and covering a total area of 152 km^2.

Aero-triangulation

The support given for the establishment of the map by photogrammetric means was as follows:

Principal aero-triangulation, consisting of spatial aerial triangulation by framework strips supported by three groups of four or five co-ordinated points in the field;

Secondary aero-triangulation, consisting of spatial aerial triangulation by strips of photographic coverage using co-ordinated points by principal aero-triangulation.

Aero-triangulation operations have been completed for the whole province. The equipment used was a Wild A7 autograph fitted with a Wild EK5 co-ordinatograph and a Wild SL15 card-punch.

The calculation and adjustment of planimetrical errors were carried out by an electronic computer, using the Van der Welle method.

The adjustment of altimetrical errors was made using the graphic method.

The accuracy obtained for the aero-triangulation is translated by the following values: average planimetrical error, $\pm$ 4.1 m; average altimetrical error, $\pm$ 2.2 m. Taking into account the accepted allowance for the map: average planimetrical error, $\pm$ 10 m; average altimetrical error, $\pm (3 + 10t)$ m (t = tangent of gradient angle).

Bearing in mind its scale (1:50,000) and contour intervals (25 m), it can be seen that the results obtained exceed the requirements of the map.

Plotting and drafting

Plotting is done two by two and reproduced in the co-ordinatograph on the scale of the published map. Contour lines are engraved directly from the autograph with a sapphire point onto a sheet of Stabilene and the other details are drawn on to a sheet of polyester material, Cronalfex UC (Dupont).

The drawing of plotted details is made on to sheets of Ashafoil, colour separated, using the scribing method.

Nineteen sheets have been plotted and drawn.

Printing

The map is reproduced in six colours by the offset system.

Eleven sheets are being printed.

Portuguese state in India

This was removed from the full and effective exercise of Portuguese sovereignty in December 1961.

Macao province

Survey and publication of hydrographic plans of the port of Macao and the islands of Taipa and Coloane was undertaken at 1:10,000.

[1] The original text of this paper, submitted in French, appeared as document E/CONF.52/L.130 and Rev.1.

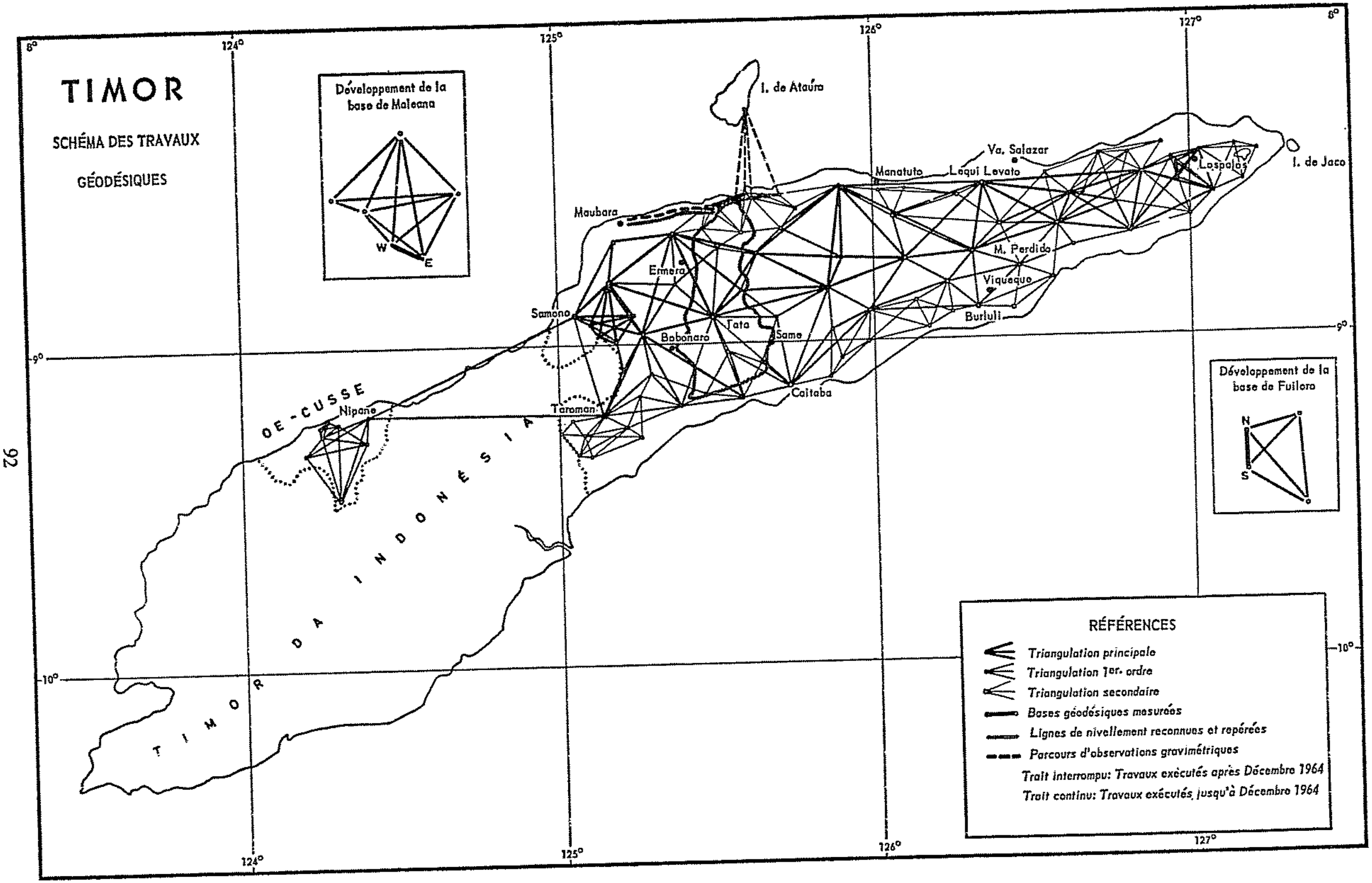


Fig. I—Portugal: Diagram of geodesic work in Timor

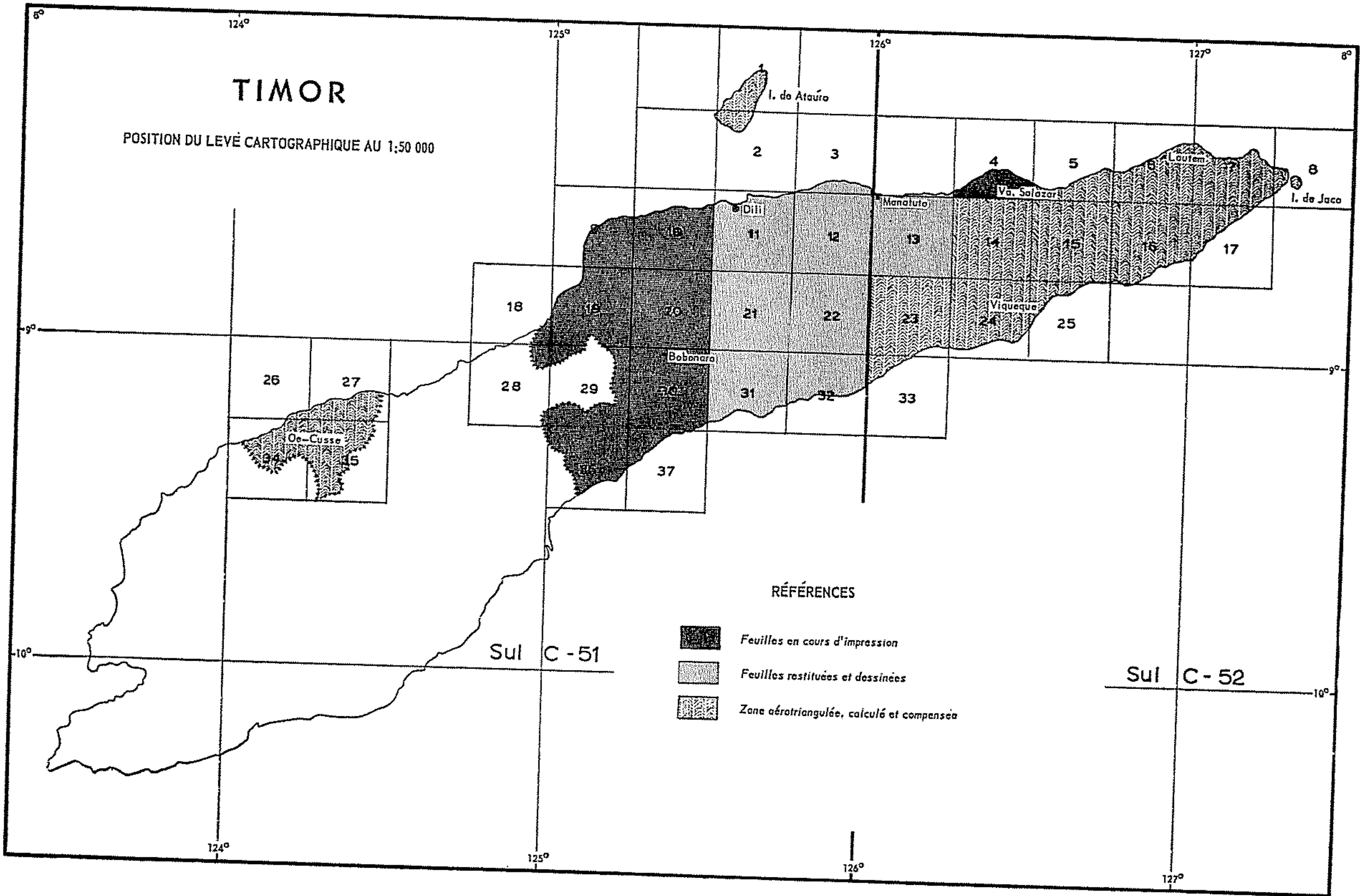


Fig. II—Portugal: Status of cartographic survey of Timor at 1:50,000 scale

CARTOGRAPHIC WORK IN MALTA

Paper presented by Malta[1]

Malta is composed of three islands: Malta, Gozo and Comino, having an area of approximately 120 square miles. The strategic position of the Maltese islands at the crossroads of ancient civilizations, the settlement in Malta of some of the most cultured peoples of their times and the presence in Malta of renowned military engineers, brought over by the Order of St. John during their long stay on the island, afforded ample opportunities for the practice of map-making, and that art had reached a very refined stage in Malta centuries before modern methods and equipment had perfected the process to what it is today.

Prior to independence, the surveying of Malta was largely the responsibility of the British services established in the islands. The first recorded survey of Malta carried out in conformity with classical practice was commenced by the Government of Malta in the 1880s. That survey, consisting of a series of triangles with very short sides, covered the whole of Malta and Gozo, and formed the framework of the 25 inch and 6 inch cadastral survey of the islands. The survey took some twenty years to complete, and the maps produced were in use by the civil government until the 1950s.

Simultaneously with this survey, but independently of it, the Hydrographic Department of the Royal Navy embarked on a similar task in 1893, concentrating rather on the defence aspects of the exercise than on the civil requirements.

During the 1930s, when the military authorities felt the necessity of bringing the topography up to date, it was found that the two triangulations did not fit to perfection, and personnel from the War Office were dispatched to Malta to tie in sufficient points in the old triangulations to recast the whole network into a new grid.

Soon after the Second World War, when development necessitated the remapping of the country, the task was taken in hand by the United Kingdom Directorate of Overseas Surveys in conjunction with the Public Works Department; making use of aerial survey and photogrammetry, a revision of the old series of maps was produced as a stop-gap. A completely new edition is now in the process of compilation.

With regard to general survey in connexion with the preparation of large-scale and detailed surveys for schemes and projects (in contrast to small-scale mapping) the conventional method of land survey is used in Malta; in view of the size of the island and of the fact that it has already been mapped, it would be uneconomical to adopt photogrammetric equipment.

[1] The original text of this paper appeared as document E/CONF.52/L.132.

CARTOGRAPHIC ACTIVITIES IN IRAN

Paper presented by Iran[1]

The National Cartographic Centre, Supreme Command, is generally responsible for all mapping in Iran, covering ground and air surveys, cadastral mapping and training of personnel.

Progress achieved since the Manila conference in 1964 is described below.

Geodetic survey

First- and second-order control has been established over 200,000 km^2.

Aerial photography

Four photographic aircraft (Aero-Commander) have been purchased and equipped with Wild RC8 cameras.

Five hundred thousand km^2 have been photographed at 1:20,000 for various development projects, including feasibility surveys for dam, railway and road construction, and for cadastral survey.

1:50,000 mapping

Approximately 70,000 km^2 have been mapped, with 10 m contours.

1:20,000 mapping

Six hundred and fifty thousand hectares have been mapped for development in the Kazvin area, near Teheran, with contours at 2 m intervals.

1:5,000 mapping

For irrigation purposes, 800,000 hectares have been mapped, with 1 or 0.5 m contours.

Urban mapping

Urban maps have been revised for 100 cities, and 280 towns have been mapped at 1:2,000 or 1:2,500.

Road and railway mapping

Two thousand km have been mapped, with contours at 2 m intervals.

Cadastral mapping

A pilot project over 250,000 hectares has been completed by photogrammetric methods.

Besides the activities of the National Cartographic Centre, geological mapping has been carried out by the Geological Department of Iran, and the Geographical Section of the Imperial Army of Iran has produced extensive mapping at 1:250,000 and 1:50,000 scales.

A Survey School, under the direction of the National Cartographic Centre, provides training in mapping and surveying. This institution trains cartographic personnel for all government bodies. Two courses of study are provided, one for geographical engineers, the other for surveyors. During the period under review, twenty persons were trained as geographical engineers and 100 as surveyors.

[1] The original text of this paper appeared as document E/CONF.52/L.135.

STATUS OF HYDROGRAPHIC SURVEYS AND OCEANOGRAPHIC RESEARCH IN INDONESIA

Paper presented by Indonesia[1]

Introduction

The Republic of Indonesia consists of 13,667 islands, 931 of which are inhabited. It is situated from 97° to 141° east and from 4° north to 11° south.

The land area is 1,905,000 km^2 and the shore length is 311,000 km, while the area of territorial waters is 3,005,000 km^2.

As Indonesia is a maritime country, the function of hydrographic surveying and oceanographic research is very important.

The agencies responsible for hydrographic surveying and oceanographic research are: the Indonesian Naval Hydrographic Directorate, concerned mainly with hydrographic surveying, marine safety and physical oceanography; the Institute of Marine Research, concerned mainly with marine biology and physical and chemical oceanography, and the Marine Fisheries Research Institute, concerned mainly with marine fisheries biology and biological oceanography.

Hydrographic surveying

Except for a part of Aru's waterways, navigational charts for all Indonesian waterways are available. The present total of charts is 358; owing to the relatively rapid changing of shore conditions, it is felt necessary to make periodic charts for certain areas, especially waterways that are frequently navigated. Owing to the technical progress which has resulted in the construction of vessels of very large tonnage, with modern navigational equipment, greater accuracy in chart-making is necessary. The present navigational charts for some regions which are to be developed are out of date.

Wide rivers in Kalimantan, Sumatra and Irian, which are increasingly important for navigation of big and medium vessels, are becoming the main transportation routes for the economic development of those areas. Certain rivers, of which navigational charts are in existence, need accurate periodic surveys, owing to rapid alteration in either shape or profile.

Physical and chemical oceanography

Tide and current

For navigational purposes, shore front installations and industries, irrigation, hydro-power, etc., knowledge of tides and current conditions is needed.

Although the data on tides and currents, especially near the shore, have been supplemented by tidal and current prediction, tide and current observations should be conducted intensively in line with the technical development that requires higher accuracy.

Salinity

Salinity observations have been effected throughout Indonesia, especially surface salinity.

Surface temperature has been observed and recorded throughout Indonesia.

O_2 has been observed and recorded throughout most of Indonesia.

Phosphate has been observed and is being recorded, especially in the waters around Java and in the Indian Ocean.

Bathythermographic observations have been few owing to defective equipment.

The new research vessel, *RI Burudjulasad* (1966), is equipped with a Kelvin Hughes deep-sea echo-sounder, but the instrument's precision is not adequate. The *RI Jalanidhi* (1963), built in Japan, has a Japanese deep-sea echo-sounder which is out of commission, although it has been frequently repaired. It is intended to equip the vessel with a Kelvin Hughes precision deep-sea echo-sounder in the course of 1967.

Geomagnetic, seismic and gravity surveys

Through lack of equipment and experts in the field, such surveys in the sea have not been conducted.

Primary productivity and plankton

Primary productivity on the sea surface has been observed through most Indonesian waters, and has been recorded from surveys carried out by Indonesian and foreign vessels.

Chlorophyll of phytoplankton has been recorded in waters around Java.

Phytoplankton spread is being investigated in the Java Sea.

Biology

Inventory is made of a variety of marine organisms: algae, molluscs, coral, fish, etc. Exploration and pre-exploitation have been made into trial for algae in Sumbawa Island.

Those that have our attention for exploitation are molluscs in Arafura waters; pearls; sea cucumber and fisheries in the Maluku Islands.

Work programme

Electronic surveying

Owing to the higher standards required for charts as a result of technical progress and regional development, accuracy must be increased in sounding and in position. Since 1963 the Indonesian Naval Hydrographic Directorate has used tellurometers.

In 1967, the Hydrodist will be introduced to determine echo-sounding positions with the necessary accuracy. The use of this instrument for off-shore surveys, however, cannot achieve good results, because its range is less than 40 km. The use of Decca-Hi-Fix, Decca-Survey, Loran-C, Toran or other position equipment for oceanographic observations will be very valuable, especially in prospecting natural resources in the sea bottom.

Resurveying

This is required in waterways which are much frequented by shipping and in waterways whose profiles and shapes have changed.

[1] The original text of this paper, submitted under agenda items 6 and 16, appeared as document E/CONF.52/L.136.

Tide and current observations

These need to be intensified. The Naval Hydrographic Directorate is setting up thirty automatic tide gauges throughout Indonesia.

Bathymetry

The Naval Hydrographic Directorate has a programme for carrying out bathymetric measurements throughout Indonesian waters.

Kurosjiwo extension

Indonesia is interested in, and willing to take part in a Kurosjiwo extension programme of the Inter-governmental Oceanographic Commission of UNESCO with one of the Indonesian oceanographic vessels.

National Oceanographic Data Centre

A data centre for all matters relating to oceanography will be established in Djakarta in 1967.

Shortages

As a developing country, surveying research is felt to be very necessary. However, shortage of equipment, vessels, experts and funds makes it impossible to carry out the necessary work. The most urgent needs in this field are for:

Equipment: observation instruments, measuring instruments, sampling and laboratory equipment, etc.;

Training: postgraduate studies and other training for technicians, oceanographers and scientists in every branch of oceanographic science;

Assistance: in the form of oceanographic experts in various fields, especially in physical and dynamic oceanography.

CARTOGRAPHIC ACTIVITIES IN NORWAY

Paper presented by Norway[1]

It would hardly be right to report on the last three years' work of surveying and mapping in an area on the other side of the planet, under natural and climatic conditions so different from those prevailing in the Asian and Far Eastern region that the figures given would have little meaning. Instead, a sketch will be attempted of the difficulties confronting surveying and map-making in Norway, and how they can be overcome with the help of modern techniques. On this point Norway's experiences might be of some use even in a region so far distant from it.

Although Norway has one of the oldest survey organizations in the world, dating from 1773, there was always, right up to the period following the Second World War, an unfortunate discrepancy between overwhelming tasks and totally insufficient resources. An area larger than the British Isles had to be mapped with the resources of a population less than one-tenth of the British Isles, and this under extremely adverse natural conditions: the country snowbound and, therefore, field work impossible for a good half of every year; a country 1,500 miles long and at one place only 3 miles across; a coast so indented that the total coastline would be of the same length as that of the Australian continent; a country behind that coast so rugged, with mountain peaks and glaciers, that each surveyor had to be not only a mathematician and a cartographer, but at the same time an accomplished alpinist and polar explorer. Five days a year are suitable for aerial photography in the southern part of the country; in the north not even that.

Norway's problem was in the last instance insoluble. A topographic map series at 1:100,000 started in 1870 had small chance of being completed by 1970.

It has been my good fortune in the last twenty years to see a technical revolution save us, and I shall name some of the decisive factors: aerial photography, electronic computers, trilateration with tellurometer; helicopter transports and photogrammetric scribing, that is, direct scribing on coated plastics in stereoplotters, thus saving the drawing, fair-drawing and photography.

A few figures will show the difference this has made.

A good fifty years were needed to finish the first-order triangulation over two-thirds of the country. The last—and by far the most difficult third—is now being completed in four or five years.

As regards lower order triangulation, in 1945 there was a total of some 2,000 trigonometrical points in the country; today nearly 3,000 trigonometrical points are observed and computed each year.

Before and after the Second World War, an average of some 3,000 km^2 at 1:50,000 were surveyed each year; today the average is between 8,000 and 12,000 km^2.

In the 1940s, Norway managed with great difficulty to publish three sheets per year of its main topographic map series. In the last ten years, seventy sheets of the main series at 1:50,000 have been published and this year there are good hopes of adding fifty more sheets, bringing the total up to 120, one-third of what has been planned so far.

Norway's facilities for map reproduction are still inadequate, but very welcome help is received from the United States Army Map Service, which reproduces on an average one-half of Norway's total number of sheets.

Moreover, in the years since the Second World War, the precise levelling has been finished, for a time at least, and the country has been covered with a fairly dense net of gravity stations, including the northern half of the European calibration base; satellite observations are now being started. Magnetic mapping has been immensely forwarded by the airborne mapping made by the Dominion Observatory of Canada in 1965.

Norway has in the main finished its quota of the IMW and ICAO map series. It has started remaking them from a common basic topographic manuscript in accordance with the new specifications determined in Bonn in 1962.

Quite recently, large-scale mapping at 1:5,000 has also been started. The organization for this is decentralized, the provinces being responsible for mapping, private firms undertaking photogrammetric compilation, and three government organizations furnishing geodetic control,

[1] The original text of this paper, prepared by K. Gleditsch, Director, Geographical Survey of Norway, appeared as document E/CONF.52/L.139.

photographic coverage, property boundaries and evaluation of soil, a check on the work of the private firms and finally map-printing. This apparently haphazard arrangement has now functioned for two years and has at least had the healthy effect of making each participating agency extremely anxious that other agencies should not get ahead of it.

It should perhaps be mentioned that some Norwegians have worked as experts in Asian and African countries. At present one is working in Afghanistan and three in Kenya.

CARTOGRAPHIC PROGRESS IN THE SYRIAN ARAB REPUBLIC

Paper presented by the Syrian Arab Republic[1]

Geodetic operations

Since 1964, complementary geodetic surveys have covered 4,600 km^2 of the country, or eight sheets at 1:50,000. Most of the Syrian territory has been covered by basic control, and in particular the part proposed for the compilation of the base map. However, there still remain certain desert and frontier areas which require basic control work.

Geodetic surveys are carried out using Wild T2 instruments for the complementary survey, and Wild T3 for the basic survey, and the results obtained have been very satisfactory.

The tellurometer will be used especially to place the geodetic network on a solid basis; furthermore, its use is foreseen in desert and border areas, as well as along the Syrian coast, when traversing methods are used. Tellurometer methods for the desert are under study and will almost certainly be used to eliminate almost completely all second-order surveys in favour of first-order surveys.

Geodetic computations are made by using the method of variation of co-ordinates. A searching, thorough study is being made of the possibility of introducing an electronic computer in the Geodetic Computing Office. This study will take into account all geodetic computations to be programmed as well as preparation of control for stereoplotting, aerotriangulation, traverse computations and computations of adjustments of the precise levelling net.

Electronic computers will be in use very shortly.

Precision levelling

Precision levelling of all orders was carried out over a distance of 3,300 km. At present, levelling covers almost all the areas already covered by the base maps, as well as those to which base-map coverage is being extended at the present time.

Levelling operations will be undertaken in the Syrian desert in the near future, and preliminary programmes have been worked out to keep pace with aerial coverage for small-scale maps of the region.

N3 instruments are used to observe first- and second-order loops; NK2 instruments are used to observe those of the third- and fourth-order.

It is also planned to use automatic level instruments for complementary levelling; this will be done when the various reports from countries using those instruments have been studied in detail.

Adjustment of the net by loops or blocks will be carried out by electronic computers.

[1] The original text of this paper, submitted in French, appeared as document E/CONF.52/L.140.

Work is now in progress to install an automatic tide gauge in the Latakia area.

The planned installation of another automatic tide gauge in the Tartus area, some 100 km to the south, is now under study.

Aerial photography

Aerial photography missions are at present being carried out in an Ilyushin 14 aircraft. The following photographic equipment is used: plate camera with Aquilor lens, focus 210 m/m; plate camera with Aquilor lens, focus 125 m/m; film camera with Aquilor lens, focus 125 m/m. The recent acquisition of a wide-angle Wild RC 9 camera has led to re-examination of the possible equipment of an aircaft other than the Ilyushin 14; this study is nearly completed, and the equipment will be put into service in the near future.

Photogrammetry

Large-scale plotting

At present, plotting is done from 18 × 18 cm negative plates.

A thorough study is being made of the use of 23 × 23 cm diapositives, taken by cameras such as the RMK or the RC 8 with 150 mm focal length. Use will be made after the following modifications: reduction of the 23 × 23 diapositive to 18 × 18 cm, and 150 mm focal length to 125 mm by means of a U4 reduction device; pinpointing and adjustment of distortion as compared with Poivilliers equipment of 125 mm focal length by use of a correcting plate.

Very large-scale plotting

The possibility is now under study of the advantageous use of the tellurometer for the stereoplotting of aerial photographs in urban mapping.

Small-scale plotting

Plotting work for the map at 1:50,000 of the Syrian desert has already begun. Aerial 18 × 18 cm photographs, which are already in existence for nearly all the desert regions, are at the scale of 1:80,000 and were taken with lenses with 70 mm focal length. We proceed as follows:

Reduction by U4 reduction equipment of the 18 × 18 cm format to 12 × 12 cm and the focal distance from 70 to 44 mm;

Elimination of the distortion of the camera lens, as well as of the curvature of the earth using the appropriate correcting plate; this takes place simultaneously with the reduction process;

Acquisition of homogeneous diapositives using the U4;

Aerial triangulation on diapositives using an A9 apparatus with sufficient accuracy for plotting at 1:50,000 on B9 plotting equipment.

Topography

The present topographical policy is, first, to complete the stereoplotting of the base map and, secondly, to compile very large scale maps requested by different organizations.

Cartography

The method of scribing on glass has been adopted with great interest; Syrian technicians prepare the coating in its entirety. This method is applied in conjunction with the classical method of drawing on reinforced paper.

The main cartographic work at the present time is the compilation of a base map and the generalizing of the small-scale maps resulting from it. However, all orders for maps and plans at varying scales placed by different organizations and companies will be fulfilled.

AGENDA ITEM 7

Reports on progress in matters which formed the basis of the resolutions or recommendations of the last conference

PRELIMINARY REPORT

Paper presented by Thailand[1]

Since the fourth United Nations Regional Cartographic Conference for Asia and the Far East, Thailand has fulfilled certain parts of the recommendations of various resolutions adopted on the basis of the availability of manpower and financial support, as outlined below.

The preparation for establishing a map information office for the region under resolution 3[2] included moving the office into a building designated for it. The office has begun to function as a national office but will eventually be modified to that of a regional office.

In accordance with resolution 14,[3] the Royal Thai Survey Department has been undertaking the revision of topical maps. The department has been giving support to various governmental units in producing topical maps of relevant interest to them. The National Statistics Office has also been working on topical maps.

In pursuance of resolution 15,[4] the Royal Thai Survey Department has been collecting data for the base maps of the regional economic atlas. The work has progressed considerably.

Under resolution 17,[5] a group of experts on geographical names has been set up and rules of transliteration and romanization have been prepared. The Royal Thai Survey Department, which will take part in the United Nations Conference on the Standardization of Geographical Names, has since 1963 forwarded relevant documents to the United Nations as contributions in preparation for the conference.

[1] The original text of this paper appeared as document E/CONF. 52/L.7.

[2] *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 1 (United Nations publication, Sales No.: 65.I.16), pp. 9 and 10.

[3] *Ibid.*, p. 12.

[4] *Ibid.*, p. 12.

[5] *Ibid.*, p. 13.

STATUS OF THE MAP INFORMATION OFFICE

Paper presented by Thailand[1]

This report is concerned with the progress made in the formation of the Thai Map Information Office in accordance with resolution 5 of the Third United Nations Regional Cartographic Conference for Asia and the Far East.[2] Although a similar report was presented at the Fourth United Nations Regional Cartographic Conference for Asia and the Far East,[3] this progress report is presented in the hope that further co-operation will be forthcoming from the various countries concerned.

A new building has been constructed for the Thai Map Information Office, which has been organized as a national agency with a framework, permitting its expansion into a regional map information office. Thailand is ready to modify the office to meet regional needs as soon as further data and material are received from the various countries of the ECAFE region.

The documents so far collected by the office include maps, charts, national atlases and technical reports on the mapping activities of Thailand. Contributions from other countries make up only 5 per cent of the documentation now available. It is understandable that, because of the short time that the office has been in existence, many countries have not been able to send data and material. It should be recalled here that, at the previous two conferences, all the participants expressed their willingness to co-operate in this endeavour.

The Government of Thailand asks all the countries to consider resolutions 3, 9 and 11 adopted at the fourth conference,[4] and to forward all data and material to the following address: Map Information Office, c/o Royal Thai Survey Department, Bangkok, Thailand.

The Thai Map Information Office is planning in the near future to issue reports on the types and numbers of documents which would be available at the office every three months. Copies of these reports will be sent to all interested countries, and especially to countries of the region.

[1] The original text of this paper appeared as document E/CONF. 52/L.10.

[2] *Third United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 1 (United Nations publication, Sales No.: 62.I.14), p. 9.

[3] *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 2 (United Nations publication, Sales No.: 66.I.3), pp. 95 to 97.

[4] *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 1. (United Nations publication, Sales No.: 65.I.16), pp. 9 to 11.

In case any country of the region cannot at present afford to part with any documents, it is suggested that at least the title and a brief summary should be forwarded to the office. Such information will in turn serve as a reference document.

It is realized that, to operate a map information office of this type with efficiency, adequate personnel and equipment are needed. Thailand has committed itself with dedication to this activity, since it feels confident that such an office is of interest to all the countries of the region and could especially help in the development of surveying and mapping techniques and methods to advance economic development projects in the region. The Government of Thailand expects formally to request the United Nations for technical assistance in this project, as was recommended in resolution 3 of the fourth conference.[5]

The Government is at present in consultation with the United States Agency for International Development (AID) to assist the Survey Department in adopting an Engineering data automated system for storage and retrieval for use by the office.

[5] *Ibid.*, p. 9.

STATUS OF THE REGIONAL ECONOMIC ATLAS FOR ASIA AND THE FAR EAST

Paper presented by Thailand[1]

The Royal Thai Survey Department, in accordance with resolution 15 of the Fourth United Nations Regional Cartographic Conference for Asia and the Far East,[2] began work on the regional economic atlas for Asia and the Far East in October 1965. A request for a budgetary allotment for the fiscal years 1966–1967 was presented to the Thai Government for the purpose of continuing the project.

Although the Survey Department has found solutions to many problems related to the projects, several remain which the department feels should be discussed and considered by the participants in this conference.

Attention is drawn to the operative part of resolution 15, sub-paragraph (*a*), recommending that all interested countries co-operate with the Government of Thailand by supplying source materials to the Royal Thai Survey Department as soon as possible and not later than October 1965. In pursuance of that resolution, the Survey Department sent a memorandum to all interested countries and countries of the region asking them for source material.

To date, eight countries of the region have contributed source material. One sent its contribution immediately after the fourth conference, while the other seven responded to the memorandum which was sent by the department.

Certain countries informed the department of the types of maps available and sent price lists for such maps. They have not so far contributed any source material within the spirit of the resolution of the last conference.

It is difficult to begin on any particular topical map for the economic atlas for Asia and the Far East because of the lack of sufficient source material. In spite of this tremendous difficulty, the Survey Department will endeavour to fulfil the aims of the resolution and again ask the countries of the region and other interested countries for closer co-operation.

The department expects to formulate requests for technical assistance from the United Nations for the compilation and reproduction of the atlas as recommended in sub-paragraph (*c*) of the resolution and considers that the participants in this conference should give the matter further consideration and support.

[1] The original text of this paper appeared as document E/CONF. 52/L.12.

[2] *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 1 (United Nations publication, Sales No.: 65.I.16), p. 12.

SUMMARY OF AUSTRALIAN ACTION ON THE RESOLUTIONS AND RECOMMENDATIONS OF THE LAST CONFERENCE

Paper presented by Australia[1]

Map Information Office (Bangkok)

Copies of all available topographic maps at 1:250,000 and smaller scale, and a copy of the National Resources Atlas, have been forwarded to the office.

Establishment of baselines to calibrate electronic and electro-optical instruments

The procedure has been to carefully check frequencies prior to and after each year's operation and to check-measure a particular line with a great variety of instruments. The latter procedure provides a means of calibration while analyses of the many results obtained indicate that it also provides a standard base line of considerable accuracy.

Calibration of crystal frequencies in electronic distance measuring instruments

Adequate facilities are available and regular frequency checks are carried out as standard procedure.

Establishment of additional world gravity base stations in the region

Gravity bases in the Western Pacific calibration lines have been established at Darwin, Mt. Isa, Cairns, Townsville, Mackay, Rockhampton, Maryborough, Brisbane, Grafton, Kempsey, Sydney, Canberra, Albury and Melbourne. These, together with those already established by pendulum surveys, form bases from which lines of stations extending from east to west across the continent have been established.

The stations are tied to the world gravity base net through the national gravity base in Melbourne.

[1] The original text of this paper appeared as document E/CONF. 52/L.78.

ESTABLISHMENT OF A REGIONAL MAGNETIC OBSERVATORY FOR CALIBRATION OF MAGNETIC SURVEYING INSTRUMENTS

The geophysical observatories at Port Moresby, Papua; Mundaring, Western Australia and Toolangi, Victoria, maintain calibration equipment for the adequate control of continuously recording magnetic variometers. The same equipment can be used to calibrate field magnetic survey equipment.

ECONOMY OF AERIAL SURVEYING AND MAPPING

These matters are currently under consideration in connexion with Australia's proposed ten-year 1:100,000 scale topographic mapping programme, but no definite information is available for dissemination at this stage.

It is planned to recommence a national mapping bulletin that will serve a useful purpose in the dissemination of details of the technical processes that are found most suitable and productive for Australian conditions.

It is hoped that the papers prepared for this conference will help in this direction also.

STANDARD SCALES FOR BASE MAPS

Decimal scales are gradually being introduced for maps at 1:50,000 and larger scale.

The bulk of Australia will be mapped at a basic scale of 1:100,000 (this was not a scale recommended at the fourth conference but is considered best suited to Australian conditions).

Other standard scales are 1:250,000 and 1:1,000,000.

EXCHANGE OF MAP DESIGN

No action has been taken on this yet, as the Australian 1:100,000, 1:250,000 and 1:1,000,000 map specifications are being completely revised. When this revision is complete, details will be distributed.

SUPER-WIDE-ANGLE PHOTOGRAPHY

The Wild RC 9 camera is being used extensively throughout Australia. Six such cameras are already in use and several commercial companies have others on order.

TOPICAL MAPS AND NATIONAL ATLASES

Australia would be glad to help the proposed committee as much as practicable.

REGIONAL ECONOMIC ATLAS FOR ASIA AND THE FAR EAST

As a first step, a full set of map sheets (and commentaries) of the Atlas of Australian Resources (mainly at 1:6,000,000 scale) has been sent to the Royal Thai Survey Department.

INTERNATIONAL MAP OF THE WORLD ON THE MILLIONTH SCALE (IMW)

Australian activity in respect of the IMW and the WAC at 1:1,000,000 scale is the subject of a special paper for this conference.[2]

GEOGRAPHICAL NAMES

A summary of Australian activity has been submitted as a paper to this conference.[3]

It is expected that Australia will be represented at the United Nations Conference on the Standardization of Geographical Names.

USE OF THE METRIC SYSTEM IN NAVIGATION CHARTS

There is no intention at present to convert Australian hydrographic charts to metric measurements.

[2] See below, under agenda item 11.

[3] See below, under agenda item 15.

PROGRESS REPORT

Paper presented by China[1]

With regard to material for the compilation of economic maps, the Government is working on the decision. As soon as it is available, it will be sent to the Map Information Office, Bangkok.

In compliance with resolution 14 of the previous conference,[2] a set of the National Atlas (editor-in-chief, Chang Chi-Yun) has been compiled and published, as shown at the exhibition at the fourth conference.

As China is inhabited by people belonging to various ethnic groups (although racial minorities in the country comprise only 4 per cent of the total population), the standardization of geographical names in China and the transliteration of Chinese are still in their formative stage. The modified Wade-Giles system now used for transliteration in topographic maps is by no means perfect, and is being revised with a view to possible improvement.

[1] The original text of this paper appeared as document E/CONF. 52/L.110.

[2] *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 1 (United Nations publication, Sales No.: 65.I.16) p. 12.

PROGRESS REPORT

Paper presented by Japan[1]

RESOLUTION 3: MAP INFORMATION OFFICE

The Geographical Survey Institute (GSI) and other governmental agencies of Japan have sent or are sending a variety of material, including maps, charts and reports, to the Map Information office in Thailand.

RESOLUTION 4: ESTABLISHMENT OF BASE LINES FOR CALIBRATING ELECTRONIC AND ELECTRO-OPTICAL INSTRUMENTS

It is difficult to find a place wide enough for the establishment of a base line of over 10 km for calibrating electronic and electro-optical instruments in flat areas in Japan, because such areas are densely populated. Existing base lines have not been reobserved for the past ten years. It is possible, however, to establish a short base line and extend

[1] The original text of this paper appeared as document E/CONF. 52/L.137.

it by triangulation. If two or more base lines can be settled at an adequate location and from a base-line network, a long calibration base and test observation field may be achieved. As a first step, a base line about 1 km in length was established at Akita, a western suburb of Tokyo. Its length was observed with four invar wires with a mean square error of less than 1 mm. This is accurate enough for calibrating the instruments used in second-order traverse surveys. Observations with several kinds of electronic distance measuring instruments are also made.

Resolution 5: Calibration of crystal frequencies in electronic distance-measuring instruments

The final accuracy of the observed length with electronic distance instruments often depends on the modulating frequency of the crystal installed in the instrument and on its stability.

At the present time, several such instruments, such as the geodemeter (models II and IV), the tellurometer (models 1, 2 and 3) and the electrotape are used for field work in Japan. The geodemeter is used mainly to determine the length of the sides in the first-order triangulation network. Its standard modulating frequency is checked several times during field observations by comparing it with that of the carrier of the standard wave, JJY, which is transmitted continuously throughout the day.

Regarding other such instruments, no legal regulation on the checking of frequency exists. As to the instruments belonging to the GSI, a frequency check with a highly stable frequency standard is usually made once a year. For instruments of private companies, the GSI suggests periodical frequency checks.

Resolution 6: Establishment of additional world gravity base stations in the region

The International Gravity Commission and the International Association of Geodesy designated five international first-order gravity stations in the region, namely, Kyoto, Singapore, New Delhi, Melbourne and Christchurch. With a view to establishing a world-wide gravimetric network, the Western Pacific calibration line project has been initiated.

Resolution 7: Establishment of a regional magnetic observatory for calibration of magnetic survey instruments

In Japan, five magnetic observatories are operating continuous magnetic observations with absolute value. They are Kakioka, Memambetsu and Kanoya, belonging to the Meteorological Bureau, Shimosato, belonging to the Hydrographic Office, and Kanozan, belonging to the Geographical Survey Institute. At the geodetic observatory of Kanozan, for example, a set of magnetic variometers has been installed for continuous observation of declination, horizontal component and vertical component. Furthermore, a set of proton precision magnetometers is used to obtain the absolute values of total force and horizontal component and the results will give the base-line values of the continuous observations. Similar observations are made at the other stations. These continuous observations are employed for reducing field observation values.

Resolution 8: An international tsunami warning system

No official international tsunami warning system exists at present. The National Meteorological Agency of Japan, however, operates a tsunami warning service for Japan in co-operation with the United States and the USSR. When a big earthquake occurs near Japan, the agency announces a tsunami warning by JMG teletype transmission to the coastal areas concerned. At the same time, this warning is directly communicated by the United States Armed Forces Control Centre to the Honolulu centre, which is the central organization for the tsunami warning system in the United States; it is also broadcast by meteorological radio teletype transmission, which may be received by the USSR and others. The agency also utilizes any warnings given by other countries such as the United States and the USSR for their own warning services. These systems are recognized and supported by the World Meteorological Organization (WMO). The agency participated in the tsunami meeting in Honolulu in 1965.

Resolution 9: Economy of aerial survey and mapping

The cost of aerial survey and mapping is a major concern in Japan, but it is now hardly possible to derive any reliable figures from the available data. A great many factors influence the cost of photogrammetric production, such as type of terrain, area, weather, condition of air and so on. Despite these difficulties, much attention is paid to this problem, so that scientific management may be devised for map production.

An attempt is now being made to work out this problem as one of the activities of the Japanese Society of Photogrammetry.

Resolution 10: Standard scales for base maps

The Geographical Survey Institute has issued topographical maps at 1:25,000 and 1:50,000 and compiled maps at 1:200,000, 1:500,000, 1:1,000,000 (IMW) and 1:2,500,000. These maps are available not only for Japan but also for foreign nations at set prices without any limitation.

Resolution 11: Exchange of map design

The Geographical Survey Institute has sent technical information about its newly designed map specifications for the 1:25,000 topographical map series and the newly prepared sheets of IMW for Japan, with copies of sheets to the Map Information Office in Bangkok, Thailand.

Resolution 12: Super-wide-angle photography

The super-wide-angle camera is not used in Japan for the following reasons: (*a*) Japan is a mountainous country and gradients of hillside often exceed 30 degrees, preventing effective use of the super-wide-angle camera; (*b*) Japan already has sufficient numbers of wide-angle and normal-angle cameras, and most plotting instruments are fitted only for wide-angle and normal-angle cameras. These instruments are adequate to the demands for aerial survey.

Resolution 13: Aerial photo-interpretation

The Geographical Survey Institute, the Geological Survey and the Forestry Agency offer annual courses in this field as one of the international training courses on surveying and mapping under the Colombo Plan and ECAFE.

Resolution 14: Topical maps and national atlases

Many kinds of topical maps have been prepared by governmental or prefectural agencies for their own administrative purposes.

RESOLUTION 15: REGIONAL ECONOMIC ATLAS FOR ASIA AND THE FAR EAST

Japan has been co-operating with the Royal Thai Survey Department by supplying the necessary source maps and material.

RESOLUTION 16: INTERNATIONAL MAP OF THE WORLD ON THE MILLIONTH SCALE

See "Cartographic activities in Japan, 1964–1966", and "Cartographic activities in Japan (hydrography)", tables 2 and 3.[2]

RESOLUTION 17: GEOGRAPHICAL NAMES

The Geographical Survey Institute and the Japanese Hydrographic Office have been co-operating in unifying geographical names used in national base maps and original charts and publications. Some of the results have been adopted in the IMW series in Japan.

RESOLUTION 18: HYDROGRAPHIC TRAINING CENTRES

A hydrographic training centre has not yet been established in Japan. However, the Japanese Hydrographic Office is accepting applications for hydrographic training made by trainees for on-the-job training. For instance, five trainees taking part in the UNESCO second regional shipboard training course, held in October 1966, have received training in physical oceanography aboard the survey ship *Meiyo* of the Hydrographic Office. One of them, a Korean, continued training at the office until February 1967. Further, under the Colombo Plan, it is planned that the office will accept a surveyor of the Thai Hydrographic office for eight months' shipboard training in physical oceanography commencing February 1967 and, under the United Nations Development Programme, the chief of the Chart Section of the Hydrographic Office of the Republic of Korea for two months' study in chart construction, starting August 1967.

[2] See above, under item 6.

RESOLUTION 19: USE OF THE METRIC SYSTEM IN NAVIGATION CHARTS

In 1920, the Japanese Hydrographic Office decided to adopt the metric system for use in its original charts in accordance with the recommendation of the International Hydrographic Conference. At present, the system is used in all original charts issued by the office. It is hoped that this system will be used internationally not only in navigation but also in all types of maps and charts as soon as possible.

It is worth mentioning that, in the recent North Sea fisheries chart series, published under joint agreements by the six participating countries of the North Sea Hydrographic Commission, one country which has not yet adopted the metric system in its navigation charts is newly compiling the series using that system.

It is a matter of urgency that countries using a non-metric system should carry out this recommendation as soon as possible, and use the metric system in new charts and new editions of charts which would eventually replace all non-metric system charts, even though such a change would require an enormous expenditure of funds and labour.

RESOLUTION 20: THE CO-OPERATIVE STUDY OF THE KUROSHIO (JAPAN CURRENT)

See "Cartographic activities in Japan (hydrography)".[2]

RESOLUTION 21: REGIONAL OCEANOGRAPHIC SURVEY OF A PORTION OF THE SOUTH CHINA SEA

Although the Japanese Hydrographic Office did not carry out an oceanographic survey specially for that purpose, the office included the survey in the oceanographic observation for the co-operative study of the Kuroshio carried out in a portion of the South China Sea in 1966. The data obtained are now being processed.

REPORT ON INDONESIAN AND AUSTRALIAN ACTIVITIES IN CONNEXION WITH THE SURVEY OF THE BORDER BETWEEN WEST IRIAN AND THE TERRITORIES OF PAPUA AND NEW GUINEA

Paper presented by Australia and Indonesia[1]

As a follow-up to talks between the Indonesian Foreign Minister and the Australian Minister for External Affairs held in Djakarta on 4 June 1964, Indonesian and Australian survey authorities have met on three occasions in connexion with the surveying and demarcation of the international border between West Irian and the Territories of Papua and New Guinea and these authorities are now actively engaged on the survey of the appropriate meridians.

At the first meeting, held in Djakarta from 31 July to 4 August 1964, it was agreed that a series of recommendations be submitted for the approval of the Indonesian and Australian Governments. The recommendations covered both the over-all programme which should be adopted and early measures to implement that programme. Specifically, they agreed that a joint Indonesian/Australian reconnaissance team should visit the border as soon as practicable to prepare the way for subsequent concurrent astronomical surveys by both countries.

[1] The original text of this paper, prepared by Pranoto Asmoro, Director of Topography (Army), Djakarta, Indonesia, and B. P. Lambert, Director of National Mapping, Canberra, Australia, appeared as document E/CONF.52/L.138.

Both Governments accepted the recommendations and the survey authorities met once more in Canberra from 21 to 24 May 1966 for the purpose of drawing up a detailed programme of survey work, considering questions of staffing, supply, transport and communications and fixing a time for commencement of operations.

At that meeting, it was agreed to recommend to the Governments that work should begin as soon as practicable and the hope was expressed that a reconnaissance of the various points along the northern part of the border where markers were to be placed and the necessary clearing of helicopter landing pads would begin by the middle of June. While recognizing that progress would be dependent on weather conditions, the meeting recommended that the six meridian markers be established at previously recommended sites from the north coast up to the headwaters of the Sepik river and, if practicable, a seventh station be established in the area of the Star mountains, by the end of the year.

It was also agreed that clearing and survey of the lines between those markers, and the establishment of a programme of work for survey and demarcation of the line to (*a*) The traverse to be measured between the Indonesian and Australian astronomical stations at each point should be to an accuracy of at least 1 part in 1,000;

(*b*) Agreement should be reached while the observing teams are still at the station as to the position of the meridian marker, and the mark placed;

(*c*) The traverses from the astronomical stations to the meridian marker should be calculated on the international spheroid;

(*d*) While copies of all observation records and computations would be exchanged, as long as agreement to within four seconds of arc for the position of the meridian marker was obtained, it would not be necessary for each team to check the other team's reductions and computations in the field;

(*e*) A personal equation correction should be applied to longitudes not observed with an impersonal micrometer eyepiece, of 0.09 seconds of time to the east;

(*f*) All longitudes should be corrected only for travel time of radio signals from their source and for personal equation where applicable;

(*g*) Observing teams should be free to select their own observation methods and stations for radio time signals;

(*h*) Latitude observations should be corrected for refraction only, those corrections to be according to pressure and temperature readings;

(*i*) Times for circum-meridian latitude observations need not be recorded on a chronograph tape;

(*j*) Checks of chronometer error by means of a chronoscope would be acceptable.

Supporting elements

18. *Aviation fuel, oil and lubricants*. Indonesia will be responsible for the provision of aviation fuel, oil and lubricants at Sukarnapura and Waris; Australia for their provision at Green river and at Telefomin.

19. *Communications*. Arrangements will be made for the establishment of direct radio telegraphic (morse code) communications between Sukarnapura and Port Moresby. There will be direct radio telephonic communication between each of these headquarters and their respective field teams. On 8 June, Sukarnapura will communicate with Port Moresby via Sydney for the purpose of establishing the direct link between Sukarnapura and Port Moresby and arranging a practical test of the link on 10 June. It is proposed that Port Moresby should operate with the call sign VJO6 on a transmission frequency of 9,380 kilocycles and a receiving frequency of 9,280 kilocycles. On 8 June, Sukarnapura will advise Port Moresby of proposed call sign and time schedules.

20. *Security*. It is recommended that the Indonesian security teams should bear responsibility for the protection of the survey teams from interference from West Irian and the Australian security teams should accept a similar responsibility in regard to the Territory of Papua and New Guinea. It is accepted that in practice it will be necessary for the leaders of security teams to act in close co-operation, and for security personnel to move freely as necessary within the area of survey operations.

Base facilities and movement arrangements

21. It is recommended that both countries should be able to use Sukarnapura for operations in connexion with positions 1–3, Waris for position 4, Green river for positions 5 and 6, and Telefomin for position 7. It is accepted that this may necessitate Indonesian movement through Imonda and Amanab to Green river.

Further meeting

22. It is recommended that, after completion of survey operations in respect to positions 1 to 6 (and, if possible, 7), survey authorities of Indonesia and Australia should meet again to arrange for continuation of the survey.

(*Signed*)	(*Signed*)
Pranoto Asmoro,	B. P. Lambert,
leader of Indonesian delegation	leader of Australian delegation

Annex III

REPORT OF MEETING BETWEEN INDONESIAN AND AUSTRALIAN SURVEY AUTHORITIES, HELD AT THE DEPARTMENT OF FOREIGN AFFAIRS, DJAKARTA, 31 JANUARY AND 1 FEBRUARY 1967, TO DISCUSS THE SURVEY OF THE BORDER BETWEEN WEST IRIAN AND THE TERRITORIES OF PAPUA AND NEW GUINEA

1. These discussions were based upon the recommendations of the Djakarta meeting of 4 August 1964 and the Canberra meeting of 24 May 1966, which had been agreed upon by the Governments of Indonesia and Australia.

2. Attendance:

Indonesia—Leader: Col. Ir. Pranoto Asmoro, Director of Topography (Army); Com. Wardiman, Director of Hydrography (Navy); Ir. J. Soenarjo, Institute of Technology, Bandung; Lt. Col. Suti Harsono (Air Force); Lt. Col. Tondomuljo (Supreme Operations Command); S. Hardjanto, Deputy Chief Commissioner of Police; Benimo Umar, Department of Foreign Affairs.

Australia—Leader: B. P. Lambert, Director of National Mapping; J. C. Macartney, Senior Surveyor, Administration of Papua and New Guinea; Captain F. T. Sherborne RAN, Naval Attaché, Australian Embassy, Djakarta; J. R. Burgess, Third Secretary, Australian Embassy, Djakarta.

3. At the meeting held on 24 May 1966 in Canberra it was decided that the first phase of the survey would be the marking of the meridians. Details were agreed upon for the marking of stations 1 to 6 and, if practicable, station 7.

4. The present meeting reports that the marking of the meridians at stations 1 to 6 inclusive has been successfully completed; and details of this marking are set out in the appendix.

5. The meeting reports that these surveys were carried out expeditiously with the utmost co-operation between the survey teams and commends the personnel of the survey teams concerned.

6. The meeting now recommends that the marking of the meridians at stations 7 to 14 inclusive be completed during 1967.

7. A similar programme of operations to that followed in 1966 is recommended, namely: (*a*) Joint reconnaissance; (*b*) Preparation of landing, camping and observation sites; (*c*) Survey operations; (*d*) Supporting elements.

Joint reconnaissance

8. The joint reconnaissance team will consist of the officers in charge of the respective survey teams and one officer from each country, and will assemble at Port Moresby at a mutually acceptable date between 1 and 10 May 1967. The actual date is to be arranged between Djakarta and Port Moresby.

9. The joint team will use for transportation a twin engine fixed-wing aircraft, to be supplied by the Australian team. An Australian helicopter will be available for use if required.

10. The joint reconnaissance team is to locate appropriate sites as near as practicable to the meridians for positions 7 to 14 inclusive; in order to assist in this operation, the Australian authorities will provide copies of air photographs of the immediate survey areas.

Preparation of landing, camping and observation sites

11. The procedures set out in paragraphs 9–11 inclusive of the report of the meeting of 24 May 1966 will be followed.

12. Immediately after the reconnaissance the clearing teams will commence preparing the site of station 8 and then prepare the other observing stations as required.

Survey operations

13. The procedures set out in paragraphs 13 and 17 of the report of the meeting of 24 May 1966 will be followed.

14. Immediately after the reconnaissance is completed, both survey teams (at minimum practical strength) will assemble at Ningerum, proceed to station 7 and commence operations.

15. The survey observing teams will then proceed to stations 8, 9, 10, 14, 13, 12 and 11, in that order.

16. At station 14, the middle of the mouth of the Bensbach river will be accepted as the centre of the line connecting the most protruding points of the high-water mark at the intersection of the banks of the river with the sea coast. These protruding points are to be jointly determined in the terrain, or, if this is not practicable, pinpointed on a vertical air photograph.

17. The survey observing teams will at each position:

(*a*) Establish astronomical stations;

(*b*) Carry out the necessary observations for the determination of latitude and longitude;

(*c*) Undertake the necessary computations;

(*d*) Mark the appropriate meridian in the terrain with a concrete pillar similar to that used for stations 1 to 6 or, in positions where materials for concrete cannot be readily transported, with a pre-fabricated aluminium marker having the same dimensions as the concrete pillars.

Supporting elements

18. *Administration and logistics.* (*a*) Arrangements should be made for the provision of visas for personnel of the field parties. The Indonesian team will obtain visas at the Australian Embassy, Djakarta, and the Australian team at the Indonesian Embassy, Canberra. Visas for team replacements will be arranged in Merauke and Port Moresby as required; (*b*) Each team is to arrange its own transportation and logistics support; this should not exclude mutual support in cases of emergency.

19. *Communications.* Arrangements will be made for the establishment of direct radio telegraphic communications between Merauke and Port Moresby. There will be direct radio communication between each of these headquarters and their respective field teams. On 2 May 1967, Djakarta will communicate with Port Moresby via Sydney for the purpose of establishing a direct link between Merauke and Port Moresby and also to nominate call signs, date, time and frequencies for a practical test.

20. *Security.* It is recommended that the procedures set out in paragraph 20 of the report of the meeting of 24 May 1966, be followed.

21. *Base facilities and movement arrangements.* It is probable that the Indonesian team will base its operations at Merauke, Tanah Merah and Boepoel, and that the Australian team will base its operations on Ningerum, Kiunga, Morehead and Weam. To facilitate the movement of both teams along the border, permission to use the above strips by both teams will be obtained when necessary.

Photogrammetry

22. It is recommended that the geodesics connecting the meridian markers should be located photogrammetrically and marked as accurately as practicable on air photographs.

23. It is expressly understood that this will be a preliminary location only, which will not prejudice subsequent marking on the ground.

24. For this purpose, the Australian authorities will supply paper prints and film diapositives to Indonesia.

25. Each country will then carry out an independent photogrammetric location.

26. It will be desirable to complete this operation as soon as practicable after the establishment of consecutive meridian markers.

27. As each country finishes the photogrammetric location of a geodesic, its results will be sent to the other country for comparison.

Next meeting

28. It is suggested that the survey authorities should meet again in Canberra during May 1968 for the purpose of agreeing on a final report to the Governments setting out the results of the joint survey of the meridians.

(*Signed*)	(*Signed*)
Pranoto ASMORO,	B. P. LAMBERT,
leader of Indonesian delegation	leader of Australian delegation

Appendix

JOINT INDONESIAN AND AUSTRALIAN SURVEY OF THE BORDER BETWEEN THE TERRITORIES OF PAPUA AND NEW GUINEA AND WEST IRIAN: BRIEF REPORT OF 1966 OPERATIONS

At the meeting of Indonesian and Australian survey authorities held at Canberra in May 1966, it was planned that the first six points on the meridian should be established in the first stage of the survey.

The Indonesian and Australian survey teams jointly commenced this work in June 1966 and successfully completed the necessary astronomical observations, and traverse to and subsequent erection of markers on the 141st meridian of east longitude as the six points. The total time involved was a period of twelve weeks, averaging one station per two weeks.

The survey was carried out in accordance with the recommendations laid down at the Canberra meeting, and the meridian markers placed after the two teams had reached agreement, within the prescribed limits of accuracy, at each position.

Copies of all observation data, traverses and calculations have been exchanged between the two teams.

At each station, a concrete marker was placed, consisting of a base 100 cm², surmounted by a frustrum 160 cm high and having a base 60 cm² and a top 40 cm².

The co-ordinates of the meridian markers placed are as follows:

Station No.	*Latitude (south)*	*Longitude (east)*
1	2° 35′ 39″	141° 0′ 0″
2	2 40 42	141 0 0
3	3 01 27	141 0 0
4	3 14 02	141 0 0
5	3 55 22	141 0 0
6	4 08 41	141 0 0

AGENDA ITEM 8

Review of techniques and recent developments in surveying and mapping

*(a) Control surveys**

THE PLANE CO-ORDINATE SYSTEM IN LAND SURVEYS IN THE PHILIPPINES

Paper presented by the Philippines[1]

Plane-table surveying is used in land surveys in the Philippines in connexion with the granting of land titles to private individuals by the Government. For about six decades, this system has been accepted in land surveys in the country. The assumption that a small portion of the curve surface of the earth is plane will not be good beyond certain limits.

As surveys within the jurisdiction of each town extended through the years, gaps and overlaps were encountered on surveys over adjoining lands. These problems are increased when two or more origins of surveys are involved. This is understandable owing to the plane used which will introduce appreciable distortions over more extensive areas.

The origin of land surveys in each city or municipality is a survey control station established by the Bureau of Lands—and is designated by a Bureau of Lands Location Monument No. 1 (BLLM ≠1) which is usually located in the centre of each locality. All land surveys in the Philippines are approved by the Bureau of Lands. Supplementary controls established within the jurisdiction of each city or municipality are tied to BLLM ≠1 and are numbered accordingly.

As of 1 January 1966, there were 1,423 cities and municipalities in the entire country and presumably there were about the same number of reference stations for land surveys. As the number of cities and municipalities increases, there is a corresponding increase in reference stations. Reference stations are established only as the need arises and the degree of precision of observations varies. While most of the survey points are not rigidly connected, each of them is given assumed plane co-ordinates, northing = 20,000.00 metres, and easting = 20,000.00 metres. Azimuths of lines connecting these points with other stations are determined usually by solar observations, except those that are tied to triangulation stations which are second- or third-order accuracies. For more extensive cadastral survey projects, the meridian passing through the BLLM ≠1 of the place is made the reference meridian of the entire cadastre.

In mapping extensive areas incorporating the various fragments of surveys of different towns and cities, there is need for a better system. Desirous of introducing an improved system of survey computations in the Philippines, the Board of Technical Surveys and Maps (BTSM) resolved in 1961 to adopt a national co-ordinate system, known as the Philippine plane co-ordinate system. The function of the Board of Technical Surveys and Maps is to co-ordinate all surveying and mapping activities of both private and public agencies in the country. The projection used as base is the transverse Mercator, which is best suited to the country, considering that the territorial extent of the country is much greater north to south than east to west. There are five zones covering the entire territorial limits of the country, with the central meridians two degrees apart in longitude.

Tables have been prepared and published by the Bureau of Lands, Department of Agriculture and Natural Resources, for use by all surveyors and engineers. The Philippine plane co-ordinate system is required for all land surveys.

Implementation of this system for all land surveys started on 26 May 1965, after the Board of Technical Surveys and Maps had conducted several training seminars designed to familiarize the government and private land surveyors with the system.

All surveys performed and computed according to this system of co-ordinates can easily be cross-referenced and gaps and overlaps reduced to a minimum.

For proper and full implementation of this system in all surveys it is necessary that triangulation work be executed to connect all BLLMs to the network extending over the entire country. To this end, the Bureau of Lands organized eight geodetic control survey parties distributed over the eight regions covering Luzon, Visayas and Mindanao islands.

The characteristics of the Philippine plane co-ordinate system are as follows:

Spheroid used—Clarke's spheroid of 1866 with the following semi-axis: equatorial, $a = 6{,}378{,}206.4$ metres; polar, $b = 6{,}356{,}583.8$ metres.

Projection—Transverse Mercator (Gauss-Krueger).

Latitude of origin—Equator (0°).

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* A paper submitted by Thailand ("Geodetic survey of Thailand: triangulation operations from 1964 to 1966") appears under item 6 above.

[1] The original text of this paper appeared as document E/CONF.52/L.11.

Longitude of origin—The following central meridians: 117° E, 119° E, 121° E, 123° E and 125° E.

Point of origin—Intersections of the equator and the central meridians.

Scale factor—At the central meridian = 0.99995.

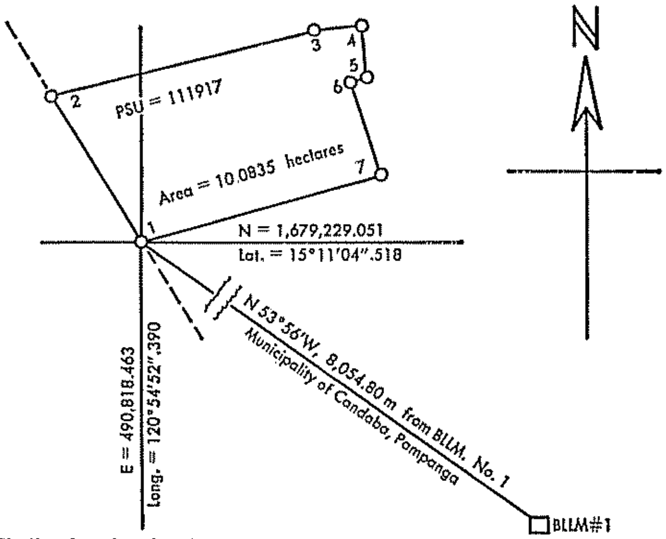
Unit used—Metre.

False easting—500,000 metres.

Zonification—Five zones at two (2) degrees of meridional limits' interval, with thirty minutes' overlap on each zone.

Table 1. Zones of the plane co-ordinate system

Zone No.	*Central meridian*	*Extent of zone*
I	117°E	116°00′ to 118°30′
II	119°E	117°30′ to 120°30′
III	121°E	119°30′ to 122°30′
IV	123°E	121°30′ to 124°30′
V	125°E	123°30′ to 127°00′



Tie line bearing (to the nearest minute) and distance are according to the Philippine plane co-ordinate system.

Sample co-ordinate conversions showing how a parcel or lot is tied to BLLM#1 of a locality

Table 2. Co-ordinate conversion, geographic to grid

Name of station: BLLM#1, zone III, central meridian 121°

$\varphi =$ 15°08′30″.248
$\lambda =$ 120°58′30″.528
$\Delta\lambda =$ (−)01′29″.472
$\Delta\lambda'' =$ (−) 89″.472
$p =$ (−)0.0089472
$p^2 =$ 0.000080053
III = 1.720; III$p^2 =$ 0.000
II = 1,890.329
(IIIp^2 + II)$p^2 =$ 0.151
$I =$ 1,674,486.090

$N =$ 1,674,486.241

*Formulas**
$N = (\mathrm{III}p^2 + \mathrm{II})p^2 + \mathrm{I}$ = northing
$E = [\mathrm{VI}p^2 + \mathrm{V})p^2 + \mathrm{IV}]p + 500{,}000.00$ = easting
$p = 0.0001\ (\Delta\lambda'')$

VI = 0.048
V = 101.684

VI$p^2 =$ 0.000
VIp^2 + V = 101.684
(VIp^2 + V)$p^2 =$ 0.008
IV = 298,542.736

(VIp^2 + V)p^2 + IV = 298,542.744
[VIp^2 + V)p^2 + IV]$p =$ 2,671.122(−)
+ 500,000.000

$E =$ 497,328.878

* See note to table 3.

Table 3. Co-ordinate conversion, grid to geographic

Name of station: BLLM#1, zone III, central meridian 121°

$E =$ 497,328.878, $E' =$ 500,000−E
$E' =$ 2,671.122, $q = 10^{-6} E'$
$q =$ 0.002671122
$N =$ 1,674,486.241

VIII = 7.376; VIII$q^2 =$ 0.000

VII = 690.115

(−VIIIq^2 + VII) = 690.115

$\Delta\varphi'' = (-\mathrm{VIII}q^2 + \mathrm{VII})q^2 =$ .005
$-\Delta\varphi =$ 0°00′0″.005
$\varphi' =$ 15°08′30″.253

Latitude = 15°08′30″.248

*Formulas**
$\varphi = \varphi' - (-\mathrm{VIII}q^2 + \mathrm{VII})q^2$
$\lambda = [-(-\mathrm{XI}q^2 + \mathrm{X})q^2 + \mathrm{IX}]q + \lambda_{CM}$

XI = 1.217

XI$q^2 =$ 0.000
$X =$ 158.140

−XIq^2 + X = 158.140

−(−XIq^2 + X)$q^2 =$ 0.001
IX = 33,496.042

[−(−XIq^2 + X)q + IX] = 33,496.041
[−(−XIq^2 + X)q + IX]$q =$ 89″.472

$\Delta\lambda =$ 0°01′29″.472(−)
$\lambda_{CM} =$ 121°00′00″.000

Longitude = 120°58′30″.528

* Values of I–XI taken from *Special Publication* No. 21, Bureau of Lands.

Table 4. Co-ordinate conversion, geographic to grid

Name of station: Point 1, zone III, central meridian 121°

$\varphi = 15°11'04''.518$
$\lambda = 120°54'52''.393$
$\Delta\lambda = (-)\ 05'07''.607$
$\Delta\lambda'' = (-)\ 307''.607$
$p = (-)\ 0.0307607$
$p^2 = 0.00094622066$

*Formulas**
$N = (\mathrm{III}p^2 + \mathrm{II})p^2 + \mathrm{I} =$ northing
$E = [(\mathrm{VI}p^2 + \mathrm{V})p^2 + \mathrm{IV})]p + 500{,}000.00 =$ easting
$p = 0.0001\ (\Delta\lambda'')$

$\mathrm{III} = 1.723$; $\mathrm{III}p^2 = 0.002$
$\mathrm{II} = 1{,}895.172$
$\mathrm{III}p^2 + \mathrm{II} = 1{,}895.174$
$(\mathrm{III}p^2 + \mathrm{II})p^2 = 1.793$
$\mathrm{I} = 1{,}679{,}227.258$
$N = 1{,}679{,}229.051$

$\mathrm{VI} = 0.048$;
$\mathrm{V} = 101.575$;

$\mathrm{VI}p^2 = 0.000$
$\mathrm{VI}p^2 + \mathrm{V} = 101.575$
$(\mathrm{VI}p^2 + \mathrm{V})p^2 = 0.096$
$\mathrm{IV} = 298{,}482.614$
$(\mathrm{VI}p^2 + \mathrm{V})p^2 + \mathrm{IV} = 298{,}482.710$
$[(\mathrm{VI}p^2 + \mathrm{V})p^2 + \mathrm{IV}]p = 9{,}181.537\ (-)$
$+ 500{,}000.000$
$E = 490{,}818.463$

* See note to table 5.

Table 5. Co-ordinate conversion, grid to geographic

Name of station: Point 1, zone III, central meridian 121°

$E = 490{,}818.463$
$E' = 9{,}181.537$
$q = 0.009181537$
$N = 1{,}679{,}229.051$

*Formulas**
$\varphi = \varphi' - (-\mathrm{VIII}q^2 + \mathrm{VII})q^2$
$\lambda = [-(-\mathrm{XI}q^2 + \mathrm{X})q^2 + \mathrm{IX}]q + \lambda_{CM}$

$\mathrm{VIII} = 7.403$; $(\mathrm{VIII})q^2 = -0.001$
$\mathrm{VII} = 692.160$
$(-\mathrm{VIII}q^2 + \mathrm{VII}) = 692.159$
$\Delta\varphi'' = -(-\mathrm{VIII}q^2 + \mathrm{VII})q^2 = (-)\ 0''.058$
$\varphi = 15°11'04''.576$
Latitude $= 15°11'04''.518$

$\mathrm{XI} = 1.218$

$\mathrm{XI}q^2 = 0.000$
$\mathrm{X} = 158.290$
$-\mathrm{XI}q^2 + \mathrm{X} = 158.290$
$-(-\mathrm{XI}q^2 + \mathrm{X})q^2 = 0.013$
$\mathrm{IX} = 33{,}502.791$
$[-(-\mathrm{XI}q^2 + \mathrm{X})q + \mathrm{IX}] = 33{,}502.778$
$[-(-\mathrm{XI}q^2 + \mathrm{X})q^2 + \mathrm{IX}]q = 307''.607$
$\Delta\lambda = 05'.07''.607(-)$
$\lambda_{CM} = 121°00'00''.000$
Longitude $120°54'52''.393$

* Values I–XI taken from *Special Publication* No. 21, Bureau of Lands

Table 6. Computation of geodetic azimuth and distance

$N_1 = 1{,}674{,}486.241$
$N_2 = 1{,}679{,}229.051$
Ave $N = 1{,}676{,}857.646$
$\Delta N = N_1 - N_2 = 4{,}742.810$
$\Delta N^2 = 22{,}494{,}246.696$
$\Delta E^2 = 42{,}385{,}503.468$
$\Delta N^2 + \Delta E^2 = 64{,}879{,}750.164$
$\mathrm{XVIII} = 0.01236413$
$q^2(\text{mean}) = 1/3(q_1^2 + q_2^2 + q_1q_2)$
$= 0.000038653$

$E_1 = 497{,}328.878$
$= -500{,}000.000$
$E_1' = 2{,}671.122$
$E_2 = 490{,}818.463$
$-500{,}000.000$
$E_2' = 9{,}181.537$
$\Delta E = 6{,}510.415$ m
$P.D = \sqrt{64879750.164}$
$= 8{,}054.797$ m
$K = 0.99995(1 + \mathrm{XVIII}\ q_m^2 + 0.000026\ q_m^4)$
$= 0.999950478 =$ Scale factor

$q_1 = 0.002671122(-)$
$q_1^2 = 0.000007135$
$q_1^3 = 0.000000019(-)$
$q_2 = 0.009181537(-)$
$q_2^2 = 0.000084301$
$q_1q_2 = 0.000024525$

Geodetic distance $= \dfrac{\textit{Plane distance}}{\textit{Scale factor}} = \dfrac{8.054.797}{0.999950478}$
$= 8{,}055.196$ m

$q^4_{(m)} = 0.000000149$
$N_2 - N_1 = 4{,}742.810$
$2q_1 + q_2 = 0.014523781(-)$
Tan. plane bearing $= \dfrac{\Delta E}{\Delta N}$
$\log\Delta E = 3.8136087$
$-\log\Delta N = 3.6760357$

$(t-T) = -0.068755\ (\mathrm{XVIII})\ (N_2 - N_1)\ (2q_1 + q_2)$
$= -0.068755(0.01236413)\ (4{,}742.810)\ (-0.014523781)$
$(t-T) = +0.06$ seconds
$T =$ Grid azimuth $= t - (t-T)$
$T = 126°04'23''.44 - (+0''.06)$

Table 6. Computation of geodetic azimuth and distance (*continued*)

Log. tan. plane bearing = 0.1375730	T = 126°04′23″.38
Plane bearing = N53°55′36″.56 W	$\Delta\alpha$ = Convergence = $XVq_1 - XVIq_1^3$
Plane azimuth = t = 126°04′23″.44	$\Delta\alpha$ = (8,749.42) (−0.002671122)
XV = 8,749.42	−(77.11) (−0.000000019)
XVI = 77.11	$\Delta\alpha$ = (−) 23.37 seconds
	Geodetic azimuth = α = $T \pm \Delta\alpha$
	T = 126°04′23″.38
	$-\Delta\alpha$ = 23″.37
	Geodetic azimuth = 126°04′00″.01

The figure on page 109 shows a parcel of land located 8,054.80 m from BLLM≠1, whose geographic position is known. The position of point 1 is computed from these known data and converted to grid co-ordinates.

Geodetic azimuth and distance of the tie line can be computed from grid co-ordinates only when grid data are known.

ADJUSTMENT OF HORIZONTAL CONTROL SURVEYS

Paper presented by Australia[1]

1. This paper discusses the adjustment of surveys by the method of variation of co-ordinates, a method which has been found suitable for the adjustment of a wide variety of control surveys. It reviews some of the basic decisions which have to be taken by a survey organization preparing an electronic computer programme for this task.

2. In this paper, control survey means any survey, of any order of accuracy, whose aim is to provide co-ordinated points for the control of mapping. It includes, at one extreme, the geodetic survey of a continent and at the other, a tacheometric traverse or photogrammetric block adjustment. This paper does not discuss the adjustment of heights.

3. In the last decade, the nature of most control surveys has changed. Until 1956, control surveys consisted of a large number of observed angles, which were used to transmit both scale and azimuth between a few scattered base lines and Laplace azimuths, or between points fixed by a survey of higher order. But the measurement of distance is now as easy as the measurement of angles, and modern control surveys are likely to contain a large number of measured lengths. Traversing has tended to replace triangulation and, as the transmission of azimuth by a traverse is relatively weak, the number of Laplace azimuths in a geodetic survey also tends to be much higher than before. Instead of merely adjusting angles, we now have the problem of adjusting angles, azimuths and distances simultaneously.

4. In Australia, for example, the geodetic survey contains 2,506 first-order stations; there are 533 Laplace stations and over 1,720 measured distances. The areas between the chains of geodetic survey are being filled either with second-order tellurometer traverses, containing equal numbers of angles and distances or with aerodist trilateration, containing distances only. This control is in turn broken down by photogrammetric block adjustments, and some tests have been made of least-squares adjustments of angles read on the air photographs in a Wild RT 1 radial triangulator; these adjustments contain angles only. In contrast, in the north-east of Australia and in New Guinea, a HIRAN survey has been made by the United States Air Force, and this adjustment contained azimuths and distances only, with no angles. All these different types of control survey have been computed and adjusted by the same variation of co-ordinates computer programme.

5. Using logarithms or desk calculators, the work of adjusting surveys by the variation of co-ordinate method, especially on the spheroid, was so great that the task was seldom attempted. It is, however, a convenient method for electronic computers, especially the more powerful machines, such as the CDC 3600 or IBM 7090. The programme will not be written in two or three days; it may contain over 1,000 Fortran cards. But the advantages of using an electronic computer for the adjustment of surveys are so great that no survey authority should ever again consider doing an extensive adjustment by hand. If no computer is locally available, the work is better contracted out or performed by some other agency.

Advantages of the method of variation of co-ordinates

6. Apart from its great flexibility, that is to say, the fact that it can be used to adjust any combination of angles, azimuths and distances, the advantages of the method are as follows:

(*a*) No conditions have to be listed; in a complicated survey network, especially one containing measured distances, the formation of the geometric conditions which the adjusted survey must satisfy is a complicated task, which it is difficult to programme for an electronic computer;

(*b*) The adjusted latitude and longitude of each survey station are produced immediately, without further computation, as well as the adjusted angles, azimuths and distances; these latitudes and longitudes can be converted by the computer into eastings and northings, which can be included in the output if desired;

(*c*) There is no limit to the number of observations which can be included in a computer of given size, and new observations are easily added to an old adjustment, and the whole work readjusted, at any time.

[1] The original text of this paper, prepared by A. G. Bomford, Division of National Mapping, Department of National Development, Canberra, appeared as document E/CONF.52/L.30.

7. The need to supply preliminary latitudes and longitudes is sometimes a disadvantage. In triangulation or traverse there is no problem, as an unadjusted traverse can easily be computed to give preliminary co-ordinates for each point. With trilateration, such preliminary computation is less easy, but it suffices to measure co-ordinates as accurately as possible from a map or diagram, and then to iterate the adjustment several times. In photogrammetric surveys, preliminary co-ordinates may be obtained from a slotted template assembly.

On the grid or on the spheroid

8. An adjustment can be performed either in terms of latitudes and longitudes on the spheroid, or in terms of eastings and northings on the grid. When computations were done by hand, the grid had the advantage that the formulae were simpler, and the work much less onerous. On an electronic computer, the saving in both programming and computing, when using these simpler formulae, is trivial. Working on the grid causes difficulty when surveys cross zone boundaries. Except in a small country which lies wholly within one zone of a projection, it is therefore best to adjust on the spheroid. Grid co-ordinates will certainly be required for the adjusted stations, but they are easily included in the output by the direct conversion of the adjusted latitudes and longitudes.

Angles or directions

9. Survey networks can be adjusted by the method of angles or by the method of directions, and the controversy as to which is the better continues undiminished to this day. The method of directions may have some theoretical advantages, but the results obtained by the two methods are similar. The method of angles is the simpler, and some experienced computers claim that in practice it produces better results. In view of this controversy, we may allow the matter to be settled in the direction of simplicity. No survey authority adopting the method of angles is likely to have serious cause to regret it, and angles are therefore recommended.

Outline of the method

10. From the preliminary co-ordinates supplied, the length and azimuth is computed of every line over which an observation has been made. If the observations and the preliminary co-ordinates were perfect, these computed azimuths and distances would accord with the observed angles, azimuths and distances. In practice, they will not accord exactly, and the problem is to find corrections to the preliminary co-ordinates which will minimize the weighted sums of the squares of the differences between the observed and computed values of the angles, azimuths and distances.

11. *Symbols:*

φ = Latitude, positive north
λ = Longitude, positive west
L = The length of a line
A_{12} = The azimuth of a line from station 1 to station 2
$\Delta\varphi$ = A small change in φ, and similarly for λ, L and A
ρ, ν = Radii of curvature of the spheroid in meridian and prime vertical
$P_{12} = (\rho_1 \sin A_{12})/L$
$Q_{12} = (\rho_2 \sin A_{21})/L$
$R_{12} = (\nu_2 \cos A_{21} \cos \varphi_2)/L$
$S_{12} = -\rho_1 \cos A_{12} \sin 1''$
$T_{12} = -\rho_2 \cos A_{21} \sin 1''$
$U_{12} = +\nu_2 \sin A_{21} \cos \varphi_2 \sin 1''$
σ = Standard error
$O - C$ = The observed value of a quantity minus the value computed from the preliminary co-ordinates
A, Z, L = Subscripts pertaining to an angle, azimuth or length

Basic formulae

12. On the spheroid, the basic formulae connecting changes in the azimuth and length of a line with changes in the co-ordinates of the end points are:

$$\Delta A_{12} = P_{12}\Delta\varphi_1 + Q_{12}\Delta\varphi_2 + R_{12}(\Delta\lambda_2 - \Delta\lambda_1) \qquad (1)$$
$$\Delta L_{12} = S_{12}\Delta\varphi_1 + T_{12}\Delta\varphi_2 + U_{12}(\Delta\lambda_2 - \Delta\lambda_1) \qquad (2)$$

In these formulae, ΔA, $\Delta\varphi$ and $\Delta\lambda$ are in seconds of arc.

13. For computing distance and azimuth from the preliminary latitudes and longitudes, the formulae of Robbins (1962) are convenient, and accurate to about 2 cms at 1,600 kms, which suffices for all aerodist and HIRAN lines.

14. For transforming adjusted latitudes and longitudes to transverse Mercator grid co-ordinates, the Redfearn formulae (1948) are correct to better than 1 mm anywhere in a 6° zone. For meridian distance, formula (8.39) in G. Bomford (1962) is correct to 0.5 mm in latitude 45°.

Observation equations

15. In a least-squares adjustment, all the observation equations must have the same dimensions; otherwise the normal equations contain coefficients with mixed dimensions, and the equations are meaningless. In paragraph 12, equation (1) is dimensionless, and equation (2) has the dimension of length.

16. It is well known that the method of least squares provides the most probable corrections to the observed quantities only if the observations are correctly weighted, and in the past this has customarily been achieved by multiplying each observation equation by the square root of the weight of the observed quantity.

17. However, the weight of each quantity is, by definition, inversely proportional to the square of its standard error. It is therefore essential, in all adjustments, but particularly one containing mixed units, to divide each observation equation by the standard error of the observed quantity. In this way we not only make the correct allowance for weights, but make each observation equation dimensionless, and independent of the units used. Provided we express an observed quantity and its standard error in the same units, and divide each observation equation by its standard error, then (and only then) can mixed quantities, of any dimensions, in any units, be rigorously combined in a single adjustment.

18. For each observed angle, by subtracting equation (1) for the line 1–2 from equation (1) for the line 1–3, and dividing through by the standard error of the observed angle, we obtain this observation equation:

$$[(P_{13} - P_{12})\Delta\varphi_1 - (R_{13} - R_{12})\Delta\lambda_1 - Q_{12}\Delta\varphi_2 - R_{12}\Delta\lambda_2 + Q_{13}\Delta\varphi_3 + R_{13}\Delta\lambda_3]/\sigma_A = (O - C)_A/\sigma_A$$

19. For a Laplace azimuth, we use equation (1) for the azimuth line, but include an extra term to satisfy the Laplace equation ($-\Delta\lambda\sin\varphi$) if the longitude of the azimuth station is changed by $\Delta\lambda$:

$$[P_{12}\Delta\varphi_1 - (R_{12} - \sin\varphi_1)\Delta\lambda_1 + Q_{12}\Delta\varphi_2 + R_{12}\Delta\lambda_2]/\sigma_Z = (O - C)_Z/\sigma_Z$$

20. For an observed distance, from equation (2):

$$[S_{12}\Delta\varphi_1 - U_{12}\Delta\lambda_1 + T_{12}\Delta\varphi_2 + U_{21}\Delta\lambda_2]/\sigma_L = (O - C)_L/\sigma_L$$

Along any geodesic $U_{21} = U_{12}$, so that computation of U_{21} can be avoided.

Standard errors

21. In practice, there is little difficulty in assessing adequate values for σ_A, σ_Z and σ_L. For example, on the geodetic surveys in Australia, the following values were used:

For a first-order angle with a Wild T3 on two nights: $\sigma_A = 0''.7$;

For a Laplace azimuth, single ended, with DKM3a or T4, with azimuths and longitudes on two nights: $\sigma_Z = 1''.0$;

For simultaneous reciprocal azimuths: $\sigma_Z = 0''.45$;

For the mean of two independent Tellurometer measurements: $\sigma_L = 0.03$ ms + 3 ppm.

For surveys of lower order, other values can be chosen. It is not even essential that the values chosen be correct; it suffices for them to be in the correct ratio to one another. It is convenient to apply general standard errors in this way, but it is easy to arrange for individual observations which are unusually strong or weak to have their standard errors modified.

Formation of normal equations—band-width

22. It is convenient to arrange for the observation equations to be formed one at a time, and for the squares and products of the coefficients to be computed and added into the matrix of the coefficients of the normal equations immediately. In this way, the number of observations is in no way limited by the size of the computer.

23. The maximum size of an adjustment for a given computer will, however, be limited by the number of unknowns, which is exactly twice the number of points to be adjusted. Thus 100 points require 200 unknowns, and the full matrix of the coefficients in the normal equations would contain 40,000 elements. Since the matrix is symmetric, little over half need be stored, but the situation can be improved much further. In most surveys, observations occur between stations which are relatively close to each other. It is possible that a HIRAN line may extend from one end to the other, but this is exceptional. Usually, if stations are allocated serial numbers which start at one end of the survey and increase steadily to the other end, observations will occur between stations whose serial numbers are not widely dissimilar.

24. When the normal equation matrix is formed, all the non-zero coefficients then tend to lie close to each other in a band parallel to the principal diagonal. The zero coefficients outside this band need not be stored. In a matrix of order N and band-width M (on one side of, and excluding, the principal diagonal) the number of elements in the band matrix is $(M+1)(2N-M)/2$. In a typical case, with $N = 150$ and $M = 20$, the number of elements to be stored is 2,940, compared with 11,325 on and above the principal diagonal, and 22,500 in the full matrix.

25. By carefully allocating serial numbers to the variable stations in such a manner that the band-width is as small as possible, large adjustments can be carried out wholly within the high-speed store of a computer, and computation times can be greatly reduced.

Solution of normal equations—direct or iterative methods

26. Direct methods have been criticized on the grounds that, if normal equations are ill-conditioned, round-off errors may accumulate and make the solution worthless. But in survey networks, a strong fix for all stations is one of the surveyor's chief aims, so the equations are never likely to be seriously ill-conditioned. In Australia, Choleski's direct method has been used, and found entirely satisfactory. It is readily modified for use with band matrices, and it is then extremely quick and economical in the use of computer storage. It is nevertheless wise to guard against an occasional unstable matrix by iterating every adjustment at least once.

Fixed points and fixed observations

27. Points are very easily held fixed: $\Delta\varphi$ and $\Delta\lambda$ are simply put equal to zero in any observation equation in which they occur. The method of variation of co-ordinates is thus very suitable for adjusting new surveys in terms of existing control.

28. There is little justification for holding an observed quantity fixed, while the terminal points are free to move; every observation has its standard error, and should receive a corresponding adjustment. However, if it is desired to hold an observation fixed, this can be achieved by giving it an arbitrary standard error artificially close to zero. Division by an exact zero is likely to cause trouble in an electronic computer, as the quotient is infinite.

Listing the data

29. It is convenient to list all observations at one station on one data sheet, on which each line, corresponding to a punched card, contains the observed direction, Laplace azimuth and distance (when the latter exist) to one distant station. Even if the adjustment is to be by the method of angles (see para. 9 above), it is best to list directions in the data, as they can be copied directly from the field book or abstract. The computer can obtain the angles by subtracting each direction from the next in turn.

External angles

30. The question arises whether to form observations with external angles, such as the angles of about 270° which occur at the corners of a braced quadrilateral. On the question whether the inclusion or exclusion of external angles gives the better adjustment, there is still controversy. One advantage of including external angles is that less care has to be taken in the tabulation of the data; the angle to be omitted does not have to be indicated. The advantage of excluding external angles is that there is a valuable reduction in the band-width, and the programme is a little simpler. On the whole, it is considered best to write a programme which does not form an observation equation with the angle lying after the last direction listed. When it is necessary to include the closing angle, as at the centre point of a polygon, then the opening direction can be repeated at the end of the list.

Iteration

31. It is essential to iterate adjustments of this type: first, because the initial set of preliminary co-ordinates may be seriously inaccurate (see para. 7 above), giving erroneous values for P, Q, R, S, T, U; secondly, as a check against instability in the normal equations (see para. 24 above). But there is no need to make iteration wholly automatic. After every adjustment, before iterating, the output should be carefully inspected to ensure that no intolerably large correction has been made, suggesting an error in the data.

It therefore suffices for the computer to punch out cards containing the adjusted latitudes and longitudes in such a form that they can be substituted for the original co-ordinates in the data deck before the adjustment is re-run. As a change in longitude implies a change in Laplace azimuth, cards containing the revised Laplace azimuths need to be punched and substituted in the data deck also.

The Australian "varycord" programme

32. A programme for the variation of co-ordinates on the spheroid has been running in Australia since September 1964. The programme is written in Fortran for the Control Data Corporation 3600 computer owned by the Commonwealth Scientific and Industrial Research Organization in Canberra. The CDC 3600 is a very fast and powerful machine, with a high speed store of 32,000 words, each containing 10 decimal digits. The programme will adjust up to 100 variable points; forty more can be held fixed. From reading the first card of the data to printing the last line of the output, a full-sized adjustment takes about five minutes. This programme was extensively used for the geodetic adjustment of Australia and it has been used to adjust all the different types of control surveys mentioned in paragraph 4 above.

33. The Division of National Mapping would be glad to make listings of this programme available to any other survey organization. A description of the programme has been written and pre-prints can be supplied. Within reason, National Mapping could also assist other survey organizations by running adjustments for them. If the observing authority can tabulate its observations on the special data sheets provided, the actual adjustments can be carried out at little or no cost. Requests for assistance of this sort should be addressed to the Director, Division of National Mapping, Canberra.

THE LEVELLING SURVEY OF AUSTRALIA

Paper presented by Australia[1]

Many thousands of miles of levelling to various standards have been carried out in Australia by survey authorities over the years. However, levelling of first-order to third-order standards (control levelling), with permanent marks placed at adequate intervals, had a slow start. Prior to 1956, about 3,000 miles of control levelling had been completed in three of the six states of the Commonwealth of Australia. Between 1956 and 1960, an additional 10,000 miles were levelled and by the end of 1966 the total amount of control levelling had reached 76,000 miles, covering the whole continent.

The purpose of control levelling is to provide a framework of level traverses along roads, railways and tracks, with permanent bench-marks placed at certain intervals. The heights of these marks are obtained by geometric levelling, with reference to a datum mark which in turn is usually referred to mean sea level of a certain period at the main tidal gauging station of the state.

The control levelling net is designed to form loops of reasonable size. Lower order geometric levelling and other survey methods, including the use of the elevation meter, of which there are two in this country, are then applied to provide heights within loops. These heights may refer to permanent marks, temporary marks or natural and man-made features. The most important ultimate application of such heights is in topographical mapping.

Commonwealth and state mapping authorities are the main customers for levelled heights. Their requirements, however, would be met if the standard error of the height of any mark above the datum mark of the levelling survey did not exceed $\pm$ 2 ft.

Faced with a requirement for early levelling data in connexion with gravity and mapping surveys, and the doubtful effects of soil settlement and earth tides, Commonwealth authorities considered that a third-order levelling net, carried out mainly by contract surveyors, would provide the only practical and timely answer.

[1] The original text of this paper, prepared by K. Leppert, Division of National Mapping, Department of National Development, Canberra, appeared as document E/CONF.52/L.43.

Commonwealth funds were provided for this purpose and the state surveyors-general have provided supervision at cost to the Commonwealth.

In terms of the National Mapping Council's *Standard Specification and Recommended Practices for Horizontal and Vertical Control Surveys*, the main requirements of the third-order levelling specifications are: the two levellings of each section between permanent bench-marks should not differ by more than $0.05(\sqrt{M})$ ft (M is the distance in miles between bench-marks measured along the levelling route); circuit closures should not exceed the same limit (M is the length of the circuit in miles along the levelling route).

The levelling survey began to take shape on a national basis in 1958. In the first instance, it was to extend vertical control to areas where oil and mineral surveys were in progress. Later on, it was to cover the whole continent with loops. This survey is of primary importance for the topographical mapping of Australia, for geological and geophysical surveys, and will be of enormous value in developing the country's water resources. Its benefit to engineering projects and to road and railway development can only be guessed at.

Some states are observing part of their levelling to second- or first-order standards and paying for this work out of state funds, assisted by a partial Commonwealth subsidy.

A diagram showing the completed and planned level traverses as of December 1966 is attached to this report.*

Since early in 1962, the Commonwealth Government of Australia has made considerable funds available for third-order levelling. The Director of National Mapping, in conjunction with the surveyors-general of the states, selects the routes of levelling. The placing of permanent marks and the actual levelling is carried out by private surveyors under contract and is supervised by the state surveyors-general.

The contract levelling work may be divided into four phases: (*a*) selection of levelling routes; (*b*) installation of

* See pocket at end of volume.

permanent marks along these routes; (*c*) actual levelling between marks; (*d*) supervision, checking and recording of the levelling work carried out in phase (*c*).

This scheme of third-order contract levelling operates in the manner described below.

(*a*) The surveyors-general of the states recommend their third-order contract levelling programmes to the Director of National Mapping well before the beginning of the next financial year. The programmes are then considered from the point of view of their usefulness to the national scheme and the likely availability of funds. The approved programmes are included in the budget proposals and the surveyors-general are asked to supply detailed proposals for marking and supervisory costs and levelling costs.

(*b*) When the budget has been approved and after procurement demands have been signed by the Minister of National Development, contracts are let to the surveyors-general by the Contracts Board of the Department of Supply for marking, supervision, checking and recording of levelling work. Placing of permanent marks is then commenced.

(*c*) In the meantime, the surveyor-general invites private surveyors in his state to take part in the levelling programme. Those who show interest are offered a section of about 100 miles in length of third-order levelling at a price between $A30 and $A38 per mile, which includes the successful check-run in the opposite direction. Contracts are then let to these surveyors by the Contracts Board.

(*d*) All levelling is carried out with modern automatic levels and high quality calibrated wooden levelling staves. The contractor is supplied with a pair of calibrated staves 12 feet long free of charge. He can hire an automatic level for a fee of $A0.30 per mile from the Division of National Mapping, which also supplies the levelling staves.

(*e*) The contract surveyor must adhere to a number of specifications which are designed to guarantee that all work is carried out in an expeditious and professional manner to the complete satisfaction of the surveyor-general.

(*f*) The contract surveyors' levelling is supervised by staff surveyors of the surveyor-general's offices, who also carry out random check levelling. After the completion of the field work, the contract surveyor submits his field notes and other relevant information to the surveyor-general. The notes are checked and if everything appears in order a progress payment of up to 90 per cent of the contract price is made. The final 10 per cent is paid on completion of a thorough check of the work.

In Queensland, where the Survey Branch of the Department of the Interior has levelled many thousands of miles in one direction only, with double-faced staves, selected routes are being levelled in the opposite direction by contract surveyors using foot/metric double-faced staves. These two-way levelled routes form large loops which will be incorporated in the national levelling adjustment. The price for one-way contract levelling varies between $A16 and $A20 per mile.

Many contract surveyors operate with one observer, two staffmen and two vehicles, arranging their work in such a way that neither the surveyor nor the staffmen have to walk at all. With a maximum sighting distance of between 200 and 300 ft in flat country, some surveyors have been doing up to 14 miles of single levelling per day. The average per-party day is 7–8 miles.

Permanent marks are placed at intervals of 1 to 4 miles along levelling traverses. There are three types of marks: non-corrodable metal marks in precast concrete set in the ground; non-corrodable metal marks in solid rock or in concrete poured into a roughly cut hole; long galvanized iron or copper pipe marks in black soil or sandy country with a loose concrete collar.

All third-order levelling is being observed with automatic levels. In the early sixties, rather large section misclosures were obtained before the influence of a systematic error in the compensating mechanism of automatic levels was recognized. This error is now being successfully compensated through an appropriate observing technique. Other systematic errors are feared to be the cause of a few misclosures just outside the allowable limit in sections of 50 miles and more in length.

An analysis of the misclosure of 95 loops of between 60 and 930 miles in length, with an average length of 280 miles, results in a standard deviation for 1 mile of levelling of ± 0.036 feet. On this basis, it should be possible to level from the coast to the centre of the continent with a standard error of ± 1.2 feet.

Simultaneous observations at thirty-one tidal gauging stations on a continuous basis for a period of twelve months is being arranged at present by members of the National Mapping Council. The object is to obtain mean sea level at these stations for the same epoch. The digitizing of gauging charts and subsequent computation of mean sea level and tidal constants for each station is being managed by the Horace Lamb Centre for Oceanographic Research of the Flinders University of South Australia.

The adjustment is to take place in 1970, when all the planned level traverses have been completed. Loops to be included in the adjustment will be recommended by the National Mapping Council in the near future. It is almost certain that normal orthometric heights will be adopted.

The adjustment will be the culmination of a concentrated effort to establish a national levelling survey in Australia. It is expected that about 100,000 miles of control levelling will be completed at the time of the adjustment and that the results will be completely satisfactory for mapping and for many other survey purposes.

AERODIST OPERATIONS IN AUSTRALIA

Paper presented by Australia[1]

INTRODUCTION

Aerodist is an electronic device developed from the Tellurometer to measure distances of up to 75 miles with an accuracy suitable for survey purposes. It was designed to be used in an aircraft to enable line of sight conditions to be obtained over this length of line and also provide a means of positioning an aircraft.

The equipment consists of up to three pairs of units, or channels, each equivalent to a pair of Tellurometer units. The master or control units are mounted in the aircraft and distance is continuously recorded in graphical form on a three-channel strip chart recorder connected to the master units. The antenna system is externally mounted and consists of a dipole and flat plate reflector for each channel set inside a fibre-glass dome and rotatable by remote control about a fixed base. The operating frequency of each channel is different to avoid interference between channels and is preselected in the range 1200–1500 mcs. The pattern-switching to provide values for the coarse figure for distance, manually controlled at each end in the Tellurometer, is automatically controlled in the aerodist and each pattern is introduced in turn for a short period at intervals of approximately 10 seconds. The ground or remote stations are portable and similar to an MRA2 Tellurometer unit. However, as all distance readings and operating procedures are controlled from the aircraft, the remote units do not require the same amount of manual operation, although they are continually monitored during operation.

The equipment can be used as follows:

(*a*) *Line crossing*—To obtain distance between two ground stations up to 150 miles apart by measuring to each end from the aircraft flying across the line between the stations; the measurement is repeated a number of times to obtain suitable accuracy from a mean result;

(*b*) *Continuous trilateration*—To fix the position of a ground station from two known stations by measuring continuous distances to the three stations from the aircraft flying approximately parallel to the line between the known stations;

(*c*) *Air station fixation*—To fix the position of the aircraft at an instant (usually related to air camera exposures) by measuring simultaneous distances to three known ground stations.

OPERATIONS BY THE DIVISION OF NATIONAL MAPPING

In Australia, aerodist was procured by the division primarily for the extension of horizontal control for systematic mapping of this large continent. After delivery of the original two-channel equipment early in 1963, and preliminary bench and ground tests, airborne trials were conducted using a helicopter to carry the master equipment and to measure distances by the line-crossing method.

Following the successful completion of these trials, field operations were conducted through the balance of 1963 and 1964, using the two-channel system in a helicopter, to measure a network of lines between stations established at 1° geographical intersections. The stations were contained within a geodetic framework of first-order stations by aerodist measurements, enabling the network to be adjusted to that framework and providing suitably accurate position values for the new stations.

During this time a prototype airborne psychrometer was developed for the division by the Commonwealth Scientific and Industrial Research Organization (CSIRO) and field trials of the equipment were conducted during the 1964 aerodist operations.

The unit made use of a thermocouple to measure the difference between wet and dry temperatures in the air-stream, while a further thermocouple gave readings to relate this difference to a reference temperature, read on a mercury thermometer within the cabin. This afforded an accurate measurement of the dry and wet temperatures outside the aircraft for later determination of the refractive index, when used in conjunction with psychrometric and pressure readings taken during an aerodist measurement at the ground stations. The aircraft altimeter gave a direct indication of the pressure reading at the aircraft, as it is set to read absolute pressure at all times.

Early in 1965, an Aero-Commander 680E twin-engined aircraft was taken on charter and, with an additional measuring channel obtained during 1964, a three-channel system was installed for the 1965 operations.

The master units were mounted in the rear cabin bulkhead while the chart recorder was placed on a bench to one side and forward of these. A panel was constructed above the recorder and units to contain the necessary ancillary equipment, including HF radio control, antennae cross-over switches, compass, altimeter, clock and the reference bulb and read-out unit of the airborne psychrometer, manufactured commercially on the basic prototype proved the previous year. The operator and booker were obliged to sit facing the rear of the aircraft. Although this tended to induce air sickness in certain operators, the installation proved satisfactory and convenient to operate.

Two master aerials were fixed externally on a tube running across the aircraft floor at the rear bulkhead in such a manner that, by manipulating a lever on the tube within the cabin, the aerials could be rotated about the tube axis so as to extend below the fuselage for operation. The aerial cross-over switches used in previous operations were again incorporated between these aerials so that optimum radiation zones could be utilized in line crossings in either direction. This also eliminated the necessity for rotating the aerials through 180° by means of the aerial remote control units each time a run was made across the line. The third aerial was mounted on a similar stub tube immediately in front of the co-pilot's seat and this provided suitable separation of the aerial units to avoid cross-interference while keeping the radiation zone of the signals clear of interference from the aircraft fuselage and propeller wash. The airborne psychrometer sensing head was mounted externally on a panel which replaced the co-pilot's window insert and afforded unobstructed air-flow, again unaffected by the aircraft.

In the early stages of operation, difficulty was experienced in operating the system using the new third channel. Use of the channel was suspended while an investigation was

[1] The original text of this paper, prepared by L. G. Turner, Division of National Mapping, Department of National Development, Canberra, appeared as document E/CONF. 52/L.44.

made which eventually determined that use of a frequency further removed from that of either of the other separate channels eliminated the interference experienced using the original frequency setting.

Meanwhile, operation was still confined to the line-crossing method with the two-channel system, but it proved the value of the fixed-wing aircraft over the helicopter for ease of operating condition, endurance and speed. The equipment was used to measure additional lines in the 1963 and 1964 operational areas to improve the tie to the geodetic framework, and some repeat measurements were made in the area originally measured in 1963 to improve the accuracy of those lines.

On completion of this project, the aircraft was returned to Melbourne for installation of air camera equipment, with a view to obtaining additional control by a combination of aerodist and camera exposures, locally called photo/trilateration. This method involves the fixation of the aircraft by three aerodist distances to known stations at the instant of a vertical camera exposure. The aircraft position can then be related to the ground below by way of the photograph, provided the tip and tilt of this are known.

A 70 mm air-camera was installed vertically in an adjustable mount which also carried an horizon camera with axis aligned to that of the 70 mm camera. The horizon camera is a 35 mm camera which by means of prisms takes simultaneous exposures of the horizon in four opposing directions. The exposure is made at the same instant as that of the vertical camera, a measure of the obliquity of the axis being obtained by comparison of the images of the horizons, with a fixed graticule appearing on the four photographs, exposed simultaneously.

On completion of the camera installation, a project was commenced with stations marked at 30-minute geographical intersections, within a geodetic loop in east central Queensland. The equipment was found to have deteriorated in efficiency by that time and considerable operational time was lost before it could be brought to satisfactory performance level by the servicing agents. Some experimental photo trilateration measurements were carried out during that period, more to consolidate the method and procedures involved than to produce usable results. It was found that some modifications to the installation were desirable, but the method was proved effective, provided the horizon camera exposures showed the line of the horizon sufficiently clearly.

At the end of the 1965 field season in November, the equipment was removed from the chartered aircraft and a complete overhaul and realignment was effected, while the third channel, with altered carrier frequency, was incorporated in the system.

At the same time, mutually acceptable arrangements were made with the aircraft charter company to use a Grand Commander aircraft for the next season's operations. The aircraft, a slightly larger version of the Aero Commander 680E used previously, had the advantage of additional payload and more cabin area. The greater cabin space allowed for the installation of the three-channel system on a rack situated centrally in the cabin and immediately in front of operators' seats set against the rear cabin wall. The recorder was mounted below the units and partly between the operators, allowing comfortable monitoring of the units and annotation of the chart during operations.

A modified camera mount was installed on the starboard side of the cabin immediately behind the co-pilot's seat with a camera operator's seat between the camera mount and the back of the equipment console. An additional feature of the new camera installation was the incorporation of a modified Williamson drift sight, aligned in the mount with the cameras, to enable more accurate tracking over features being photographed, and vertically mounted remote units used to check the accuracy of the aircraft altimeter. This method of calibrating the aircraft altimeter uses a comparison between the pressure altitudes at the aircraft and on the ground and the distance between ground and aircraft is recorded on the aerodist while passing over a vertically mounted remote unit.

The 1966 field season commenced in south-west New South Wales, where an area of secondary priority to the mapping programme had been marked to enable operations to commence earlier than possible in the northern wet summer areas, and offered a "shake-down" period closer to headquarters in case alterations or adjustments were required to the aircraft installation or aerodist equipment. The operation went well, apart from minor field adjustments in the early stages and some modification to the camera installation. It was also the first opportunity to have a permanent technician, employed by the division, at the scene of the operations, and subsequent operational continuity was due in no small measure to the ability to provide constant field servicing of the equipment.

Following the successful completion of the east central Queensland programme, commenced in 1965, the density of a previously measured 1° area was increased by establishing stations at the centre of each quadrilateral. While incorporating these in the network by line-crossing measurements to previously established stations, the density of control was further increased by systematic photo-trilateration measurements at the 30′ intersections, using the established stations as a basis for these measurements.

In view of a requirement to use previously established off-shore hydrographic triangulation stations as control for 1:100,000 mapping along the coastal area of Queensland, a programme was undertaken in September 1966 to tie selected stations to the mainland geodetic network. In this way it is anticipated that the sometimes unrelated third-order hydrographic surveys conducted over a number of years, when recomputed between the newly fixed stations, will become a homogeneous network of more accurate control.

As the island stations involved in this scheme presented a problem of occupation by aerodist remote units, arrangements were made with the Hydrographic Service, Royal Australian Navy, to provide a small survey vessel to move the various units from island to island as the work progressed. The arrangement proved eminently suitable and, as the ship was able to sail at night, the moves were made without any delay in the measuring programme. In this way some forty line measurements were made to connect ten offshore stations in a matter of three weeks. In the course of the operation, some difficulty was experienced with strong reflections over the water surfaces, particularly from elevated stations.

The balance of the field season was spent in further systematic measurements in preselected areas, and some time was spent in testing the maximum range of the equipment and other operational experiments.

Field party composition

The division has obtained two remote units to operate with each channel, thereby increasing the capacity to measure lines without involving remote station moves. In a two-channel operation, the remote units are distributed between three remote parties, one of which carries remote units for both channels, so that three line crossings can be made without movement of remote stations.

When three-channel aerodist is used for line-crossing operations, four remote parties are deployed so that the five new lines of a braced quadrilateral can be measured before it is necessary to move remotes. As the braced quadrilateral is the basis of a network built up of line crossings, this method has been adopted since the three-channel system became fully operative.

The project is normally programmed so that all measurements of a quadrilateral are made on one flight of approximately five to six hours, leaving the balance of the day for the remote parties to move to the next quadrilateral.

In 1966, the aerodist measuring party consisted of fourteen personnel, including the aircraft pilot employed by the charter company. Four remote parties were used, each of two officers equipped with a 30 cwt, four-wheel-drive vehicle and HF radio for communication with the aircraft and base camp. The master party was made up of the party leader, electronics technician and three officers who alternated as master equipment operators and engaged in field office duties, including the preliminary assessment of charts, to confirm that successful measurements had been made. The charts were then periodically dispatched to headquarters for processing and final computations.

COMPUTATIONS

In the computation of results from aerodist measurements, the extraction of the digital information from the graphical representation provided by the strip chart recorder is a time-consuming operation. It includes extraction of the coarse figure, which must be verified for each channel by repetition at a minimum of three separate places on the chart. Owing to poor trace quality and sometimes ambiguous resolution, considerable time is needed to obtain a satisfactory answer. In the case of a line-crossing chart, the next step is to read off pairs of distances at ten selected intervals on either side of the chart. These values are entered on to data sheets together with field-book and other basic information prior to being punched on to cards for electronic computation of the final spheroidal length of the line. The values obtained for each of the five to nine measurements of the line are then averaged to give the value of the line length used in the mathematical adjustment of the network. Such adjustment is also performed on an electronic computer, using the variation of co-ordinates programme by means of which the national geodetic adjustment of Australia was obtained.

The division has recently purchased a chart reader which was originally developed by the CSIRO Land Research Division to extract digital information from strip chart recordings. This device provides digital output of the information depicted by the trace on a chart recording and it is expected that much of the tedious work involved in

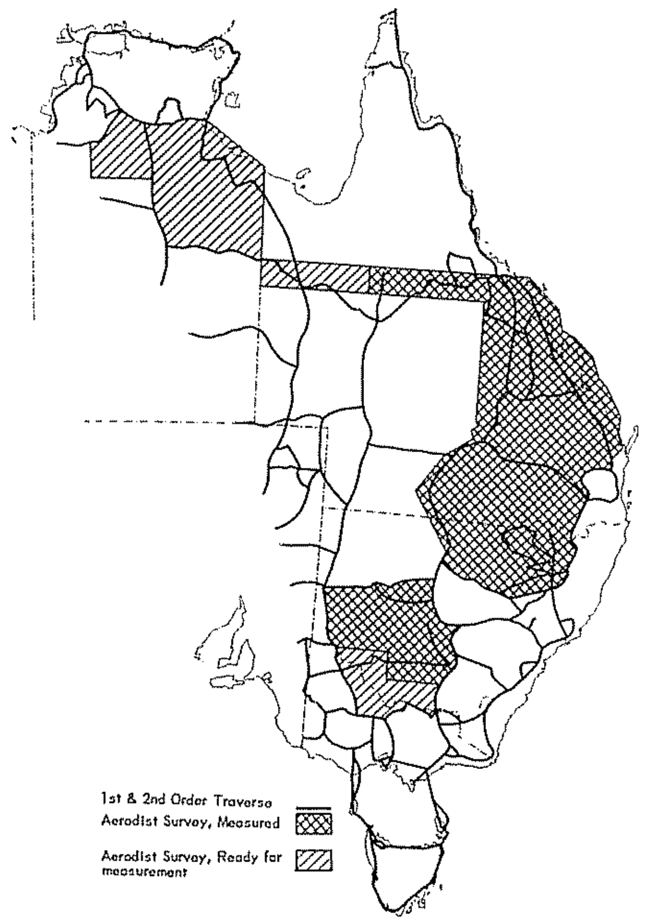


Fig. I—Australia: Aerodist control surveys as at 31 December 1966

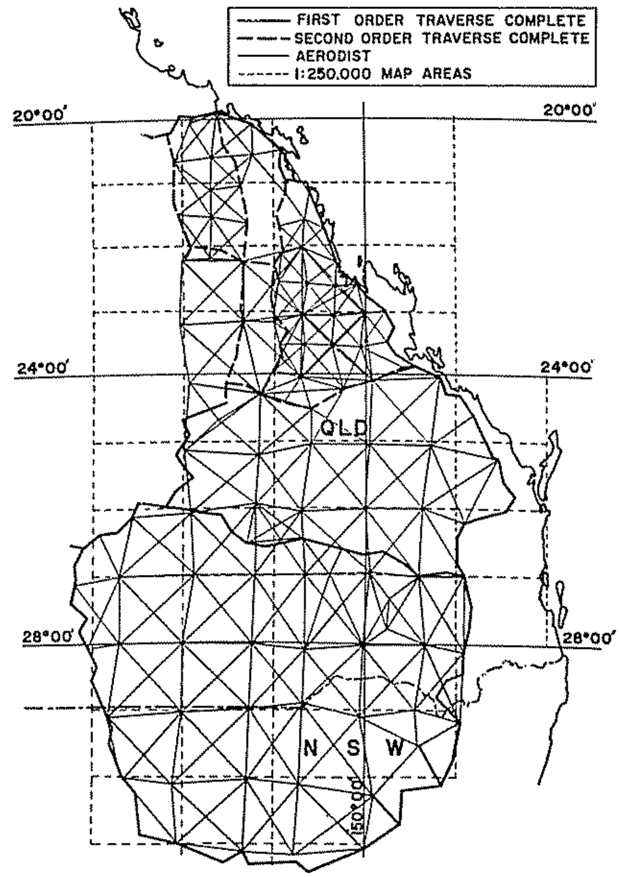


Fig. II—Australia: Aerodist measurements, May 1966

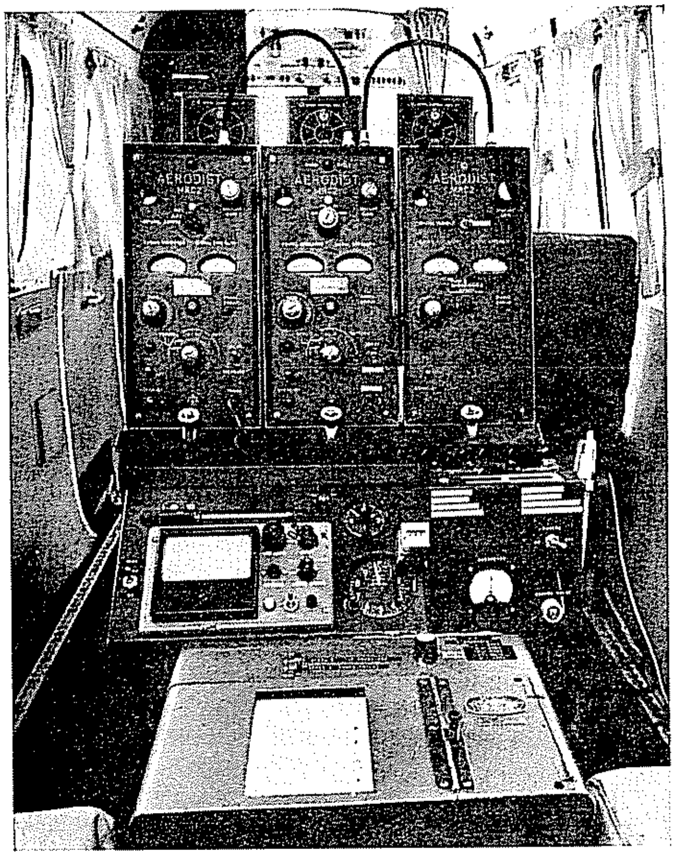


Fig. III—Australia: Master installation, Grand Commander chart recorder in foreground

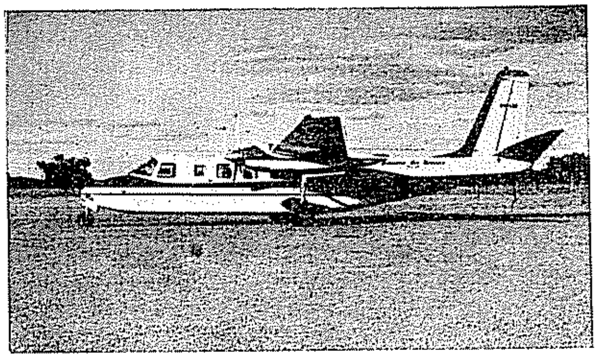


Fig. V—Australia: Grand Commander aircraft used for 1966 operations

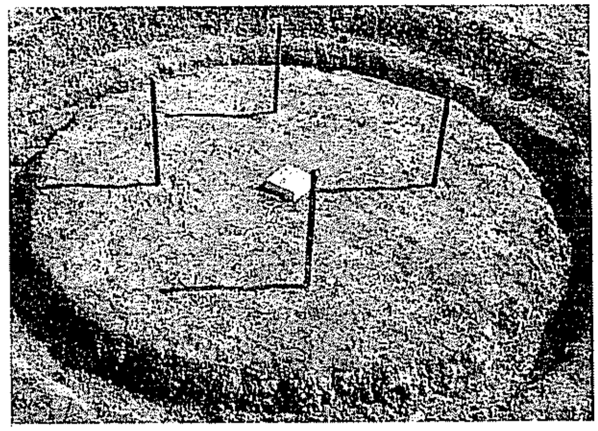


Fig. VI—Australia: Aerodist station block with marker posts and trench

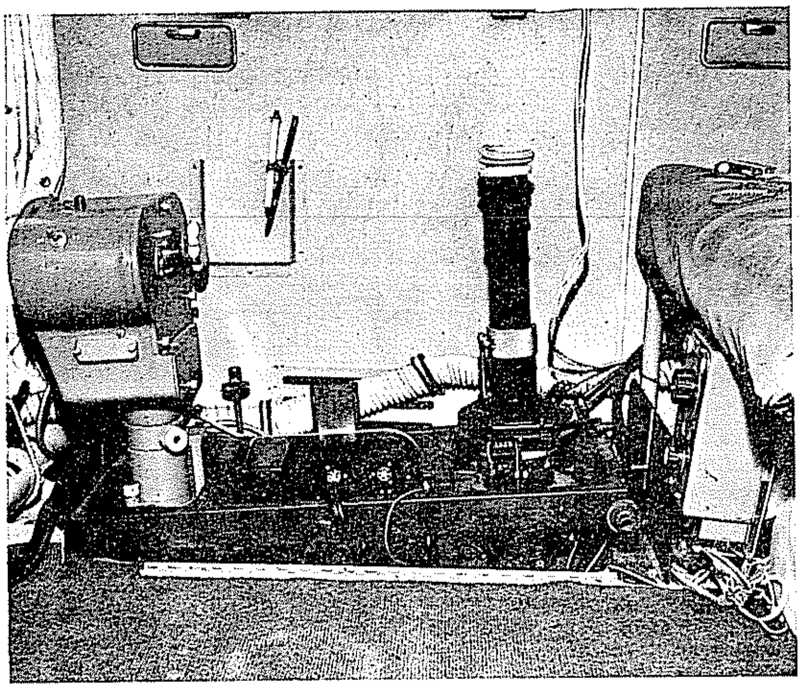


Fig. IV—Australia: Horizon 70 mm vertical camera and drift sight in tilting mount

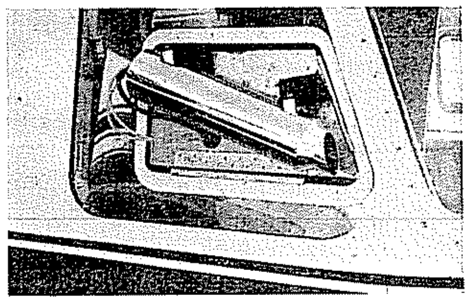


Fig. VII—Australia: Airborne psychrometer sensing head

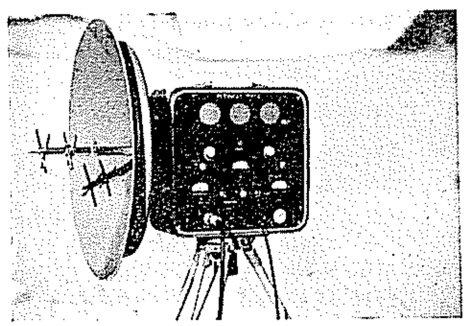


Fig. VIII—Australia: Aerodist remote unit extracting distances from aerodist charts will be overcome by use of this equipment.

A computer programme has recently been written to provide air stations positions from the photo/trilateration measurements previously mentioned. This computation requires the abstraction of distances from each of the three channels used at the instant of camera exposure, as indicated by a momentary deflection of the trace. These distances together with field-book information and basic data provide the means of computing the air station positions, which can then be related to the mapping photography by way of the positioning photograph.

Station establishment

The aerodist stations are marked by a concrete block surrounded by four marker posts and a circular trench or ring of stones. The trench or stones act as a marker for aerial spot photography. Reference marks are inserted and the stations are situated in readily accessible positions wherever possible, and commensurate with the restrictions imposed by survey requirements.

A station marking party usually consists of two groups under the leadership of a surveyor, each group consisting of an observer and three assistants. The station marking party, in addition to establishing the stations, is responsible for obtaining prior approval for the establishment from property owners affected, clearing of aerodist lines out of the station, levelling of the station either by automatic levels or barometric methods, and providing access information for the measuring party.

It has been found that a marking party of this size can establish an average of four new stations per week in addition to visiting and clearing existing geodetic stations selected for measurements to contain the aerodist network.

The station marking programme for the latter part of 1966 included an extensive area of the northern territory for which transport was provided by chartered helicopter. This means of overcoming the restrictions imposed by inaccessible terrain proved quite suited to the purpose and it is anticipated that remote measuring parties will be transported by the same means when the aerodist measurements are carried out in 1967.

Station identification

As an adjunct to the provision of horizontal control stations, the requirement for positive identification of the station on mapping photography has been covered by means of spot aerial photographs of the stations from various altitudes. This enables the exact position of the station, located by actually seeing the station mark or markers on the low level photographs, to be progressively transferred by differential stereoscope on to higher level, smaller scale photographs until a final transfer is made on to the appropriate mapping photographs.

Spot photography was originally carried out with hand-held Williamson or 35 mm cameras, but the installation of the Vinten 70 mm vertical camera provided a means of obtaining stereopairs of photographs of the station at each altitude, which increased the accuracy and facility of identification and transfer of the image position from scale to scale. Spot photography has now become an integral part of the aerodist survey and all new stations are photographed during the measuring operations.

Conclusion

Aerodist is now well established in Australia as a means of rapidly and accurately extending horizontal control for mapping purposes. With the present requirement for control accuracy suitable for mapping at scales of 1:100,000 and larger, there is no doubt that the aerodist will play a major part in providing such control.

An additional advantage of this programme could well lie in the use to which the resulting stations could be put for other survey purposes in a country where areas are thought of in square miles rather than acres. Such uses as control for mineral leases and pastoral and other surveys in the more remote areas are foreseen and this network of stations, closely integrated with the national geodetic survey of Australia, will undoubtedly provide great practical and economic benefits to the development of this larger continent over the years to come.

PROGRESS AND RESULTS OF HIGH-PRECISION TRAVERSE SURVEYS

Paper presented by the United States of America[1]

During the past five years, the United States Coast and Geodetic Survey has been conducting high-precision surveys with accuracies approaching one part per million. These surveys were started in 1961 to fulfil a request for positioning satellite cameras at various places along the east coast of the United States, north and south of Cape Kennedy, Florida. In order to meet this requirement and the increasing demands for high accuracy surveys, a system of high-precision traverse was developed. This traverse network consists of elongated diamond shaped figures as shown in the sample scheme for high-precision traverse on page 21.

The instructions for carrying out these surveys, the progress accomplished through December 1966, and the results obtained, are given in this report.

[1] The original text of this paper, prepared by Buford K. Meade, Chief, Triangulation Branch, Division of Geodesy, Coast and Geodetic Survey, Environmental Science Services Administration, appeared as document E/CONF.52/L.46.

Description

These surveys will follow existing arcs and main scheme triangulation to the extent practicable. Auxiliary stations (designated with station name RM A) shall be established at every other point along the traverse route. The auxiliary station shall be not less than 25 m, seldom more than 50 m, and never more than 100 m from the main traverse station and oriented so that the angles between the short lines and the main traverse legs will differ from 90° by not less than 10° or more than 35°. These limits will ensure a significant difference between the long sides of the slim triangles and maintain sufficient strength of figure to permit a good mathematical check between the geodimeter lengths.

Specifications for angle observations and traversing

(*a*) Each station shall be occupied on at least two nights. A set of observations on the long traverse lines on each night will normally consist of sixteen positions of the circle, never fewer than twelve, and the horizon shall be closed on each position by setting at zero just before and after reversal of the telescope, as well as at the beginning and end of each position. When the mean of each of the two sets, taken on each of two nights, differs by more than one second, a third set shall be taken on a third night.

(*b*) The average closure on slim quadrilaterals encountered in these surveys shall not exceed 0.7″ and the maximum shall seldom exceed 2.0″. In the slim triangles, the closure shall not exceed, in seconds, 600 divided by the short length in metres. Thus, if the short length is 50 m, the triangle closure shall not exceed 12″.

(*c*) The short distances between main and auxiliary traverse stations shall be measured with first-order accuracy using base-line procedures. Standardized invar tapes should be used for full 50 m or 25 m measurements if practical, but steel tapes shall be used for shorter measurements.

(*d*) Reciprocal vertical angles shall be observed over each traverse length. Adequate ties (every four to six main traverse lengths) shall be made to bench-marks.

(*e*) First-order astronomic azimuth observations will be made at each single station along the traverse. These observations will be taken on two nights with a probable error not to exceed ± 0.3 second and a different observer each night. The astronomic positions required for Laplace corrections will be observed by an astro-party at a later date.

Specifications for geodimeter observations

(*a*) Each line shall be measured with at least two nights' observations, one leg of each figure being measured with the model 2 Geodimeter: (i) when using the model 2 Geodimeter, with two measurements on each of the three frequencies, a total of six measurements will constitute one night's observation; (ii) when using the model 4D Geodimeter, one night's observation will consist of four complete measurements: one measurement with the mirror on minus 0.4 m, one measurement with the mirror on plus 0.4 m, and two measurements with the mirror at the centre point. One complete measurement is a mean result of measurements using each of the three frequencies.

The check between the two nights' measurements shall not exceed either of the following: for lines greater than 8 km in length, 1.7 cm plus one millionth of the distance measured; for lines less than 8 km in length, 2.5 cm.

In all cases, the mean value of two nights' measurements when projected through the slender triangle shall agree with the mean measured length to within 2.5 cm. If these limits are exceeded, observations on additional nights shall be made until any two nights' observations are within the above limits.

(*b*) Additional temperature readings will be taken along the geodimeter lines at intermediate points. The intermediate points will be within 0.1 mile of the line and within the central one-third segment if possible. A single intermediate meteorological station will suffice for the pair of geodimeter lines radiating from a single station to the next traverse station and its auxiliary station. The temperatures at the intermediate points are to be observed at the height of the geodimeter ray paths. The reconnaissance party was instructed to determine the sites of the intermediate points as well as the heights of the ray paths. Meteorological data at these points will be obtained by the use of balloons. Temperature readings will be recorded to 0.1° C and the intermediate temperatures will be given a weight of two and each end temperature given a weight of one in the computations. In the event that geodimeter lines cross varying terrain where tests indicate divergent temperatures, additional intermediate observations will be taken.

(*c*) Calibration and frequency checks will be made at various intervals during the progress of this project. These checks as well as any changes or adjustments made to the instruments will be noted, with dates, and submitted with the computations.

Astronomical position and azimuth

Taped distance (25 to 50 m)

Geodimeter distance (8 to 15 km)

United States of America: Sample scheme for high-precision traverse

In order to check the internal consistency of the observational data, the small angles at each end of the diamonds are computed and compared with the observed angles. The computed results are generally within 0.5″ of the observed values. Differences between the projected geodimeter distances and the direct measurements seldom exceed 1.5 cm.

Progress

The programme for establishing these high-precision traverse surveys was started in the latter part of 1961. Since that time, one field party has been in operation continuously and a second party has been operating since May 1965. At the end of December 1966, these surveys had been extended over a distance of 5,190 km (3,225 miles). The total length of all lines measured with the Geodimeters is double this distance, or 10,380 km. In these surveys, approximately 900 lines have been measured, each line with two different Geodimeters. Areas where this work has been accomplished, and the distance of each section, are given below.

Distance (in km)	*Section*
376	Vicinity of Cape Kennedy, Florida, south to Homestead, Florida
1,091	Vicinity of Cape Kennedy, Florida, north to vicinity of Jacksonville, Florida, then west to Lumberton, Mississippi
333	Lumberton, Mississippi, north to Greenville, Miss.
178	Greenville, Miss., west to Camden, Arkansas
329	Camden, Arkansas, south to DeRidder, Louisiana
365	DeRidder, Louisiana, east to Lumberton, Miss.
1,426	Vicinity of Jacksonville, Florida, north to Aberdeen, Maryland
344	Chandler, Minnesota, north to Fargo, North Dakota
517	Chandler, Minnesota, south to Kansas-Nebraska state line
231	DeRidder, Louisiana, west to New Waverly, Texas
5,190	

At the present time, one party is extending the traverse south from the Kansas–Nebraska state line; the other is operating westerly from New Waverly, Texas. These sections, when completed, will connect the Greenville, Mississippi and Chandler, Minnesota, satellite stations.

Results

In areas where the high-precision surveys have been accomplished, the results show conclusively that relative accuracies approaching one part per million have been obtained. However, these results do not take into account the error in the adopted value for the speed of light, which is estimated to be one part per million, standard error.

Astronomic positions, observed at each azimuth station and spaced at intervals of 20 to 30 km along the traverse, furnish deflection information for determining differential geoid heights. These geoid heights, based on zero at Meades Ranch, Kansas, are used to reduce all measured distances to the spheroid.

The adjustment of the direction, length and azimuth observations is carried out simultaneously by the method of variation of co-ordinates. Geodimeter measurements are given the same weight as direction and azimuth observations, that is, a correction of one part in 206,000 (arc 1″) to a length is considered the same as a correction of one second to a direction. The short taped distance in each quadrilateral is held fixed in the adjustment.

Adjustments have been completed for the following three sections of these surveys: (1) Cape Kennedy to Homestead, Florida; (2) Cape Kennedy to vicinity of Jacksonville, Florida to Greenville, Mississippi; (3) vicinity of Jacksonville, Florida, to Aberdeen, Maryland.

Results obtained from the observations and adjustments are as follows:

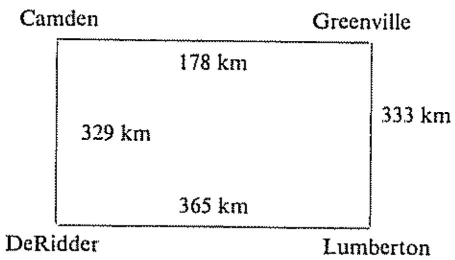
	(1)	*(2)*	*(3)*
		(in seconds)	
Average closure of diamond	0.51	0.63	0.74
Maximum closure of diamond	1.89	2.16	2.55
Average correction to a direction	0.26	0.20	0.22
Maximum correction to a direction	0.77	1.30	0.91
Average correction to Laplace azimuth	0.28	0.50	0.36
Maximum correction to Laplace azimuth	0.53	1.45	1.13
Probable error of single observation	0.29	0.28	0.25
		(cm)	
Average correction to geodimeter length	0.5	0.5	0.4
Maximum correction to geodimeter length	1.7	2.1	1.5

Each of the three sections adjusted is a spur traverse, with only one station used as position control. Since there are no position closures involved in these nets, the residuals from the adjustments represent only the internal consistency of the observations.

Preliminary computations for position closure were completed recently for the closed loop, Greenville, Mississippi, Camden, Arkansas, DeRidder, Louisiana, Lumberton, Miss., Greenville, Miss. The section of the loop from Lumberton to Greenville was in the adjustment of the spur traverse from Cape Kennedy, Florida to Greenville, Mississippi. Closures as indicated below were obtained from the unadjusted Laplace azimuths and geodimeter lengths.

Closure in metres

	Lat.	*Long.*	*One part in*
(1)	0.92	0.13	938,000
(2)	1.19	0.38	964,000



(1) Computations based on adjusted position at Greenville and closing on adjusted position at Lumberton, total distance 872 km.

(2) Computations continued from Lumberton to Greenville to complete loop, total distance 1,205 km.

After the geoid height computations are completed round the loop, all distances will be reduced to the speroid. The loop will then be adjusted as a spur in order to determine the closure after the observed directions, Laplace azimuths and geodimeter measurements have been corrected for consistency. A second adjustment will be performed to close the loop. The results from these adjustments should give a good indication of the accuracy, relative to Cape Kennedy, of positions at Homestead, Aberdeen, and Greenville.

Reduction of geodimeter data

The value for the velocity of light, 299,792.5 km per second of time, adopted by the International Association of Geodesy, Toronto, 1957, is used in the reduction of all measurements. Temperature readings taken near the mid-point of each line are given a weight of 2 and each end temperature a weight of 1 in the computations for refractive index, computed from the Barrell and Sears formula.

Each field party is equipped with a portable frequency deviation counter and frequency checks, on the model 4D Geodimeters, are made at intervals of about two weeks. Frequencies of the model 2A instruments are very stable and show little or no change over long periods. Frequency counts are taken on all Geodimeters at intervals of about six months. Measurements made with the 4D instruments are corrected to the standard frequencies based on the small changes obtained from the deviation counters.

The deviation counters have been in use during the past two years and over this period the model 4D results have been on the same order of accuracy as that obtained from the 2A. Some of the increase in accuracy is due to the procedure of making measurements with the mirror offset at intervals along the line. This procedure tends to mean out small errors in the calibration curves.

Geodimeter checks against taped base

In order to evaluate the Geodimeter results, a base line nine km in length was taped in northern Virginia in 1965. All Geodimeters in use on the high-precision traverse surveys were tested over this precise base during the period from April to June 1966. Results of the taped measurements are:

Date	*Taped base (in metres)*
27 October 1965	9,051.7482
29 October 1965	9,051.7476
2 November 1965	9,051.7590
3 November 1965	9,051.7492
Mean	9,051.751

The result obtained on each date is based on measurements made with four tapes which had been certified by the National Bureau of Standards to have an accuracy of one part per million. Tentative plans have been made to retape the base during the spring or summer of 1967.

Geodimeter results over the taped base follow:

Date (1966)	*Instrument & No*	*(A)*	*Length (metres)*	*Mean (metres)*
4 April	2A–140	10	9,051.741	
5 April	2A–140	10	9,051.731	9,051.736
5 April	2A–144	12	9,051.746	
7 April	2A–144	12	9,051.745	9,051.746

Date (1966)	Instrument & No.	(A)	Length (metres)	Mean (metres)
7 April	4D–284	7	9,051.746	
20 April	4D–284	7	9,051.740	9,051.743
20 April	4D–288	7	9,051.730	
29 April	4D–288	7	9,051.754	
2 May	4D–288	6	9,051.748	9,051.741
9 June	2A–114	12	9,051.754	
10 June	2A–114	11	9,051.766	9,051.760
9 June	2A–151	11	9,051.761	
10 June	2A–151	9	9,051.743	9,051.753
13 June	4D–246	6	9,051.752	
14 June	4D–246	6	9,051.752	9,051.752
13 June	4D–376	9	9,051.736	
22 June	4D–376	7	9,051.735	9,051.736
13 June	4D–441	6	9,051.744	
14 June	4D–441	6	9,051.747	9,051.746

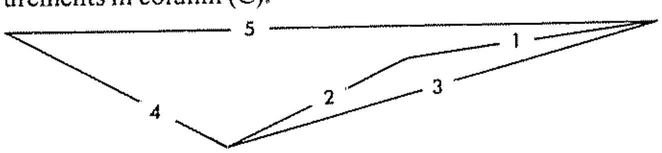
Lengths given above are the mean result of the number of measurements shown in column (A).

The mean result of all geodimeter measurements made in June is 2 mm less than the taped value and the mean of the first group of measurements is 9 mm less than the taped. In April, the atmospheric conditions were very unstable and during some measurements the temperature variations along the line were on the order of 5° C. Temperature readings were taken at the terminals of the line and at three equally spaced points along the line.

Laser Geodimeter

In the latter part of 1965, the Coast and Geodetic Survey started experiments to modify a model 4D Geodimeter and equip the instrument with a laser light source. This modification was completed in the summer of 1966 and test measurements were made over lines ranging in length from 2 to 16 km. These test measurements indicated that the accuracy of the results with the laser would be on the same order as that obtainable with models 2A or 4D; also, the lengths of lines probably could be increased to 25 or 30 km.

Late in October and early November 1966, the laser Geodimeter was tested along the high-precision traverse surveys in Nebraska. Results obtained with the various instruments are tabulated by line numbers as indicated hereunder. The number of complete measurements made on each date is given in column (A), the mean result in column (B), and the weighted mean of each group of measurements in column (C).



Line No.	Date	Instrument & No.	(A)	(B) (in metres)	(C) (in metres)
1	5 Oct.	4D–441	4	14,514.840	
	11 Oct	4D–284	4	14,514.838	14,514.839
1	1 Nov.	Laser	5	14,514.839	
	2 Nov.	Laser	7	14,514.839	14,514.839
2	3 Oct.	2A–114	6	15,653.487	
	11 Oct.	2A–151	6	15,653.466	15,653.476
2	31 Oct.	Laser	1	15,653.465	
	2 Nov.	Laser	4	15,653.471	15,653.470
3	31 Oct.	Laser	1	29,856.194	
	1 Nov.	Laser	5	29,856.213	
	10 Nov.	Laser	2	29,856.189	29,856.205
3*	—	—	—	—	29,856.205
4	6 Oct.	2A–114	6	14,980.279	
	13 Oct.	4D–284	4	14,980.252	
	27 Oct.	2A–151	6	14,980.269	14,980.268
5	10 Nov.	Laser	1	41,968.662	41,968.662
5**	—	—	—	—	41,968.670

* Projected length based on models 2A and 4D measurements over lines 1 and 2.
** Projected length based on models 2A and 4D measurements over lines 1, 2 and 4

The maximum spread of the various measurements on each date, for each model Geodimeter, was as follows:

Model	Spread of measurements (cm)
2A	3.5
4D	2.4
Laser	2.9

These results show conclusively that the laser Geodimeter will be a useful tool in obtaining high-precision over lines up to 40 km in length. Tentative plans have been made to modify six model 4D Geodimeters with a laser light-source and put these instruments in operation on the high-precision traverse surveys.

Programme for continuation of high-precision surveys

At the present time, the primary requirement for these surveys is to connect the Minnesota–Mississippi and Minnesota–Washington satellite stations. After these connexions are completed, the direct connexion from Maryland to Minnesota will be started. The results of these surveys, with relative accuracies approaching one part per million, will be used to scale the United States satellite triangulation network.

The map* attached to this report shows the proposed high-precision surveys, the sections completed at the end of December 1966, and the satellite triangulation stations. One additional satellite station has been established about 100 km north-east of Los Angeles, California.

* See pocket at end of volume.

A CONCEPT FOR AN UP-DATED THREE-DIMENSIONAL WORLD-WIDE GEODETIC REFERENCE SYSTEM

Paper presented by the United States of America[1]

The ultimate goal of world-wide geodesy may be described as the formulation of a three-dimensional mathematical model to which the following can be related uniquely: (*a*) the astronomical right ascension-declination system; (*b*) the geometry of the physical surface of the earth, and (*c*) the mathematical description of the gravitational field associated with the earth's mass, where the presentation of that potential surface, as represented hypothetically by the idealized oceans—the geoid—is of special interest.

Realistic accuracy requirements for global geodetic information, as well as the accuracy of presently available measuring methods, suggest a solution referred to the Euclidian-Newtonian space-time concept. In so far as this discussion will emphasize the significance of geometric concepts, it appears logical to introduce as a reference system a three-dimensional, orthogonal co-ordinate system with its origin at a point representative for the centre of mass and oriented in such a way that one of its axes coincides with the rotational axis of the earth.

The assumption is made that a standard deviation of one part in a million, in terms of earth dimensions, is obtainable or at least desired for the parameters of the final geodetic model. It is then obvious that the definition of a static geodetic solution, as given above, must be assumed to include such normalizing corrections as those related to the up-dating of the right ascension-declination system for a certain epoch, and to the elimination of the influence of pole movement on time, positions and directions by referring the rotation axis of the earth to a specified mean pole.

Small disturbances, such as earth tides, continental drifts, secular changes in the position of the centre of mass, etc. are assumed to be negligible when compared with the goal of a one part in a million globe-wide accuracy, or when it is recalled that they occur cumulatively over too long a period to be of influence for the establishment of a geodetic world reference system.

The foregoing statement about the objectives of global geodesy are classic in concept. To restate them here is to call attention to the known difficulties which geodesy encounters in its theories and in the reduction of its field observations when trying to accomplish its fundamental task: the determination of a homogeneous world-wide reference system.

The major shortcomings of classic geodesy become evident if it is considered that:

Until only recently, geodetic operations were restricted to individual land masses isolated by oceans;

For physical reasons (refraction), it is necessary to circumvent the three-dimensional character of the earth's geometry by executing separately the determination of positions and heights;

The need exists for introducing locally biased reference surfaces to which the field data, collected on the physical surface of the earth, must be reduced, necessitating the acceptance of certain hypotheses;

Most of the classic geodetic measurements are made in relation to the local direction of gravity; the basic assumption about the orientation of a chosen reference surface introduces a bias error, comparable to the influence of a DC-component in electrical circuits; the influence of the irregular character of the direction of local verticals is superimposed on the long, gentle slopes of the geoid which are similar to the ripples of an AC-component; because of the localized nature of the irregularities of the mass distribution in the earth's crust, this "AC-component" is characterized by relatively high frequencies with quite large amplitudes;

The so-called physical methods (gravity measurements), while avoiding the disadvantages caused by the noisy AC-components (plumb-line anomalies), still demand the acceptance of an undesirable number of hypotheses during the reduction of the corresponding field data.

Furthermore, classic geodetic triangulation nets must be established with all too many triangles, because of the limitation in the length of the line of sight between stations on or near the physical surface of the earth. The large number of figures which must be combined, together with unfavourable error propagation laws which are typical for any triangulation by angles, cause systematic errors, necessitating frequent checks by additional base-line and astro-azimuth measurements. Again, hypothetical assumptions are necessary to reduce these control measurements to a form suitable for incorporation into the basic triangulation.

Finally, the determination of the third co-ordinate (height) by levelling constitutes a physical measurement of "work" which can be reduced to a geometric length only by making certain assumptions about the mass distribution along the route of levelling.

In summary: classic geodetic methods derive their results by a cycle of iterations, where the observed field data are made compatible within themselves and with certain hypotheses which are accepted *a priori*. Despite the ingenuity applied to the field of higher geodesy, it stands to reason that a certain prejudicing of the final results is unavoidable and that the geodetic information obtained in a specific area is significant in terms of a specific datum only.

This situation is particularly undesirable when the different datums established by classic methods are amalgamated into a world datum. Because of a lack of geometric ties, such a task can be accomplished by classic geodetic methods only with the help of gravitational measurements; this explains the early interest shown by the international geodetic community in establishing accurate gravity base lines around the world.

Even if successfully executed, the corresponding results will still suffer under the uneven distribution of gravity measurements and particularly on account of the lack of such data over the ocean areas. Airborne gravity measurements and both surface and submarine gravity data could remedy the situation, at least in theory.

At best, such a world datum is a conglomeration of physical and geometric measurements welded together by and depending on certain geophysical hypotheses.

With full awareness of the weakness of any generalization of a subject as complex as geodesy, the foregoing was

[1] The original text of this paper, prepared by Hellmut H. Schmid, Director, Geodetic Research Laboratory, Institute for Earth Sciences, Environmental Science Services Administration (ESSA), appeared as document E/CONF.52/L.47.

presented to give some idea of the problems confronting classic geodesy when it seeks to establish a world-wide geodetic reference frame, a situation which existed when the first artificial earth satellites were launched.

With the advent of man-made satellites, geodesy was provided with a new tool. The geometry of their orbits can be considered as instantaneous representations of the gravitational field. Orbits suitably spread in terms of inclination and orbital heights allow an investigation in depth of the outer gravitational field. This possibility drew early attention to dynamic satellite geodesy. Significant results obtained thus far are the detailed description of the outer gravitational field and the discovery of systematic errors in classic geodetic datum parameters.

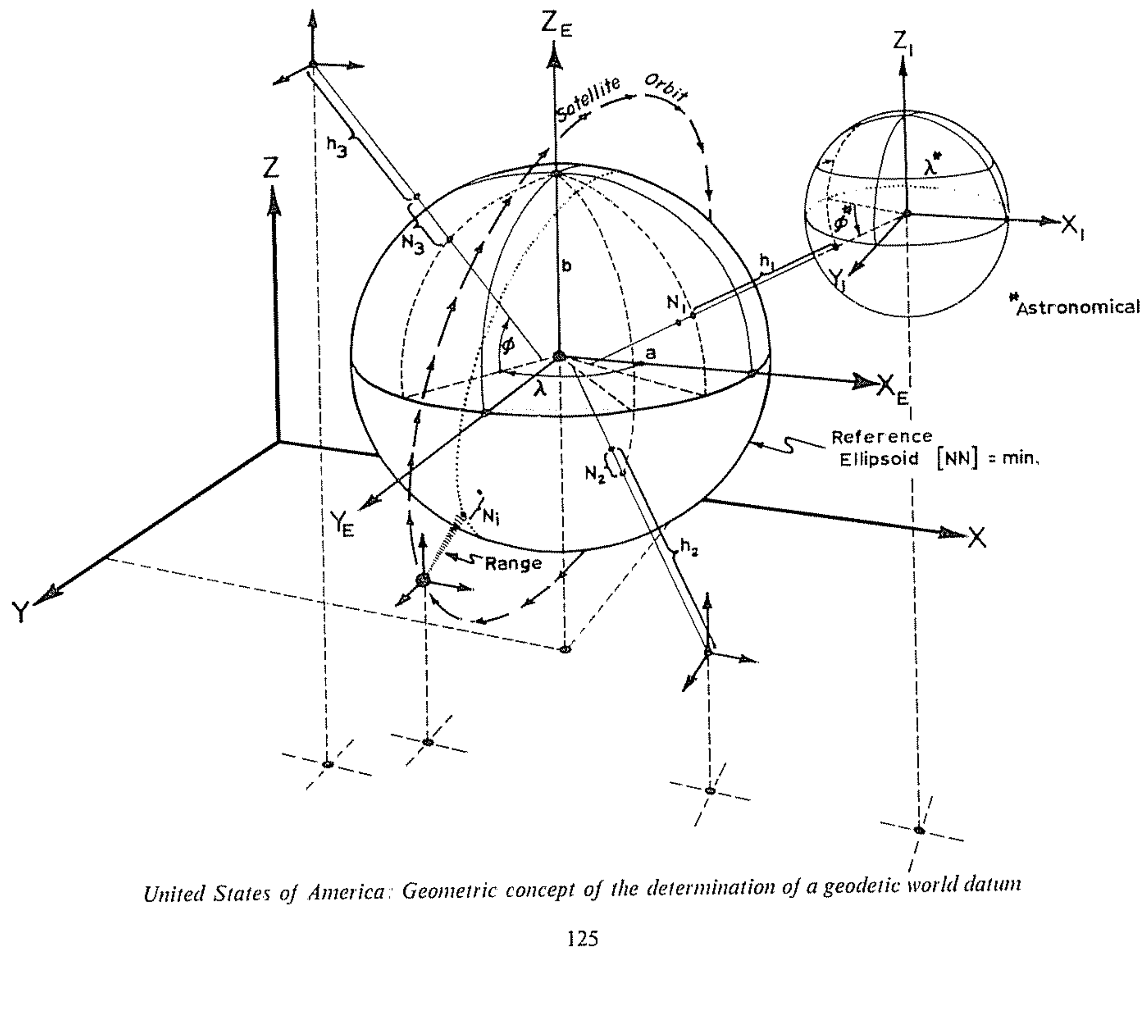
With the accumulation of data from increasingly more precise tracking systems and corresponding data evaluation procedures, however, certain discrepancies have become apparent between various results which are not to be explained from an accuracy standpoint in terms of the internal precision of the individual measuring systems. At best, the derived geometry of the tracking stations is biased by the particular character of the orbital model used to fit the tracking data.

Therefore a growing interest has developed in the application of geometric satellite triangulation. This method permits the determination of the three-dimensional positions of a certain number of selected stations on the physical surface of the earth, without reference to any geophysical hypotheses, specifically without reference to either the direction or the magnitude of the force of gravity.

Three-dimensional geometric satellite triangulation is, in all aspects, a determination of directions by an interpolation of measurements in the astronomic right ascension-declination system.

It is obviously necessary to consider physical influences, such as: non-linearity of scales and lack of perpendicularity of comparator axes; radial and decentring distortions of camera lenses; astronomical and parallactic refraction; diurnal aberrations; light travel time; satellite phase angle (a function of the satellite's size and reflectance characteristics); scintillation; proper motions; magnitude and spectral characteristics of the reference stars; pole movement, etc. All these perturbations can either be measured independently with superior accuracy, or determined from the recorded star field. Most of them cause only small second-order effects on the process of geometric satellite triangulation.

Using the *Echo* I and *Echo* II satellites, a three-dimensional geometric satellite triangulation net covering the North American continent has been established during the past three years. The scale was determined by geodimeter



United States of America: Geometric concept of the determination of a geodetic world datum traverses (cf. "Progress and results of high-precision traverse surveys", immediately preceding the present paper). This exercise has proved the absolute accuracy of the method to be, for the horizontal direction components, between 1 and 2 parts in a million and, for the vertical direction component, at least 3 parts in a million.

The United States National Aeronautics and Space Administration (NASA) launched the *Pageos* satellite in June 1966. It is a 100-ft diameter balloon and is in a nominally circular, nominally polar orbit about 4,200 km above the earth. In the framework of the United States geodetic satellite programme, a world-wide geometric satellite triangulation is now being executed. The goal is to establish, during the next three years, the three dimensional positions of forty to fifty stations well distributed over the globe. Improvements of the data acquisition equipment and data reduction techniques suggest that the accuracy of the world-wide triangulation will result in a positional accuracy approaching one part in a million in terms of earth dimensions.

Setting aside the disturbing factors of tides and currents, the surface of the ocean represents the geoid. A new tool of considerable theoretical and economic value becomes available with the tracking of satellites from stations positioned by the aforementioned geometric satellite triangulation method. Portions of orbits of such satellites can now be determined more or less continuously by using electro-optical ranging techniques (e.g., by SECOR, Doppler or laser).

When equipped with radar altimeter or laser ranging equipment, such satellites can measure, with an extremely high sampling rate, the separation between orbits and the surface of the ocean with an accuracy of a few metres. The abundance of data obtained with such geoid profiles, executed at different times in order to eliminate oceanographic effects, would provide, in a most desirable form, badly needed gravimetric information at sea. These data would contribute essential information to the determination of the configuration of the potential surface close to the physical surface of the earth, as needed especially for developing a significant model of the mass distribution in the crust of the earth, and, in addition, would provide a strictly geometric approach for the determination of a best-fitting reference ellipsoid.

The strictly geometric concept of the determination of a geodetic world datum is schematically shown in the figure on page 125.

With the geometry of the tracking stations determined independently and without reference to geophysical hypotheses, it will be possible to describe the outer gravitational field in abundant detail by observing satellites and computing the geometry of their orbits relative to the Cartesian system of the tracking stations. The investigation of the gravity field can then be conducted strictly in the realm of celestial mechanics and considering only geophysical influences.

Both geometric satellite triangulation and investigations concerning dynamic satellite geodesy together will eventually provide geodesy with the information necessary to establish the ultimate uniform world-wide reference system, which then will be representative for both the geometry of the physical surface of the earth and the gravitational vector field associated with its mass distribution.

With the assumption that by 1970 the execution of the current United States geometric satellite triangulation programme will be completed, it should be possible to establish a uniform global geodetic reference frame in the first half of the next decade.

The significance of the up-dated, three-dimensional, world-wide geodetic system is not limited to scientific investigations and the possibility (and probable necessity) of readjusting the historically accumulated geodetic data in the various countries with respect to such a new reference frame. An important economic contribution will be the use of these results to support geological programmes concerned with the study of mass irregularities in the crust of the earth; specifically, in the areas of continental shelves and in the ocean basins. Equally important, geodetic-topographic results obtained in the future can be based, geodetically speaking, on an absolute reference frame, eliminating the need for any costly up-dating in the foreseeable future.

Such considerations appear to be especially significant in the light of the potential of producing maps of large portions of presently still uncharted areas of the world, using satellites as carriers for precision photogrammetric measuring systems.

The existence of a globe-wide, accurate geodetic reference system will also satisfy requirements for precise globe-wide navigation. Finally, such a system may very well provide new background information on which future investigations in the general field of the earth sciences, such as a programme to study continental drifts, can be based.

THE GEODETIC SURVEY OF AUSTRALIA

Paper presented by Australia[1]

Progress of the survey

Early history

In 1912, a conference to discuss the survey and mapping of Australia was convened by the Commonwealth Minister for Home Affairs and was attended by the Director of Commonwealth Lands and Surveys, the Surveyor-General and the Government Astronomer of New Zealand, and the surveyors-general of the states of the Commonwealth.

[1] The original text of this paper, prepared by B. P. Lambert, Division of National Mapping, Department of National Development, Canberra, appeared as document E/CONF.52/L.51.

Appended to the report of that conference were detailed descriptions of the trigonometrical surveys that had been completed by the various states. The coverage of the geodetic survey as then reported is shown in figure I.

Of these surveys, only that of New South Wales conformed to first-order standards. The remaining surveys were of varying quality and, although not accurate by modern standards, served as immensely valuable reconnaissance schemes for more recent geodetic surveys.

At the 1912 conference it was recommended that a geodetic survey of Australia should be undertaken by the Commonwealth Government, but no effective action was taken during the next twenty years.

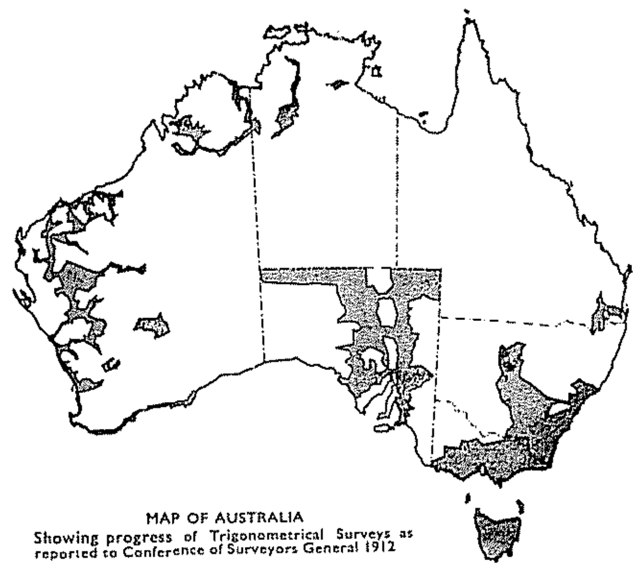


Fig. I—Australia: Trigonometrical surveys, 1912

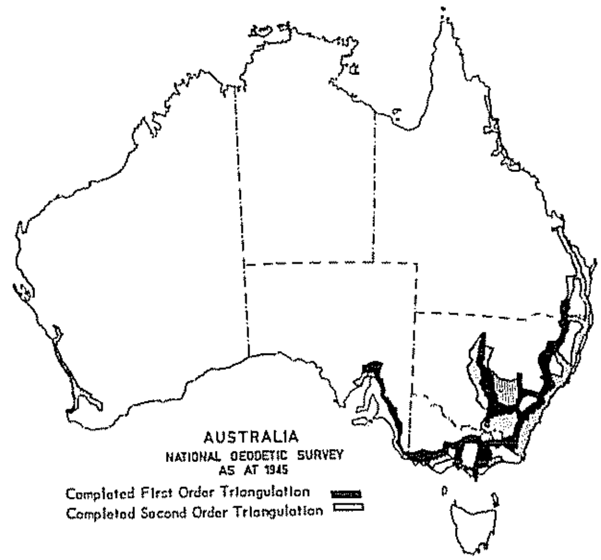


Fig. II—Australia: National geodetic survey, 1945

Reactivation by the Army Survey Corps

In the early 1930s, the Australian Army Survey Corps reactivated the geodetic survey and at first investigated the possible co-ordination of the geodetic surveys already completed by the state authorities in New South Wales and Victoria. This involved a close study of the New South Wales and Victorian records and also recomputation of sections of the triangulation. As a result of these investigations it was decided that the best approach was to run a new survey through both schemes.

This was done and the surveys were later extended into South Australia. The astronomical co-ordinates of the Sydney observatory were adopted as origin and Clarke's 1858 figure of the earth was used for computations.

Between 1935 and 1939, in conjunction with the University of Adelaide, special equipment and techniques were developed which resulted in a marked increase in the accuracy of base-line measurement. These involved the field standardization of invar tapes by the measurement of electrical resistances of previously calibrated steel tapes.

Aircraft reconnaissance was used to locate base lines but unfortunately no Laplace observations were included.

The Second World War intervened and included in the war effort was the extension of the geodetic survey along the north-eastern coast of Australia and the commencement of separate second-order surveys in northern coastal areas of Queensland and in Western Australia.

The Clarke 1858 figure was used in the computation of these separate surveys. Astronomical values were used for the origins of the local Queensland surveys, while the astronomical values of the Perth observatory were adopted in western Australia.

The status of the geodetic survey in 1945 is shown in figure II.

National Mapping Council participation

In 1945, the Commonwealth and state governments agreed to the setting up of a National Mapping Council for the co-ordination of mapping activities in Australia. It then became the responsibility of the Director of National Mapping to plan and direct the National Geodetic Survey, with full regard to the recommendations of the National Mapping Council.

Since its formation, the National Mapping Council has met at least once each year and has, as necessary, made many recommendations in respect of specific geodetic and topographic survey and mapping activities in Australia.

The Council first gave consideration to the practicability of using airborne radar for the geodetic survey but, after reading the reports of a very thorough investigation by the Radiophysics Division of the Commonwealth Scientific and Industrial Research Organization (CSIRO), and in the light of the developments then just beginning in respect of ground instruments for electronic measurement of distances, the council did not recommend proceeding with radar survey.

In 1948, the council resolved that a basic scheme of geodetic survey be proceeded with; this scheme is shown in figure III.

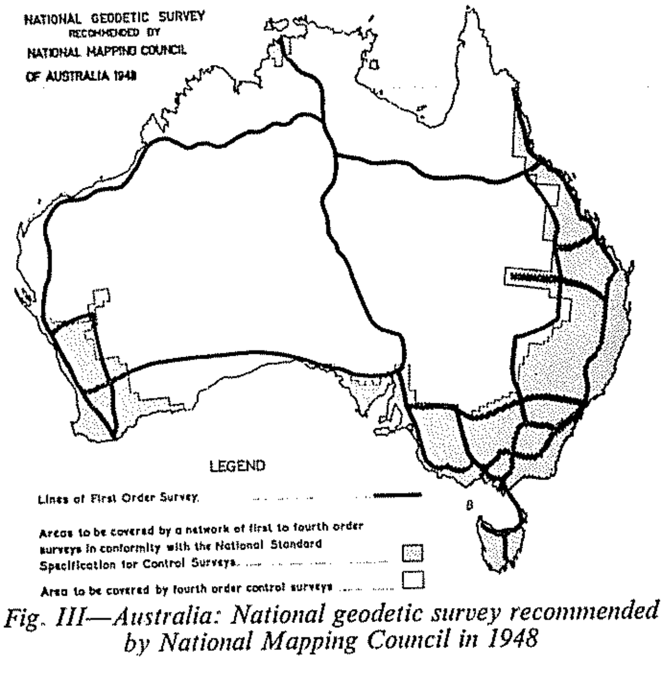


Fig. III—Australia: National geodetic survey recommended by National Mapping Council in 1948

Introduction of electronic distance-measuring equipment

Progress in the implementation of this scheme was slow at first and minor additions were made by the council in 1958 as the work gained impetus with the introduction of the Geodimeter in 1951 and the Tellurometer in 1957.

The base lines previously measured by the Army Survey Corps, using the resistance technique for field standardization, were again measured with the Geodimeter and a value derived for the velocity of light. This value agreed exactly with that which subsequently received international acceptance.

In 1959, the council adopted a much more ambitious scheme for the national geodetic survey (see figure IV below) and added to that basic scheme in 1961 and 1962. Progress in reconnaissance and design was accelerated by the availability of air photographs and the use of low-flying light aircraft for detailed location of stations.

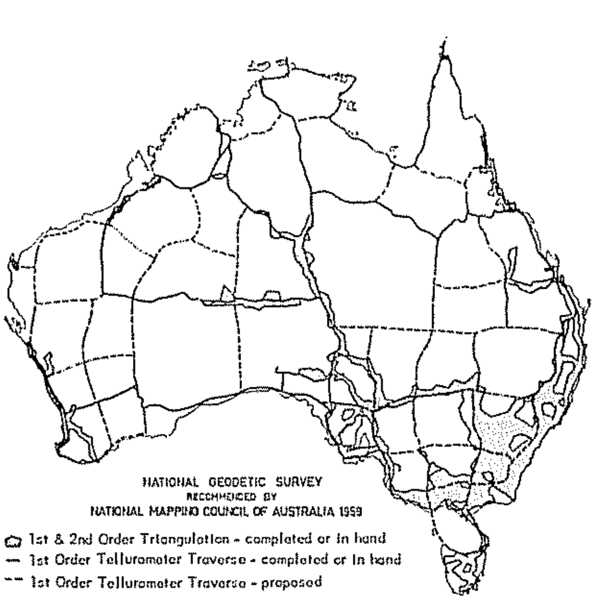


Fig. IV—Australia: National geodetic survey recommended by National Mapping Council in 1959

The Tellurometer very soon proved a practical proposition and first-order traversing became the regular procedure. Special techniques and operational procedures were evolved for the large central desert areas and led to a rapid expansion of the geodetic network. However, early loop closures were disappointing and investigation into the double summation effects resulting from cumulative angular errors led to a much closer spacing of Laplace azimuths.

Extension into New Guinea

In the period 1962–1964, the United States Air Force completed a HIRAN survey which extended from north-eastern Australia to New Guinea and the outlying islands of Australian controlled territory. This HIRAN survey has been integrated with Australian geodetic surveys that have been carried out over the eastern half of the island of New Guinea.

Satellite observations

In recent years, Australia has undertaken satellite observations of geodetic value on behalf of United States agencies. These have included Tranet observations at nine stations and the operation of one Baker-Nunn camera at Woomera.

Present status

The Commonwealth Departments of National Development and the Interior, the Royal Australian Survey Corps and all state and territorial lands departments have contributed to the national geodetic survey, the status of which, as at the end of 1966, is shown graphically in figure V.

National geodetic datum

Concurrently with the field surveys, investigations were undertaken to establish the best value of an origin for the survey and the most suitable figure of the earth.

In 1961, a preliminary analysis was made of the geodetic and astronomical data available by then, along the continuous survey between Sydney and Perth, in order that approximately correct values might be supplied for the Mercury project tracking stations at Woomera and Muchea. This was followed by an analysis of all astro/geodetic comparisons in the vicinity of the 32° parallel; and as a result a preliminary origin was determined at the Maurice station (South Australia).

In 1962, an investigation was made into the most suitable reference ellipsoid that could be derived from available data and one with the following dimensions was adopted: semi-major (equatorial) axis (a) = 6,378,165 m; flattening = $^{1}/298.3$ m.

In 1963, as the survey and subsequent computations progressed, the Maurice origin was converted to a central origin based on the analysis of 150 astro/geodetic comparisons.

In that analysis, approximate isostatic corrections for the influence of the topography were calculated, but they had only a minute effect on the mean value from the uncorrected values.

In 1965, the National Mapping Council adopted spheroidal dimensions accepted by the International Astronomical Union. It also adopted for an origin the Johnston Geodetic Station, named after F. M. Johnston, a former Commonwealth Surveyor-General and the first Director of National Mapping.

Computation and adjustment

The whole survey has since been adjusted on this datum by least squares, using the variation of co-ordinates method, first to the main loops, then to the portions of the surveys between the fixed intersections of those loops.

The computations and adjustment were carried out by officers of the Division of National Mapping of the CSIRO CDC 3600 computer.

The final adjustment involved the processing of approximately 18,000 data cards and the closures of 59 loops varying in length from 580 to 2,700 km, with an average length of 1,440 km. The extension into New Guinea involved another 1,500 data cards.

Future intensification

In 1963, a start was made on the intensification of the survey by Aerodist, using trilateration measurements to fix ground stations at the 1° intersections of latitude and longitude and in some instances at the 30′ intersections.

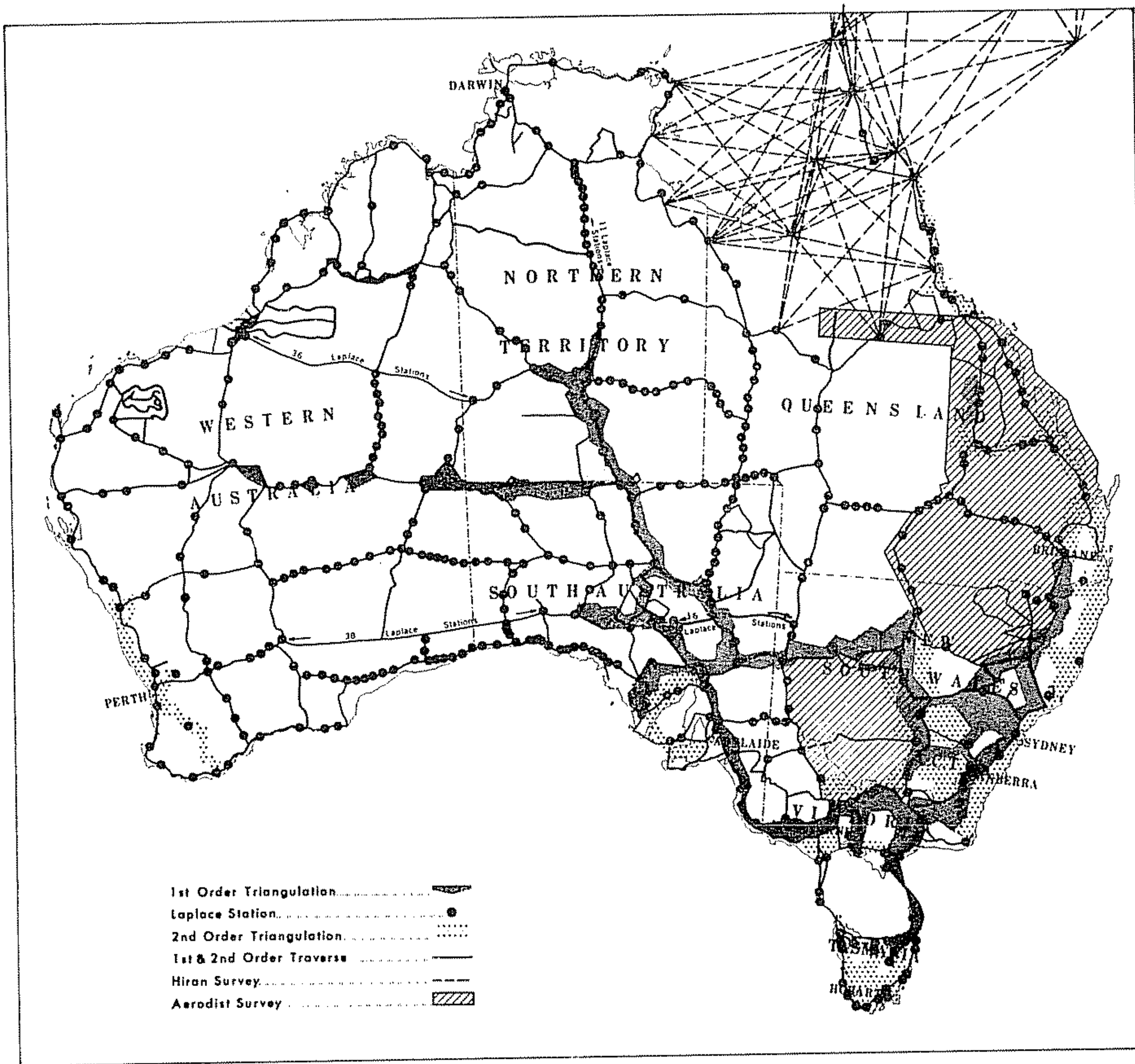


Fig. V—Australia: Geodetic control surveys as at 31 December 1966

This type of trilateration, together with second-order tellurometer traversing, will be used to provide a general pattern of horizontal control over the whole continent. The resultant data will provide direct map control and should be of sufficient accuracy to locate isolated significant errors, if any, that might have slipped through despite the care taken in the primary survey and its adjustment.

Probable accuracy

Scale standardization is based on the internationally accepted value for the velocity of electro-magnetic waves in vacuo and on the application of proper corrections for "atmospherics".

The precision of lengths, azimuths and co-ordinates of the origin may be assessed internally from closure data and estimated from the corrections applied in the course of the national adjustment.

External comparisons can be made with the United States Air Force HIRAN Survey in New Guinea and with any available data derived from satellite geodesy.

Origin

A final comparison with 275 well-spaced astro/geodetic stations gave mean deflections of:

Meridian $(A - G) = +0.12''$

Vertical parallel $(A - G)\cos\varphi = -0.33''$

A similar comparison in respect of all available 573 astro/geodetic stations gave a mean deflection of $+0.05''$ and $-0.58''$ respectively. These comparisons indicate that the continental consistency of the co-ordinates of the origin is likely to be within $\pm 0.5''$.

However, available comparisons with satellite observations indicate that there is a substantial and uniform slope of the geoid across Australia, with a maximum rise from the south-west to the north-east.

On the other hand, a shift of from 30 to 120 m in the satellite Cartesian co-ordinates will bring about a very good agreement with the geoid.

It would appear better to await later developments before arriving at any conclusion in this matter.

Scale and azimuth

In the course of the national adjustment, an analysis of observations led to the following estimate of standard errors:

Laplace azimuth (relative to the adopted origin): single end, ±1″; double end non simultaneous, ±0.7″; double end simultaneous, ±0.6″.

Intermediate: about ±1″ (depending on spacing of Laplace azimuths).

Distances: Tellurometer: rms error of 0.03 m plus $^3/10^6$.

In practice, the linear accuracy is affected by the errors accumulated in carrying forward trigonometric heights and by the lack of knowledge of geoidal undulations.

Loop closures

The average length of 59 loop surrounds was 1,440 km. The average misclosures were, in both latitude and longitude, ±2 m and in vector ±3.1 m.

The actual adjustments applied to 161 sections of these loops averaged ±0.56″ in azimuth and ±0.45 m in distance. The average length of these sections was 278 km.

As a test of internal consistency, three sets of independent traverses were selected, crossing from side to side of the continent and averaging about 4,800 km in length (see figure VI).

The co-ordinates of the national adjustment were adopted at a common starting point for each group. The co-ordinates of the terminals of the individual traverses were computed and then compared with the national adjustment values.

The results are listed in the annex on page 131. They show an average displacement in latitude and longitude of 1 $1/10^6$ of the traverse length with a maximum of 2 $3/10^6$.

The means of the groups of three independent terminal values were then compared with the national adjustment value. The average direct map distance from start to finish is 3,300 km and the average of the displacements of the means along and perpendicular to the respective direct lines is ±2.4 m, while the maximum displacement is 4.7 m.

Comparison with HIRAN measurements

In the adjustment of the surveys covering north-eastern Australia and the Territories of Papua and New Guinea,

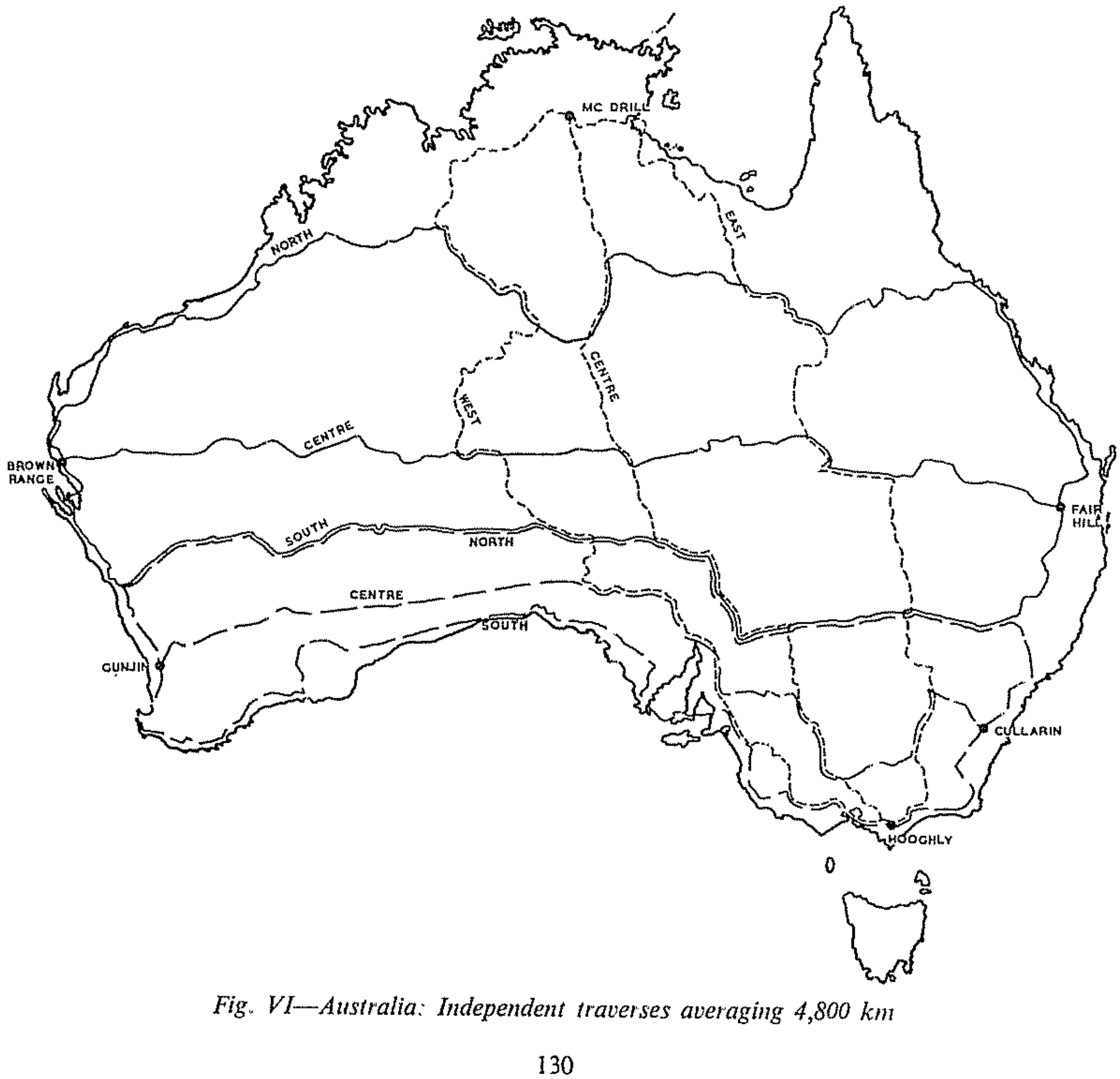


Fig. VI—Australia: Independent traverses averaging 4,800 km tellurometer distances were weighted much more favourably than HIRAN measurements.

One hundred and six HIRAN lines were included ranging from 136 to 877 km long, and the rms value of the adjustments to these lines was −6.2 m, regardless of length. There was a slight bias of +0.15 m which, on the average length of 562 km, gives a ratio of $0.3/10^6$.

Estimated accuracy

There would appear to be a 9 per cent probability of errors in azimuth (with respect to the adopted origin), and in length not exceeding for individual lines, 7.5 parts in 10^6, and across the continent, 1.5 parts in 10^6.

Manpower involved

With so many organizations contributing, it is difficult to assess the over-all manpower involved.

However, the following figures are available in respect of one organization only.

During the years 1963 to 1965 inclusive, approximately forty personnel of the Geodetic Branch of the Division of National Mapping completed 12,000 km of first-order tellurometer traversing and 280 Laplace observations. The range of their activities covered reconnaissance, initial planning, field surveys, tabulation and reduction of data and preliminary computations.

The nature of the terrain in which surveys were undertaken during that period varied from the deserts of central Australia to the mountains of New Guinea.

The national geodetic adjustment occupied a further 4 to 5 personnel from about 1964 to 1966. They were engaged in the development of programmes and procedures and in processing the tabulated data supplied by the organizations participating in that survey.

Probable future extension

The aerodist equipment has been used successfully to measure distances of up to 250 km, and it is hoped to extend that to 300 km in order to measure trilateration schemes that will connect offshore islands to the national geodetic survey.

Geodetic satellites may be used, in the triangulation mode to fix the position of more distant islands such as Cocos and Norfolk.

Preparations are already in hand in anticipation of the proposed world-wide geodetic satellite triangulation scheme.

Conclusion

There is good evidence that the Australian national geodetic survey is of high accuracy in respect of horizontal co-ordinates. The national levelling survey, now in hand, will improve its vertical accuracy.

It will be of the greatest interest in future years to compare this survey directly with the long-range azimuths and distances that will surely be measured in the course of future geodetic satellite operations.

Annex

CLOSURE OF TRANS-AUSTRALIAN TRAVERSES*

1. Hooghly, Vic, to McDrill, NT.

Opening co-ordinates of Hooghly from national adjustment: −38° 23′ 18″.3263 −146° 27′ 53″.1433
McDrill from national adjustment: −14° 34′ 26″.4479 −133° 02′ 28″.4322

McDrill from:	Traverse distance(km)	φ″	Δφ″	Δφ(m)	*ppm*	λ″	Δλ″	Δλ(m)	*ppm*
East traverse	4,596	26.6433	+0.1954	+6.01	+1.31	28.3241	−0.1081	−3.24	−0.70
Centre traverse	3,646	26.3060	−0.1419	−4.36	−1.19	28.5860	+0.1538	+4.60	+1.26
West traverse	4,985	26.3650	−0.0829	−2.55	−0.51	28.4554	+0.0232	+0.69	+0.14
				10.37	2.50			7.84	1.96
Range: Means (ignoring signs)	4,410	26.4381	0.1401	4.31	0.98	28.4552	0.0950	2.84	0.64

2. Gunjin, WA, to Cullarin, NSW

Opening co-ordinates of Gunjin from national adjustment: −31° 59′ 24″.6345 −116° 07′ 45″.1273
Cullarin from national adjustment: −34° 43′ 31″.9812 −149° 23′ 39″.4708

Cullarin from:	Traverse distance(km)	φ″	Δφ″	Δφ(m)	*ppm*	λ″	Δλ″	Δλ(m)	*ppm*
North traverse	4,974	32.3515	+0.3703	+11.41	+2.29	39.4320	−0.0388	−0.99	−0.20
Centre traverse	4,082	31.8361	−0.1451	− 4.47	−1.10	39.2546	−0.2162	−5.50	−1.35
South traverse	4,990	32.0982	+0.1170	+ 3.61	+0.72	39.3179	−0.1529	−3.89	−0.78
				15.88	3.39			4.51	1.15
Range: Means (ignoring signs)	4,682	32.0953	0.2108	6.50	1.39	39.3348	0.1360	3.46	0.74

3. Brown Range, WA, to Fair Hill, Qld.

Opening co-ordinates of Brown Range from national adjustment: −24° 54′ 04″.0734 −133° 42′ 59″.3515
Fair Hill from national adjustment: −27° 03′ 29″.4632 −151° 43′ 36″.8653

Fair Hill from:	Traverse distance(km)	φ″	Δφ″	Δφ(m)	*ppm*	λ″	Δλ″	Δλ(m)	*ppm*
North traverse	6,269	29.3443	−0.1189	− 3.66	+0.58	36.9437	+0.0784	+2.16	−0.34
Centre traverse	4,291	29.7071	+0.2439	+ 7.51	−1.75	37.1441	+0.2788	+7.68	+1.79
South traverse	5,135	29.8080	+0.3448	+10.61	−2.07	36.6944	−0.1709	−4.71	+0.92
				14.27	2.65			12.39	2.13
Range: Means (ignoring signs)	5,232	29.6198	0.2359	7.26	1.39	36.9274	0.1760	4.85	0.93

*See figure VI on p 130.

SOME AUSTRALIAN DEVELOPMENTS IN AIRBORNE SURVEY CONTROL

Paper presented by Australia[1]

The problem

Field survey work is often restricted and unduly time-consuming when ground stations which are ideally suitable for use as mapping control are located in areas virtually inaccessible to conventional means of transport, or where access is so difficult as to make the establishment of control points uneconomical.

It is relatively easy for a helicopter to land on or adjacent to any desired control point, but by the very nature of the terrain and the distances involved, the unknown ground station and the known ground stations are not always intervisible. The situation then requires some form of tower to be erected at one or all of the stations concerned, or for some form of greatly elevated platform to be positioned above the unknown ground zero.

United States approach to the problem

The United States Geological Survey decided that this could best be achieved by employing a helicopter with extremely good hovering capabilities to remain suspended above ground zero at an acceptable height for periods of time sufficient to enable theodolite observers at distant known ground stations to read vertical and horizontal angles and for a series of rapid electronic distance measurements to be determined.

For this purpose, a Hiller 12E helicopter was selected with a special stabilizing device to assist the pilot to hover. To this helicopter was fitted a flashing beacon to make identification easier and permit accurate angular observations.

For distance measuring, the Hydrodist system manufactured by Tellurometer, Inc., was installed in the aircraft and also employed on known ground station locations. The instrument gave direct read-out in metres with accuracy to 20 cm.

A hoversight was especially designed for use in the Hiller 12E and consists of a dampened pendulum which has a self-contained light source for projecting a beam of collimated light through a semi-transparent mirror. With the aid of another mirror, the observer can view an erect image of the terrain below and the image of the light. The image of the lamp filament projected against the terrain image defines the vertical.

A height indicator consisting of a reel of dacron line with a weighted end completed the airborne equipment. As the line is played out, it passes around a calibrated drum geared to a dial counter graduated in feet.

The known ground stations parties were each equipped with a Hydrodist remote station and a suitable theodolite.

The United States Geological Survey decided after extensive tests that the Airborne Control System (ABC) was suitable for surveys not exceeding 70,000 ft in length; that the maximum hover height was 300 ft but preferably lower, and that redundant measurements were needed for checked position and elevations. It decided further that two measurements were needed for horizontal control points, and for vertical control points where a horizontal angle was less than 15° and, lastly, that the known ground stations should be stronger than the results desired.

An alternative method is to delete distance measurements and establish position by triangulation on the flashing beacon. The usual requirements for an intersected point apply in this instance.

Australia's approach to the problem

Faced with the problem of fixing numerous control points in inaccessible or difficult terrain in Australia and New Guinea, and of a requirement to position such control as economically as possible for 1:250,000 and 1:100,000 map series, the use of a helicopter-borne platform as opposed to erecting towers became immediately apparent. However the limiting factors of the United States Geological Survey's system precluded its use in Australia under the aforementioned conditions.

Other limiting factors had to be considered, which were not compatible with the United States Geological Survey system. They were: the non-availability of a stabilized Hiller 12E helicopter; the absence of a Hydrodist system for distance measurement; the lack of a suitable hoversight.

In an endeavour to overcome these difficulties, the Royal Australian Survey Corps requested assistance from the Defence Standards Laboratory (DSL), situated in Victoria, and the Weapon Research Establishment (WRE), in South Australia.

Parameters stated for the acceptance of such a system were considerably more extensive that those attainable with the United States Geological Survey equipment.

The requirements were as follows (see figure I):

The helicopter must be capable of being observed over a minimum distance of 20 miles and preferably up to 35 miles;

The helicopter must be able to adopt a measurable hover at altitudes from 10 to 4,000 ft above ground level to a maximum altitude above mean sea level of 12,000 ft;

The helicopter should be able to hold position within a sphere of 10 ft radius of a point in space above ground zero;

The pilot must be capable of hovering within that given radius for approximately five minutes at a time, over a period of 20 to 25 minutes, allowing not fewer than four separate rounds of observations to be taken;

The equipment so designed should by preference be completely airborne. If this causes undue delay or expense, a ground located equipment would be acceptable as a partial solution.

Our requirements were studied by both DSL and WRE and, after consultation with experts in the electronic and optical field, and talks with helicopter pilots, it was established that the parameters stated were possibly too critical to enable an equipment of reasonable cost to be produced in a short period of time. Consequently, the parameters were generally scaled down to meet the conclusions reached by a feasibility study, and were revised as follows:

Observations to a helicopter at a 20-mile distance were readily acceptable, but 35 miles was considered extremely

[1] The original text of this paper, prepared by W. Child, Royal Australian Survey Corps, appeared as document E/CONF.52/L.52.

unlikely unless special lights were installed in the helicopter;

It was found that most pilots deprecated hovering below 500 feet when not in ground effect; the minimum hovering altitude was therefore raised from 10 to 500 ft;

The ability of the helicopter to hold position within a sphere of 10 ft radius of a point in space above ground zero was reduced to 5 ft; this was considered to be an optimum target;

The time condition of five minutes for hovering to permit observations would normally be met under good flight conditions; that time might have to be reduced to three minutes when weather conditions deteriorated.

It was agreed that the efforts of the two research organizations should be divided into two separate investigations. After consultation, WRE undertook preliminary research into a completely airborne optical plummet device whilst DSL concentrated on a ground-located equipment to assist the pilot to hover over a point.

In the space of two to three weeks, both organizations produced mock-up models of their deliberations.

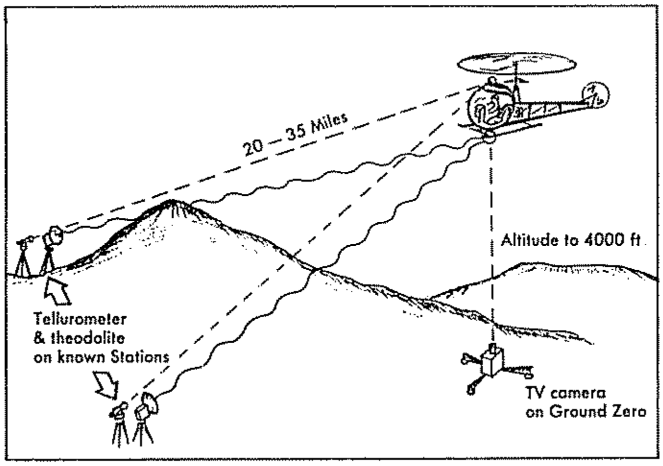


Fig. I—Australia: Airborne survey control system

THE GYRO-STABILIZED OPTICAL PLUMMET

The Weapon Research Establishment (WRE) produced a gyro-stabilized sight with semi-reflecting mirror. Because of the lack of suitable helicopters, it was necessary to fasten the sight externally to the Bell G347-B1 helicopter on the passenger's side. The mirror could not be used to effect because of the position of the sight in respect to the pilot.

J. Wood of WRE, despite his enthusiasm for the task ahead, soon realized that the optical sight was suitable only for low altitudes because of the lag inherent in that particular gyro-stabilized system. It was possible to plumb successfully to an altitide of 1,000 ft, but anything beyond that height was considered unfeasible. The project was finally abandoned.

The Defence Standards Laboratory (DSL) commenced investigation into a projected light-beam system based on a method developed for guiding ships into narrow channels. As adapted to the present problem, it comprises a vertically directed light beam consisting of three segments of different colours. By focusing the image of the segmented boundaries at infinity, the boundaries always appear well defined to an observer at distances greater than about 150 ft from the projector. Thus, in a typical arrangement the source when viewed from a distance appears to be red, green or yellow according to the segment in which the observer happens to be. If he is close to a boundary between two segments, then small movements (of the order of 10 inches at a distance of 2,000 ft) cause the colour to appear to change, and if he is at the point where the three segments meet, the source appears to be white. A mirror could be placed on the canopy of the helicopter so that the pilot might view the vertically directed light source.

As a first test of the feasibility, the system was flight-tested near Amberley, Queensland, on 26 and 27 January 1966, using helicopters of the 16th Army Light Aircraft Squadron. A suitable mirror had not been constructed, so that the beam was of necessity inclined at angles varying up to 40° from the horizontal.

The slide pattern shown in figure II was projected so that the red-green boundary coincided with the wind direction and the yellow segment was down-wind from the central patch. The pilot's task in hovering a helicopter is least difficult when the helicopter is heading into the wind. The pilot reported over a radio network when he considered that he was in the central white patch and theodolite readings were made, which enabled his position to be calculated.

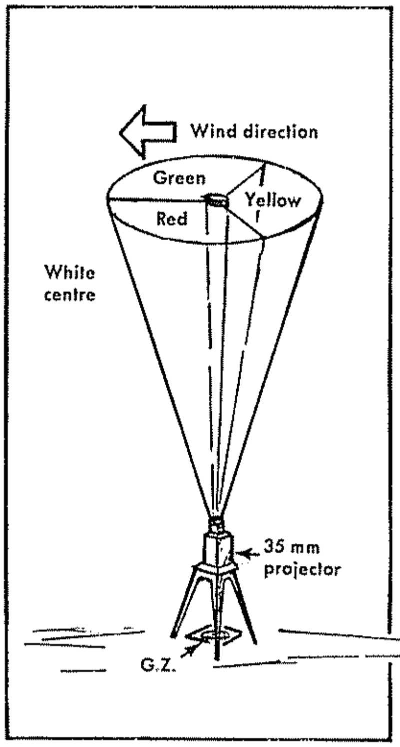


Fig. II—Australia: Projected light beam

Little difficulty was experienced in locating the aircraft within the light beam or with recognition of each of the three colours at distances of nearly 10,000 ft. However, it was hard to distinguish the central white region from the yellow beam.

The positions of the aircraft calculated from theodolite readings are not recorded in detail here, but they may be summarized as follows: of the fifteen readings obtained, about 50 per cent were within the distance of about ± 20 ft from the mean line; it was thought that in the remaining 50 per cent the pilot was mistaking the yellow light for the central white patch.

Those results may be compared with a spread of approximately ± 150 ft when the pilot was asked to hover (without the aid of the projector) at 3,000 ft above a farm house.

A second trial was held at Amberley from 22 to 24 February 1966, but owing to a number of adverse factors such as inclement weather, poor radio communications and rapid change-over of pilots, the trials were not very fruitful. However, some interesting results were obtained. The mirror was shown to be usable. It was very difficult to maintain both horizontal position and altitude simultaneously. In one flight, the hover point was over 40 feet from the mean position.

At this stage of development, therefore, the system using a projected light beam did not appear to be promising and although it could not be discarded, it was decided to concentrate on a television system as an aid to hovering.

The television system

In this system, a television camera is placed on the ground with the camera optical axis vertical. The picture is transmitted to the aircraft and displayed on a receiver placed in front of the pilot and alongside his instrument panel. The pilot therefore sees an image of his own aircraft and can manoeuvre it into the centre of the screen of the television camera. He is thus provided with information not only of position, as in the light projector method, but also of rate; that is, he knows where he is, in which direction he is flying and his velocity. A television system was considered suitable because its ground-based equipment is compatible with the projected beam system which was then being constructed in the DSL engineering workshops.

It was quickly shown that a satisfactory picture could be received in the aircraft. A major difficulty, however, was encountered early in the trial: the pilots' reluctance to view the receiver, which, of necessity, must be small (a 5-inch picture tube is used). The pilots at first declined to watch it on the grounds that there were too many other instruments to watch and that they feared losing control over the aircraft's attitude. Expressed in another way, they wished to use the horizon as an indication of their flying attitude as they had been trained to do.

On the earliest flights, therefore, an observer viewed the screen and continuously called instructions to the pilot. That method gave some success; at 1,500 ft the aircraft remained almost continuously within a radius of approximately 70 ft of the centre point and made quite frequent slow passes through it.

On an average, 10 per cent of the time was spent within a radius of 20 ft. This represented a great improvement over any previous result with the light projector.

Eventually a pilot was persuaded to view the screen himself, which he did without any trouble. There was an immediate improvement; in one short flight of 10 minutes at 2,000 ft, the aircraft remained within approximately 10 ft of the central point, except for two or three very short excursions to about 50 ft. Positions calculated from theodolite observation confirmed those data, which were deduced from motion-picture film records from a ground-based monitor television receiver.

Having therefore established the feasibility of the system, it was decided to carry out a series of flight tests at the School of Military Survey in Bonegilla, Victoria. The detailed conduct of those tests is too lengthy to be included in this paper. However, to provide an idea of the accuracies obtainable with this method, a summary of observations is given in the table below.

Airborne equipment

The following airborne equipment was used in the Bell 47 G3 B1 helicopter:

Two television receivers, "Sony" 5–202v, 5 inch; operating from helicopter 24V power supply, or similar; one for pilot, one for operator surveyor;

Antenna for television receivers, mounted on airframe to rear and forward of tail rotor;

Electronic distance measuring equipment: an MRA2 Tellurometer, positioned on the centre seat of the helicopter and powered from a 12V external wet battery on the skids;

A 17-inch parabolic reflector and dipole fitted to an elevated aerial which protruded through the floor of the cabin and was capable of being pointed in any direction by manual control in the cabin;

Altimeter to provide height information;

VHF radio communications provided by AN/PRC 25 dry-battery-operated radio fitted with duplex receiver and headgear so as to allow operation by both pilot and surveyor; this radio could also be operated from 24V wet-battery in the helicopter if so desired;

Antenna for VHF radio: a fixed copper wire aerial secured to the air frame and the starboard skid;

Meteorological equipment;

Standard aircraft flashing warning light: a suitable beacon light has not been developed and the helicopter warning light was used for this purpose; this light proved unsuitable.

Ground zero equipment

Pye "Lynx" TV2A with vidicon pick-up tube, powered by 24V DC batttery (figure III);

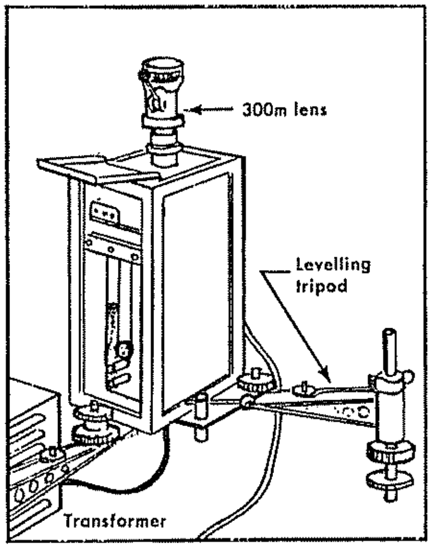


Fig. III: Australia: Television camera

Tripod for positioning the camera centrally over the point to be co-ordinated, and to allow levelling so that the optical axis of the camera is truly vertical;

Antenna for TV transmitter;

VHF radio communcations (in this case AN/PRC 25 radio);

Altimeter to determine the altitude of the ground zero; where large altitude ranges and changes in meteorological conditions are expected, a psychrometer is required with this altimeter.

Television camera calibration equipment

Calibration equipment is located at the base to check and adjust the bubbles on the TV camera which cannot be reversed during setting up in the field and must therefore be checked regularly and frequently to ensure verticality of the system (figure IV).

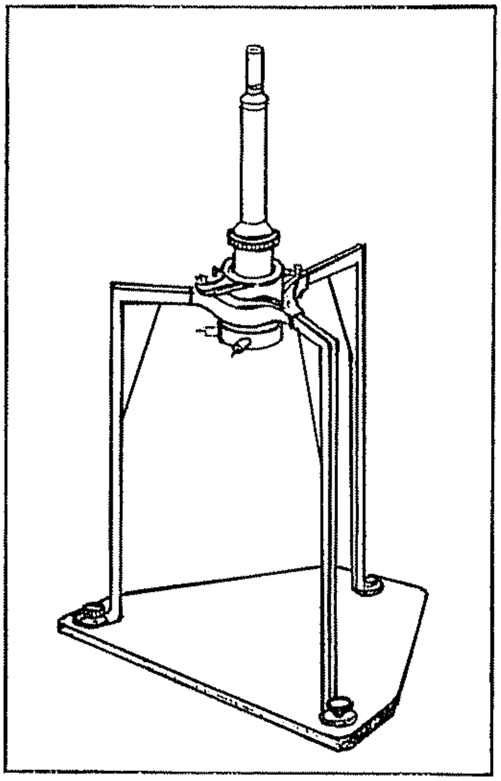


Fig. IV—Australia: Television camera calibration equipment

Equipment located at known ground stations

The survey equipment located at known ground stations comprises:

Distance measuring system: Tellurometer MRSa Mk 2 model; the circular 17-in reflector should always be used in the field in preference to the smaller rectangular reflector;

Theodolite fitted with artificial illumination and rheostat control to obviate use of the sun for internal illumination;

VHF radio communications with two handsets or microphone and head gear assembly to allow free use of hands;

Altimeter and meteorological equipment for height and refractive index observation data.

Operational procedures

Considering the difficulties to be overcome when attempting successful tellurometer distance measurements to a hovering helicopter, and the requirement to observe simultaneous angular observations, it is evident that observations must be extremely well controlled and completed as speedily as possible. Some factors which assist in efficient operations are given below.

Location of the airborne party

Points to be co-ordinated are preselected and, to assist ground-observing parties in quickly locating the helicopter, approximate bearings and distances are extracted, together with a table of elevations or depressions from the ground station for varying altitudes above ground zero. These need not be precise tables but should be sufficiently accurate to locate the helicopter in the theodolite telescope. The field of view of the theodolites used is 40′ of arc. Where distances are short and the helicopter can be sighted with the naked eye, these preliminaries are not essential.

Horizontal observations

During the early experimental stages, it was necessary to reduce observation times to a minimum, and to effect this horizontal and vertical observations were taken in one face only. After the observational techniques were improved, there was sufficient time to permit pointings on both faces. A simple technique was evolved as follows:

A suitable RO was selected and pointed prior to the commencement of observations to the helicopter;

On command from the controller, a bracket of pointings was made to the helicopter; the RO was re-pointed on completion of the bracket and the mean of the two pointings was taken as the result of that round of observations; in the early stages, horizontal angles were observed in groups of 5 and 10 pointings; later it was substantiated that 6 pointings made simultaneously with distance measurements constituted the optimum.

Vertical observations

As in the case of horizontal observations, initially one face only was used. Before each bracket was observed, observations were made to an adjoining point on both faces to determine collineation in the instrument. This field value was applied to the single-face observations to give a corrected altitude angle from the station to the helicopter. Later both faces were observed.

Distance measurements

The employment of an electronic distance measuring system (originally designed for static use) in a ground-to-air role poses many problems, the important ones being: determination of a coarse figure, ground swing, and correct interpretation of a trace which obviously oscillates in direct proportion to the instability of the hovering helicopter.

In standard observational procedures, coarse readings would be read before and after each set of fine readings.

Coarse readings are observed to give the basic measurement to within 6 inches or so of correct distance. As the system has a reading capability of 100,000 milli-microseconds, each of which is valued at 0.5 international feet in double transit time, it will be realized that the equipment as such has a measuring capability of only 50,000 ft, which is approximately 10 miles. Therefore it is essential to know the distance to be measured to within 10 miles. Thus for distances greater than 10 miles, 100,000 milli-microseconds are added to the observed values; for distances greater than 20 miles, 200,000 milli-microseconds are added, and so on.

In the normal course of events, a series of fine readings would be observed and the mean of these would always almost equal the last two digits of the coarse reading. If this was not so, the coarse reading would normally be suspect. In the case of observing a moving target (hovering helicopter), the system of reading "fines" has to be abandoned for lack of time. Nevertheless, a series of four coarse-fine-coarse measurements taken on differently calibrated settings should produce a figure within ±4 millimicro-seconds, which is acceptable for this type of operation.

Radio communications

Well controlled and adequate radio communications are essential. All personnel involved must be briefed on voice procedure. Once the radio network has been established, it is essential that only necessary radio traffic be permitted, and this should be brief and explicit.

Conclusion

It is evident from the results so far attained that the television technique can be usefully employed for the control of medium- and small-scale maps, when the points are accessible but not visible on the ground.

The equipment produced by the Defence Standards Laboratory was made from mock-up material only, and the fact that such pleasing results were achieved is due in full measure to the ingenuity and determination of the people involved.

Work has already commenced on the first prototype equipment and further tests are scheduled for March 1967. In the meantime, DSL is continuing experiments on a suitable and reliable airborne dampened optical system which, when attached to a TV camera, will provide a truly vertical system in the aircraft. If this airborne system can operate successfully at altitudes in excess of 4,000 ft the means of obtaining control in completely inaccessible areas will have been found and, provided ground zeros can be positively identified, control points may be established in any areas and selective positions most ideally suited to meet the requirements of any mapping system, be it slotted template, analogue or analytical plotters.

Annex

SUMMARY OF OBSERVATIONS: AIRBORNE SURVEY CONTROL SYSTEM

Trials area: School of Military Survey, Bonegilla, Victoria, Australia

Projection: Transverse Mercator Spheroid: Clarke 1858

Horizontal datum: Sydney Observatory, Lat. 33° 51′ 41″. 105, Long. 151° 12′ 17″. 85E

Vertical datum: LWM Hobson Bay, NSW

The ground zero in each case was Bonegilla peg No. 1, the coordinates of which are: eastings: 499 472.13 yards; northings: 540 255.56 yards.

Obs. serial	*Observer from stations*	*E (yards)*	*N (yards)*	*Number of pointings and distances measured*
1	Lady Franklin and Loka . . .	−1.05	−3.51	18
2	Lady Franklin and PM21 . . .	+3.80	−3.80	109
3	Talgarno and PM21	+2.31	+3.2	6
4	Huon No. 2 and Whytes . . .	−0.46	+1.02	46
5	Huon No. 2 and Whytes . . .	+0.58	−0.2	6
6	Huon No. 2 and Whytes . . .	−0.48	+1.1	38
7	Huon No. 2 and Whytes . . .	−0.86	+0.64	36
8	Huon No. 2 and Whytes . . .	−1.07	+0.89	29

	Distance to ground zero (miles)	*Height value (feet)*
Lady Franklin	16	1 792
Loka	19	2 187
Talgarno	7	2 116
PM21	12	1 970
Huon No. 2	6	1 480
Whytes	4	702

OPERATION OF AERODIST DISTANCE EQUIPMENT IN PAPUA-NEW GUINEA

Paper presented by Australia[1]

Introduction

Aerodist is an electronic distance-measuring equipment that continuously measures the range between a master unit in an aircraft and one, two or three remote units on the ground. It enables the distances to be measured between ground points that are not in line of sight of each other, or a ground point or aircraft to be fixed with reference to two known ground points.

In Papua-New Guinea, where optical lines of sight are difficult to obtain owing to dense jungle and continuous cloud conditions, Aerodist has proved particularly economical, and has provided results of suitable accuracy in establishing rapid horizontal control over extensive areas for medium-scale mapping. Conventional triangulation or traverse in such areas entails time-consuming, major clearing commitments, to be followed almost immediately by instrumental observations so as to avoid jungle regrowth problems. Aerodist patterns can normally be designed to take advantage of natural clearings, air strips, river sandbanks, rock hilltops and so on and obviate most of the clearing. Ground movement in western Papua-New Guinea is very difficult and extremely slow, by foot track, so that helicopters are essential for movement of ground-station equipment and personnel to ensure that repositioning of ground stations keeps pace with the speed of measurement possible with Aerodist.

A first-order geodetic survey of Papua-New Guinea was completed in 1965 and the aerodist net is to be adjusted to that framework (see figure I).

Characteristics of Aerodist

The aerodist equipment generally comprises three channels, although two channels are sufficient for single-line measurement techniques. The master units are installed in an aircraft and the corresponding remotes of each channel are positioned on ground stations. Simultaneous measurements can be made from the aircraft to up to three remotes of differing channel frequencies. For simple reference, the channels are called Red, White and Blue. The third channel is necessary only when controlled photography (i.e. fixing the aircraft position) is envisaged, but it may also be used in combination with either of the other two channels in conventional trilateration. The equipment provides a continuous chart recording of ranges

[1] The original text of this paper appeared as document E/CONF. 52/L.53 and Add. 1.

between the aircraft and the relevant ground stations. The frequencies of the carrier wave are in the 1,200 to 1,500 Mcs band.

Channel frequencies

Colour	*Master frequency*	*Intermediate frequency*	*Remote frequency*
Red	1 298	34.65	1 263.35
White	1 390	29.20	1 360.80
Blue	1 218	31.50	1 249.50

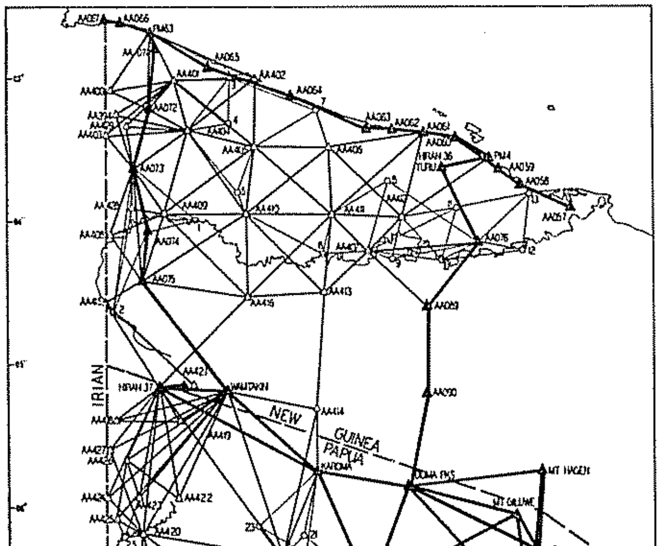


Fig. I—Australia: Aerodist control, Papua-New Guinea, 1964–1966

OPERATIONAL TECHNIQUES

Line crossing

Simple line measurements are normally made by flying for a distance of two or three miles backwards and forward across the line joining two remote stations, using two channels of the equipment. The sum of the two distances, in any one crossing, will become minimum when the aircraft is in line between the two ground stations. The two minima will occur simultaneously when the aircraft flies at right angles to the line between the two ground stations. Although it is not essential to fly exactly at right angles, it is important that the flight path during crossings should be straight and level, as any deviation will cause error to the reduced distance (see figure II).

The resultant slope distances, through the aircraft station, for each of the line crossings, may then be reduced graphically by plotting the sums of the measurements through their respective minima, or computed mathematically.

Geometry

The aerodist equipment measures the slope distances from aircraft to ground stations. The absolute heights of the aircraft and ground stations are therefore required for the reduction of the sea-level distance. They may be obtained by simultaneously taking altimeter readings at the aircraft and ground stations at the instant of the line crossing. The altimeter in the aircraft should be connected to a static line and frequently indexed by comparison with aerodist heights, measured vertically to a remote station of known height, whilst flying at the approximate altitude of the line crossing. The absolute heights of the ground stations may be established by separate altimeter heighting techniques, or higher order levelling.

Horizontal control pattern

Initially, in Papua-New Guinea it was intended to establish a regular 30′ pattern of points by Aerodist for photographic control, but, owing to the nature of the terrain and the random photographic cover, networks for adjustment had to be treated separately from those for detailed photo control. The main network was designed in longer lengths, using open ground such as air fields, kunai patches etc. for remote stations, and secondary connexions were made from these main stations to the specific location of points required to control the photography. It should be stated that the terrain in the border area ranges from palm-covered swamps and rain forest, through kunai slopes, low jungle-covered hills, large rivers with some sandbanks, to peaks of 12,000 feet and then large tracts of savannah-covered flats with very occasional clearings.

Main adjustment network

The main network was designed to contain as many redundant lines as possible, and to be connected to as many first-order geodetic stations as possible. This simplified the solution of ambiguities resulting from the use of scaled position from small-scale maps in reduction of line measurements. The main stations were chosen as far as possible on airfields because they provided access by fixed wing aircraft, as well as helicopter, and the vertical clearances for aerodist lines of sight were good. Telescopic towers, up to 70 ft high, were also used to raise the antenna of the remote instrument clear of local obstructions. All stations were targeted and then photographed by the aerodist aircraft. The longest line planned was 150 miles, and signal strength was excellent, indicating that that was not the limit. The shortest line, used for fourth-order connexion, was 10 miles, but index error and inaccuracies in ground station and aircraft heights significantly reduces accuracy on short lines. The average length of line planned

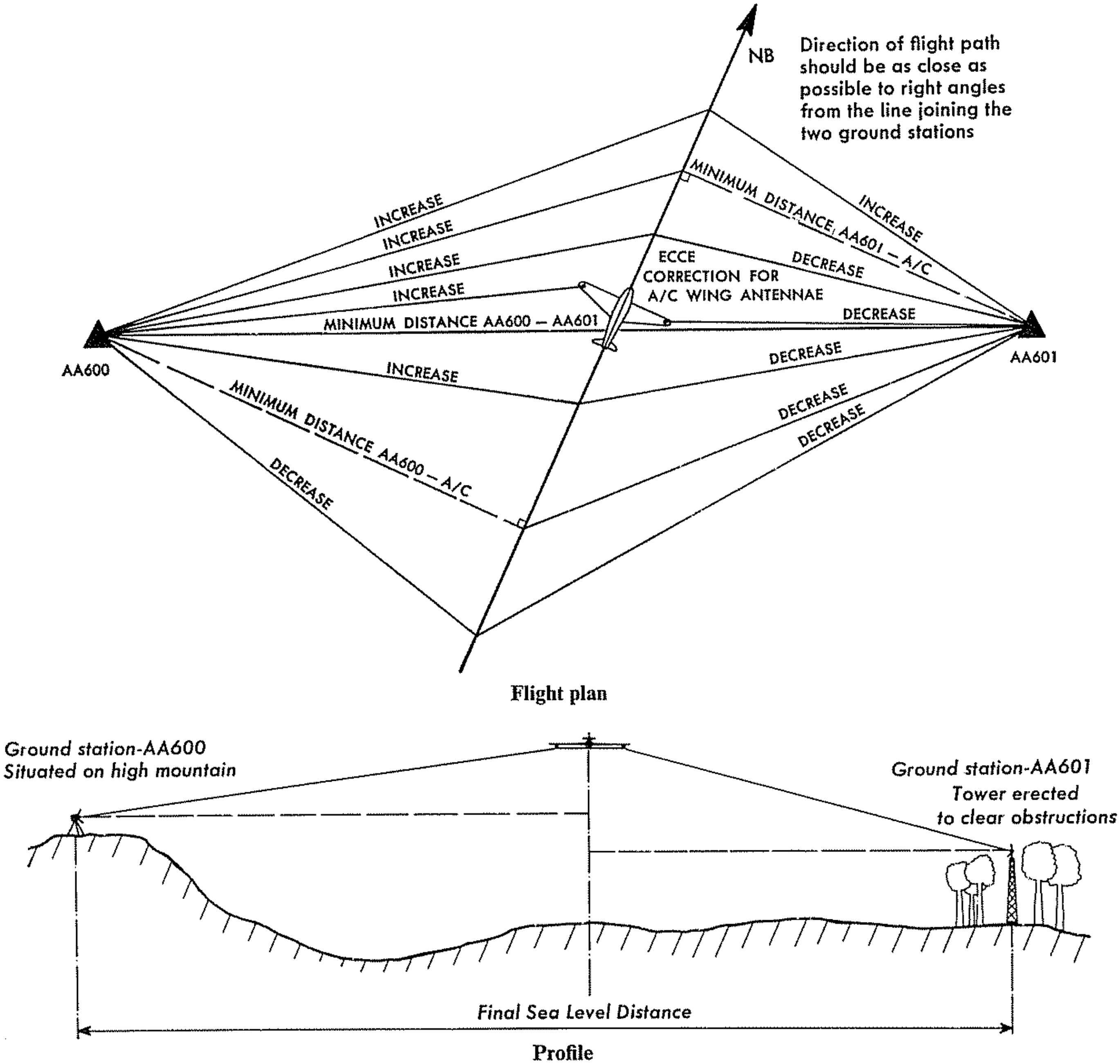


Fig. II—Australia: Geometry of line-crossing technique

was 50 to 60 miles, although many lines exceeded 100 miles. The targets were white plastic sheets, each 10 ft × 4 ft, laid in the form of a cross about the ground mark. All stations were additionally identified on the survey photography by ground parties.

The lines forming the main network were measured by a minimum of five crossings, at an altitude of between 8,000 and 10,000 ft. The position of the crossings along the line was usually central, although not essentially so, and the point of each crossing was deliberately varied to sample, as far as possible, the meteorological conditions along the line. The altitude of 8,000–10,000 ft was dictated by the height of the terrain, vertical angle of clearance from ground station, and cloud. Normally a height range of between 3,000 and 7,000 ft above terrain is the optimum, dependent of course on the length of line. The best altitude is the lowest height at which a good signal is received.

The photographic cover of Papua-New Guinea is irregular and disjointed owing to the continuous prevalence of cloud. In order to design a control pattern for photogrammetric adjustment, a composite mosaic of all available photography was assembled. The best of the east-west and north-south runs were selected to form the framework for ultimate strip adjustment and control was positioned accordingly. These points were selected at villages, airstrips, in river-beds or any natural clearings, where possible.

Whereas the selected photo strips were to be controlled and adjusted numerically, the areas contained within those strips were to be adjusted and plotted by multiplex bridging and semi-graphical means, so that an extra distribution of heights was required within those areas.

The accurate identification of the ground control on the survey photography demanded great care and attention, mainly to avoid gross error. For this reason, as stated earlier, all points were identified on the survey photographs by ground inspection and, in addition, were targeted and photographed individually by the aerodist aircraft. Because of the sporadic photographic weather, it was not feasible to pre-target before survey photography was taken.

The lines to the photo-control points were measured with a minimum of three crossings from each of at least three main stations, by the line-crossing technique. Supplementary heighting of all aerodist stations and strip and block control was obtained by barometric means by helicopter.

Organization of the project

Planning

Detailed planning for such a project is of utmost importance. Owing to the intense use of aircraft, fuel must be pre-positioned if the project is to run smoothly. Stores and equipment must be grouped, weighed and tested. Registered and unregistered airfield location and classification must be known. The technical plan must be clearly understood by all technical staff involved and air-crews briefed thoroughly.

Manpower

Altogether about 50 men, including air-crews, were employed on the project, and the outline organization is shown in annex I. An aerodist remote party of two men, with their equipment, can normally be moved in two light helicopter lifts, depending upon distance and altitude of their stations above sea level. The aerodist aircraft crew comprised pilot, navigator, camera operator, aerodist operator, meteorological data recorder and a co-ordinator who controlled the operational flying and the air-to-ground communications to all stations. Use of a smaller and less complicated aircraft would of course reduce the crew required. Six personnel were required to examine charts as they became available to ensure that measurements were acceptable and to keep pace with the measurement rate.

The administrative staff required to support the project amounted to six. Two radio operators were required to maintain continuous contact during daylight hours with forward stations and aircraft operating over mountainous jungle terrain in bad weather conditions.

Summary of output

In the main trilateration network, 45 points were fixed, and from these a further 34 photo control points were established. 149 lines were measured (5 crossings per line) in the main net, and 103 lines (3 crossings per line) to photo-control points. This was accomplished in a total of eight months' field effort. Altogether, the control so established provided data for the production of 77 maps at a scale of 1:100,000, or 46,000 square miles approximately.

The rate of measurement by Aerodist depends largely on the time taken to fly from the aircraft base to the operations area, from one line to the next, and the number of crossings per line; the rate of progress of the project depends upon weather conditions, the nature of the terrain and the means of movement, which dictate the rate at which the ground parties can be maintained and repositioned. One main line of five crossings can be measured in as little as 15 minutes' flying over the line and a subsidiary line of three crossings in 7 minutes when conditions are satisfactory.

The over-all accuracy of the instrument is expressed by the manufacturers as plus or minus 1 metre, plus or minus 1 part in 100,000 of the distance. This has been shown to be possible by comparison of aerodist measurements with known lines, where elevations of remote stations were accurately fixed. In Papua-New Guinea, where there is no basic level network and long-range barometer techniques have been used, the accuracy is naturally expected to fall away.

Conclusions

Some of the more important lessons learned from experience with Aerodist over the last three years are:

An area of operations should be sufficiently extensive to warrant the effort of mounting a major control project;

The main aerodist trilateration for adjustment within the geodetic framework, and the supplementary photo-control for photogrammetric adjustment, should be planned and measured conjointly, though designed for different purposes;

The detailed planning of the administrative and logistic support for an aerodist project is of utmost importance;

The rate of repositioning the ground stations must be in balance with the rate of the aerodist measurements;

Sufficient computers must be available in the field to prove line measurement charts before leaving the area;

A two-channel aerodist system would normally be sufficient for line measurement techniques;

The accuracy of the system is within the manufacturers' stated limits, subject to conditions stated previously.

Whilst the foregoing may give the impression that the aerodist equipment was introduced and operated efficiently without initial difficulty, this is far from the truth. Until the frequencies of the three channels had been given their current spread of approximately 90 mcs in late 1965, more line measurements were abortive than successful, due to inconsistency of signal strength and minor equipment failures. However, at the present time it is possible to measure with almost guaranteed success up to five lines in a three-hour sortie, when the aircraft base is reasonably close to the area of measurement and sufficient remote stations are available for deployment.

Annex I

ORGANIZATION OF NEW GUINEA AERODIST PROJECT

Main Base

Officer in charge
Fixed wing pilot—light aircraft

Administrative group of 6

Operational group

Aerodist aircraft pilot
Aerodist aircraft navigator
Aerodist aircraft camera operator
Aerodist aircraft engineer
Radio operator
Electronics technician
Aerodist operator
Meteorological reader
6 computers

Forward Base

Officer in charge
2 helicopter pilots
2 helicopter engineers
Administrative element

8 remote aerodist stations

(each of 2 men)

Annex II

AERODIST ADJUSTMENT PAPUA AND NEW GUINEA: SUMMARY OF REDUCED AND ADJUSTED MEASUREMENTS, PROVISIONAL VALUES, SEPIK NET ADJUSTMENT

Spheroid: ANS (160).
Projection: UTM (zone 54).
Datum: Horizontal, Johnston origin; vertical: MSL.
Unit: Metres.

Line	*Reduced measurement*	*No. of measures*	*Range from mean*	*Adjusted correction and parts ratio*	*Adjusted length*
AA 405			+6.40	+0.39	
AA 410	52 744.27	8	−4.25	13 525	52 744.66
AA 404			+1.60	−9.17	
AA 405	51 744.06	7	−3.44	5 642	51 734.89
AA 073			+3.29	−2.46	
AA 404	49 338.84	6	−3.72	20 055	49 336.38
AA 410			+5.27	−9.67	
AA 409	61 500.75	8	−7.06	6 359	61 491.08
AA 404			+2.02	−7.99	
AA 409	64 469.30	6	−2.26	8 068	64 461.31
AA 404			+1.19	−7.32	
AA 410	77 665.07	6	−1.92	10 609	77 657.75
AA 073			+2.41	−9.38	
AA 409	42 791.90	7	−2.09	4 561	42 782.52
AA 411			+2.72	−20.80	
AA 410	56 332.10	4	−5.20	2 707	56 311.30

Line	*Reduced measurement*	*No. of measures*	*Range from mean*	*Adjusted correction and parts ratio*	*Adjusted length*
AA 406			+1.38	−1.09	
AA 410	81 077.43	6	−1.11	74 381	81 076.34
AA 406			+2.85	−0.06	
AA 411	52 698.67	5	−5.79	878 160	52 698.61
AA 405			+2.86	−21.54	
AA 406	55 535.08	4	−4.72	2 577	55 513.54
AA 405			+4.33	+3.55	
AA 411	72 369.91	7	−7.03	20 386	72 373.46
AA 405			+3.15	−8.05	
AA 409	84 554.48	8	−4.09	10 503	84 546.43
AA 406			+7.40	−22.03	
AA 061	73 624.01	5	−5.40	3 341	73 601.98
AA 406			+2.09	−0.61	
AA 412	79 980.40	6	−1.07	131 114	79 979.79
AA 411			+6.29	−0.32	
AA 412	57 653.67	5	−6.78	180 167	57 653.35
AA 411			+1.55	−0.47	
AA 061	97 190.39	4	−1.50	206 787	97 189.92
AA 394			+2.48	−3.94	
AA 402	54 184.02	5	−3.34	13 751	54 180.08
AA 394			+4.25	+4.56	
AA 404	56 933.71	7	−5.52	12 486	56 938.27
AA 394			+5.55	−3.24	
AA 073	41 255.20	5	−4.41	12 732	41 251.96
AA 429			+6.71	−2.21	
AA 401	50 057.26	5	−9.41	22 649	50 055.04
AA 429			+0.59	+2.03	
AA 404	48 411.21	5	−1.58	23 848	48 413.24
AA 429			+2.81	−1.81	
AA 073	35 416.49	5	−2.60	19 567	35 414.68
AA 403			+2.80	−0.05	
AA 401	66 881.62	5	−4.39	1 337 631	66 881.57
AA 403			+3.18	+0.06	
AA 404	60 573.71	7	−3.88	1 009 563	60 573.77
AA 403			+8.08	−0.04	
AA 073	30 568.38	7	−4.12	764 209	30 568.34
AA 401			+2.84	−4.84	
AA 405	79 581.46	9	−2.76	16 441	79 576.62
AA 428			+3.89	00	
AA 409	29 307.01	5	−3.31		29 307.01
AA 416			+4.44	−2.85	
HIRAN 37	99 778.23	7	−3.96	35 009	99 775.38
AA 428				00	
AA 073	28 727.64	Telle			28 727.64
AA 412			+1.40	−3.33	
PM 4	88 414.90	7	−2.21	26 550	88 411.57
AA 412			+0.62	+0.50	
AA 061	69 037.69	3	−0.40	138 076	69 038.19
AA 407				−2.65	
AA 412	32 403.60	Telle		12 227	32 400.95
AA 407				−5.15	
AA 413	44 644.82	Telle		8 668	44 639.67
AA 407			+1.87	−9.41	
AA 411	44 740.81	5	−1.94	4 754	44 731.40
AA 407				−7.75	
AA 089	61 789.70	Telle		7 972	61 781.95
AA 407				−3.38	
AA 076	90 750.71	Telle		26 848	90 747.33
PM 63			+1.18	−11.60	
AA 401	42 842.85	5	−2.36	3 692	42 831.25
AA 072			+1.91	+3.84	
AA 401	28 743.40	4	−3.78	7 486	28 747.24
AA 072			+25.46	00	
AA 400	32 587.99	12	−6.26		32 587.99

Annex II (*continued*)

Line	Reduced measurement	No. of measures	Range from mean	Adjusted correction and parts ratio	Adjusted length
PM 63			+5.78	00	
AA 400	50 810.29	5	−4.79		50 810.29
AA 401			+4.33	−2.39	
AA 402	61 443.28	6	−3.78	25 707	61 440.89
AA 072			+4.33	−19.00	
AA 404	36 216.20	6	−3.78	1 905	36 197.20
AA 401			+5.93	−6.51	
AA 404	41 760.57	9	−5.12	6 414	41 754.06
AA 402			+3.02	−2.33	
AA 404	65 450.39	6	−5.87	28 089	65 448.06
AA 075			+10.17	−13.54	
AA 409	54 187.46	5	−9.30	4 001	54 173.92
AA 075			+16.16	+10.77	
AA 408	44 190.83	7	−13.34	4 104	44 201.60
AA 073			+1.54	+13.63	
AA 408	54 726.05	6	−2.50	4 016	54 739.68
AA 410			+3.79	−11.15	
AA 416	62 164.79	5	−3.24	5 574	62 153.64
AA 416			+2.17	+6.70	
AA 075	81 883.14	6	−2.59	12 222	81 889.84
AA 416			+3.89	−4.62	
AA 409	89 252.05	7	−3.18	19 318	89 247.43
AA 075			+2.85	−2.76	
AA 410	93 905.44	6	−1.56	34 023	93 902.68
AA 411			+2.15	−3.46	
AA 413	58 254.54	6	−1.82	16 836	58 251.08
AA 413			+0.64	−9.72	
AA 416	53 588.69	6	−4.20	5 512	53 578.97
AA 413			+6.94	+8.13	
AA 410	79 502.63	9	−2.51	9 779	79 510.76
AA 416			+8.04	+16.30	
AA 411	83 364.00	5	−6.29	5 115	83 380.30
PM 63			+3.25	+4.60	
AA 402	89 518.26	6	−4.36	19 461	89 522.86
AA 409			+2.41	−12.21	
AA 408	47 416.47	6	−1.45	3 882	47 404.26
AA 402			+5.21	+3.40	
AA 405	51 593.20	5	−9.78	15 175	51 596.60

Annex III

AERODIST ADJUSTMENT: PAPUA AND NEW GUINEA, SUMMARY OF REDUCED AND ADJUSTED MEASUREMENTS, PROVISIONAL VALUES, FLY NET ADJUSTMENT

Spheroid: ANS (160).
Projection: UTM (zone 54).
Datum: Horizontal, Johnston origin; vertical: MSL.
Unit: Metres.

Line	Reduced measurement	No. of measures	Range from mean	Adjusted correction and parts ratio	Adjusted length
HIRAN 25			+1.69	−1.74	
AA 439	201 030.17	5	−2.82	115 534	201 028.43
HIRAN 25			+8.88	−3.02	
Deliverance	143 525.10	10	−6.13	47 524	143 522.08
HIRAN 25			+1.27	+3.23	
AA 440	204 645.13	4	−1.34	63 359	204 648.36
B 088			+3.25	−6.35	
Deliverance	119 664.90	4	−1.61	18 844	119 658.55
B 088			+1.36	+5.86	
AA 439	173 036.03	6	−2.75	29 529	173 041.89

Line	*Reduced measurement*	*No. of measures*	*Range from mean*	*Adjusted correction and parts ratio*	*Adjusted length*
B 088			+2.04	−0.24	
AA 440	98 706.48	5	−1.66	411 276	98 706.24
B 089			+2.76	−1.73	
AA 440	82 754.95	5	−3.12	47 834	82 752.58
B 089			+2.13	−3.67	
Deliverance	106 820.95	4	−3.36	29 106	106 817.28
B 089			+2.02	+2.02	
AA 439	151 617.07	4	−0.27	75 059	151 619.09
B 089			+3.73	−8.41	
AA 438	125 883.48	4	−2.29	14 967	125 875.07
B 089			+10.25	−10.00	
AA 437	97 790.33	4	−10.79	9 778	97 780.33
B 089			+8.54	−4.99	
AA 436	158 279.94	5	−6.90	31 718	158 274.95
AA 439			+2.09	−13.03	
Deliverance	59 182.79	5	−2.91	4 541	59 169.76
AA 439			+1.14	−16.12	
AA 435	59 439.50	6	−2.41	3 686	59 423.38
AA 439			+2.53	+14.06	
HIRAN 38	135 789.56	5	−0.84	9 659	135 803.63
AA 439			+0.24	−6.28	
AA 438	69 854.08	4	−0.45	11 122	69 847.80
AA 435			+0.84	+6.75	
Deliverance	111 005.19	6	−2.81	16 446	111 011.94
AA 438			+2.07	−5.59	
Deliverance	90 142.93	4	−1.55	16 125	90 137.34
AA 437			+4.80	+7.22	
Deliverance	160 825.18	6	−6.73	22 276	160 832.40
AA 437			+1.68	−3.48	
AA 438	112 655.00	5	−1.64	32 371	112 651.52
AA 435			+0.69	−6.39	
AA 438	56 021.10	5	−0.88	8 766	56 014.71
HIRAN 38				+1.83	
AA 440	199 528.50	1		109 033	199 530.33
AA 437			+0.87	−0.16	
AA 440	85 764.29	5	−1.44	536 026	85 764.13
AA 437			+0.72	−3.54	
HIRAN 38	115 676.51	6	−1.11	32 676	115 672.97
AA 438			+3.06	−21.51	
HIRAN 38	74 103.88	4	−3.18	3 444	74 082.37
AA 435			+5.56	+8.17	
HIRAN 38	89 908.56	8	−5.83	11 006	89 916.73
AA 435			+5.86	−16.93	
AA 434	63 829.57	6	−8.79	3 769	63 812.64
AA 434			+13.60	−4.40	
HIRAN 38	60 009.51	5	−9.33	13 638	60 005.10
AA 434			+0.87	+6.47	
AA 438	89 948.97	5	−0.42	13 903	89 955.44
AA 434			+1.55	−7.48	
AA 433	88 639.25	5	−1.03	11 849	88 631.77
AA 433			+7.75	−7.33	
AA 431	51 210.80	5	−5.05	6 985	51 203.47
AA 433			+1.98	+4.89	
HIRAN 38	113 218.47	5	−2.06	23 154	113 223.36
AA 434			+1.06	−4.36	
AA 431	119 089.26	5	−1.13	27 313	119 084.90
AA 431			+4.80	−8.42	
HIRAN 38	117 917.12	6	−3.84	14 003	117 908.70
AA 438			+4.52	+5.72	
AA 436	161 049.05	6	−0.64	28 156	161 054.78
AA 440			+1.47	−0.84	
AA 436	118 362.56	5	−2.07	140 907	118 361.72
AA 437			+1.41	−4.71	
AA 436	63 607.24	5	−2.00	13 504	63 602.53

Annex III (*continued*)

Line	Reduced measurement	No. of measures	Range from mean	Adjusted correction and parts ratio	Adjusted length
HIRAN 38			+2.36	−2.74	
AA 436	134 053.47	6	−3.15	48 924	134 050.73
AA 440			+1.15	+2.11	
Aird Hills (DLS)	221 239.63	4	−1.23	104 854	221 241.74
AA 436			+0.99	+1.03	
Aird Hills (DLS)	169 763.54	3	−0.78	164 820	169 764.57
AA 436			+1.81	+2.33	
AA 431	197 208 59	6	−4.13	84 640	197 210.92
HIRAN 38			+1.54	−2.62	
AA 432	124 479.55	4	−1.19	47 510	124 476.93
AA 433			+1.62	+4.13	
AA 432	150 742.21	5	−1.14	36 500	150 746.35
AA 431			+1.99	−5.11	
AA 432	108 443 56	6	−2.49	21 221	108 438.45
AA 433			+0.83	−0.02	
AA 420	126 010.55	4	−0.50	6 300 527	126 010.53
AA 431			+2.39	−12.27	
AA 420	100 341.61	5	−2.05	8 177	100 329.34
AA 431			+1.99	−2.12	
NM/J/28	154 585.73	6	−2.79	72 896	154 583.61
AA 432				−3.34	
NM/J/28	78 324.61	Telle		23 449	78 321.27
AA 432			+0.63	−5.21	
AA 436	109 122.11	5	−1.53	20 944	109 116.90
AA 432			+0.46	+6.20	
Aird Hills (DLS)	211 759.51	3	−0.81	34 156	211 765.71
AA 432			+2.07	−10.88	
AA 417	112 076.31	5	−1.78	10 300	112 065.43
AA 436			+2.04	−5.15	
AA 417	104 004.98	4	−0.83	20 194	103 999.93
AA 417			+1.37	−10.33	
Aird Hills (DLS)	100 094.47	5	−0.86	9 689	100 084.14
Erave			+2.54	+3.79	
Aird Hills (DLS)	105 904.02	7	−3.39	27 944	105 907.81
Erave			+2.52	−6.61	
AA 417	87 761.50	5	−3.13	13 276	87 754.89
AA 420			+2.56	+2.35	
AA 430	105 279.68	6	−1.70	44 801	105 282.03
AA 420			+1.18	+0.35	
AA 432	174 339.90	7	−1.02	498 115	174 340.25
HIRAN 37			+1.61	−1.12	
AA 418	42 817.17	5	−1.09	38 229	42 816.05
AA 418			+3.26	−1.51	
AA 419	50 412.65	6	−3.32	33 385	50 411.14
HIRAN 37			+4.32	+0.80	
AA 419	29 731.70	3	−1.49	37 166	29 732.50
NM/J/30			+18.96	−1.28	
AA 419	45 461.99	4	−25.05	35 516	45 460.71
NM/J/30			+2.20	+2.50	
AA 418	92 129.09	4	−1.29	36 853	92 131.59
AA 427			+1.15	+0.72	
NM/J/30	103 843.71	4	−3.84	144 227	103 843.71
AA 427			+1.46	−0.81	
HIRAN 37	64 224.44	5	−1.46	79 288	64 223.63
AA 426			+6.72	−1.41	
HIRAN 37	63 368.74	7	−2.92	44 941	63 367.33
AA 426			+2.43	+0.59	
NM/J/30	96 952.58	5	−5.16	164 327	96 953.17
AA 426			+2.74	−0.80	
AA 422	49 274.50	4	−4.55	61 592	49 273.70
NM/J/30			+0.52	−0.99	
AA 422	90 448.06	4	−0.43	91 361	90 447.07
NM/J/30			+3.41	+0.88	
AA 423	102 671.56	6	−1.84	116 673	102 672.44

Line	Reduced measurement	No. of measures	Range from mean	Adjusted correction and parts ratio	Adjusted length
NM/J/30			+1.77	+1.24	
AA 424	122 885.07	7	−1.45	99 102	122 886.31
AA 426			+3.38	+0.74	
AA 423	28 660.55	4	−4.38	38 731	28 661.29
HIRAN 37			+1.61	−1.24	
AA 424	92 351.14	4	−2.33	74 476	92 349.90
AA 432			+2.02	−5.17	
AA 430	102 332.51	8	−3.02	19 793	102 327.34
NM/J/28			+1.58	+1.31	
AA 430	73 061.71	9	−1.09	55 773	73 063.02
NM/J/29				−4.52	
AA 430	69 371.50	Telle		15 347	69 366.98
NM/J/30			+1.70	+1.06	
AA 425	129 928.87	5	−2.80	122 575	129 929.93
AA 425			+2.78	−0.96	
AA 426	44 540.43	3	−1.96	46 395	44 539.47
HIRAN 37			+0.08	−10.39	
AA 420	107 935.55	5	−3.04	10 387	107 925.16
NM/J/30			+7.66	−0.23	
AA 420	121 252.43	6	−2.51	527 183	121 252.20
AA 420			+3.95	−0.53	
AA 424	39 064.94	4	−3.95	73 706	39 064.41
AA 420			+1.39	−0.36	
AA 427	63 007.61	3	−0.61	175 020	63 007.25
HIRAN 37			+0.22	+0.54	
AA 430	157 189.41	3	−0.23	291 093	157 189.95
AA 431			+2.22	−4.44	
AA 430	113 915.60	8	−1.96	25 656	113 911.16
AA 425			+1.33	−0.62	
AA 420	23 282.07	2	−1.33	37 552	23 282.07
NM/J/30			+1.63	−4.49	
AA 430	128 006.29	6	−2.81	28 508	128 001.80
AA 414			+11.99	00	
NM/J/30	68 942.06	6	−10.51		68 942.06
AA 414			+1.50	00	
AA 430	109 315.25	3	−0.98		109 315.25
AA 432			+2.73	+5.84	
Erave	172 278.60	2	−2.71	29 501	172 284.44
AA 440			+0.57	−0.08	
AA 417	203 022.57	3	−0.83	2 537 781	203 022.49

Annex IV

SUMMARY OF AERODIST AND GEODETIC COMPARISONS

Spheroid: ANS (160).
Projection: UTM (zone 54).
Datum: Horizontal, Johnston origin; vertical, MSL.
Unit: Metres.

Aerodist and HIRAN Comparisons

Line	Number of measurements and range	Aerodist reduced measurement (a)	HIRAN reduced measurement (b)	Differential and parts ratio (a)-(b)	Geodetic adjusted length (c)	Differential and parts ratio (a)-(c)
HIRAN 24	4 +1.15	221 444.90	221 443.44	+1.46	221 448.02	−3.12
HIRAN 23	−1.23			151 674		70 977
HIRAN 24	4 +1.27	204 441.26	204 434.09	+7.17	204 438.66	+2.60
HIRAN 25	−1.34			28 512		78 630
HIRAN 24	1	199 506.20	199 492.43	+13.77	199 500.86	+5.34
HIRAN 38				14 487		37 360

Annex IV (*continued*)

Aerodist and computed comparisons

Line	*Number of measurements and range*	*Aerodist reduced measurement (a)*	*Geodetic computed length (b)*	*Differential and parts ratio (a)-(b)*
HIRAN 24 B 089	5 +3.03 −3.12	82 562.94	82 552.34	+10.60 7 788
HIRAN 24 B 088	5 +2.04 −1.66	98 500.04	98 492.99	+7.05 13 971
HIRAN 38 B 089	5 +3.98 −5.13	176 135.67	176 132.35	+3.32 53 052
PM 63 AA 072	6 +3.21 −3.05	58 634.97	58 630.86	+4.11 14 265
AA 073 AA 075	6 +2.38 −2.71	86 398.28	86 392.20	+6.08 14 209
AA 061 AA 412	3 +0.62 −0.50	69 037.69	69 027.55	+10.14 6 807
PM 4 AA 412	7 +1.40 −2.21	88 414.90	88 411.51	+3.39 26 080

ADJUSTMENT OF SURVEY OBSERVATIONS

Paper presented by Australia[1]

Introduction

This paper attempts to make a critical appraisal of the various forms of adjustment used by surveyors to adjust the data obtained in different types of survey work. Particular emphasis is placed on the adjustment of routine traversing carried out in the day-to-day work of the surveyor. The observations which follow represent the conclusions which the author has drawn from his own work and in no way reflect the practice or opinions of the Department of the Interior.

One of the most essential features to be recognized in any survey observation is that it is subject to error. When we collect a series of observations in a survey we have a set of data all of which are subject to error. The result of this is mathematical inconsistencies when computations are made. These inconsistencies are a nuisance, as it is impossible to assign unique values for the computation at any point while they exist.

In practice, these inconsistencies may be large enough to indicate the presence of a gross error. Such errors must be located and corrected before any adjustment procedure is commenced. Therefore they will not be considered in this paper. The terms "error", "discrepancy", etc. will be taken to mean small, unlocated inconsistencies which are unlikely to be resolved by reobservation.

Two methods of dealing with the inconsistencies are available to us. We may, if we wish, set a standard of approximation such that we can ignore them and round off the results accordingly. Alternatively we can use some statistical means of distributing the errors back through the data in such a way as to give unique values for the computation at every point.

For survey requirements, the method of rounding off is generally not acceptable, as the standard of approximation tends to be too large. Therefore for most work we are faced with finding a suitable statistical means for eliminating the discrepancies.

Basically, three types of adjustment are used by surveyors: by inspection; by proportion; by least squares or a method based on least squares.

Let us consider each of these in turn to discover the underlying assumptions and merits or otherwise of the various methods.

Adjustment by inspection

It must be realized that in any instance the only means the surveyor has at his disposal for assessing the error is by closing his own work and also closing on to previous work. The actual discrepancy at any point may quite possibly be larger than the resultant misclosure as shown in the computations.

The principal assumption of the inspection method is that the misclosure enables a fair estimate of the actual error at any point to be made. Since the only error to be distributed is the misclosure, then the corrections will all be smaller than the misclosure. For this to give a truly satisfactory result the actual error at any point should also be smaller than the misclosure. This assumption is usually invalid, but the method is very useful where the misclosure is well inside the tolerable limits for the job and it is unlikely that any error larger than these limits exists.

Difficulty arises with the method when anything other than a simple traverse or level loop is to be adjusted. Complex nets can be adjusted in this manner but it is a tedious and time-consuming task. Each junction point must be examined several times in the course of the adjustment. At the present time this method is probably the only way of getting the most accurate values from a network unless many more precautions than usual are taken in the observations.

Adjustment by inspection is a very powerful tool. It is extremely simple in simple traverses and loops. More

[1] The original text of this paper, prepared by K. H. Wellspring, Department of the Interior, Canberra, appeared as document E/CONF.52/L.54.

importantly, it allows the surveyor who made the observations to place the corrections at the points where, from experience, he thinks they should go and where they will do the least damage to the final result.

Adjustment by proportion

Several different forms of this adjustment are used. For instance, it is quite common in a simple level loop to proportion the misclosure over the number of change points. In traversing, a different type of proportional adjustment is frequently used where a traverse is run between two fixed points. Here the computed closing line is compared with the original line between the two fixed points, the azimuth is swung to fit the original and the difference in the two distances over the original distance proportioned into each line of the traverse. My basic criticism of the method applies to both of these uses, but I shall devote a little extra space to the traverse adjustment.

From the theoretical point of view, this method seems to be the least satisfactory of all adjustments. It is based on the assumption that the only class of error present is one of standard. As we generally make every effort to eliminate errors of this type before we start observations, it is singularly inappropriate to adjust the observations as though they were the only class of error present. I am prepared to admit that in certain cases this form of adjustment can be useful, but in most cases I would favour an approach depending on estimated probable errors rather than on proportion.

A further consideration applying specifically to the traverse adjustment outlined at the beginning of the present section is that the sum of the corrections applied is invariably larger than the original misclosure. Still another unfortunate feature of this adjustment is that only two angles, the first and the last, receive any correction. Do we really consider that these two angles are the weakest or are we justified in assuming that the remaining angles are free from error?

The method of least squares

Undoubtedly this is the most common principle invoked in survey adjustment. It is used in such a wide variety of circumstances that at the moment I will discuss only the assumptions on which it is based. The theory of least squares is derived from the theory of the normal probability curve. Hence the basic assumption is that the error distribution follows the same curve as that of the normal probability curve, or, to put it in more colloquial language, that the errors are accidental. How true this is in fact will be the subject of discussion now. Granted the validity of the assumptions, however, then obviously the most logical adjustment is one which is a direct application, or a derivative, of the method of least squares.

The circumstances of error

We shall consider first the first-order triangulation survey of an area. Every possible precaution is taken to ensure the elimination of all forms of non-accidental error. If the use of least squares is ever justified, then it is surely in this circumstance.

The third-order level net of Australia could well be the subject of a separate paper, so that my reference to it must necessarily be very brief. While quite stringent precautions are taken, they are not nearly as stringent as those taken in the observation of a first-order triangulation. The results, after adjustment by least squares, seem to indicate that the errors were not entirely accidental.

Let us now turn our attention to the vast bulk of traversing which is carried out every day by surveyors. Most of the work is of very good quality, but does not come under the category of precise traversing. It would probably be fair to say that most surveyors reading a traverse angle set their theodolite over the required mark, using an optical plummet or plumb-bob, and read the angle on either two or four faces. Provided reasonable agreement is obtained within the set of results, the arithmetical mean is taken and used for the angle. The sources of non-accidental error in such a procedure are manifold.

First, there are the plumbing errors which occur at both targets and theodolites. Since no plumb-bob is perfect, the point of the bob will describe an approximate circle centred on the string at the height of the target. (Optical plumbing systems are generally more accurate than plumb-bobs and, provided they are in good adjustment, this error will not be appreciable at the theodolite.) Therefore, when the point of the bob is over the ground mark, the target will usually not be so, although it may lie on the correct line. It may appear, at first sight, that this would give rise to accidental error, as the plumb-bob is picked up in an arbitrary manner. However, if this were the case, we would expect that the probability of plumbing the target on line would be greater than that of plumbing it off line. Clearly, this is ridiculous, since, over the area of the circle mentioned, there is an equal probability of plumbing in any position. While it would be true to say that the mean of a large number of attempts will be the correct position, the error distribution will not be normal.

Next, there are instrumental errors. Some of these (such as collimation in azimuth) are eliminated by changing face and averaging the results. In particular, the error caused by the non-verticality of the vertical axis of the instrument will not be eliminated by changing face. It will appear as a systematic error in each individual angle at each station. Over a large number of stations, this may or may not be randomly distributed. In any event, for a given angle it will not be an accidental error.

Another source of small discrepancy could well be the circle graduation errors. Unless a circle analysis is carried out and the result applied to each angle, another source of non-accidental error is generally present. The same argument applies equally and independently to the error in the run of the micrometer in the instrument.

The final source of instrumental error to be considered is the non-coincidence of the optical and mechanical centres of the theodolite. When the instrument is truly plumbed over the ground mark, the angle is read at the optical centre, which is a slightly eccentric station. How large this error may be can be indicated by the fact that this decentring as measured in a Wild T3 theodolite is generally of the order of 0.1 mm, but in one instrument was as large as 1 mm. Although this will be a small error, it will nevertheless by a systematic error at any station.

Observer errors are far less amenable to discussion than any other type. There will, in fact, be two personal errors in each ray of the angle. These are the error in centring the target on the cross-hair and the error in reading the circle. The nature of the error in any given circumstance will depend on the psychological and physiological state of the observer, the illumination on the targets and theodolite and the nature of the targets. Obviously such an error can only be considered to be generally random and no theory can possibly cope with such a wide variety of unknown and unknowable conditions.

Finally, it should be borne in mind that all sights are taken in the atmosphere. Once again, a variety of conditions gives rise to a variety of errors. It is unlikely, however, that the resultant angle will be free from the effects of lateral refraction. Here again, we have something which is in the nature of a systematic rather than a random error.

Listed in the last few paragraphs are some eight causes of error in the observation of an horizontal angle. Of these, only one—observer error—may really be considered to be accidental in nature. Therefore it seems unfair to take a very small sample (only 2 or 4 measures) of the angle and treat the result as though it were subject to an accidental error.

When we traverse, we measure distances as well as angles. So we must examine the types of errors which might be expected in careful chaining. Once more, we see the familiar type of plumbing error, but in careful work this is eliminated at all but the terminal points. While this leaves the error a very small chance of being accidental, it also makes it a very small proportion of the total error and so not a cause for serious concern.

Perhaps the most serious cause of non-accidental error in chaining is one of standard. Even so, this will not be an error caused by failure to know the standard temperature of the tape but rather an error in the determination of the temperature of the tape under field conditions. Depending on the conditions of wind, cloud cover, temperature and the surface over which chaining is carried out, the wire will generally be at a different temperature from that indicated by the recording thermometer. Thus there will be a non-constant error with a systematic trend. In order to indicate the size of this error, I will quote figures very briefly which were published in the *Sudan Survey Department Records*, vol. II, 1943–1952. On pages 91 ff. there is a description of an experiment using suspended mercury thermometers and a simultaneous measurement of the temperature of the tape using a resistance bridge. The measurements were taken over a period from 14 March to 14 April 1955, in temperatures ranging from 75° F to 109° F. In full sunshine, with the temperature near the century, the value of "mercury minus resistance" for some nineteen observations was approximately +20° F. In shade or darkness, an extended series of observations gave the same function values, ranging from −0.2° F to −4° F. While the climate in the Sudan is definitely tropical, I do not think the figures quoted are unrealistic for Australia.

Observer errors once again present a complex problem. Two separate sources of error appear to be combined in the total error. These are an accidental error, which is presumably a maximum of 0.005 ft, using a tape graduated in units of 0.01 ft, and an error caused by the personal parallax of the two observers. This parallax will nearly always be present unless microscopes are used to read the tape and will be different for each observer.

I have devoted considerable space to the question of the sources of error in the ordinary type of survey traverse because I feel that it is very important to understand the nature of the errors which we are trying to adjust. If these errors are largely accidental, then we are justified in proceeding to distribute them on the least-squares principle. But enough has been said, I think, to indicate that, in addition to accidental errors (which have been omitted for the sake of brevity), there will be a large percentage of non-accidental error in the accumulated misclosures. This would lead us to suspect that the error distribution in this type of survey is very likely a Skew distribution. However, that is a field which deserves very close attention and study to determine the shape of the error curves in that class of work.

RESULTS OF ADJUSTMENT

The preceding discussion leads naturally to the question of how satisfactory the results of adjusted traverses are in practice. Let us look first at what is required for an adjustment to be satisfactory. Naturally the basic requirement is that it should produce mathematical consistency. As we are discussing existing forms of adjustment, this is no problem and will not be considered. Another important factor to be considered is the size of the correction imposed by the adjustment. It should generally be smaller than the probable error in the observed quantity and, except in occasional instances, should not exceed twice the probable error. The real reason for this lies in the question of remeasurement as much as in theoretical argument. It should be possible to remeasure an adjusted traverse and agree, within reason, with the adjusted values. My own experience is that most adjustments in common usage fail on this score.

BOWDITCH'S RULE

Bowditch's rule is probably the most common formal adjustment used. The weakness of the basic assumptions is well known but should be outlined in the interests of completeness. Each length is given a weight inversely proportional to that length. In fact, no account is taken of the probable error in the measurement of the length. The second basic assumption is that the probable errors in length and bearing produce equal displacements at the end of the line. This surely needs no comment.

Quoting from volume 1 of Clarke's *Plane and Geodetic Surveying*, on page 272 we find, "From a purely theoretical point of view, the Bowditch rule is more suitable for the adjustment of compass traverses than it is for that of theodolite traverses . . . ". In all fairness to the method, I must make two further quotations from the same page of the same reference lest the one made is read too much out of context. First we have: "Moreover, the corrections obtained are corrections to the latitudes and departures and one disadvantage of the rule is that these corrections may cause excessive disturbance to the bearings . . . ". This is the point which I made earlier, that reobservation must be in substantial agreement with the adjusted values. Further on, Clarke states: "However, for ordinary work as opposed to precise traversing for primary framework purposes, any elaborate method of adjustment, which involves a considerable amount of labour, is hardly justified, so that Bowditch's rule can quite safely be, and usually is, employed in nearly all cases of normal traverse adjustment."

Certainly I agree in principle that elaborate adjustments are no improvement but I think that it is possible to develop a simple adjustment which would give more realistic corrections than those resulting from the application of Bowditch's rule.

THE TRANSIT RULE

This rule has no theoretical foundation. It adjusts the misclosures in latitude on a proportional basis among the latitudes and similarly with the misclosure in departure. As far as practical results are concerned there is little to choose between this and Bowditch's rule.

Crandall's rule

For the adjustment of precise work at the present time, this is one of the best forms available. First, the angular misclosure is adjusted and the angles are then held at their adjusted values. This gives the surveyor who carried out the work a chance to distribute at least some of the errors in the most likely places.

Secondly, the distances are adjusted using the least-square principle. Naturally I object to this because I challenge the assumption that the errors are random. However, it has the considerable merit of not upsetting the previously corrected azimuths. There is a side effeet of this, that a line at right angles to the misclosure receives no correction. The objection is obvious that it is unlikely that any line should receive a zero correction unless exceptional circumstances appertain to the measurement of that line. While endorsing this objection in principle, I would point out that, first, if there is a line at right angles to the misclosure then this line is probably free from error, and secondly, this is a minor consideration compared with the advantage of not upsetting the previously adjusted azimuths.

Variation of co-ordinates

The routine solution of a network using this method is well known and will not be discussed here. It has an advantage over figural adjustments in so far as any type of figure can be adjusted without the problem of finding the geometrical conditions of odd-shaped arrangements.

For the real subject matter under this heading I am indebted to M. McDonald of the Victorian Division of this institute. Working for the State Electricity Commission of Victoria, he has developed a variant of the routine method which has considerable advantages over that method. To do the subject full justice I shall quote the following paragraphs verbatim from Mr. McDonald:

"The method uses the 'variation of co-ordinates' formulae and minimizes the sum of the squares of the ratio of the least squares corrections to the estimated probable errors of the observations. (The quantity to be minimized is thus a dimensionless one.)

"The system was developed specifically for use on an electronic computer, the aim being to eliminate as much manual processing as possible. In a single programme, the final co-ordinates are obtained directly from the field observations of directions and distances, and a table showing the correction made to each individual observation is provided.

"A feature of this system is the allocation of each observation of its own probable error For the directions, the probable error is nominated in angular measure and for the distance it is quoted in units of the length measurements. Each observation can be given a different value of probable error if desired, which allows the simultaneous adjustment of work which has been done to different standards of accuracy.

"Multiple observations of any direction or distance can be included and preliminary station adjustment and reduction of eccentric stations is largely eliminated.

"Whilst this programme was designed primarily for triangulation adjustment, it can also solve resections and adjust traverse of up to sixty new stations."

M. McDonald has said all that needs to be said on this adjustment. It is the only method available, besides Crandall's rule, for the adjustment of precise work. It far outstrips any of the common methods by its power to handle dissimilar quantities and varying standards of accuracy in the one adjustment.

Composite figural adjustment

No paper on adjustments at this time would be complete without suggesting that a geodetic quadrilateral should be considered in which all the angles and sides have been measured. As with the other adjustments, we shall be more concerned with the results than with the theory used to derive them. For this purpose, let us think of such a quadrilateral and three separate adjustments. The first of these will be a simple angular adjustment, the second a simple trilateration adjustment and the third a composite adjustment considering all the observed data.

The data may be thought of in the manner which we shall now describe. Angles fix the shape of the figure and distances fix the scale. Thus a simple angular adjustment fixes the shape of the figure without consideration of scale. If one or more length equations are added to the conditions, then the scale and shape are both fixed and this is probably the simplest means of solving the problem. It does not seem warranted to engage in additional labour, as subsequent changes of scale and shape are insignificant in the over-all picture. In any case, "variation of co-ordinates" as outlined in the preceding section gives a better, more flexible and more general solution.

Trilateration, on the other hand, seems a far more satisfactory way of attacking the problem. Using modern electronic distance measuring equipment, it is possible to measure lines with an accuracy of approximately 1:250,000. A little simple arithmetic shows that, for lines 5 miles long, we have to be sure of the angle to $\pm 1''$ of arc to be comparable with a distance measurement of 1:250,000. So for lines over, say, 10 miles long, it would probably be better to use trilateration with well conditioned shapes and adjust by the method of variation of co-ordinates.

Azimuth usually raises a practical problem in simple trilateration. From my knowledge of the subject, it appears that azimuth discrepancies calculated through a path of computed angles are generally somewhat larger than those using a path of observed angles. Perhaps someone with more current experience in this field can correct me on this point.

For the sake of completeness, the simple trilateration adjustment will be mentioned. Through this adjustment, since three sides are sufficient to specify a triangle, we get a simultaneous consideration of the scale and shape of the figure. Angles computed from the sides would be expected to be better than observed angles (see preceding paragraph). Provided that sufficient care is taken to ensure that errors are accidental, then this should represent an acceptable solution.

A new approach of the theory of adjustment

Before any new adjustment formulae are produced, much research must be done on the question of distribution of error in survey observations. We are not dealing with the errors in first-order work but with the error distribution in the vast bulk of day-to-day work. The statistics of extremely small samples (say two or four observations) poses a delicate problem in this field. However, with time and patience this can be overcome and some realistic estimate made of exactly what happens in those few observations. This represents a truly mammoth task; however, I am convinced that it is the first step to be taken in producing a more satisfactory form of adjustment for this class of work.

The second feature of any new adjustment is that it should make the correction to a quantity a function of the probable error of that quantity. After adjustment, the observations, their estimated probable errors and their corrections will set the real accuracy of the work at any point. Most importantly, under this system it should be possible to remeasure adjusted quantities and agree with them within the limits of the estimated probable error.

SUMMARY

The present methods used to adjust most classes of survey data are generally unsuitable for two reasons. First, except in the highest order work, the errors present are probably not accidental. Secondly, when reobservations are made after adjustment, the surveyor's tendency is to regard them as agreeing better with the initially observed values than with the adjusted values.

For the future we should strive to develop an analysis of the error distributions in the currently accepted methods of observing angles, distances and levels. We should also aim at determining a suitable functional relationship between correction and probable error governed by the error function as determined above.

From my own experience, a survey is usually worse after adjustment than before and this is the unsatisfactory position which confronts most of us.

SURVEY TRAINING IN THE FEDERAL REPUBLIC OF GERMANY

Paper presented by the Federal Republic of Germany[1]

INTRODUCTION

In Germany, three types of specialists are engaged in surveying: the technician, the engineer who has studied at a school of engineering, and the engineer with a university diploma, corresponding to the graduate engineer. This paper treats of the instruction offered in these three branches, especially the third.

Some preliminary explanations about the structure of surveying in Germany are necessary. Geodetic and cadastral surveying is performed exclusively by survey authorities and by chartered surveyors working on their own responsibility, but under the supervision of the survey authorities and requiring a special licence to carry out geodetic and cadastral surveys.

The geodetic survey comprises the establishment and maintenance of the triangulation (or trilateration) network, the principal traverse net, the levelling net and the gravity net; also the topographical survey by terrestrial methods and by photogrammetry, and cartography proper, which consists of the compilation and revision of the topographical map series at scales 1:5,000, 1:25,000, 1:50,000, 1:100,000, 1:200,000, 1:500,000 and 1:1,000,000. The cadastral survey comprises the survey of real estate and buildings by traversing and detail survey and the compilation of cadastral plans of real estate and buildings and their development, mainly at scales 1:500, 1:1,000, 1:2,000 and 1:5,000.

Even technical surveys, including the laying out and surveying of roads, railways and water courses, the survey and inspection of structures such as bridges, tunnels and industrial buildings, agricultural engineering and so on, are, for the most part, carried out by official institutions, only a small part being done by other engineering agencies.

Because of this structure of surveying, most survey specialists are attached to official institutions, and here the specialists of all three branches receive their practical training, too.

AIMS OF TRAINING

The technician must be able to carry out the technical work assigned to him; he has to know the methods and the instruments needed to carry out this work. The engineer receives a practical and theoretical instruction superior to the more mechanical training of the technician. He has to consider more complex surveying problems and be able to resolve them independently. In practice, he carries out special assignments or more difficult surveys independently. Through his university studies, the graduate engineer should become capable of tackling every kind of problem, using the fundamental knowledge he received during his studies and applying scientific methods. His task is not confined to the application of tried methods; through critical consideration, he has to develop and use new and more efficient methods. As the head of a large firm or of a large surveying project, he must select the most suitable methods and instruments and he is especially responsible for the right choice and right employment of his staff. The activities of the technician, of the qualified engineer and of the graduate engineer may be summed up as follows: the technician knows *how* something is done, the qualified engineer knows *why* something is done and the graduate engineer knows *how something could be improved.*

THE SURVEY TECHNICIAN

The survey technician attends elementary school for nine years, after which he serves a three-year apprenticeship at a public survey office or with a chartered surveyor. During this training period, he is instructed in the more or less mechanical work of drawing and plotting, simple reproduction processes, surveying calculations, especially computation of co-ordinates and of areas, and simple methods of planimetric and altimetric survey. He is also introduced to the administrative problems of a survey institution, especially to the surveying, calculating, mapping and registering connected with the making of a cadastre.

[1] The original text of this paper, prepared by W. Torge, Hanover, appeared as document E/CONF.52/L.81.

The training ends with a public examination, which includes plotting as well as written and oral tests.

THE QUALIFIED SURVEY ENGINEER

The qualified survey engineer generally attends elementary school for four years and intermediate school for six years. Here, after an examination, he receives a special certificate of education. He reaches the same level of education by six years' attendance at a secondary school. For special training in surveying, there are now two possibilities. He may either serve an apprenticeship which has been shortened to two and one-half years, ending with the technician's examination, or he may acquire the practice necessary for admission to a school of engineering by a probation of one year and ten months. Such probation corresponds from the technical point of view to the technician's training, but the probationer is not introduced to administrative problems.

Having finished the apprenticeship or probation, he studies for three years at an engineering school (public polytechnic school). (The polytechnic school is also open to qualified technicians who have not attended the intermediate but only the elementary school.)

After eighteen months' study, a first examination is held. Eighteen months later, the engineering examination takes place, consisting of a written part and an oral part. The material presented and examined at the polytechnic school comprises the following:

	Per cent
Fundamental elements of mathematics and natural sciences (mathematics, physics, descriptive geometry, geology, soil science, architecture, English)	26
The surveying disciplines:	
Surveying calculation and drawing	12
Surveying including survey instruments	29
Topography, cartography, reproduction technique, photogrammetry	11
TOTAL:	52
An introduction to public surveying:	
Surveying in practice (cadastral survey, town planning, land consolidation)	11
Jurisprudence and history of surveying (public law, economics, sociology, history of geodesy and surveying)	11
TOTAL:	22

At the present time, survey departments exist at ten polytechnic schools: in Berlin, Essen, Frankfurt a. M., Hamburg, Karlsruhe, Mainz, Munich, Oldenburg, Recklinghausen and Stuttgart. Two of the schools, in Berlin and Munich, offer cartographic training for engineers. Of the number of engineers who finished their studies in those schools in 1965, 424 were engineers in surveying and twenty in cartography.

THE GRADUATE SURVEY ENGINEER

The future graduate survey engineer attends elementary school for four years and secondary school for nine. After a final examination, he obtains the secondary school certificate which permits him to study at a university. Before entering university, he has to practise surveying for six months with a survey authority or a chartered surveyor. This probation gives him a general view of the profession he has chosen, and he acquires the technical rudiments. These include training in simple surveying and calculation methods and in drawing and plotting. The lectures and studies assigned during the first half-year of study are based on this practical training.

This probation period is followed by a course in surveying engineering at an institute of technology. (A qualified survey engineer who has not obtained the secondary school certificate may also, under special conditions, be allowed to pursue university studies.)

Generally, the course is divided into fundamental studies, taking two years, and special studies, also of two years' duration. The fundamental studies conclude with a preliminary examination, the special studies with the diploma examination.

The fundamental studies cover about one-half of the total material. The differences in the material covered in the various technological institutes are small. For instance, the following classification will be found:

	Per cent
Fundamental disciplines	
Mathematics (including descriptive geometry)	13
Physics	4
Related earth sciences (geology, geomorphology, geography, soil science, botany)	5
Jurisprudence and economics (civil law, public law, economics)	3
TOTAL:	25
Fundamentals of surveying	22
Special studies consist of	
The main geodetic disciplines:	
Surveying (general control network in situation and height, precise laying out, measurement of lengths by physical methods)	16
Photogrammetry	5
Least-squares adjustment, including fundamentals of mathematical statistics	4
Mathematical geodesy (geodetic computations and projections)	3
Cartography (topography and cartography, map projections, official map series, reproduction processes)	4
TOTAL:	32
Supplementary disciplines:	
Physical and astronomical geodesy (geodesy, astronomical determination, applied geophysics, satellite geodesy)	5
Engineering and hydraulics (general engineering, road construction and traffic sciences, agricultural engineering, hydrography and hydraulics)	4
Planning and land order (land law and land register law, public surveying and land registry, rural planning, including land consolidation, settlement, renewal of villages, town planning, town order and land development, estimating of agricultural and town properties)	7
TOTAL:	16
Advanced studies in one of last-named disciplines	5

This material is given to the students in lectures and exercises, the lectures including about 60 per cent, the exercises about 40 per cent of the total time of training. At the end of certain periods of study, larger practical projects are carried out. These are, for example:

After the first year, a real estate survey, consisting of the cadastral survey and mapping of a village, including the necessary calculations of co-ordinates and areas;

After the second year, a topographical project, in which one sheet of the German fundamental topographic map at 1:5,000 is surveyed, using terrestrial topographic methods;

After the third year, a project known as "densification of the general control network"; here students have to fix further control points in the existing network by triangulation, trilateration, principal traversing and precise levelling; the co-ordinates of the points are computed by rigorous adjustments.

In the field, these projects take two weeks each. Generally they are carried out in such a way that the results may subsequently be used by the survey authorities.

In the fourth year, geodetic seminars are held consisting of the independent treatment of a theoretical theme and of the investigation of a new survey instrument.

After the fourth year, the student receives his diploma project. He may choose the discipline from which the project is to be given. The theme of the project is taken either from practical problems or from the research work of the institutes. He has to complete the project independently, using scientific methods. Generally the completion of the diploma project takes three months. The project is part of the diploma examination, including written and oral tests and assessment of work done during the course. Altogether, the passing of the diploma examination takes about six months.

As the student works in seminars and on his diploma project, he is to a large extent participating in the current research projects of the institute concerned. Working together on research projects produces understanding among professors, assistants and students.

A complete study of surveying engineering, concluding with the diploma examination, is possible at seven technological institutes, and a study leading up to the preliminary examination at two.

Table 1. Technological institutes, student enrolment and graduate engineers, 1965–1966

Technological institute	*Students in 1965–1966*	*Graduate engineers in 1965*
Berlin	58	5
Bonn	267	54
Darmstadt	30	—
Hanover	153	13
Karlsruhe	106	10
Munich	158	35
Stuttgart	64	9
Aachen	9	—
Braunschweig	30	—
TOTAL:	875	126

In 1962 and 1963, foreign students constituted 11 per cent of all students enrolled in these universities. Of these, 37 per cent were Iranians, 14 per cent came from Greece and 13 per cent from Turkey.

The proportion between the number of qualified survey engineers and graduate survey engineers in 1965 was 3.5 to 1. Altogether, from 1945 to 1965, 5,886 engineers and 1,980 graduate engineers were trained in Germany, or a proportion of 3 to 1.

PROPORTIONS OF THE THREE BRANCHES IN PUBLIC SURVEYING

As already mentioned, most survey specialists are engaged by survey authorities and chartered surveyors. Immediately after passing the examination, the technician, engineer or graduate engineer may be employed with these institutions or with private companies; but he may also undertake additional training in public administration. Such training takes eighteen months for the technician, two years for the engineer and two years and three months for the graduate engineer, each type of training ending with an examination.

The training includes the application of surveying in administration: in geodetic survey, cadastre, land consolidation, town and country planning, and so on. Furthermore, a solid knowledge of administrative work is given. Later, special tasks involving administrative problems may be carried out only by these additionally trained specialists, who are then engaged as government officers. The graduate engineer in particular needs the second examination, in order to be able to direct a public survey office or to obtain a licence as a chartered surveyor. A cadastral survey, too, may be carried out only by a graduate engineer or an engineer who has passed the second examination. Corresponding to this type of demand, some 90 per cent of graduate engineers, 40 per cent of qualified engineers and only 15 per cent of technicians pass the second examination.

The following table provides data on survey specialists engaged in public surveying. About 10 per cent of the staff holds a university degree, one-third has been educated at a polytechnic school, and one-third has received technical training. One-sixth is employed as chain-men, the rest being employed as clerks.

Table 2. Survey specialists engaged in public surveying

Survey staff	*Surveyors*	*Chartered surveyors*	*Total*	
Graduate engineers	2,542	441	2,983	(9 per cent)
Engineers	12,191	434	12,625	(38 per cent)
Technicians	10,733	434	11,167	(34 per cent)
Clerks	858	241	1,099	(3 per cent)
Chain-men	4,545	619	5,164	(16 per cent)
TOTAL:	30,869	2,169	33,038	(100 per cent)

HORIZONTAL AND VERTICAL CRUSTAL MOVEMENT IN THE PRINCE WILLIAM SOUND, ALASKA, EARTHQUAKE OF 1964

Paper presented by the United States of America[1]

Foreword

The tremendous forces unleashed by the Alaska earthquake of 1964 disarranged the earth's crust over a large area centred on Prince William Sound. This was the strongest earthquake ever recorded on the North American continent. Shortly thereafter, the Coast and Geodetic Survey dispatched geodetic parties to determine the amount of earth movement, both vertically and horizontally. The work was conducted during both the 1964 and 1965 field seasons. Parts I and II of this paper deal respectively with the vertical and horizontal aspects.

Since some of the surveys performed before the earthquake date back many years, the resulting evaluation of crustal displacement reflects not only movements caused directly by the earthquake itself, but also any slow movement that may have occurred over the intervening years. The determination of the vertical movement is more definitive than that of the horizontal movement, for a number of reasons. On the one hand, the surveys before the earthquake do not date back as far as the horizontal work, the earlier work was of the same accuracy as the later work, and the results may be considered as reflecting absolute movements, inasmuch as the level line was anchored in the Fairbanks area of proven stability to the north, and to mean-sea-level determinations to the south.

On the other hand, the earlier horizontal surveys were of a much lower order of accuracy, a fact which is bound to reflect on the final determination of horizontal movements. Moreover, the horizontal data are related to a point near Palmer, assumed to be stable. Time did not permit these surveys to be carried to areas of proven stability. Whereas the uncertainties due to errors in the levelling surveys probably do not exceed some 5 cm, a comparable figure for the horizontal work may run as high as 3 or 4 m or perhaps 15 per cent of the reported relative movement, depending on the distance from Palmer.

I. Vertical bench-mark displacement

During the period from April to October 1964, 956 miles of first-order levelling was undertaken by the Coast and Geodetic Survey in Alaska to establish up-to-date elevations of bench-marks for engineering and mapping purposes and also to determine the changes in bench-mark elevations since the previous levellings. Of that total, 722 miles was a relevelling of previously established first-order levelling by the Coast and Geodetic Survey and 234 miles was new levelling on the Kenai peninsula. From May to August 1965, 623 miles of first-order levelling was undertaken. Of that total, 469 was relevelling and 154 miles original levelling. Therefore in 1964 and 1965 there was a total of 1,579 miles of levelling—1,191 miles of relevelling and 388 miles of original levelling.

When comparing the results of the original levelling and the relevellings of 1964 and 1965, we should not assume that all the divergences between levellings represent vertical movement caused by the earthquake of 1964, but no doubt most of the changes took place at that time. It is believed that it would be appropriate first to review a history of the precise levelling in Alaska and in the nearby Yukon territory along with the vertical changes noted by a small amount of relevelling undertaken prior to 1964 (see figure I).

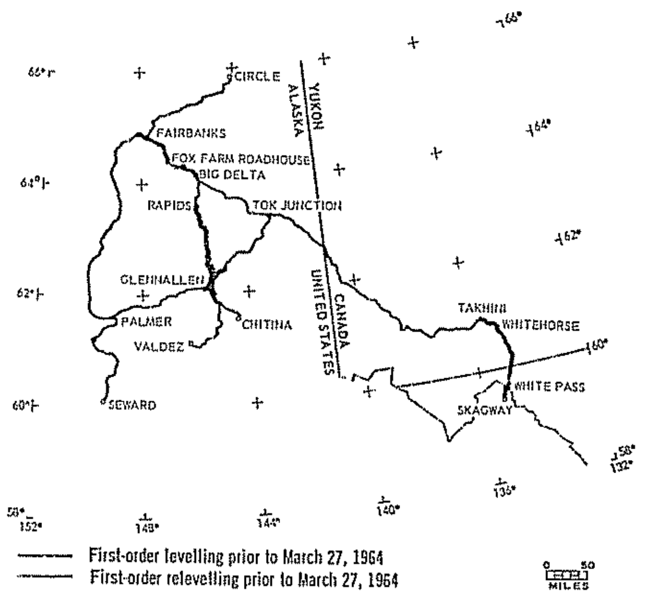


Fig. I—United States of America: Level net of Alaska; original levelling and relevelling prior to 27 March 1964

The first precise levelling established in Alaska was in 1910, from Skagway to White Pass, by the Alaska Boundary Commission. All marks were set in solid rock. The Geodetic Survey of Canada extended that levelling from White Pass to Whitehorse to Takhini in the Yukon territory in connexion with the boundary survey along the 141st meridian from 1908–1910. Some of the marks were in solid rock and others in iron pipes.

First-order levelling was established in 1922 from Anchorage along the Alaska railroad to Fairbanks and south-east along the Richardson highway to Fox Farm Road House (50 miles south-east of Fairbanks). In 1923, levelling was continued from Fox Farm Road House to Valdez, with a spur from Willow Creek to Chitina, and a levelling was established along the Alaska railroad from Seward to Anchorage.

In connexion with establishing levelling along the Alaska highway in 1943, it was planned to start at Whitehorse with a tie to levelling by the Geodetic Survey of Canada, but since the field party failed to obtain an agreement at Whitehorse with the original levelling, relevelling was continued to White Pass before a check between two old marks was obtained. Since the divergence between the relevelling and the original levelling was so large, relevelling was undertaken in 1944 from Skagway to White Pass to determine the changes on this portion. The total divergence between the original levelling and relevelling from Skagway to Whitehorse to Takhini was 1.636 metres, or 5.367 ft. It should be noted that this is practically a straight-line divergence from Skagway to Takhini. This was the first indication of

[1] The original text of this paper, prepared by James B. Small and Earnest J. Parkin, Coast and Geodetic Survey, Environmental Science Services Administration, appeared as document E/CONF.52/L.88.

regional tilt in the area, as shown through precise levelling activities.

The rise in bench-marks of 68 cm or 2.2 ft at Skagway from 1910 to 1944 is based on tidal observations. The rate of land rise at Skagway is about 2 cm per year.

In 1944, the levelling from Matanuska to Tok Junction indicated some sizable changes in elevation along the Richardson highway in the vicinity of Glennallen and Gulkana, where 41 miles of the 1923 levelling was relevelled from Copper Centre to 7 miles south of Sourdough in obtaining a tie.

A tie was obtained in the vicinity of Copper Centre, but at the northern extremity subsidence at bench-marks R 8 and Q 8 was 1.297 m or 4.255 ft, based on observed differences in elevation. The divergences between the two levellings are shown below.

Table 1. Measurements from Copper Centre to 7 miles south of Sourdough, Alaska

Bench-mark	*Distance (km)*	*1923 Observed elevation (m)*	*1944 Observed elevation (m)*	*New minus old (mm)*
D9	0.0	313.0915	313.0915	0.0
C9	2.6	314.4291	314.4288	− 0.3
Z8	16.7	363.8527	363.8525	+ 0.2
W8	34.1	487.2277	487.1678	− 59.9
V8	38.0	486.3245	486.0912	− 233.3
U8	42.0	420.0926	419.8914	− 201.2
R8	60.0	541.9255	540.6284	− 1297.1
Q8	64.7	577.9082	576.6120	− 1296.2

In view of the large divergence between the 1944 and 1923 levellings, relevelling was undertaken in 1952 from 11 miles south of Copper Centre to Rapids to determine the extent of the changes.

The 1952 relevelling showed that bench-marks in the vicinity of 7 and 11 miles south of Sourdough continued to subside. Based on observed differences, the maximum was at bench-mark Q 8, which subsided 0.377 m, or 1.237 ft, more for 1944 to 1952, or a total of 5.492 ft since 1923, assuming stability at Copper Centre, where an agreement between levellings was obtained on four marks. A comparison of the 1944 and 1952 levelling shows a maximum heaving of 0.162 m or 0.531 ft.

A fair agreement between the original 1923 levelling and the 1952 relevelling was obtained at the extremities, with a maximum subsidence using adjusted values of Q 8 = 5.213 ft and R 8 = 4.708 ft from 1923 to 1952.

Relevelling of 1951–1952 from Fairbanks to Big Delta again shows good over-all agreement between the extremities with a maximum subsidence of 0.824 m or 2.703 ft.

The levelling undertaken in 1964 and 1965 is shown in figure II.

Three levellings were undertaken in the vicinity of Valdez in 1964, as that area was believed to be continuing to move. A levelling in April was undertaken from Valdez to 20 miles north-east of Valdez when the field party first arrived in Alaska, a second in July on the main line from Glennallen to 5 miles north-west of Valdez, and a third in September from 5 miles south-east of Valdez to 5 miles north-west of Valdez. Changes in bench-mark elevations were of small magnitude, with a maximum subsidence of 2 cm.

A second relevelling was undertaken in 1964 from Portage to 22 miles north-west of Portage and showed an additional subsidence at Portage of about 4 cm.

The 1964 levelling was adjusted by making new mean-

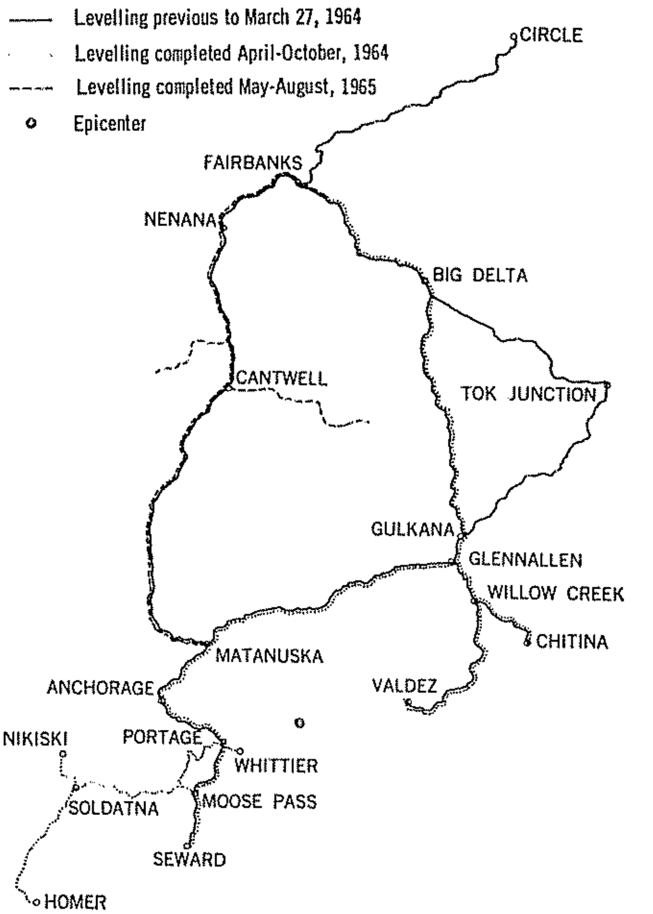


Fig. II—United States of America: Levelling completed in Alaska by August 1965

sea-level determinations at Homer, Seward, Whittier and Valdez (see figure III). The pier on which the gauge was located at Valdez was settling; that is the reason for a shorter series at that location. There is a slope in mean-tide level in the Cook Inlet; tidal observations at Anchorage were not held because that location does not represent open coast conditions. Also held in the adjustment were previous adjusted elevations about 27 miles south-east of Fairbanks.

There were twenty-three bench-marks for the 11 miles portion from 16 miles south-east of Fairbanks to 27 miles south-east of Fairbanks, where the previously adjusted elevations were not changed by the adjustment of the 1964 levelling. The 1965 relevelling was fitted to the 1964 adjustment by distributing the closing error from Matanuska to 16 miles south-east of Fairbanks.

In general, the subsidence on the entire portion from Seward to Anchorage was from 2.342 ft to a maximum of 6.243 ft. For the portion from Anchorage to Matanuska to Glennallen, the average subsidence was from 1 to 2.5 ft, with a maximum of 5.151 ft and a minimum of 0.167 ft. The only evidence of upheaval along the relevelling from Seward via Anchorage and Glennallen to Valdez was for two marks located 5 and 10 miles east of Valdez, which heaved 0.55 and 0.35 ft respectively. Towards Fairbanks from Glennallen, the maximum subsidence was 7.028 ft at bench-mark Q 8, with an upheaval of 0.3 to 0.9 ft in the Alaska range along the Richardson highway (see figure IV).

Since a fair agreement between the 1923 and 1952 levellings was obtained from the vicinity of 4 miles south of

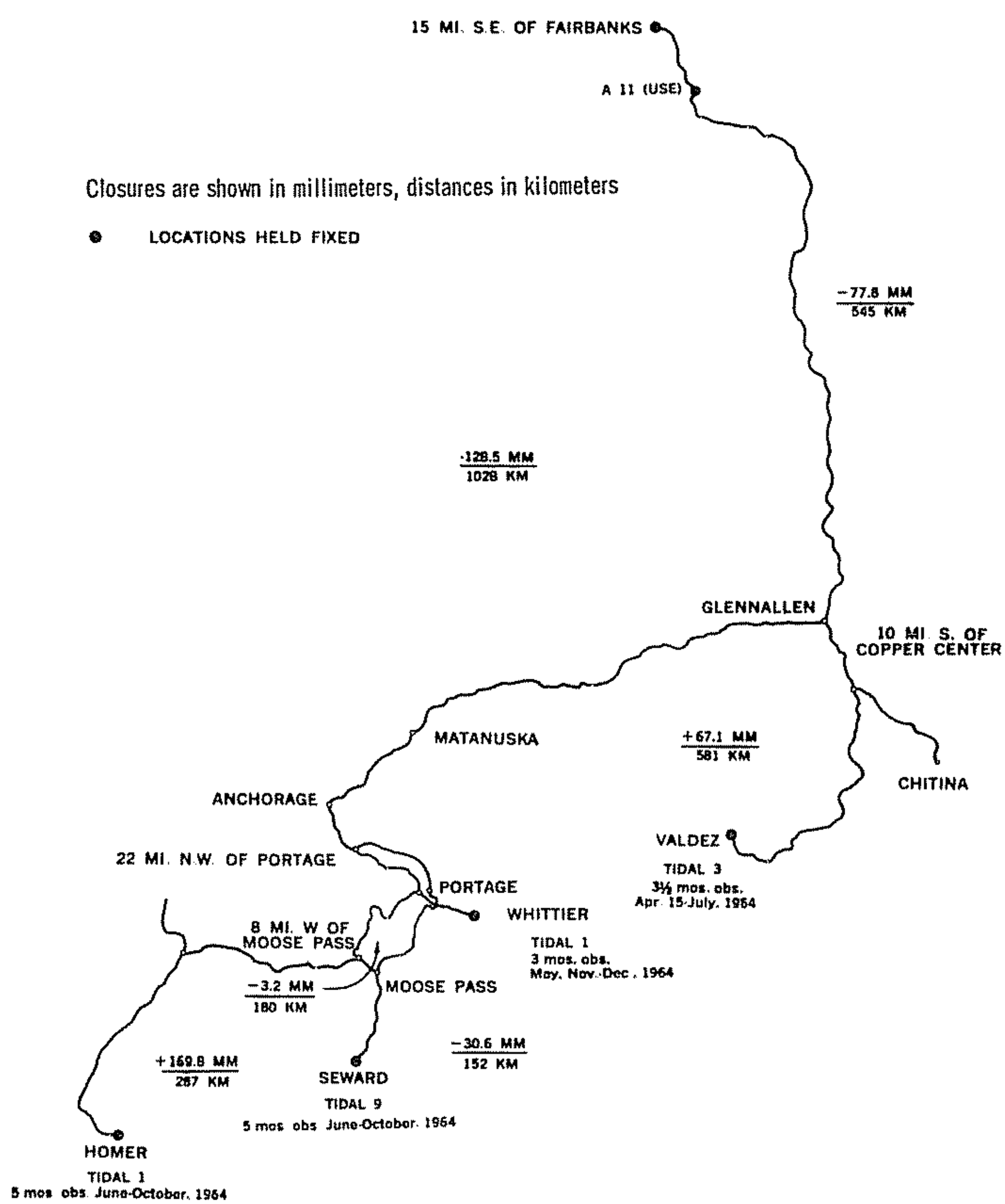


Fig. III—United States of America: Adjustment sketch of 1964 levelling in Alaska

Sourdough to Rapids, it is believed that the uplift shown by the 1964 relevelling in the Alaska range along the Richardson highway resulted from the earthquake of 1964.

From Matanuska to 15 miles south-east of Fairbanks, there was a maximum subsidence of 1.9 ft near Matanuska and an upheaval in the higher elevations of the Alaska range of 0.4 ft.

The first choice for the location of the installation of bench-mark disks is in bed-rock, with second choice in a substantial structure such as a building or bridge. Since those locations were not available in many cases, bench-marks on the levelling prior to 1964 were placed in concrete posts 5 ft in length with a belled-out portion at the base. On the 1964 and 1965 levelling, rather than install concrete posts for new marks, copper-coated steel rods driven to refusal were used as bench-marks. It was believed that those marks would better cope with changes resulting from frost action.

The rods are procured in 8-ft lengths, threaded at each end, and driven with a gasoline hammer. The hammer is placed on an 8 ft section which is driven to the ground surface. A second section is attached to the first section with a brass coupling and also driven to the ground surface. This is continued until refusal is reached, at which time the rod is cut off slightly above the ground and a disk fastened to the top of the rod. There were 742 rod-type marks established on the 1964 and 1965 levelling which were driven to an average depth of 22 ft. The minimum depth was 5 ft and the maximum 96 ft.

On the 1910 levelling from Skagway to White Pass, pictures of all bench-mark locations were taken: a nearby picture and a distant picture that had some mountain terrain in the background if possible. The field party reported in 1944 when relevelling that line that the pictures were invaluable and that not many of the old marks would have been found had the pictures not been available. The

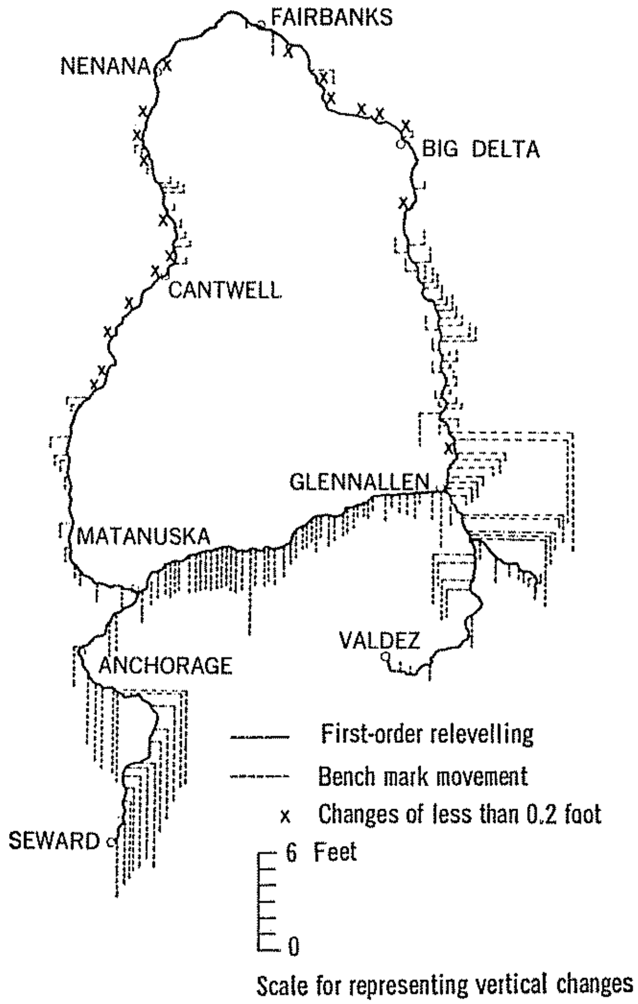


Fig. IV—United States of America: Magnitude of bench-mark changes

practice of taking pictures of bench-mark locations was continued in the 1964 and 1965 levelling.

In 1965, a relevelling was undertaken from Anchorage to Portage which followed the route of the 1964 relevelling. It was undertaken because it was believed that Anchorage and Portage were still subsiding. In comparing the 1964 and 1965 relevellings, there was a check among thirteen bench-marks that indicated a stability about half-way between those two locations, with a subsidence of 0.36 ft at Anchorage and 0.52 ft at Portage. Gravity observations of 1964 to 1965 showed a similar subsidence. Admittedly the gravity anomalies are not a precise measurement of vertical changes but they give some indication of large crustal movement. Since gravimeter observations can be obtained at relatively low cost, it is considered desirable in areas of movement that relevelling and gravity observations should be carried out simultaneously.

Repeat gravity observations at two locations in Middleton island show a gravity decrease of about 0.18 mgals from 1964 to 1965, which is an indication of about a 2 ft upheaval in that time. Therefore the indications are that changes and warping are still going on.

In the study of vertical changes in Alaska, data are available from the following surveys: precise levelling, tidal observations, gravity anomalies, vertical angle measurements and barnacle studies. The barnacle studies have been undertaken by the United States Geological Survey. It is interesting to note how the results from one type of survey support the data from another. For example, tidal observation showed an upheaval of 31.5 ft at Macleod harbour, Montague island, and the United States Geological Survey barnacle study noted an upheaval of 33 ft. A repeat of hydrographic surveys off Montague island showed an underwater upheaval of from 42 to 50 ft.

Vertical angle measurements taken during the re-triangulation survey shows a subsidence of from 2 to 10 ft from Anchorage to Seward of stations on mountain peaks.

The results of vertical changes noted from tidal observation are shown in table 2.

Table 2. Tidal observations

Illustration No.	*Location*	*Length of tide series*	*Land movement (ft)*
1	Cordova, Prince William Sound	May–Nov. 1964	+ 6.2
	Cordova, Prince William sound	May–Nov. 1965	+ 6.2
2	Port Gravina, Prince William Sound	3–31 July 1964	+ 4.5
	Port Gravina, Prince William Sound	16 May–16 June 1965	+ 4.2
3	Port Fidalgo, Prince William Sound	18 June–17 July 1965	+ 2.4
4	Valdez, Prince William Sound	May–July 1964	− 0.9
	Valdez, Prince William Sound	July–Nov. 1965	− 3.5
5	Whittier, Prince William Sound	May–June, Oct.–Dec. 1964	− 5.4
	Whittier, Prince William Sound	July–Nov. 1965	− 5.7
6	Chenega Island (south-west end), Prince William Sound	7 July–4 Aug. 1964	+ 4.8
7	Green Island, Prince William Sound	August 1965	+ 6.6
8	Port Chalmers, Montague Island, Prince William Sound	19–30 May, 7 July–6 Aug. 1964	+ 10.6
	Port Chalmers, Montague Island, Prince William Sound	19 July–23 Aug. 1965	+ 10.5
9	Sawmill Bay, Evans Island, Prince William Sound	20 May–1 June, 14 June–7 July 1964	+ 7.2
	Sawmill Bay, Evans Island, Prince William Sound	29 July–31 Aug. 1965	+ 7.2
10	Hogg Bay, Bainbridge Island, Prince William Sound	20 July–16 Aug. 1965	+ 5.8
11	Day Harbour, Kenai Peninsula	7 May–30 June 1965	− 0.5
12	Seward, Kenai Peninsula	June 1964–Jan. 1965	− 3.6
	Seward, Kenai Peninsula	Jan.–Sept. 1965	− 3.6
13	Aialik Bay, Kenai Peninsula	May–June 1965	− 4.5
14	Two Arm Bay, Kenai Peninsula	14 May–30 June 1965	− 5.4
15	Chance Cove, Kenai Peninsula	15 May–30 June 1965	− 6.6
16	Shelter Cove, Nuka Bay, Kenai Peninsula	July 1965	− 5.4
17	Port Dick, Kenai Peninsula	21 May–30 June 1965	− 6.2

TABLE 2 (*continued*)

Illustration No.	*Location*	*Length of tide series*	*Land movement (ft)*
18	Port Chatham, Kenai Peninsula	22 May–4 June 1965	− 4.6
19	Seldovia, Cook Inlet	June–Oct. 1964	− 3.9
	Seldovia, Cook Inlet	April–July 1965	− 3.8
20	Homer, Cook Inlet	June–Dec. 1964	− 5.4
	Homer, Cook Inlet	Sept.–Nov. 1965	− 5.8
21	Nikiska, Cook Inlet	18 June–31 July 1964	− 0.9
22	Anchorage, Cook Inlet	May–Oct. 1964	− 2.6
	Anchorage, Cook Inlet	April–Oct. 1965	− 2.3
23	Carry Inlet, Shuyak Island	8 July–7 Aug. 1965	− 3.2
24	Red Fox Bay, Afognak Island	1 July–8 Aug. 1965	− 3.4
25	Tonki Bay, Afognak Island	10 July–7 Aug. 1965	− 5.2
26	Nachalni Island, Kupreanof Strait	14 June–10 July 1965	− 3.9
27	Dolphin Point, Afognok Island	7 June–8 July 1965	− 2.9
28	St. Paul Harbour, Kodiak Island	June–Oct. 1964	− 5.5
	St. Paul Harbour, Kodiak Island	May–Nov. 1965	− 5.0
29	Ugak Bay, Kodiak Island	12 June–10 July 1965	− 4.2
30	Port Hobron, Sit Kalidak Island	26 July–27 Aug. 1965	− 0.7
31	Jap Bay, Kodiak Island	28 July–24 Aug. 1965	0.0
32	Lazy Bay, Kodiak Island	11–30 June, 1 July–14 Aug. 1964	− 0.4
	Lazy Bay, Kodiak Island	28 July–15 Aug., 20–24 Aug. 1965	− 0.2
33	Larsen Bay, Kodiak Island	13 June–31 Aug. 1964	− 2.5
	Larsen Bay, Kodiak Island	18 July–17 Aug. 1965	− 2.4
34	Uyak Bay (eastern passage) Kodiak Island	22 July–17 Aug. 1965	− 1.9
35	Port O'Brien, Uganik Bay, Kodiak Island	July–Aug. 1964	− 3.6
	Port O'Brien, Uganik Bay, Kodiak Island	8 June–19 July 1965	− 3.6
36	Kukak Bay, Alaska Peninsula	17 July–16 Aug. 1965	− 0.5
37	Chignik, Chignik Bay, Alaska Peninsula	19 June–17 Aug. 1964	− 0.3
38	Humboldt Harbour, Shumagin Islands	19 June–18 Aug. 1964	+ 0.2
39	King Cove, Alaska Peninsula	21 June–18 Aug. 1964	+ 0.2

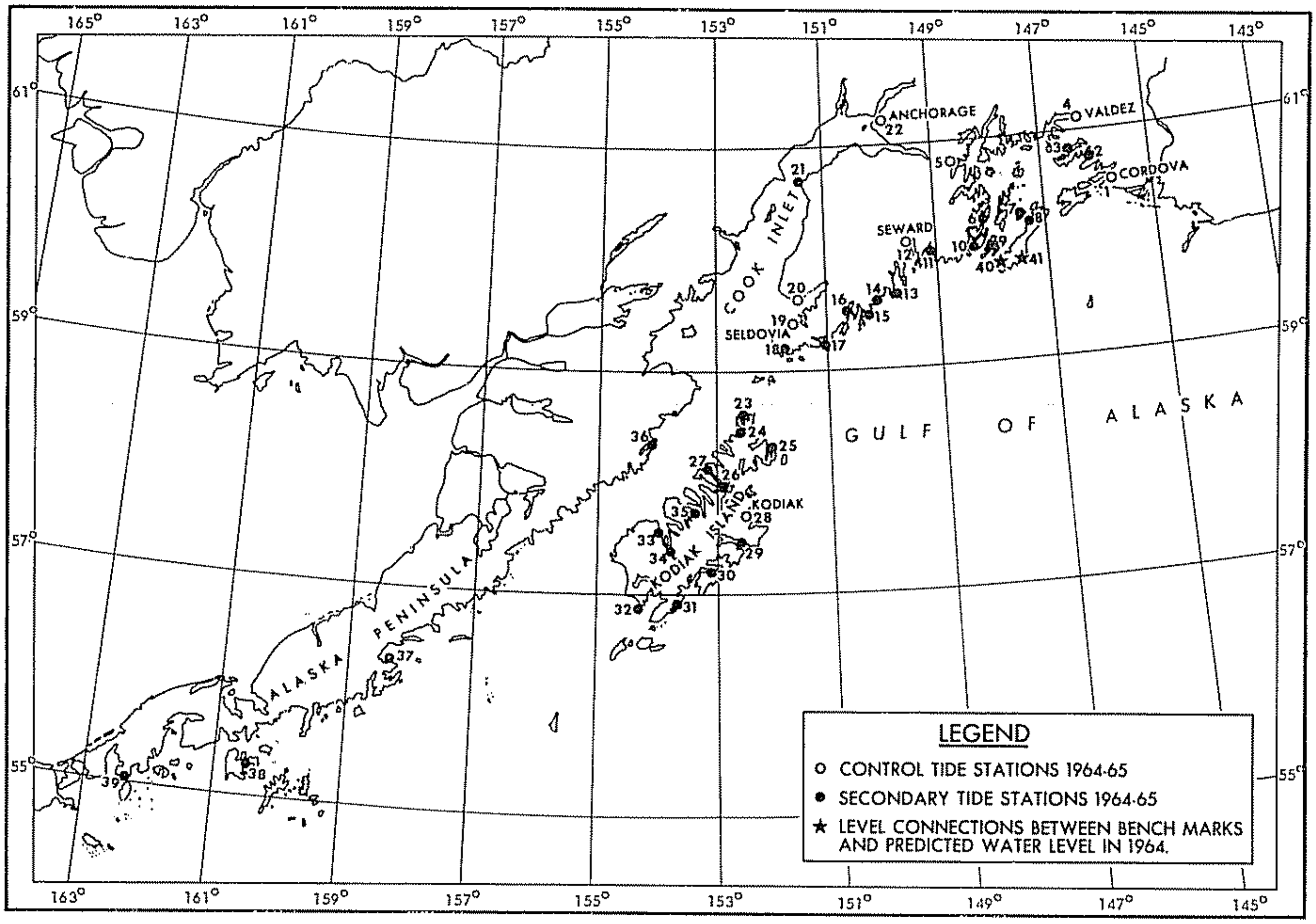


Fig. V—United States of America: Tidal observations, 1964–1965

Listed below are two additional locations giving the amount of land movement relative to sea level which was obtained during 1964 by levelling from the existing bench-marks to the predicted water level. No tide observations were obtained which could be referred to the original bench-marks.

Illustration No.	Location	Land movement (ft)
40	Macleod Harbour, Montague Island .	+31.5
41	Patton Bay, Montague Island	+14.9

The 1965 tidal observations when compared with the 1964 observations, for the stations where mean sea level was used in the 1964 tentative adjustment, show: Homer, 0.4 ft lower; Seward, no change; Whittier, 0.3 ft lower; and Valdez, 2.6 ft lower. Disregarding the Valdez change, which was due to a sloughing off of the pier area, the 1965 mean-sea-level values at Homer and Whittier, when substituted for the 1964 values, generally improve circuit closures.

It is hoped that the line from Cantwell to Paxson can be completed, at which point a final adjustment will be undertaken. At that time it will be necessary to decide whether the later tidal observations are contributing to a better mean-sea-level determination or whether Homer and Whittier are still subsiding slightly. If Homer and Whittier subsided from 1964 to 1965, it would be advisable to use the 1964 mean-sea-level determination, since that was the date of the levelling to the tide station.

Tidal observations of 1965 at Anchorage result in a mean-sea-level value that would indicate upheaval of 0.3 ft from 1964 to 1965. This is an anomaly that does not agree with the levelling or gravity findings, but when noting that the tidal range is about 30 ft at Anchorage, mean-sea-level determinations at different dates could vary by 0.5 ft or more at that location.

Future plans call for a continuation of the relevelling of all lines established prior to 1964 and the establishment of new levelling along all existing roads.

II. Horizontal displacement

Introduction

The earthquake which struck south-central Alaska at about 5.36 p.m., local time, on 27 March 1964, was the strongest ever recorded on the continent of North America. The epicentre of the main shock was located at latitude 61° N, longitude 1477°. W. This position is roughly midway between Valdez and Anchorage and a little south

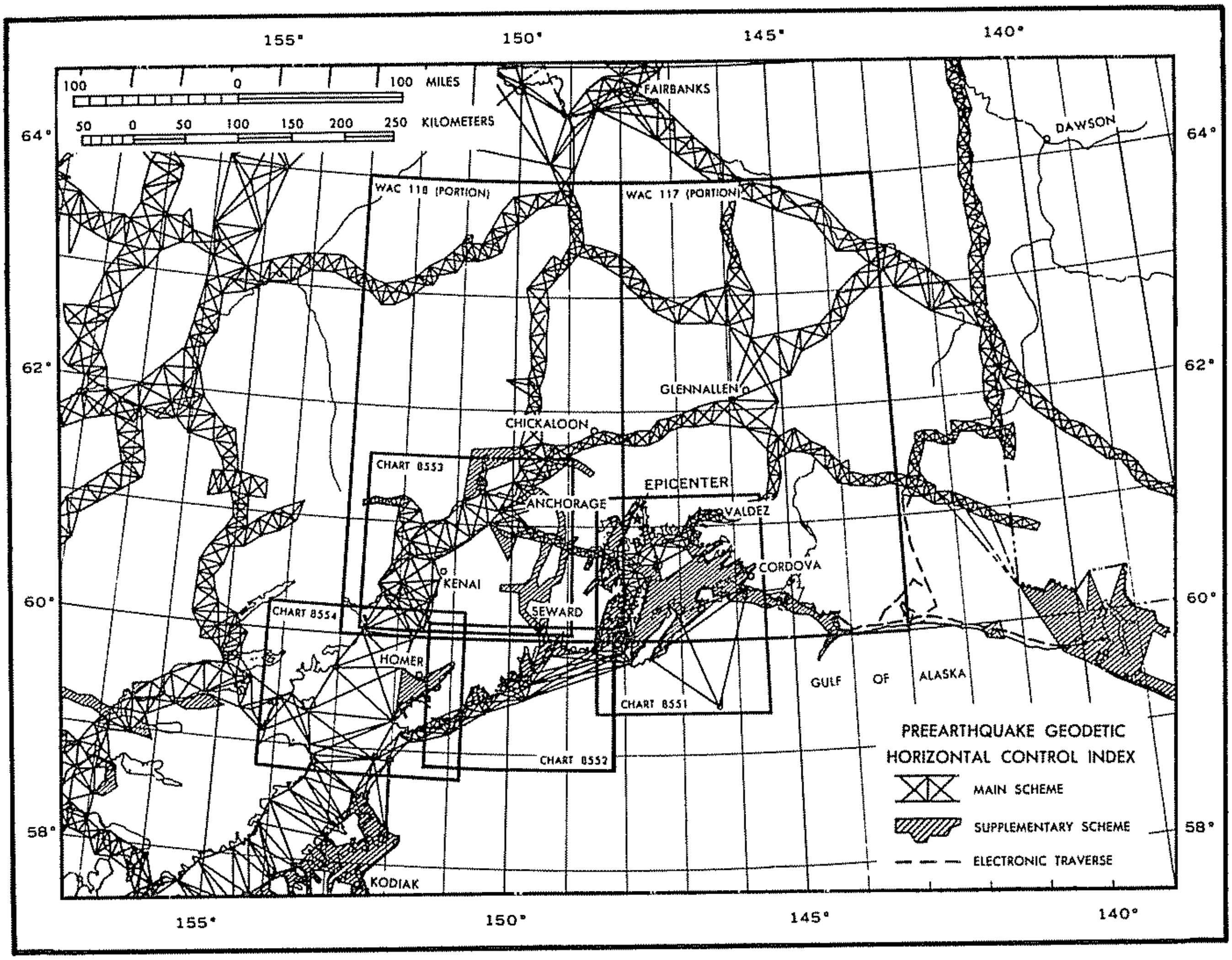


Fig. VI—United States of America: Pre-earthquake geodetic horizontal control index

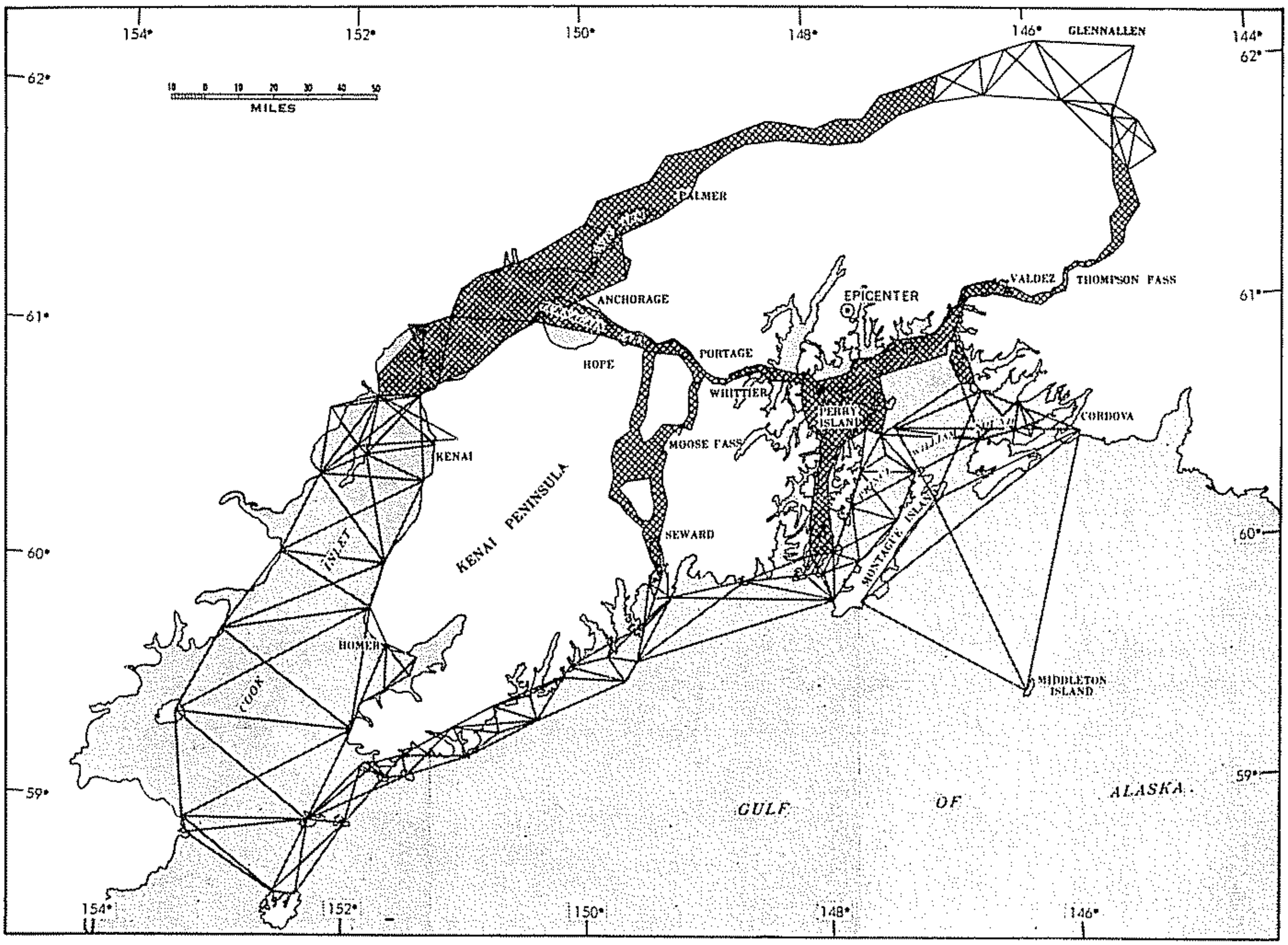


Fig. VII—United States of America: Pre-earthquake triangulation of south central Alaska (1900–1961)

of a line joining the two cities. It is on the north shore of Prince William Sound, near Unakwik inlet (see figure VI).

The seismic sea-wave warning system, which is maintained by the Coast and Geodetic Survey, was immediately alerted and began to issue the necessary tsunami warnings. But much more than that, the survey initiated many other programmes to determine the nature and extent of the disaster area: seismological operations; geodetic surveys—horizontal and vertical control and gravimetry; photogrammetric operations; oceanographic observations, and hydrographic surveys for emergency charting.

Part I of this paper has shown in detail the amount of subsidence or uplift revealed by a comparison of the precise levelling surveys made before and after the earthquake. It is the purpose of this paper to discuss the horizontal displacement of the earth's crust shown by a comparison of the results of triangulation and traverse surveys made before and after the earthquake.

Pre-earthquake triangulation (1900–1961)

The area studied extends from about latitude 59° to 62° N, longitude 145° to 154° W. The pre-earthquake network of triangulation in this area was begun in 1900 and developed over a period of about sixty years. It consists of the following work:

A primary arc extending from Anchorage north-eastward via Palmer to Glennallen, and from that point south and west via Thompson Pass to Valdez was surveyed in 1941 and 1944;

A second-order arc extending across the north shore of Prince William Sound from Valdez to Perry Island, 1947–1948;

This north loop is closed by a third-order arc from Perry Island to Anchorage, which was observed between 1910 and 1914;

The southern half of the net, spanning Prince William Sound, the Kenai peninsula and Cook Inlet, is all third-order triangulation; the double arc from Seward north to connexions at Turnagain Arm was done by the Corps of Engineers, United States Army, in 1941–1942; the rest of it was done mainly for chart control between 1900 and 1961 (see figure VII).

All these observations were combined into a single composite network and a free adjustment made by the method of variation of co-ordinates. The expression "free adjustment" means that the net was not constrained to fit previously adjusted geographic positions; only one position was held fixed. The station which was held in the adjustment is station Fishhook, located about nine miles north of Palmer. This station was selected because, in the area under study, it was believed by the seismologists to be the most stable.

Four hundred and forty stations and a total of about 2,350 directions were included in the adjustment. The average and maximum triangle closures are respectively 2.88″ and 15.69″. In considering these figures, it must be borne in mind that the net consists largely of third-order surveys made principally for charting purposes. At the time those surveys were planned, there was no thought of ever using them for studies of crustal movement.

To furnish orientation and scale for the net, five Laplace azimuths, fifteen taped base lines and one tellurometer length were included in the adjustment as observations equations. The azimuth and base lines were each given a weight of unity. This means that a correction of 1 part in 200,000 to the length of a base is equivalent to an azimuth correction of 1″. The direction observations were weighted as follows: first-order, 1.0; second-order, 0.5; third-order, 0.25.

The average corrections made through the adjustment to the directions (v's) and the maximum corrections to the angles in the various orders of work are as follows:

Order	*Average v (in seconds)*	*Maximum correction to an angle (in seconds)*
First	0.43	3.56
Second	0.96	5.26
Third	1.22	10.76

The average correction to a Laplace azimuth was 0″.97, the average correction to a base line was 1 part in 270,000, and the correction to the tellurometer length was 1 part in 63,000.

The probable errors of the resulting geographic positions of stations in Prince William Sound relative to the fixed station near Palmer, considering the size of the residuals, are estimated to be 15 to 20 ft.

Post-earthquake triangulation and traverse (1964–1965)

The following first-order triangulation was accomplished from June to Octover 1964; Anchorage via Palmer to Glennallen, Anchorage to Whittier, Hope to Seward, and Valdez to Thompson Pass. During the same season, tellurometer traverse was run on the Kenai peninsula from Moose Pass via Kenai to Homer. The rest of the network was observed during the summer of 1965. This work consisted of first-order triangulation in Prince William Sound, in the vicinity of Seward, and from Thompson Pass to Glennallen, and tellurometer traverse from Perry island to Whittier and from Seward via Resurrection Bay to Homer (see figure VIII).

A free adjustment was made of all of this work by the same method as had been used to adjust the earlier work, and the same station was held fixed. The adjustment included 292 stations and 1,476 observed directions. The average triangle closure was 0.91 seconds, the maximum being 4″.13.

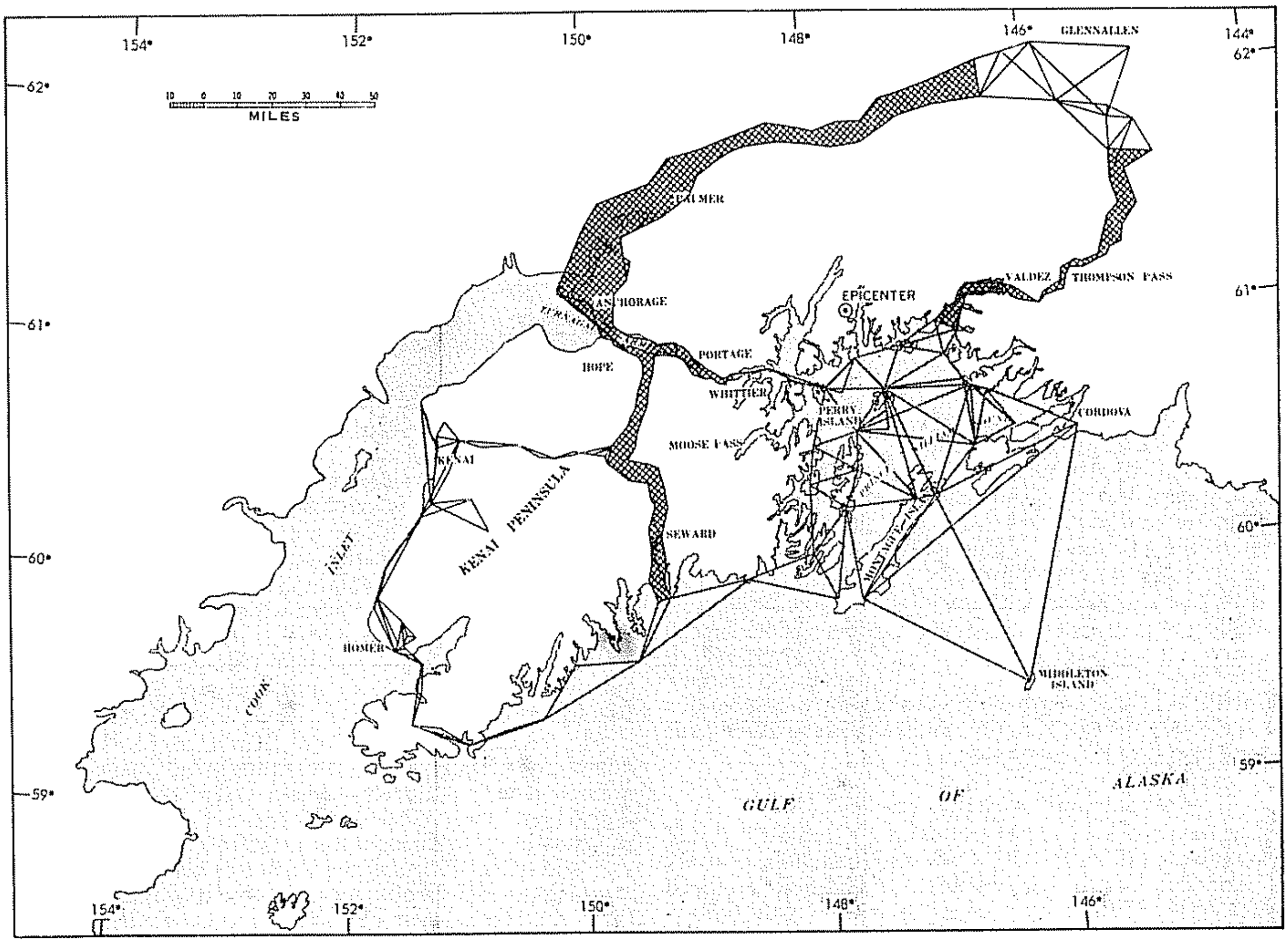


Fig. VIII—United States of America: Post-earthquake triangulation and traverse of south central Alaska (1964–1965)

Orientation for this network was supplied by 5 Laplace azimuths observed after the earthquake. Scale was furnished by 8 geodimeter lengths and 146 tellurometer lengths. Weights for the various types of work were assigned as follows: directions (which were all first order) 1.0, Laplace azimuths 1.0, geodimeter lengths 1.0 and tellurometer distances 0.1.

The following corrections to the various types of work resulted from the adjustment:

Directions: average $v = 0''.34$; maximum correction to an angle $= 2''.86$;

Laplace azimuths: average correction $= 0''.6$;

Geodimeter lengths: average correction = 1 part per 1,000,000; maximum = 1 part in 290,000;

Tellurometer lengths: average = 1 part in 170,000; maximum = 1 part in 40,000.

The probable errors of the geographic positions of stations in Prince William Sound resulting from this adjustment, estimated from the residuals, are 6 to 8 ft. These are again relative to the fixed station at Palmer.

Results

Plane co-ordinates based on the Alaska plane co-ordinate system were computed from the geographic positions resulting from the two adjustments. Stations east of the 148th meridian were computed on zone 3; those west of 148° on zone 4. The differences between the plane co-ordinates resulting from the two adjustments of a representative group of common stations are shown in the table below. This table covers about 20 per cent of the stations in the arc from Anchorage via Palmer and Glennallen to Valdez and from Hope south to Seward. On these arcs, where the pre-earthquake survey was fairly recent, about 90 per cent of the old stations were recovered in the 1964 survey. In the rest of the area, nearly all stations recovered in the 1964–1965 surveys are tabulated.

The columns in the table below contain the following information:

Columns 1 and 2: Station number and name;

Columns 3 and 4: Differences in the X- and Y-co-ordinates (in feet); these are taken in the sense "new minus old", so that plus signs in ΔX and ΔY indicate shifts to the east and north respectively;

Columns 5 and 6: Length and azimuth of the resulting vector, where the length is the hypotenuse of the right triangle formed by the X- and Y-shifts; the azimuth is reckoned clockwise from south.

Differences in plane co-ordinates

Station No.	*Station Name*	*Position shifts* ΔX *(feet)*	ΔY	*Resultant vector* *Length (feet)*	*Azimuth*
	North loop				
	Palmer-Glennallen-Valdez-Whittier-Anchorage-Palmer				
139*	Fishhook	0	0	0	
138	Lazy	+ 1.55	− 4.74	4.99	340°
137	Moose	+ 0.83	− 2.37	2.51	340°
133	Ram	+ 1.45	− 6.61	6.77	350°
132	Young	+ 1.46	− 3.91	4.17	340°
126	Mat	+ 3.88	− 9.23	10.01	335°
125	Rush	+ 3.83	− 7.09	8.06	330°
118	Glacier	+ 4.64	− 12.48	13.31	340°
117	Bou	+ 5.26	− 8.88	10.32	330°
108	Nel	+ 8.01	− 10.23	12.99	320°
107	Tahneta	+ 8.47	− 7.73	11.47	310°
102	Taz	+ 10.05	− 9.03	13.51	310°
57	Shepard	+ 11.74	− 6.82	12.72	300°
56	Hudson	+ 10.08	− 10.47	14.53	315°
55	Klawasi	+ 10.06	− 7.82	12.74	310°
50	Scarp	+ 8.45	− 11.84	14.55	325°
47	Little Tonsina	+ 11.17	− 14.32	18.16	320°
29	Ptarmigan	+ 17.32	− 15.39	23.17	310°
5	Power	+ 21.66	− 11.50	24.52	300°
4	Valdez N. B.	+ 18.74	− 13.73	23.23	305°
519	Reef	+ 22.13	− 22.78	31.76	315°
521	Anchor	+ 19.46	− 28.40	34.43	325°
526	Kinik	+ 18.01	− 37.17	41.30	335°
528	Waver	+ 18.19	− 45.85	49.33	340°
536	Perry	+ 16.68	− 44.77	47.78	340°
347	Shakespeare	+ 10.72	− 24.23	26.50	335°
346	Vista	+ 9.68	− 21.89	23.93	335°
321	Triple	+ 3.94	− 14.22	14.76	345°
318	Wood	+ 3.26	− 15.58	15.92	350°
312	Bird Point	+ 2.96	− 10.69	11.09	345°
306	Cape	+ 3.29	− 5.50	6.41	330°
305	Isle	+ 2.77	− 4.83	5.57	330°
157	Mac RM 3	− 1.54	− 2.43	2.88	30°
152	Ship	+ 0.58	− 5.56	5.59	355°
150	Fossil	− 0.07	− 4.38	4.38	0°
149	Long	− 2.46	+ 2.06	3.21	130°
148	Whitney	− 0.51	− 2.04	2.10	15°
147	Fishlake	− 1.84	+ 3.15	3.65	150°
145	Peters W. B.	− 0.49	− 3.41	3.45	10°
144	Peters E. B.	+ 0.40	− 3.68	3.70	355°
142	Eklutna	+ 0.58	− 4.71	4.75	355°
139*	Fishhook	0	0	0	
	West loop				
	Cook Inlet-Homer-Resurrection Bay-Seward-Hope				
180	Audry	− 2.57	+ 7.45	7.88	160°
184	Ninilchik	− 2.78	+ 12.23	12.54	165°
186	Anchor Point	− 2.26	+ 11.06	11.29	170°
188	Homer E. B.	− 1.95	+ 9.03	9.24	170°
218	Chiswell	+ 5.08	− 58.20	58.42	355°
438	Ward	+ 8.84	− 46.34	47.18	350°
437	Tune	+ 5.34	− 41.20	41.54	355°
424	Axis	+ 1.85	− 21.59	21.67	355°
422	Stetson	− 1.08	− 17.25	17.28	5°
419	John	+ 2.64	− 18.23	18.42	350°
416	Summit	+ 2.63	− 14.85	15.08	350°
486	Bear	+ 4.09	− 11.98	12.66	340°
	Prince William Sound				
576	Agnes	+ 22.24	− 45.30	50.46	335°
580	Giant	+ 23.59	− 48.63	54.05	335°
558	Red Head	+ 25.94	− 23.87	35.25	315°
555	Cordova	+ 20.85	− 41.30	46.26	335°
554	Zaikof	+ 18.63	− 39.50	43.67	335°
591	Evans	+ 18.60	− 67.40	69.92	345°
609	Knob	+ 22.06	− 66.56	70.12	340°
610	Stair	+ 11.30	− 66.35	67.30	350°
553	Cape Cleare	− 3.14	− 28.77	28.94	5°
552	Middleton	− 21.56	− 22.61	31.24	45°

* Held fixed in the adjustment.

These results are shown graphically in figure IX below. This figure shows much more vividly than any column of numbers the relative changes in the positions of the stations.

Beginning at station 139, Fishhook, the station held fixed in both adjustments, the vector difference in the plane co-ordinates is necessarily zero. Proceeding clockwise round the loop, the divergences increase to 15 ft in the

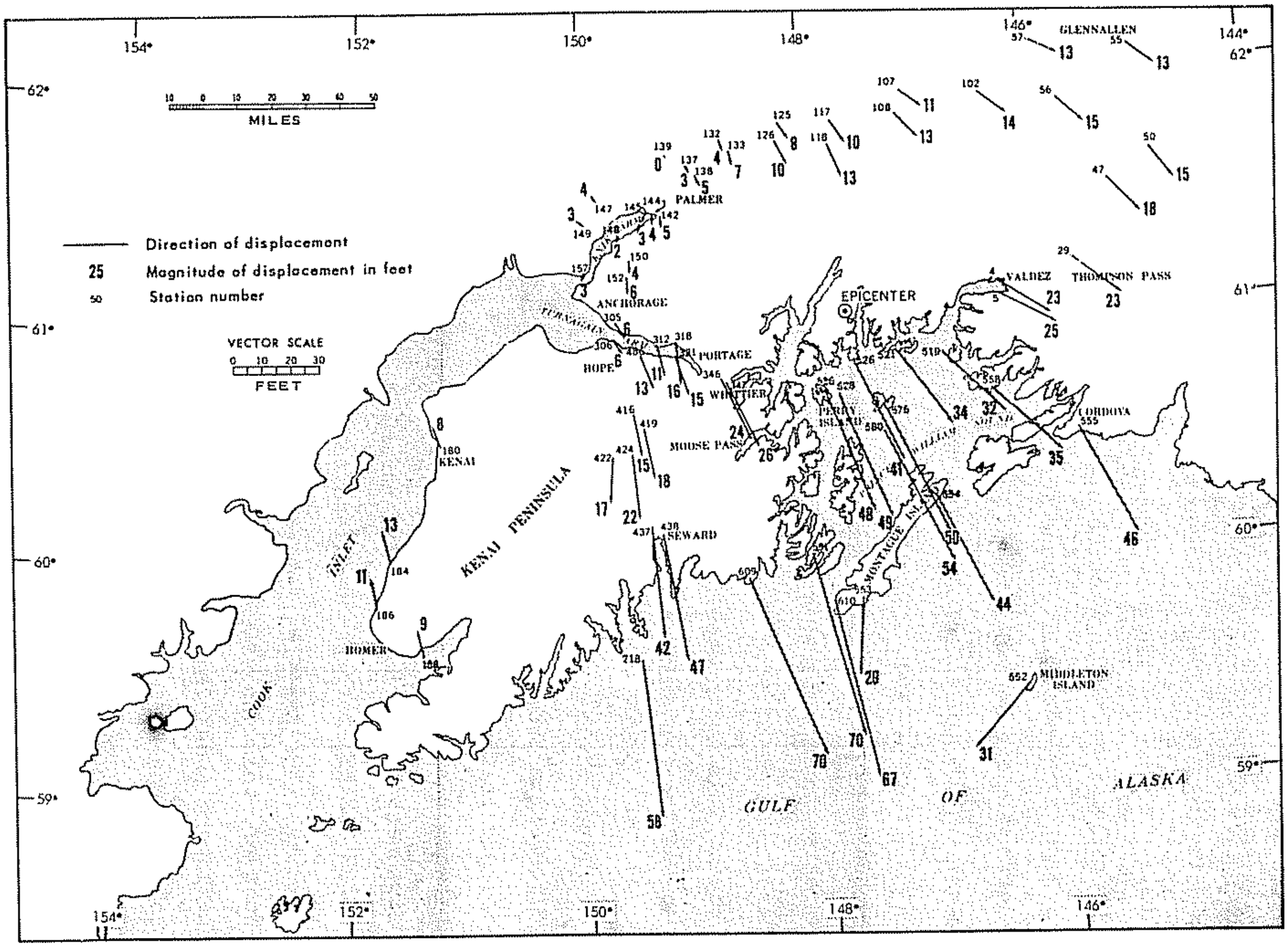


Fig. IX—United States of America: Apparent horizontal displacement in south central Alaska

vicinity of Glennallen, and to about 25 ft at Valdez. Continuing west along the north shore of Prince William Sound, the divergence increases to almost 50 ft at Perry island, which is just south of the epicentre. It then decreases to 25 ft near Whittier, to 12 ft at Hope, on Turnagain Arm, and back to zero at station 139. It will be noted that the direction of these vectors is generally south-east, varying in azimuth from about 300° to 350°.

If the divergences from Palmer north-eastward along the Matanuska river are examined more closely, it will be noted that the stations south of the river show slightly larger divergences (on the order of 2 ft) than those to the north, as though some slight dilation had taken place there. Also examining the vector divergences of the stations on either side of Knik Arm from Palmer south-westward, it will be noted that the stations north-west of Knik Arm have moved about 3 ft north-westward, while those south-east of Knik Arm have moved 2 to 5 ft southward, all relative to the fixed station near Palmer.

Stations along the east shore of Cook Inlet show discrepancies of up to 10 ft at Homer, but this can probably be attributed to weakness in the triangulation and not to any crustal movement. Proceeding south-east-ward to the station on Chiswell island, the vector difference is 58 ft south; then proceeding north through Seward to Hope there is a gradual decrease to 12 ft. Although all these vectors are generally southerly, closer examination of the divergences from Seward northward shows that those at stations on the east side of the arc are greater than those at stations on the west side. The difference is a maximum of 5 ft at Seward, tapering off to zero at Hope. This is in keeping with the right lateral movement found across the San Andreas fault in California.

In Prince William Sound, there is a general increase in the divergences from about 50 ft near Perry island to 70 ft on islands in the south-west part of the sound. The discrepancy between the shifts of 70 ft at station 610 (Stair) on the south-west tip of Montague island, and 29 ft at station 553 (Cape Cleare) across the island is difficult to explain, as is also the small size of the vector, 31 ft, at Middleton island. However, this shortening of the distance between stations on La Touche and Knight islands and stations to the south-east is consistent with the results of reobserving a small isolated scheme spanning Montague Strait between La Touche and Knight islands to the north-west and Montague island to the south-east.

Comparison of distances measured by tellurometer in 1964 with a 1933 survey indicate that the distance across the strait is now 15 to 20 ft shorter.

Conclusion

Most of the stations in the Prince William Sound area that were occupied during the summer of 1965 are those located on the peaks of the islands and these divergences therefore represent the shifts of stations at elevations of 1,500 to 3,000 ft above sea level. It is hoped that additional triangulation can be done in the near future observing at stations at sea-level to determine what changes have taken place at that level. A tilt of 1° in a block of the earth's crust containing a 3,000-ft peak would result in a differential horizontal movement between sea level and the peak of 50 ft.

It would also be desirable to extend the triangulation at the north-west and north-east corners of this network further northward to see if the station selected as the fixed station is really as stable as we believe it to be.

AERODIST IN GEODETIC SURVEYING IN CANADA

Paper presented by Canada[1]

INTRODUCTION

The aerodist system has been used by the Canadian Topographical Survey Division since 1962, when equipment consisting of a three-channel master system with four remote sets and other necessary accessories was purchased. The technique used and the various operations carried out up to 1965 have been previously reported by the author in a paper entitled "Aerodist, the Flying Chainman".[2] The present report contains a brief review of early operations but mainly concerns the application of Aerodist to first-order geodetic control projects in 1965 and 1966.

HISTORY

1962

The first project selected for control by aerodist was one that presented a most formidable obstacle to the national mapping programme. A trilateration net of braced quadrilaterals some 1,100 km in extent was established along the south and west shores of Hudson and James bays, through a region of vast muskegs and wooded swamps unrelieved by any height or useful vantage points. The airborne equipment was mounted in a de Havilland Beaver aircraft and all distances were measured by the line-crossing method. The success of this initial project, despite troubles inherent in the new and untried systems, encouraged plans for more ambitious projects that included positioning of vertical air photography.

1963

Two major projects were launched in 1963, both of which were continued in 1964. Control for 1:50,000 mapping in northern Ontario was provided by positioning of vertical photography flown in a grid pattern of 1° longitude and 30′ latitude. This control covered the heavily forested belt north of the United States boundary and the Great Lakes, an area broken by few roads or settlements. It would be impractical to survey this region by conventional methods.

The second project was a survey of offshore portions of James Bay and eastern Hudson Bay, where the numerous and widely scattered islands and shoals have never been accurately positioned; indeed, some were unknown and uncharted. Complete coverage of this large water area was flown, and the islands, rocks and shoal areas that could be interpreted on the photographs were accurately located by aerodist-controlled vertical photography.

In addition to the two major projects described above, Sable island, which lies about 240 km off the coast of Nova Scotia, was accurately positioned for the first time.

1964

The positioning of vertical photography to control 1:50,000 mapping in Ontario was continued, and the project was extended into Quebec. A total of 220,000 km^2 was controlled and 1,000 km of trilateration network established in the two seasons on the project. Of this network, about 800 km were completed by continuous trilateration.

The survey of offshore portions of James Bay and eastern Hudson Bay was completed. All islands and visible shoals in an area 109,000 km^2 in extent had been located, and 62,000 km^2 of land area were controlled for 1:50,000 mapping. Again in 1964, in a separate operation, aerodist was used to locate an offshore feature, Funk island, which lies about 100 km off Newfoundland and was positioned by line crossing. Two isolated navigational aids in Newfoundland were also positioned.

In co-operation with the Geodetic Survey, a test had been carried out in the autumn of 1963 to determine the accuracy of aerodist measurements made by the line-crossing method with a view to using the method to extend geodetic first-order control. A series of line-crossing measurements was made on the six lines of a braced quadrilateral. The stations of this quadrilateral were common to first-order geodetic triangulation that had been strengthened by tellurometer measurements and had been analysed for accuracy. The comparison of the aerodist-observed lengths with the geodetic distances indicated that aerodist could give the accuracy required for first-order control surveys. The standard deviation of aerodist measurements was estimated to be about 5 parts per million.

The Geodetic Survey made further mathematical investigations to determine a suitable structure for aerodist trilateration network and proposed a network of double-braced quadrilaterals, all fifteen lines of which should be measured.

1965

The Topographical Survey and the Geodetic Survey carried out a joint operation, the primary objective of which was the extension of the first-order geodetic network in two directions. The first spanned Hudson Strait between the mainland and Baffin Island, and the second extended over the islands across the northern end of Hudson Bay. Placement of several second-order control points for 1:250,000 mapping was a secondary objective. Each of these nets bridged large water areas that could not be spanned by conventional methods. The operation began in late March while near-winter conditions prevailed, so that the ice cover would provide a margin of safety for the helicopters on the long over-water flights necessary to occupy ground stations on the islands and across the straits. The aerodist was mounted in a ski-equipped DC-3.

This operation effected under low temperatures, blowing snow, high winds and adverse ice conditions, was a severe

[1] The original text of this paper, prepared by A. C. Tuttle, Chief Topographical Engineer, Topographical Survey Division, Surveys and Mapping Branch, appeared as document E/CONF.52/L.95 and Add. 1.

[2] *Second United Nations Regional Cartographic Conference for Africa 12–24 September 1966* (United Nations publication, Sales No.: 67.I.22), vol. 2.

test for the remote instruments, and considerable time was lost through failures in ground-station equipment.

The survey was completed by mid-June. Computations and analysis by the Geodetic Survey indicated that first-order standards for control networks had been satisfied.

1966

In 1966, another joint Topographic-Geodetic project was carried out. The area of operation and the network completed are shown in the figure on the 1966 aerodist programme for Saskatchewan.

Seven double-braced quadrilaterals spanning 800 km were established between two nets of existing triangulation in Alberta and Saskatchewan. All phases of this work were carried out in accordance with specifications set up by the Geodetic Survey for extension of first-order control by aerodist trilateration.

An area of 140,000 km^2 through which this network extended was also controlled for 1:50,000 mapping by aerodist-positioned air photography in a grid of 1° longitude and 30′ latitude. Six additional ground stations required for the photo-positioning were located by continuous trilateration, and three isolated air navigational aids were positioned as well.

The area lies in the heavily forested belt north of settlement, where survey by conventional methods is very slow and costly.

An extensive series of continuous trilateration flights was made in one quadrilateral for test purposes. All lines in this figure were also measured three times on different days by the line-crossing method to ensure first-order basic data with which to analyse the results of continuous trilateration.

Field operations

Equipment used

A DC-3 aircraft was used for all aerodist measuring and aerial photography. This aircraft has been our choice since 1964 because of its size, availability, economy and reliability. The air crew on line-crossing flights during the 1966 season consisted of two pilots, one APR operator, two aerodist operators and one meteorological observer. On photo flights, the only change was the addition of a cameraman.

Three DC-3 pilots were available for the greater part of the season, and they rotated, giving each man one day off in three. This arrangement was necessary to keep the individual flying time below the maximum allowed by the Department of Transport. No time was lost through DC-3 unserviceability, and the necessary periodic aircraft inspections were done on days unsuitable for flying. The DC-3 was in the field sixty days and flew 388 hours.

Auxiliary surveying equipment carried in the DC-3 included the following: APR Mark V with 35 mm tracking camera; Doppler navigator GP APN81; Wild RC-8 aerial camera; VHF and HF radios; meterological equipment.

Two Beaver (DHC-2) aircraft and two Bell G-4 helicopters were used to transport and supply the remote aerodist stations. Flying time on the Beavers amounted to 435 hours and, on the helicopters, 515 hours.

Initially, this aerodist system consisted of three master sets, four remote sets and two recorders. During the 1965 season, appreciable time was lost due to a combination of poor weather and aerodist unserviceability, some of which could have been saved if back-up equipment had been available. For this reason, and also to provide greater flexibility in ground station layouts, two additional remote sets and one additional control master set were purchased during the winter of 1965. The three-channel system was retained, with two remotes being tuned to each channel. The fourth master set, which could be used either as a control or as an auxiliary master, was mounted alongside the other master sets as a spare in case of breakdowns. Spare klystrons, tuned to the three channels, were carried on board to convert the spare master to any channel. To complete the conversion, the receiver was retuned to the relevant frequency and the whole change-over could be completed in about five minutes.

Two of the rotatable antennae were mounted on top of the fuselage, the third being positioned under the fuselage. The top forward antenna was mounted over the astrodome port, the top rear on the centre line 26 ft (7.9 m) behind the front antennae, and the bottom antenna to the left of the centreline under the fuselage, in line with the top rear antenna. All three antennae were used during the photo-fixing; for line crossings only the two rear antennae were used, which eliminated off-centre corrections.

A fourth aerodist antenna, with a flat-plate reflector, was mounted on the underside of the aircraft and was used to height the aircraft over aerodist ground stations.

Facilities and spares were available at the field base camp from which the DC-3 operated.

Major test equipment consisted of an electronic frequency counter for calibration of the modulating frequencies, frequency meter for checking the carrier frequencies, oscilloscope, audio signal generator, FM and AM signal generator, and a vacuum-tube voltmeter. Complete repair and calibration of the aerodist equipment could be carried out at the field base.

No major breakdown occurred during the season, most repairs being effected either at the ground stations or in flight.

Each remote operator carried a small portable test set (built in the Topographical Survey laboratory) which could be used to set switching levels, modulation levels and receiver frequencies. It could also be used as a quick method of ensuring that there was no trouble with the receiver sections of the aerodist.

Height and elevation determination

The aircraft height was determined by use of a Mark V APR. In many cases, it was possible to carry out the line crossings over, or near, a lake of known elevation, but when this was not possible an APR traverse was run from the closest lake of known elevation. The hypsometer portion of the APR is designed to operate over a range of 200 ft (61 m). To accommodate the two height changes of 200 ft (61 m) each specified for a line-crossing group, a Wallace and Tiernan altimeter was used to rezero the APR after each height change. This does not adversely affect accuracy, as the Wallace and Tiernan altimeter measures small elevation differences very accurately. Where flight levels were changed between lines, the same system was used to make the APR line continuous.

During the early part of the season, some trouble was experienced with the APR, and heighting was carried out by means of a radio altimeter SCR 718, in conjunction with a Wallace and Tiernan altimeter. The aircraft height was determined by the radio altimeter, read over a lake of known elevation, and simultaneously the Wallace and Tiernan altimeters were read to establish an air base elevation. The Wallace and Tiernan altimeter was then read at 5 to 10 second intervals along the line crossings. On completion of a line, the aircraft height was again checked over a lake of known elevation with the radio altimeter. The radio altimeter was checked on ten occasions against an aerodist heighting over a ground station. Frequent checks were made during the season on the APR by means of the radio altimeter and aerodist, to ensure against gross errors. Comparisons of the radio altimeter against the APR and aerodist gave a relative accuracy for the radio altimeter of plus or minus 25 ft (7.6 m).

When height checks were made by means of the aerodist, the distance by which the aircraft diverged horizontally from the plumb was determined by sighting the aircraft through a vertical sighting device designed and built at the Topographical Survey and named "Zeni-flub". This device has graduated rings representing the angular distance from the zenith to the aircraft. When the aircraft flew overhead, the ring on which it appeared in the sighting device provided a correction factor which, when multiplied by the aerodist distance, gave the true height of the aircraft above the ground station.

Ground-station elevations were determined from points of known elevation, Wallace and Tiernan altimeters being used to measure elevation differences, and these determinations were repeated to give more reliable elevation values. The maximum distance to any station from a point of known elevation was less than 25 km.

Operating procedures

The aerodist party was divided into two main camps. One consisted of the DC-3 crew, the aerodist master operators, and the computing crew; the other included the remote operators, the Beaver and helicopter crews, and reconnaissance crews. Three or four of the remote operators spent the greater part of their time camped at the remote stations.

The first survey figure was set up with the three parties for the western stations camped on site and each composed of two men. The blue remote operator lived at the base camp and travelled each day by helicopter to one of the eastern stations, moving between measuring flights of the DC-3 to one of the two remaining eastern stations. The sixth remote was held as a spare. Six lines could be measured on any one flight, six flights being necessary to measure the twelve lines twice on separate flights.

In the second and subsequent figures, four remote parties camped on site, while the fifth remote operator alternated between the two unoccupied stations. With this arrangement of remotes, nine lines could be measured on any one flight and four flights were necessary to measure the twelve lines twice on separate flights.

Upon completion of a figure, all remote camps were moved to the next station east of the one previously occupied. The moves were made in one day with the two Beavers and helicopters. Prior to the moves the new stations had been reconnoitred and equipped with portable towers, if necessary, and a landing spot for a helicopter cleared. Where possible, stations were located on hilltops near lakes where the Beaver aircraft could land and cache equipment, which would later be ferried to the ground station by helicopter.

The portable towers used this year were constructed of tubular aluminium weighing 30 pounds for each 10 ft (3 m) section. Each section of tower consisted of three flat sections, each 10 ft (3 m) by 2 ft (0.6 m), all connected by Dzus-type fasteners. Maximum tower height used this year was 50 ft (15 m) and most towers were about 30 ft (9 m) high. A 30 ft (9 m) tower could be raised by three men in one-half hour, provided that there was room enough to assemble it on the ground and pivot it into place. Each succeeding 10 ft (3 m) of tower required approximately one-half hour to put up.

Ground stations were marked with bronze tablets embedded in cement or bed-rock and referenced by three reference tables. Of the twenty-six stations, eleven were photo-identified from the air with an F-24 aerial camera in a light aircraft, eight stations were photographed by land camera from a helicopter, and six were included in the aerodist-controlled photography.

Operational specifications

The specifications listed below for first-order trilateration by the aerodist line-crossing method were prepared by the Geodetic Survey in consultation with the Topographical Survey.

1. Lines are not to be shorter than 75 km and the distance from aircraft to either ground station is not to be shorter than 30 km on any line.

2. Line measurements are to be made at aircraft elevations as low as terrain and good signals permit.

3. A line crossing is to have at least 2 minutes of recorded A traces, with the minimum point falling at least 25 seconds after the start, or before the end. The record is to have distinct A-minus, coarse, and ambiguity traces. The following information is to be recorded on the aerodist chart: crossing number, altitude synchronization data, and altimeter readings.

4. A measurement or group is to consist of at least six acceptable line crossings in pairs, separated in elevation by at least 200 ft (61 m).

5. Each line is to have a minimum of two groups and, where lines are shorter than 100 km, there must be a minimum of three groups. Each group on a line is to be flown on a different day (separated by at least twelve hours).

6. If the spreads of crossings in the minimum required number of groups are all greater than 6 m, another group is to be flown.

7. If the spread between groups is greater than 1 m + 10 parts per million, another group is to be flown.

8. An additional group is to be flown on a line that has a residual larger than 10 ppm as indicated by a figural adjustment.

A-minus data. The A-minus switch must be depressed for approximately one-half second, every 10 seconds during each line crossing. A short pause must be allowed after the coarse reading tone so that the A-minus data will not interfere with the coarse readings on the recorder chart.

Specifications for auxiliary data

Meteorological data (using psychrometer and pressure altimeter). For each pair of line crossings flown at the same altitude, pressure altitude shall be observed and recorded to 5 ft (1.5 m), wet and dry bulb temperatures to 0.1°C, and aircraft speed to the nearest knot.

Meteorological soundings shall be flown just before and just after a series of line-crossing groups flown in the same general area. Each sounding shall consist of pressure altitude, wet and dry bulb temperature and air speed, observed at altitude intervals of 1,000 ft (310 m), from 1,000 ft (310 m) above ground to line-crossing height. Note if sounding is in cloud. All line crossings shall be flown within 80 km of either sounding location and within two hours of either sounding. Instrument numbers and times of all meteorological observations shall be recorded.

All remote operators shall observe and record meteorological data every half hour as long as the aircraft is doing line crossings, or is flying meteorological soundings. They shall observe and record meteorological data before and after each group of aerodist heighting over-flights on the ground station.

If a tower is used, meteorological data shall be taken at the top. On a waveguide, an electronic temperature differential device or a reliable minimum-maximum thermometer shall be used, in conjunction with an electric psychrometer operated at ground level. If the station is at ground level, the temperatures shall be observed in as large a clearing and as high above ground as possible. Wherever possible, the psychrometer shall be exposed to a breeze, away from direct sunlight. Temperatures shall be recorded to tenths of a degree and pressure altitude to the nearest foot (0.3 m).

The height of the altimeter above or below the station marker shall be recorded.

Drift data. Drift shall be recorded to the nearest degree on all APR traverses.

Eccentric and height data. For each aerodist measurement, or series of measurements, the following data shall be recorded: height of dipole axis above the station marker recorded to tenths of a foot (0.03 m); and either confirmation that remote set plumb point is immediately above the station marker, or horizontal distance and direction between the remote set plumb point and the station marker. (For separated antenna atop a wave guide mast, the centre of the short wooden section of the mast immediately below the antenna assembly shall be used as the plumb point.)

Heighting by radio altimeter checks. If the aircraft elevation during line crossings is determined by pressure altimeter, aircraft height by radio altimeter or aerodist shall be obtained.

Heights by radio altimeter shall be observed just before or just after flying a group of line crossings. Two sets of comparison readings shall be obtained, each with pressure altimeter and radio altimeter, at two altitudes bracketing elevations at which the line crossings were flown and observed over a water surface of known elevation near the line-crossing area. These radio-altimeter heightings may suffice for two groups of line crossings if the two crossing points are within 25 miles (35 km) of each other and one line is measured immediately after the other. In this case, radio altimeter heights shall be read at the lowest and highest altitude flown for the line crossings, and all altitude readings shall be recorded to the nearest 5 ft (1.5 m).

Aerodist height checks. When visibility is good, aerodist height checks against the radio altimeter should be obtained by flying the aircraft directly over a ground station and recording aerodist height and corresponding pressure altitude. Three acceptable passes should be flown for each aerodist height check, complete with aircraft eccentric data to the nearest half ring on the Zeni-flub. Two such checks should be made on two different ground stations for groups of line crossings flown during a flight.

FIELD REDUCTION OF DATA

In order that the aerodist data may be computed and assessed in the field, a geodetic computing team forms part of the aerodist field party. Data reduction is a time-consuming process and there is constant pressure on the computers as they try to keep up with the observing team. During the 1965 operations in northern Canada, where fifty-one aerodist lines were measured, five computers handled the observed data. In the 1966 operations in the prairie provinces, ninety-two lines were measured and the computing team comprised seven men.

The main steps in reduction of aerodist data are: extraction of aerodist range data from the recorder charts, computation of minimum-sum distances, reduction of meteorological data, computation of aircraft elevation, and computation of sea-level lengths.

Aerodist-range data

The line-crossing method of length measurement is used (Ross 1955). Approximately fifty pairs of aerodist ranges are scaled from the recorder chart at 1-second intervals for each line-crossing measurement. The pairs of ranges are so selected that the middle pair is at the line-crossing point. The pairs of ranges are summed and a sum-versus-time graph is plotted. Also extracted from the recorder chart are time data and A-minus readings. The time data are used to correlate aircraft elevations and range data. The A-minus readings are averaged to give an A-minus correction. Approximately five A-minus readings are recorded and averaged for each of the two sets of aerodist ranges.

Minimum-sum distance

A clear plastic overlay inscribed with a series of parabolas and a vertical bisector is used to determine the point on the sum graph that corresponds to the point of line crossing. Corresponding sums on either side of this point are averaged and a minimum sum is computed by least squares. Twenty- to fifty-range sums are used, depending on the smoothness of the plotted sum curve. Mathematical checks on the computed minimum sum are available, but to save time the computed value is checked by visual inspection of the sum graph. The computed minimum sum is separated into its two component slope ranges for reduction to sea level.

Meteorological data

Meteorological data observed at the ground stations and in the aircraft consist of wet- and dry-bulb temperatures and pressure altitude. For each observed wet- and dry-bulb temperature and pressure altitude an index-of-refraction value is computed with the aid of a nomograph. A graph showing index of refraction versus altitude is then plotted for all data observed during a flight. The plot shows the vertical distribution of index of refraction in the survey area.

Aircraft elevation

As described earlier, aircraft elevations over lakes were determined in 1966 mainly by a Mark V airborne profile recorder (APR), but in some cases a radio altimeter (SCR 718) was used. The aircraft was then flown at a constant barometric elevation to the line-crossing area and then to another lake. Steps normally of a few hundred feet, but occasionally of 1,000 ft (310 m) or more, were measured by means of a Wallace and Tiernan altimeter (FA 181).

Several corrections must be applied to the readings obtained from these instruments. The radio altimeter has a zero correction that varies with height. This was computed from comparisons with vertical aerodist measurements at various heights. A zero correction for the APR was computed from double-echo checks and from comparisons with vertical aerodist measurements. Instrument calibration, temperature and humidity corrections were applied to the barometric-height steps.

The hypsometer in the APR gives aircraft elevation changes with respect to a reference pressure surface. If an APR traverse was more than about 20 miles from a lake, the correction to the elevation of the reference pressure surface due to its slope in the direction of travel was computed from the formula (Henry 1947):

Correction = 0.035 × true air speed (mph) × distance (miles) × sin lat. × sin drift angle

The correction is positive for a left drift and negative for a right drift. It sometimes amounted to 10 to 20 ft (3 to 6 m), but was often negligible. The closure correction from the check on a second lake was distributed back over the traverse in proportion to time, or distance, or both. The average closure was about 17 ft (5 m) and the maximum about 40 ft (12 m). The APR chart shows the deviation of the aircraft above or below the reference pressure surface. The average value of this deviation for the few seconds at the time of line crossing is scaled for each crossing and the appropriate correction applied.

Reduction to sea level

Each line-crossing measurement is reduced to a sea-level distance. For aerodist measurements prior to 1966, the conventional method of reduction was used, including corrections for slope, sea level, path curvature and chord to arc. In addition, an index-of-refraction correction, based on an estimated path curvature, was computed and applied. This was derived from mean index-of-refraction values obtained at elevation intervals of 1,000 ft (310 m) and increments of line length within the elevation levels.

In 1966, the Godson method of reduction was adopted (Godson 1953, Ross 1955). In this method, aerodist slope ranges are reduced directly to sea-level lengths, with corrections for slope, sea level, path curvature, chord to arc and index of refraction being combined. The graph of index of refraction versus altitude is divided into one to four straight-line sections, and elevations for the junction points are derived. The elevations and index-of-refraction values for these points and for the aircraft and ground stations, together with aerodist slope ranges, are the basic data. The total sea level corrections for one aircraft to ground station range is:

$$\sum [0.66644\Delta D_i\{(\delta-\mu)_i + (\delta-\mu)_j + (\sqrt{[\delta-\mu]})_i(\sqrt{[\delta-\mu]})_j - \tfrac{3}{2}(330-\mu)\}10^{-3}] + [(330-\mu)(D-\sum \Delta D)10^{-3}]$$

where

D = aerodist slope range in metres;

$\Delta D_i = \dfrac{0.43160\,\Delta h_i}{(\sqrt{[\delta-\mu]})+(\sqrt{[\delta-\mu]})}$ = portion of aerodist slope length in elevation layer Δh_i in metres;

δ = n + height modifier, where n = (index of refraction − 1) 10^6 and height modifier $= \left(\dfrac{\text{elevation}}{\text{earth radius}}\right).10^6$;

μ = Godson's constant = $\delta + G$,

where δ is mean δ at aircraft and ground elevations and G is a function of index of refraction distribution in a standard atmosphere. G has been tabulated and can be determined by interpolation for all possible aircraft elevation and aerodist slope range combinations.

The constant 330 is derived from the aerodist design value of index of refraction, 1.000330.

A computation form is used for the reduction to sea level of both aircraft-to-ground ranges comprising a line crossing. Corrections for A-minus, aircraft and ground station eccentricities and aerodist frequency are also recorded on this form, and the corrected sea-level length is shown.

The frequency correction is derived from periodic calibrations of the aerodist master frequency. A frequency counter is used for these calibrations.

A computer programme has been written for the Godson reduction and is being used to check manually performed field computations.

When two groups of line crossings on a line have been reduced to sea-level lengths, the difference of the group means is obtained.

Although six line crossings constitute a group, generally only four are reduced in the field, and the remaining crossings are processed at a later date. The field assessment is therefore based on preliminary values, but the reduction in field computations assists the computers in their attempt to keep up with the observing crew.

Adjustment of data

Consistency of aerodist measurements is determined by least-squares adjustment using the Groom computer programme. The basic unit for adjustment is a six-station, double-quadrilateral figure with observed data of fifteen measured lengths. Fixed data consist of co-ordinates of one station and an azimuth to a second station, obtained if possible from a previous first-order triangulation survey. This was done in the 1966 survey, but in the 1965 work only scaled map values were available. The adjustment yields adjusted station co-ordinates, azimuths and lengths, and lists the v's, or corrections to observed lengths.

As soon as all lines in a double quadrilateral are measured and sea-level lengths are computed in the field, the data are passed by telephone to headquarters in Ottawa. There an adjustment is made on an electronic computer, and the results are promptly telephoned back to the field party. Any line with a v larger than 10 ppm is checked for computational error and, if necessary, a remeasurement is made.

As lines in successive double quadrilaterals are measured, the data are sent to Ottawa, where subsequent adjustments are made, using previously adjusted data as well as the new work. Thus, the final adjustment made while the field party is still operational includes all lines observed in all double quadrilaterals of the aerodist net. In 1966, seven double quadrilaterals were included in the final adjustment made before the field party was disbanded.

Following the field season, extensive checks are made on the aircraft elevations computed in the field and the backlog of line crossings is reduced. All line-crossing measurements are then reduced to sea-level lengths by the Godson computer programme and final observed lengths are obtained.

A final adjustment is now made with all first-order triangulation stations in the net held fixed. This gives adjusted co-ordinates for the aerodist stations consistent with previously established geodetic work.

For the 1966 work, a free adjustment of the aerodist data was also made. One station at one end of the net and an azimuth from that station to a geodetic station at the other end of the net were held to values determined from first-order triangulation. This adjustment imposes no scale restrictions other than the aerodist lengths themselves, and permits analysis of the internal consistency of the aerodist system. Adjustment results and analysis are included in an annex to this paper.

Main sources of error

The main sources of error are: chart read-out and recording of aerodist range and A-minus data, aircraft elevation, index of refraction, ground swing, aerodist modulation frequency and zero error.

Aerodist chart read-out

Resolution of aerodist range is given by the manufacturer as ± 1 m for an aircraft-to-ground range and therefore ± 1.4 m for a line-crossing measurement. The ranges are recorded to the nearest metre and the minimum sum is computed to 0.01 m. Even with careful adjustment, mechanical misalignment of the recording pens can introduce errors as large as 0.5 m in the minimum-sum distance, but in general this should average out to a few tenths of a metre. A-minus readings are recorded to an estimated accuracy of 0.5 m, with approximately five readings averaged for each range measured.

It is estimated that all these factors give a standard error of 1.8 m in a line-crossing measurement, which for an average length of line of 150 km is 12 ppm. For an aerodist measurement composed of two groups of six line crossings each, the standard error is therefore estimated to be 3.5 ppm.

Aircraft elevation

Aircraft elevations for line crossings in 1966 were obtained by APR. Maximum error of aircraft elevation on a line crossing is estimated at 12 m and a standard error of 4 m is estimated. Errors in aircraft elevation introduce the largest errors in length on short lines flown at high aircraft elevations. For example, with ground station elevations near sea level, an error of 12 m in an aircraft elevation of 3,000 m on a 60 km line flown at the mid-point would result in a length error of 2.46 m or 41 ppm. The same 12 m error in an aircraft elevation of 1,500 m on a 150 km line flown at the mid-point would result in a length error of only 0.62 m or 4.1 ppm. If the error in elevation is 4 m on this average line, the error in length is only 0.21 m, or 1.4 ppm.

In general, lines are flown as near as possible to the mid-point and at lowest practical aircraft elevations, so it is reasonable to estimate standard error on an average length measurement due to error in aircraft elevation as 1.5 ppm. This figure is confirmed by sample computations on representative 1966 data with an assumed standard error in aircraft elevation of 4 m.

Aircraft elevations determined in 1965 by radio altimeter are judged to be less precise than those determined by APR. However, no attempt has been made to estimate their standard error.

Index of refraction

Index of refraction is determined from meteorological data observed at ground stations and at the aircraft on line crossings and during soundings in the area at 1,000 ft (310 m) altitude levels. There are instrumental errors in observing temperatures and pressure altitude, as well as errors due to the observed data not being completely representative of that existing along the ray paths being measured. An error of 1 ppm in index of refraction and hence in measured length results from an error of 1.4°F in dry-bulb temperature, or 0.1 inches of mercury in barometric pressure, or 0.006 inches in vapour pressure.

With the present system of observation of meteorological data, it is expected that error in refractive-index determination will not exceed 12 ppm. Therefore a standard error of 3.5 ppm is estimated for this source of error.

Ground swing error

Ground-swing error is mainly a function of carrier and modulation frequency, path length difference of direct and ground-reflected components of each aircraft-to-ground ray path, and reflectivity of the surface at the point of reflection. Large path length differences and a highly reflective surface such as water can result in large ground-swing errors.

Large spreads in sea-level lengths within groups of crossings on a small percentage of lines measured to date indicate that some ground swing is present. However, the operating technique of flying line crossings at low aircraft elevation, and varying aircraft elevation on groups of line crossings, should minimize ground-swing error. Since assessment of ground-swing error is very difficult, only an estimate of a nominal 2 ppm in standard error for ground swing is made. It is, however, conceded that in some cases very large errors from this source are possible.

Aerodist modulation frequency

Aerodist range measurements are controlled by the 1.5 mc/s modulation frequency of a crystal oscillator at the master station. In 1966, the crystal frequency was checked before, during and after the field season. The over-all change was only 0.3 cycles per second. Frequency error is therefore considered to be negligible.

Zero error

Measurements on the aerodist test net indicated negligible zero error, so we have assumed that there is no zero error in our aerodist system.

Summary of error sources

Based on the foregoing, the following is a summary of estimated standard errors in the measurement by aerodist of an average length of line of 150 km.

Source of error	*Standard error (ppm)*
Instrumental and computed minimum sum	3.5
Aircraft elevation (APR)	1.5
Index of refraction	3.5
Ground swing	2.0
Standard error for combined sources	5.5

Accuracy of aerodist

An indication of accuracy of aerodist is available from adjustment of aerodist data where relative consistency may be determined, and from comparisons of aerodist lengths with first-order triangulation or geodetic lengths.

1965 aerodist adjustment

The two aerodist nets observed in 1965 were adjusted separately as free nets. Average length for the fifty-one lines measured was 164 km, and the range of lengths 68.5 to 271.5 km. Each line was measured by 2 or 3 groups of six line crossings each. Average spread in a group was 3.7 m and the maximum 6.3 m. The average range of group means was 1.7 m and the maximum 4.4 m.

The standard deviation for a measured length in the smaller Hudson Strait net was 7 ppm. The average correction to measured lengths was 0.63 m and the largest 1.8 m or 10 ppm. On the larger net, the standard deviation for a measured length was 6.6 ppm. The average correction to measured lengths was 0.61 m and the largest 2.65 m or 11.5 ppm.

Analysis of the final adjustments of the 1966 aerodist net is given in the supplement to this paper.

Comparisons with geodetic lengths

Because of the high accuracy attainable with Aerodist, bases for determining absolute accuracy must be very precisely measured. Such base lines are very scarce, and only comparisons with first-order triangulation lengths are readily available. The table in next column gives comparisons of aerodist lengths with first-order triangulation (geodetic) lengths for three groups of lines.

Group 1 includes all six lines shown in the figure of the aerodist test range near Ottawa. This net comprises previously established arcs and recent triangulation, including thirteen tellurometer lengths. The data were adjusted to provide the most precise geodetic lengths possible. Standard deviations for geodetic lengths in this group are in the range 1.3 to 2.0 ppm.

Comparisons of aerodist and geodetic lengths

Group	*Line*	*Length in metres*		*Difference*	
		Geodetic	*Aerodist*	*Geodetic (metres)*	*Aerodist (ppm)*
1	1	89,699.18	89,698.69	+0.49	5.5
1	2	202,621.77	202,621.31	+0.46	2.3
1	3	173,038.52	173,038.10	+0.42	2.4
1	4	154,858.58	154,859.19	−0.61	3.9
1	5	183,052.93	183,053.25	−0.32	1.8
1	6	117,678.00	117,678.43	−0.43	3.7
2	Wake-Foul	71,713.28	71,711.39	+1.89	26.3
2	Wake-Charles	169,529.43	169,525.60	+3.83	22.6
2	Foul-Charles	97,860.67	97,859.12	+1.55	15.8
2	Erik-Bilson	86,434.68	86,434.62	+0.06	0.7
2	Erik-Youville	152,808.08	152,807.03	+1.05	6.9
2	Bilson-Youville	68,511.98	68,512.08	−0.10	1.5
3	Relay-P. Mound	98,706.61	98,705.82	+0.79	8.0
3	Relay-Zawale	194,789.31	194,792.05	−2.74	14.1
3	P. Mound-Zawale	97,016.04	97,017.82	−1.78	18.4
3	Waden-Wathaman	210,726.63	210,724.68	−1.95	9.3
3	Waden-Brabant	111,418.41	111,418.40	+0.01	0.1
3	Brabant-Wathaman	107,664.62	107,664.82	−0.20	1.9
3	Brabant-Hugh	146,010.94	146,014.04	−3.10	21.2
3	Hugh-Wathaman	82,194.10	82,197.35	−3.25	39.5
3	Hugh-Boundary	79,084.09	79,084.50	−0.41	5.2

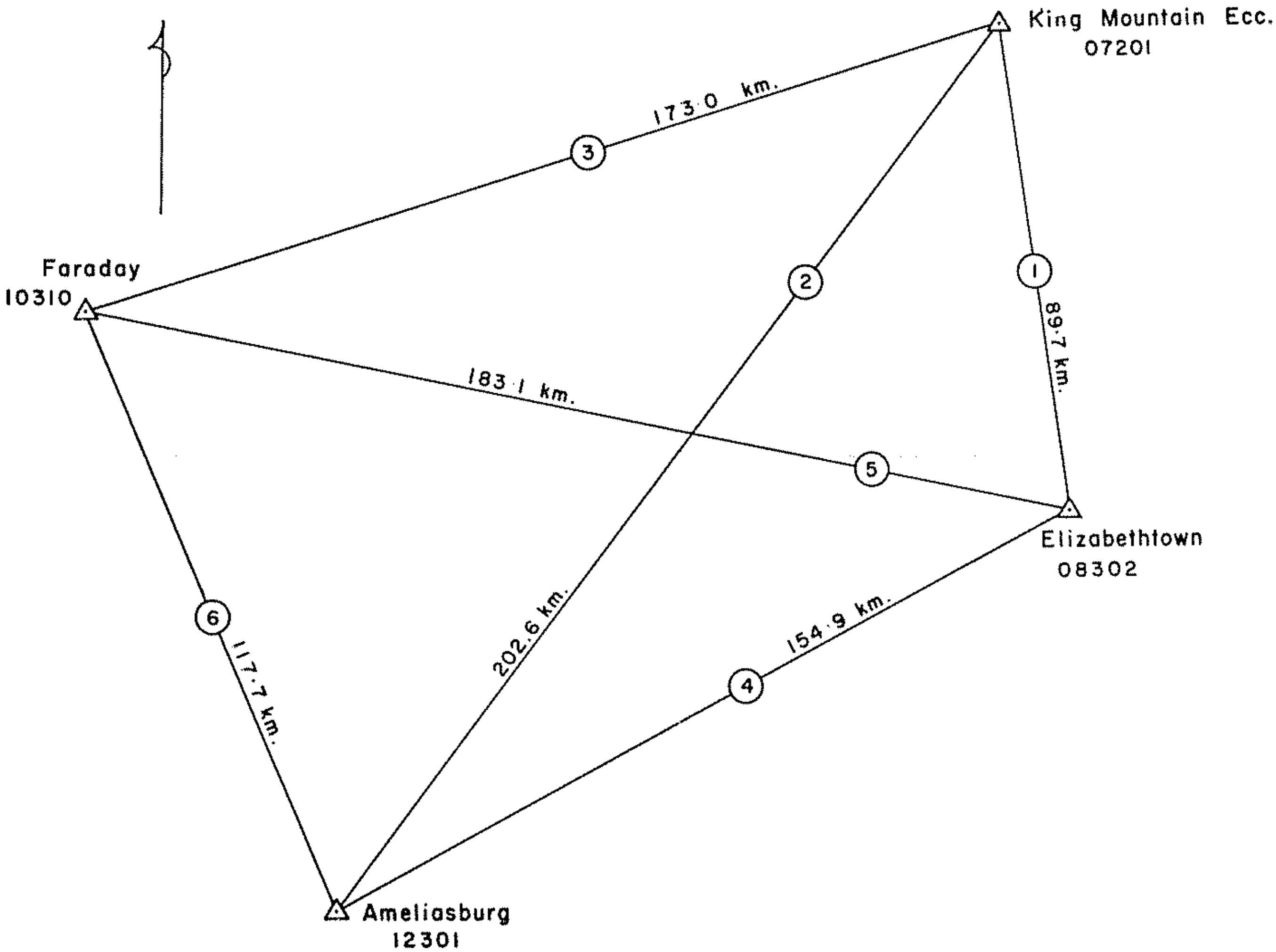


Fig. 1—Canada: Aerodist test range near Ottawa

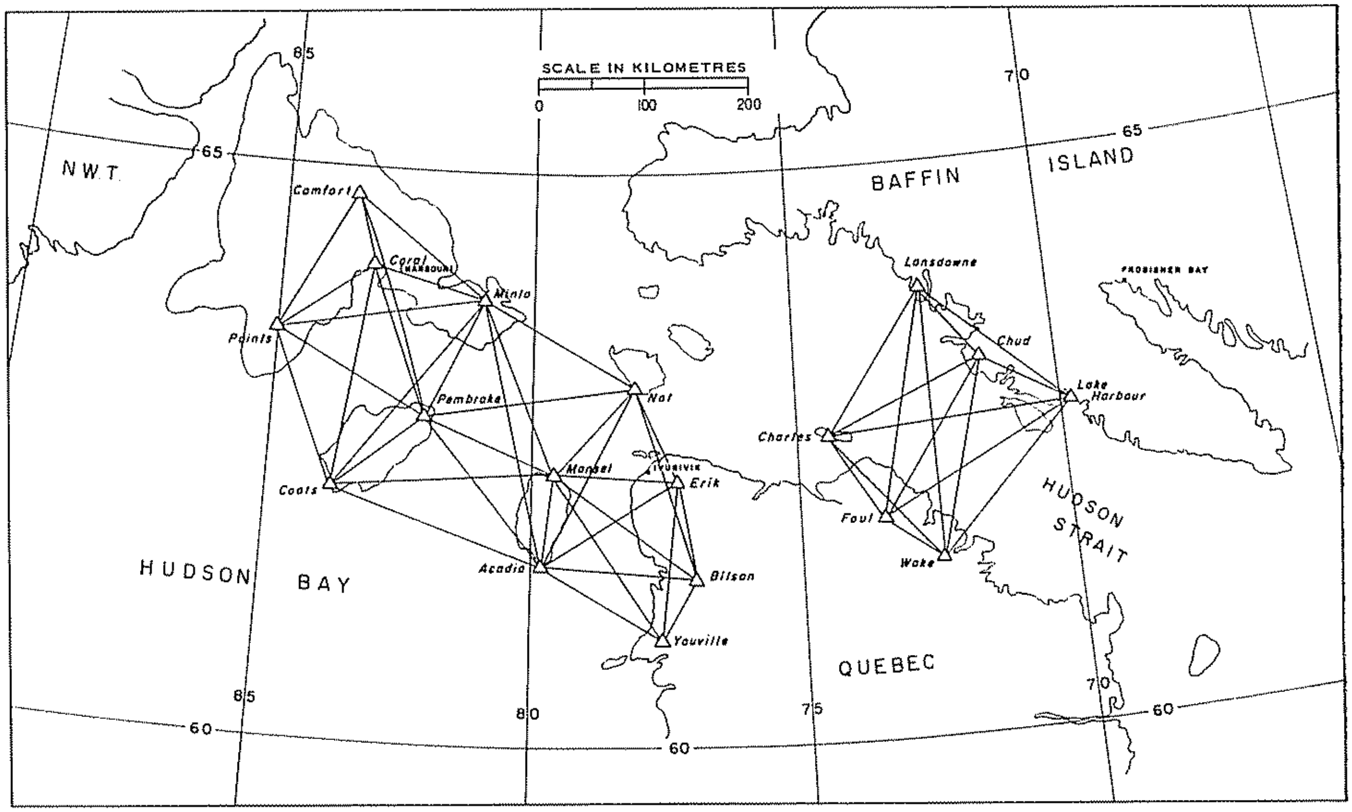


Fig. II—Canada: 1965 aerodist nets

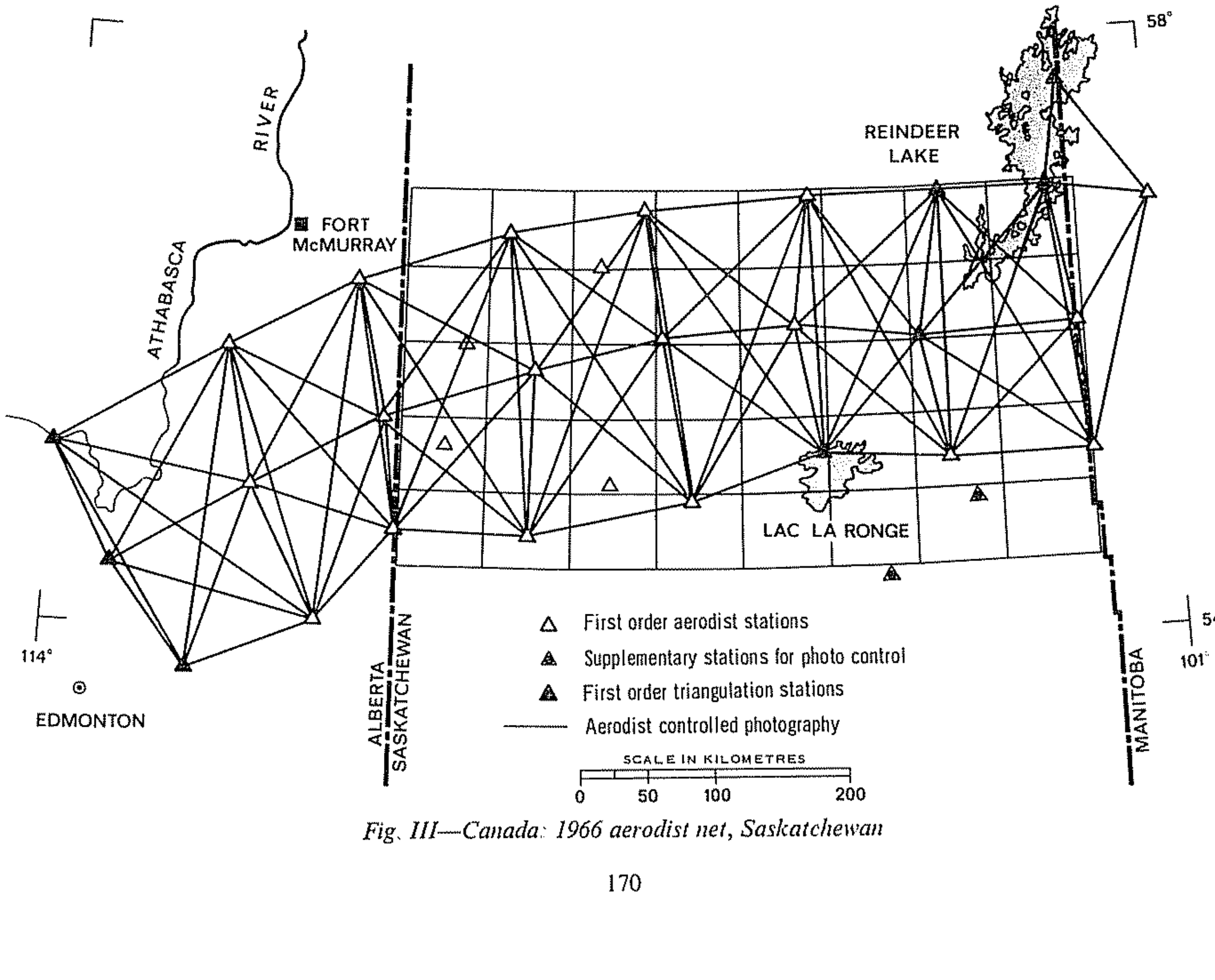


Fig. III—Canada: 1966 aerodist net, Saskatchewan

Group 2 consists of six lines shown in the figure of the 1965 aerodist nets. The aerodist stations were tied to a single-chain first-order triangulation net in which all directions were observed and all lengths measured by Tellurometer. Connexions between the aerodist stations and the triangulation net were made by triangulation or short closed traverses and in some cases a combination of both. Station co-ordinates are based on a non-closure adjustment. Geodetic lengths in the main triangulation net are estimated to have a standard deviation of 3 or 4 ppm, but for the geodetic lengths connecting the aerodist stations the standard deviations would be somewhat larger.

Group 3 comprises nine lines as shown in the figure of the 1966 aerodist net, Saskatchewan. The geodetic lengths are derived from conventional triangulation arcs having no tellurometer scale control in the area. It is difficult to estimate accurately the standard deviations of these geodetic lengths, but they could be considerably larger than 10 ppm, judging by results from geodimeter measurements in various parts of the triangulation network.

Aerodist nets and error figures

The accuracy of an aerodist trilateration survey depends on the degree of accuracy of scale and azimuth maintained in the net. The latter depends on the precision of length measurements, but also on the strength of the geometric configuration of the net. To attain a high accuracy, a high density of lines is required, whereas economy dictates a minimum number of lines. A compromise must be made such that the required accuracy is achieved through inclusion of a reasonable number of lines in the aerodist net.

The double quadrilateral configuration for nets has been used to date and is similar to that used in HIRAN trilaterations.

It is possible to analyse a trilateration net by computing and graphically depicting error figures for stations in the net (McLellan 1966). The error figures are curves that delineate the standard deviations about the points. These curves show graphically the accuracy with which the stations are determined by an adjustment and how the standard deviations vary with azimuth. In an analysis of a proposed net, the starting data consist of the standard deviation of an adjusted observation of unit weight, the latitude and longitude of the stations in the net, and the length, position or azimuth data that are to be either observed or held fixed. An electronic computer programme is available for computation of error figure data.

Error figures for the major portion of the 1966 aerodist net are shown in the figure of the proposed aerodist net for Alberta, Saskatchewan, for 1966. These are based on a preliminary net layout and an assumed standard error for a measured aerodist length of 6.6 ppm. Six fixed geodetic stations are shown as solid circles. The error figures are drawn to the same scale, with the semi-axes of the largest given in metres. The semi-major axis of 0.88 m indicates deterioration in azimuth, but this is not considered serious. From analysis of these and other error figures, it is concluded that the double quadrilateral net configuration is capable of carrying azimuth adequately for three or four figures without additional azimuth control.

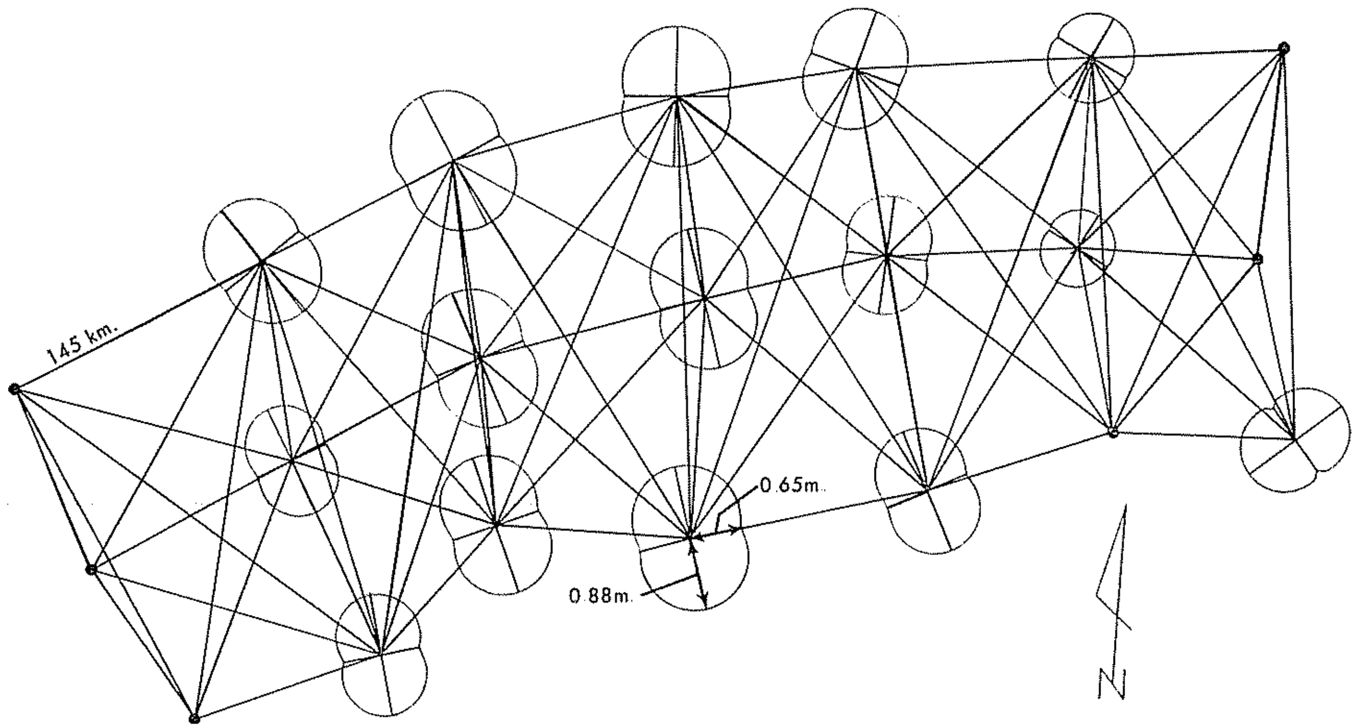


Fig. IV—Canada: Proposed aerodist net for Alberta, Saskatchewan, 1966; error figures

FUTURE DEVELOPMENTS

Small computer application (PDP8S)

To reduce the computation time, it is proposed to digitize the output of the aerodist to give both a teletype and perforated-tape read-out of the data—uncorrected slope distance in continuous trilateration or photo work and a sum of the uncorrected slope distances on line-crossing work. This should result in a time saving of the order of 35 to 40 per cent of the computation time in line-crossing work.

Work on the digitizer is under way and it is planned to have it completed in time for the 1967 field season. The heart of the digitizing equipment will consist of a DEC PDP8S electronic computer, an inexpensive small-scale general-purpose computer.

At the present time, the output of the Aerodist is continuously recorded for each air-to-ground station on a three-channel strip-chart recorder. In line-crossing work about 15 per cent of the computation time required to reduce the raw data to the sea-level distance is spent solving, reading and recording the graph distances, and a further 30 per cent is spent drawing the minimum-sum curves and solving mathematically for the minimum-sum slope distances.

Theory of aerodist digitizer.—The aerodist recorder input for each channel is in the form of two sine waves (1 Khtz) whose phase difference is dependent on distance. In the digitizer these sine waves will first be filtered, and by means of a high-frequency clock the pulses occurring between corresponding points of the two sine waves will be counted, giving a digital representation of the phase shift between the two sine waves. With a judicious choice of clock frequency, the digital read-out may be made to correspond with the actual A, B, C, or D readings that would have been read from the aerodist graph. With the aid of the computer, these readings will be converted to indicate the uncorrected slope distance. The last two digits of the distances will be printed once per second and the full distance at 9 second intervals. Up to four channels may be interrogated simultaneously. In the case of line crossings where only two channels are used, the sum of the two slope distances will also be printed.

Some of the salient features of the digitizer are described below.

A-plus and A-minus readings will be alternated to remove instrumental phase-difference errors.

A running count of each phase reversal (1 per 100 m of distance) will be printed at 9 second intervals as a check on the coarse distance readings.

Each distance printed will be the mean of twenty successive cycles taken in a time interval of 20 milliseconds.

Final resolution will be 0.5 m.

The teletype print-out will provide a visible check on the operation of the equipment as well as simplify the delimitation of the usable portions of the work.

During photo-control work, the elapsed time between the reception of the camera shutter pulse and the start of the next measuring cycle will be indicated.

The aerodist equipment can be returned to its original state by the use of switches in the master and remote sets.

Total cost of the digitizing system is expected to be about $CAN20,000, including the computer and printer.

The computer will be used in the field to reduce the uncorrected slope distance to datum in the hours that it is not being used on line. It will also be available for office use during the off-season.

Future plans include automation of the handling of meteorological and height data, to be printed out with the distance record.

Meteorological data by electronic means

Wet-bulb and dry-bulb temperatures have been obtained in flight by means of a United States Air Force psychrometer ML 313, which uses mercury bulb thermometers in two ranges (− 35°C to + 15°C and 0°C to + 50°C). Although this psychrometer is capable of the accuracy required if certain precautions are taken and appropriate corrections applied, it was felt that a better system could be devised not only to automate the system but also to eliminate the difficulties experienced in obtaining accurate wet-bulb readings during the freezing conditions that frequently occur at flight altitude. Such a system was built and tested during the 1966 field season.

The active measuring portion of the system is made up of three platinum-resistance temperature sensors, each with its own calibrated Wheatstone bridge. The output of each of these bridges is fed sequentially to a two-channel strip-chart recorder with a read-out in degrees Fahrenheit. One channel of the recorder with a twenty-second cycle is used for the three sensors, so that each temperature is recorded for six or eight seconds during each cycle, while the second channel is reserved for outputs from the Doppler navigation system (ground speed, compass heading, drift).

One of the platinum sensors is mounted outside the aircraft in a housing shielded against radiation. The outside dry temperature is obtained from this sensor, after calibration and dynamic heating corrections have been applied.

The other two sensors are used to obtain the water vapour pressure of the outside air by measuring the wet- and dry-bulb temperatures of a sample of outside air that is brought inside the aircraft and heated, so that no condensation of water vapour can take place. This sample is baffled to slow its velocity to about 10 miles per hour and ensure mixing, and the temperatures are measured before the air evacuates into the aircraft cabin. These temperatures, after calibration corrections have been applied, will give the outside vapour pressure, provided no moisture has been added or removed and the pressure at the sensors is that of the outside air. Since the air can be heated to any desired degree, freezing of the wet bulb with its attendant problems is avoided.

Refractive-index figures computed by this system show an agreement of 1 ppm with those obtained from the ML 313 system.

Electronic computer programme for three-channel recording

A computer programme is being developed to reduce data from three-channel aerodist recording and is designed to run on a CDC 3100 electronic computer. It is being written in Fortran 3200 coding and makes use of magnetic tape storage. The programme will handle data either for geodetic networks or for photo-fixing.

When three-channel recording is used for determining positions for stations in geodetic networks, it is referred to as continuous trilateration. Simultaneous ranges to three ground stations are taken from the continuous recording made when the plane is flown across the area between stations. A number of air stations are chosen at regular time intervals of the recording, and are then treated as temporary stations in the geodetic network. Ranges between ground and air stations are reduced to sea level, and the complete network of ground and air stations is adjusted by the method of least squares. One or more ground stations may be held fixed and ground measurements between ground stations may be included in the adjustment.

The programme input will be range distances, meteorological data, etc., and will produce adjusted positions for ground stations. The programme will thus result in a complete sequence of reduction and adjustment of observed data.

A partial test of three-channel recording for geodetic control was made in 1965, but data were inadequate to produce conclusive results. The 1966 programme included a more comprehensive test on four stations of the Saskatchewan network, and those data will be processed by the programme to determine the accuracy that can be expected from that method. The result of the test will determine the probable future application of continuous trilateration to control extension.

FUTURE APPLICATIONS

There is an urgent requirement for both first-order and mapping control in a wide band of heavily forested terrain across the northern and central part of Canada. Several years of survey by aerodist can be foreseen on projects similar to those carried out in 1965 and 1966, where both first-order control and additional control for 1:50,000 mapping were required. It can also be anticipated that there will continue to be a requirement for bridging water gaps and positioning offshore islands and shoals.

In the sub-Arctic and in the Arctic, where forest cover is not an obstacle, conventional surveys using tellurometer and geodimeter are considered to be more economical. The large complement of men and aircraft required to mount an aerodist operation causes a very steep rise in costs as operations move further from established lines of communications and supply. It is possible that continuous trilateration and the automation of computations by the digitizing development may speed the survey by aerodist and reduce costs.

Experience in 1966 shows that the measurement of a double-braced quadrilateral to first-order specifications by the line-crossing method can be completed by four flights made in two days. The control photography required for 1:50,000 mapping of the area embraced by the double

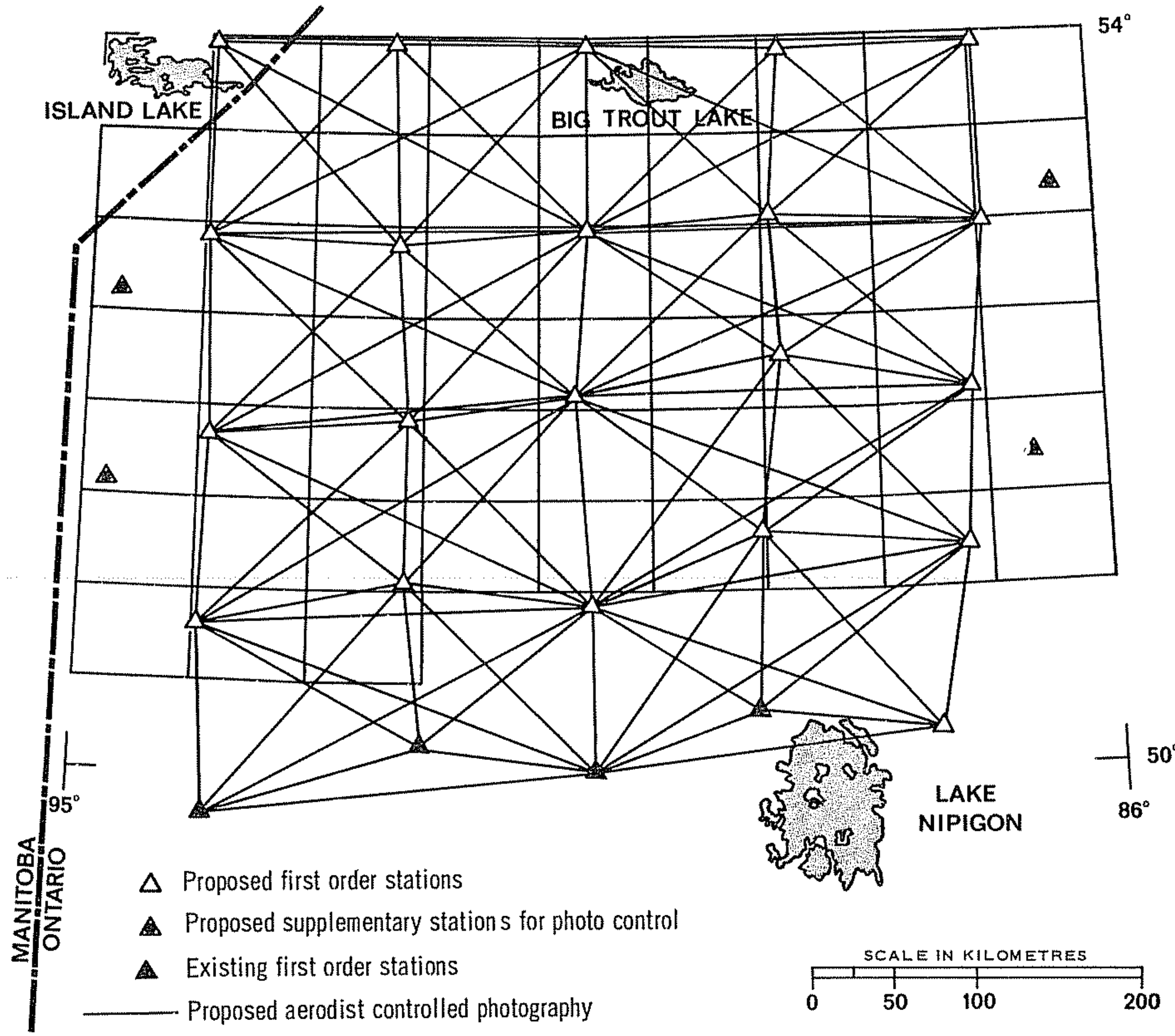


Fig. V—Canada: Proposed aerodist programme, Ontario, 1967 quadrilaterals could be flown in two flights on two days. The movement of ground stations to occupy the next figure requires one day, bringing to five days the total time required to complete one figure encompassing an area of approximately 25,000 km^2. This, of course, presupposes suitable weather, which is unlikely to continue for more than a few days at a time in most areas, especially when air photography is involved. The weather factor must always be considered when estimating for a control extension project.

The rate of five days for one figure also presupposes that check computations are carried forward very rapidly to permit moving the ground stations. This should be readily possible when digitization of the aerodist output is developed and field computations are automated by use of a computer. In fact, experience in 1966 indicated that one extra day per quadrilateral was required to complete computations and re-measure some lines a third time.

It is proposed to establish a geodetic net in 1967 in north central Ontario in conjunction with extensive controlled photography in the area. The proposed net and grid of controlled photography for 1:50,000 mapping is shown in the figure of the proposed 1967 aerodist programme for Ontario. This net will consist of adjoining braced double quadrilaterals in an area coverage configuration. It is expected that the over-all net will have good strength of figure. It is hoped that the proposed improvements in meteorological data observation and in aerodist range data read-out and processing will be incorporated for this work.

Annex

A STATISTICAL STUDY OF THE 1966 AERODIST NET IN NORTH-WESTERN CANADA

The data from the 1966 aerodist net was studied and it was concluded that the standard deviation of a measurement was between 4 and 5 ppm. The net comprised ninety-two lines joining twenty-six points forming seven double braced quadrilaterals plus two extra points. Forty-one of the lines were measured with two groups of at least six crossings; fifty lines had three groups; and one line had four groups. The lines varied in length from 79 to 257 km with an average of 150 km. Two sets of error figures for the computed station positions were derived: one set for a free adjustment in which one station and an azimuth from it were held fixed, and one set for a closure adjustment in which stations at both ends of the net were held fixed.

The free adjustment of the complete net was made using the Groom programme for an electronic computer. The number, n, of redundant length measurements was forty-two. For each line the average of all the groups of measurements was used. The weights, p, for the lengths were computed using the equation $\sqrt{p} = .04\ \sqrt{km}$, where km is the length in kilometers. An estimate of the standard deviation, σ, for unit weight was computed from the formula $\sigma = \sqrt{\Sigma pv^2/n} = 2.211$ ppm. The average value of $\sqrt{p}$ was .49; thus the value of the standard deviation of the average line measurement, which was the average of 2 or 3 groups, was $2.211/0.49 = 4.5$ ppm. Other results are tabulated below.

The average correction to a measurement was 0.39 metres = 2.6 ppm;

The maximum correction in metres was 1.33 metres = 5.8 ppm;

The maximum correction in ppm. was 0.99 metres = 8.0 ppm.

A second, independent, method of estimating the standard deviation of the measurements is to consider the range of the means of the groups of measurements on a line. If the standard deviation of a single set of observations is S, then the standard deviation of the differences between the mean of the three and each of the observations is 0.816S, and of the difference between the mean of two and each of the observations is 0.707S. The standard deviation of the differences between each of the 233 groups and its respective mean was 0.96 m. As this is a combination of some lines with three and some with two groups we can equate it to an average 0.77S, and S therefore is 1.24 m. The standard deviation of the mean of 2 or 3 groups would be about $1.24/\sqrt{2.5} = 0.78$ m or, for an average line of 150 km, 5.2 ppm. This is a reasonable agreement with the first method of computation.

When the final adjusted lengths were compared with the individual group means it was clear that on some flights all the measurements tended to be low or high by as much as a metre or more on the average and on one day the average difference was 3.3 m. The most reasonable explanation is that this is a meteorological error resulting from soundings which were not truly representative of the ray paths. There were forty flights on which three to eight lines were measured, giving forty estimates of sounding errors. As some of these estimates were much more accurate than others, it was necessary to weight them inversely to their standard deviation in computing the standard deviation of the sounding error. The computed value was 1.0 m. This tends to indicate that sounding errors constitute a major problem.

There was some question as to whether the two groups of measurements taken on the same day but with different soundings were as good as two groups taken on different days. Twenty-three lines were flown twice on the same day but on different flights. The standard deviation of the difference between the two groups was computed to be 1.32 m. From a consideration of all the measurements the standard deviation of the difference between two groups was computed to be 1.75 m. The difference between these two figures is not significant at the 95 per cent level according to Fisher's ratio test. Therefore the requirement that measurements must be taken during two days can be relaxed.

There were thirty lines for which groups of measurements were made at elevations differing by 1,000 ft or more. There was a slight tendency for the measurement made at a higher elevation to be longer. The average height difference was + 1,640 ft and the corresponding length difference was + 0.40 m, but the range was large, from − 2.39 to + 3.07 m.

The error figures from the closure adjustment indicate that, for this particular net, if the positions for the end points were perfect, the standard deviation of the computed positions most distant from the control would not exceed 0.6 m in any direction. The free adjustment indicates the ability of the double-braced quadrilateral configuration to keep the net from swinging to one side. The figures most remote from fixed control points have a 1/2 width about 6.5 m perpendicular to the length of the net (about 700 km). Thus the standard deviation of this swing is of the order of 2 seconds, indicating that azimuth control is required every seven or eight figures.

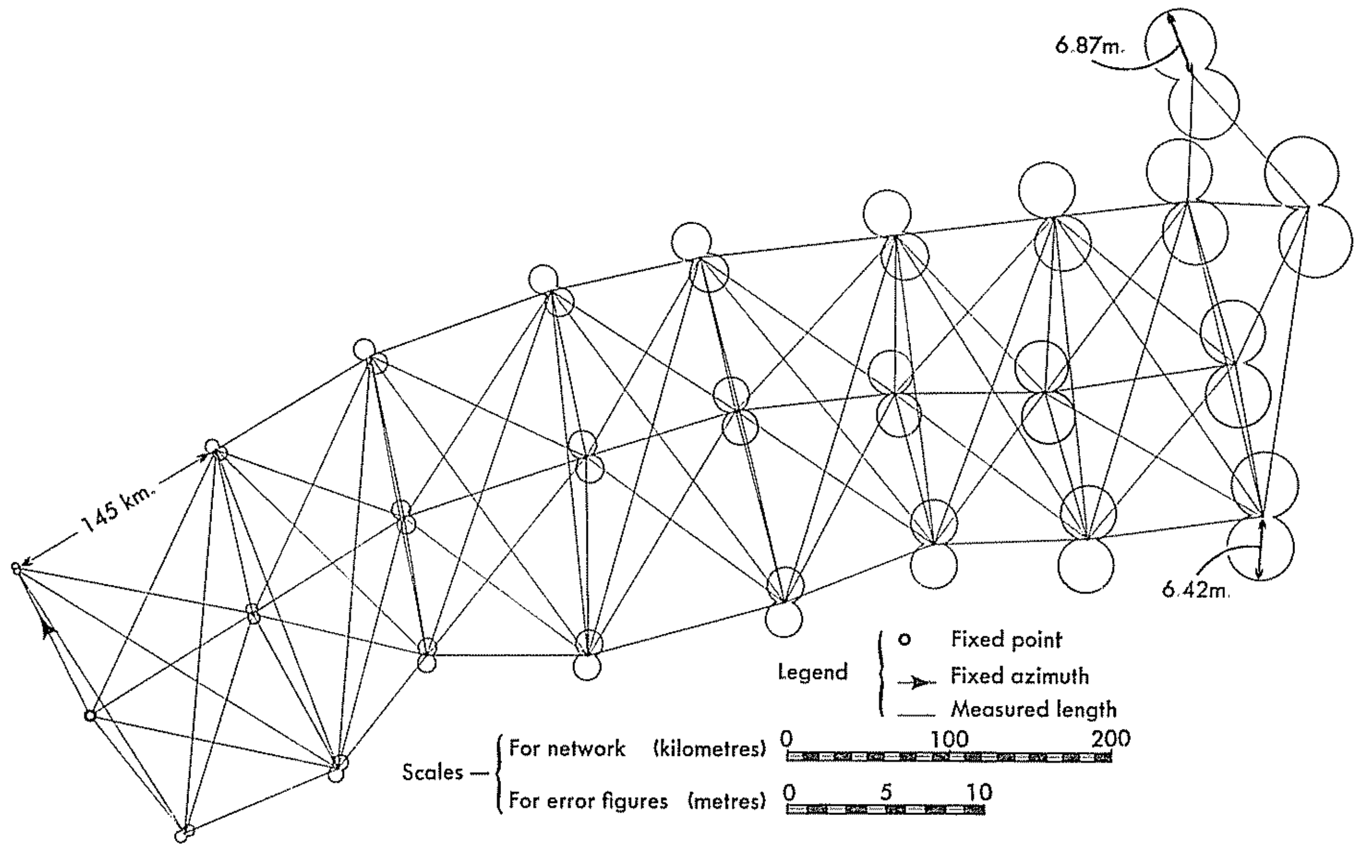


Fig. VI—Canada: 1966 aerodist net, free adjustment; error figures showing standard deviations in all directions

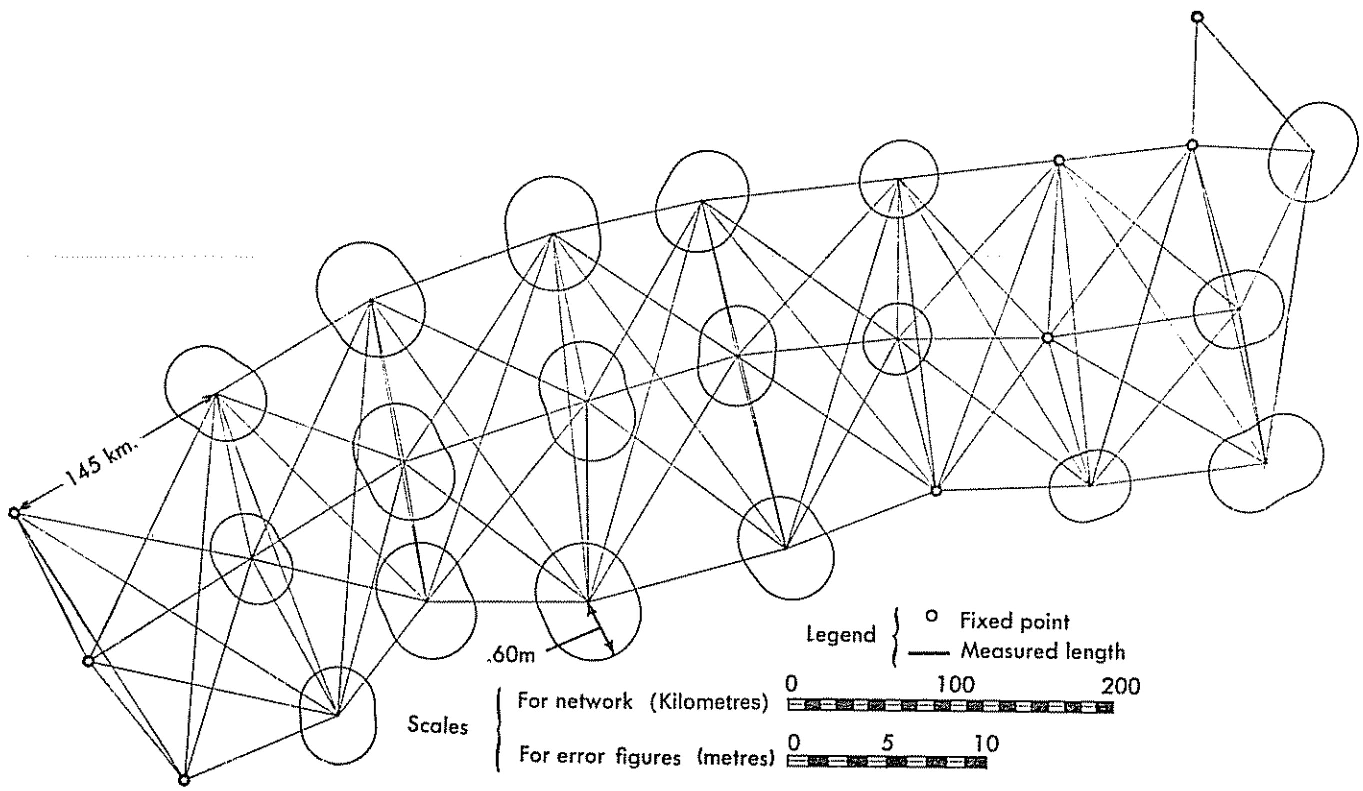


Fig. VII—Canada: 1966 aerodist net, closure adjustment; error figures showing standard deviations in all directions

TOPOMETER DATA-PROCESSING SYSTEMS FOR PHOTOGRAMMETRY AND GEODESY

Paper presented by Switzerland[1]

INTRODUCTION

The principles of the topometer programme systems are as follows:

Greatest freedom for the planning engineer in laying out terrestrial survey networks and photogrammetric aerotriangulation blocks;

Elimination of programme-dependent measuring rules; choice of simple measuring structures, that is, greatest possible simplification of the work of field and office technicians; measurement recording forms of great clarity;

Automation of the often complicated and time-consuming preparatory work (especially with terrestrial methods); topometer programme systems accept the measuring data in random sequence;

Comprehensive utilization of the least-squares adjustment method with attendant elimination of all poorly founded, recipe-like computational procedures;

Well-developed error-reporting and error-locating systems; computation of the standard co-ordinate error for each network or block point.

In essence, the topometer aerobloc and topometer polar programme systems have the same structure. The operational groups designated A to F are of course adapted to the typical conditions of the problem at hand, but they have the following procedure in common:

A. Read-in of measurement data and fixed point co-ordinates;

B. Checking and arranging of measurement data;

C. Composition of the measurement network or block, intermediate results;

D. Approximate computation of the network, intermediate results;

E. Iterative adjustment, intermediate results;

F. Punching and printing of final co-ordinates; printing of standard errors.

All operations from A to F run automatically; it is possible to interrupt them for an error analysis at a suitable point and to continue them after. It should be borne in mind that, in many of the survey programmes known so far, operations B and C must be done manually.

In form, the ground control point co-ordinate input and the resulting co-ordinates of the new points are identical. The results of a certain programme system can thus be used without change as basic data for another, arbitrarily chosen topometer programme system (see annex I).

Topometer programme systems are written in Fortran IV.

TOPOMETER AEROBLOC

General

The topometer aerobloc programme system composes individual spatial stereo models which are generated only by relative orientation into a least-squares adjusted spatial block. Standard co-ordinate errors are computed for each point in the block that was registered more than once.

In contrast to other programmes in this field, topometer aerobloc includes elevations in the comprehensive adjustment.

Two operational sequences are available.

Complete sequence I (see Figure I). All operations are carried out. This sequence is chosen for control network densification.

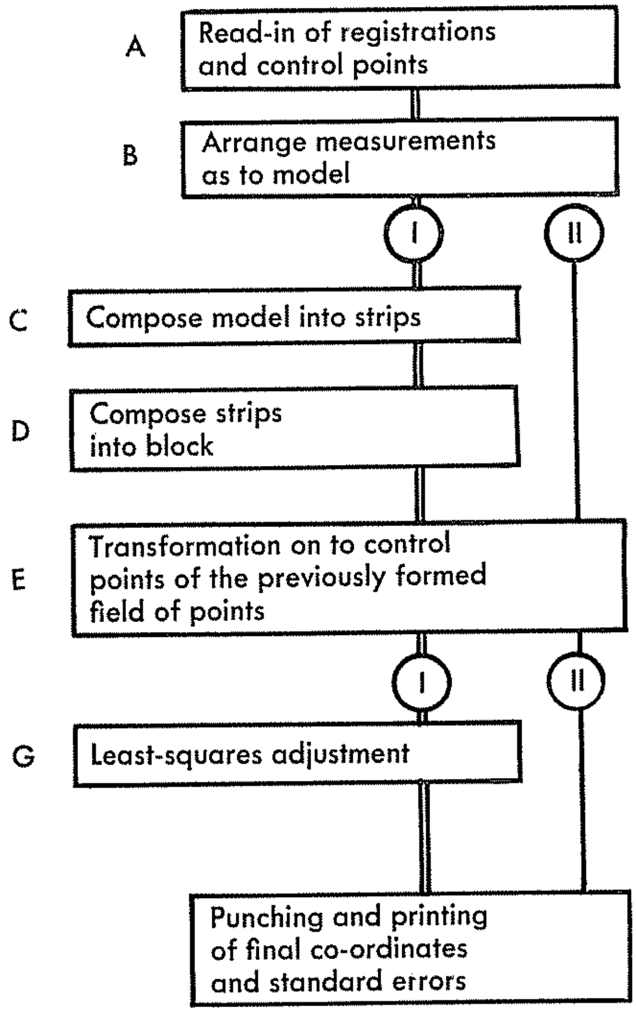


Fig. I. Switzerland: General flow diagram

Sequence II. Operations C, D, and G are skipped. This sequence is used for photogrammetric detail point surveys if an adequate number of control points per model are available. The preceding control network densification is preferably done by means of the topometer aerobloc sequence I; as can be seen from the flow diagram, in this sequence the individual models are transformed into the network of control points. This is a least-squares transformation, but the influences of neighbouring models are neglected.

Mathematical principles

All model transformations are based on the following Euler formulae for finite rotations about a spatial Cartesian axes system:

[1] The original text of this paper, prepared by Paul Vetterli, Fribourg, appeared as document E/CONF.52/L.120.

$$X = a_1x + b_1y + c_1z + d_1$$
$$Y = a_2x + b_2y + c_2z + d_2$$
$$Z = a_3x + b_3y + c_3z + d_3$$

Twelve transformation parameters are thus determined for each model. In these twelve parameters, nine independent quantities are contained:

3 rotations, i.e. Euler's angles $\alpha_1, \alpha_2, \alpha_3$;
3 translations d_1, d_2, d_3;
3 scale factors $\lambda_X, \lambda_Y, \lambda_Z$.

It is seen that each model has three scale factors, of which each belongs to a certain axis direction:

Scale factor in X direction $\lambda_X = \sqrt{(a_1^2 + b_1^2 + c_1^2)}$
Scale factor in Y direction $\lambda_Y = \sqrt{(a_2^2 + b_2^2 + c_2^2)}$
Scale factor in Z direction $\lambda_Z = \sqrt{(a_3^2 + b_3^2 + c_3^2)}$

The mathematical model on which the chosen transformation formulae are based respects the basic geometrical properties of the stereo models: straights remain straights, parallelism is maintained.

A welcome advantage of this transformation is the elimination of certain model errors resulting primarily from inadequate adjustment of the plotter (for instance, focal length or width error).

If sufficiently great weights are assigned to the prescribed control points, the Euler transformation will remove discrepancies in these points, provided that there are not more than four control points per model. For this reason the weights of the control point co-ordinates can be freely preselected for each block.

It will be advantageous to make use of the latter property in all cases where a (mostly widely spaced) control point network is inflexibly provided. This is nearly always the case in cadastral surveys.

Lay-out of the block

A block consists of an arbitrary number of strips; a strip in turn consists of an arbitrary number of models. A model must have at least four common points (transfer points) with each of the neighbouring models of the same strip. Among strips, the same applies analogically. Naturally, surplus transfer points must be provided, permitting the discovery of gross measuring errors at the time of composing the strips.

It should be especially noted that the above-mentioned term "strip" is not identical with the well-known flight strip. The condition of a sufficient number of transfer points between successive models of a block strip is the only requirement in the selection of the strip.

Topometer aerobloc does not pose any special requirements as regards flight disposition. Experience shows that the accuracy of the new points of a block adjusted by least squares corresponds approximately to the inner accuracy of the individual stereo models. The flying height for a spatial block triangulation may therefore be deduced from the accuracy requirements of the map or plan to be produced, according to the customary rules.

For obvious reasons, a generous lateral overlap of the flight strips is to be recommended for spatial block triangulations of highest precision. The block thereby gains greatly in stability. The substantial increase in number of surplus registrations of the points, possibly due to the large lateral overlap, increases the accuracy and reliability of the adjustment.

Numbering

Models. Each stereo model must be assigned an unambiguous number. The model numbers of a strip must form a rising natural numerical sequence. The sense in which this sequence progresses can be chosen freely. At least one number must be skipped between the number of the last model of one strip and the number of the first model of the following strip.

Control points and new points. The points of the block can be arranged in up to 100 sections or sheets. Within a section, the point numbers can be freely chosen in the interval (0,1,999). Gaps in the numerical sequence are harmless. When using Topometer Aerobloc, sequence I, a model must have not more than thirty control points and new points altogether. With sequence II, the corresponding number is 1,000.

Computation, adjustment, definite co-ordinates, error report

The computer reads the registrations, which may be arranged in any sequence (see annex II), arranges them according to models, composes the models into strips and the strips into the block. Before adjustment, the block is transformed into the field of control points, thereby providing the basic data for the block adjustment according to least squares. The adjustment is done by classical methods, whereby the voluminous equation systems are treated with the help of iterative computing procedures.

After the adjustment, the transformation parameters of each model are determined in such a way that the sum of the squares of all residual distances between homologous points of the block is minimum (an arbitrary point is always imaged in two or more models; these images we call homologues of the point concerned). Each point in the block is associated with as many co-ordinate triplets X, Y, Z as it has homologues. The arithmetic mean of the homologous co-ordinates provides the final co-ordinates. The standard deviation of this arithmetic mean accompanies the point as a measure of its accuracy, and the number N of homologues as a measure of reliability (see annex V).

Error analysis

An aerobloc of medium size comprises thousands of operations that are subject to errors, such as: transfer of pass points in the point transfer device, assignment of numbers, entering the numbers through the keyboard of the recording instrument, and identification errors of the points in the plotter. Blocks measured without errors are a rare exception. It is therefore absolutely necessary that gross errors should be discovered and eliminated conveniently and speedily.

To uncover errors, the results of any computational phase can be printed out, for the first time following the composition and the transformation of the block into the ground co-ordinate system. With the help of the standard errors of the block points, the erroneous points can be found rapidly. By comparing the homologues in the corresponding models, the erroneous registration can be located and eliminated. It is important to carry out the error analysis in the first stage of the computation, thereby limiting the computational effort to the necessary minimum.

Measurements in the stereo models

The transformation formulae applied are valid for any rotations and scale factors. The measurements can therefore be made in the relatively oriented model. An absolute orientation, even an approximate one, is entirely superfluous.

The accuracy of the block triangulation depends largely on the careful execution of the relative orientation. Numerical orientation methods are therefore recommended.

Since the block triangulation described does not presuppose a bridging procedure, but is based on the registrations of the individual model, a great variety of plotter types can be used. The measuring procedure is most simple and does not require any of the delicate operations as there are in bridging.

It should be noted that the projection centres can be included in the block survey. The projection centre of the picture l of a sequence (k,l,m) of aerial photographs has homologues in the models (k,l) and (l,m). The projection centres are positioned high above the field of ground points and contribute greatly to the rigidity of the strips of models. In this case, it is preferable to choose a constant base for all models and to leave the common tip at zero. It is thereby achieved that the two model nadirs in all models correspond to two given instrument positions which can be determined before the block triangulation.

Annex II shows the form of point registrations on the punch card. The registration on punched tape is analogous (annex III).

Results

The processing of various aeroblocs has shown that, with good data and with the use of first-class photogrammetric equipment, the following average values of standard co-ordinate errors can be achieved: planimetry, approximately 7 microns, measured in the plane of the picture; elevation, approximately 12 per cent of the planimetric value.

On this basis, the following co-ordinate errors can be expected:

Flying height 1,000 m (3,000 ft) $mx = my = 3\text{–}5$ cm, $mz = 4\text{–}6$ cm

Flying height 2,000 m (6,000 ft) $mx = my = 6\text{–}10$ cm, $mz = 8\text{–}12$ cm

These average values, as well as the spread of the standard co-ordinate errors, are of course dependent on numerous factors. The values quoted above must therefore be considered as order of magnitude only.

Topometer Polar

General

With Topometer Polar, entirely new possibilities have become available in traverse surveying. Restrictions as to shape of the polygons, arrangement and number of the knot points and incorporation of hybrid measuring elements no longer apply. Moreover, the programme system works fully automatically. Immediately after taking the measurements "fresh off the field", they can be punched on cards or tape and fed into the computer. There the computation is carried out automatically all the way to the adjusted co-ordinates and the standard deviation.

Network structures

The basic element of the topometer polar net is no longer the traverse survey between fixed points, but the radial measuring pattern (RMP), which is characterized by the central station point and the net points measured from there. The rays of the RMP can be traverse elements (direction and distance), directions or distances, always with or without an elevation measurement. A topometer polar net must have at least two normally connected fixed points; this is the case if these fixed points are origins of traversed legs.

Knot points. These can be chosen in any number and position. However, one and the same knot point should not be used to branch off more than six traverse sides.

Hybrid net. From any point in the net to any other point (new stations or fixed points), single or mutual directions and distances can be measured to increase the rigidity of the net. These additional elements are included in the least-squares adjustment.

Inaccessible points. Tie-ins of inaccessible fixed points by means of directions may be included in any number.

Direction measurements. Such measurements to fixed points may be used unrestrictedly, but they can also be omitted altogether.

The practically unlimited freedom in setting up hybrid traverse nets is possible only thanks to the simultaneous least-square adjustment. It is a well-known fact, however, that there are relatively few surplus measurements in classical survey traverses. In order to augment the efficiency of the adjustment when using Topometer Polar, the surplus measurements should therefore be increased wherever possible. The most important instruction in this respect is that topometer polar nets must be linked together as strongly as possible, and the traverse survey should display a cell structure. Observance of this instruction augments the accuracy and reliability of the net. It is noted that the call for strong links is diametrically opposed to the classical rules of traverse surveying.

Numbering of traverse points and fixed points

Any number may be assigned only once. There are no rules as to numerical sequence to be observed. Gaps in the sequence of point numbers are harmless.

Network computations, adjustment, final co-ordinates, error report

The computer reads in the field measurements, which have been transferred to punch cards, in random sequence, arranges them as to stations (RMP) and composes from the latter the net by successive link transformation. The further sequence is very similar to that of the aerobloc system. The adjustment is of course considerably more difficult than in the case of Aeroblocs because of the variety and dissimilarity of the constituent measuring elements. The fact that a traverse point again has various homologues in the corresponding RMP makes it possible to compute the final co-ordinates and the corresponding standard errors in an analogous way.

Computation and adjustment of elevations are done simultaneously. Since the determination of elevations is subject to error conditions differing from those of the planimetric elements, the adjustment of planimetry is done entirely independently of that of the elevations.

Presentation of the results is identical to that of the topometer aerobloc with the exception of the number N, which is insignificant in traverse surveys and therefore omitted (see annex V).

Error analysis

The remarks on error analysis in connexion with the topometer aerobloc systems apply here too. With the help of the intermediate results of the adjustment, the erroneous RMP and even the erroneous measurement can be located conveniently and quickly.

The new interpretation of the traverse survey net on which topometer polar is based ignores the closure terms of the classic survey traverses. This is occasionally thought a disadvantage because it disturbs long established practices, but it is offset by the overwhelming advantage that, through the topometer polar method, measuring errors can be located and eliminated in a simple way, independently of the shape of the traverse. Check measurements in topometer polar nets are restricted to individual RMP or even single measuring elements, in contrast to classical traverse surveys where remeasuring whole traverses is often unavoidable.

Field measurements

The field measurements and the appropriate form are based on the concept of the measuring element, which is always referred to a station point and a measured point. It is composed of four administrative figures and four measuring figures, as follows:

Administrative figures: Station code, station number, code of the point measured, number of the target;

Measuring figures: Distance, direction, vertical angle, value (I–S).

In smaller technical nets (without division in phases and sheets), coding is omitted.

Measuring figures can of course be present or absent, depending on whether we are dealing with a plane net, with pure directions or distances.

A measuring element can be accommodated easily in one punched card (see annex IV) or on one line of the form together with the appropriate readings.

All directions measured at one station must form a set of directions. This is the only measuring rule of topometer polar; if necessary, it can be bypassed by a simple manoeuvre. In consideration of the least-square adjustment, it is preferable not to average distances measured in both directions.

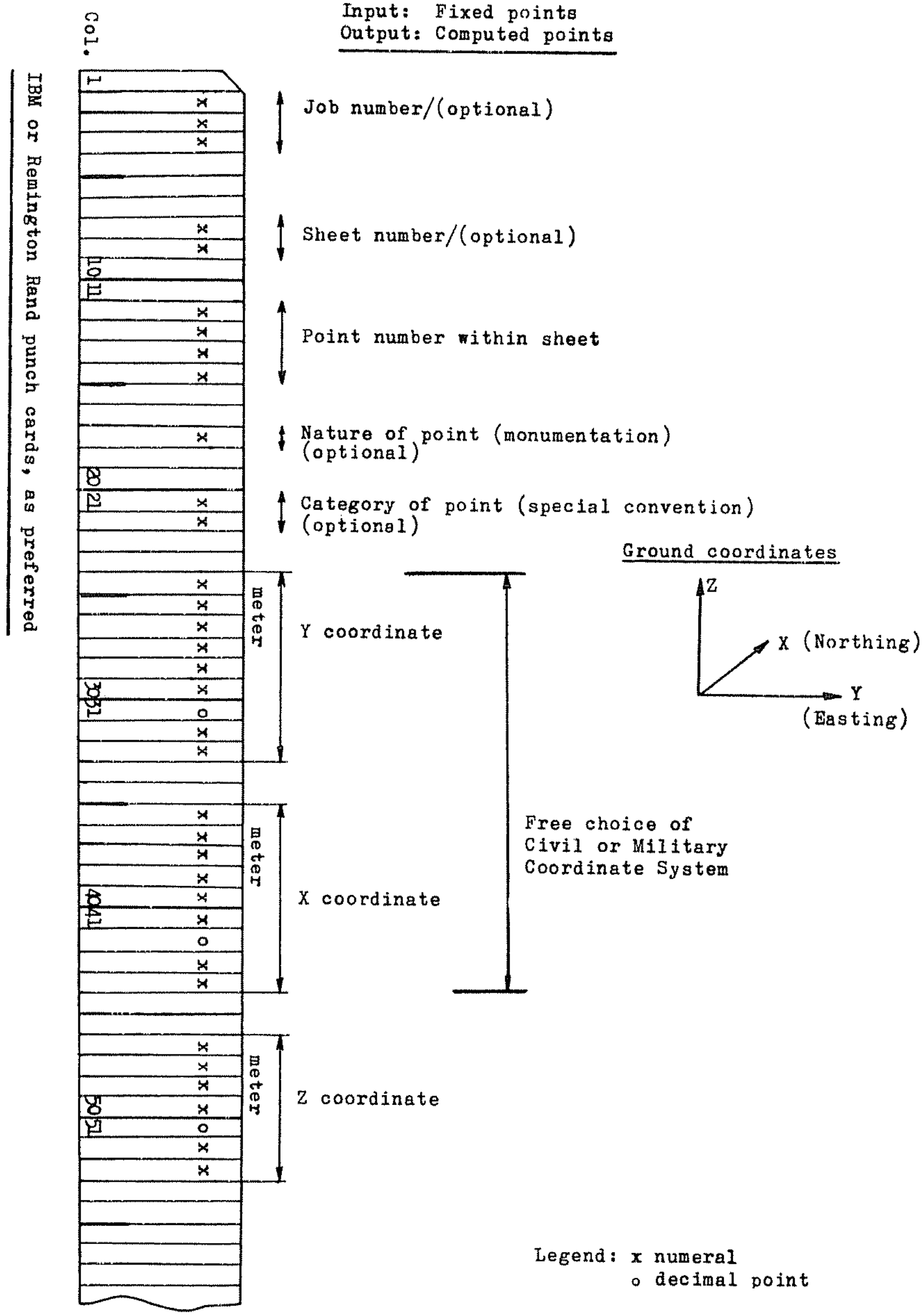
Results

In recomputing conventional nets with topometer polar, significant improvement of accuracy and regularity were noted. What the users appreciate most is the newly won freedom in the layout of the nets, the pleasant work with the lucid topometer field form, the precise error report and the simplicity of communications with the computing centre.

Annex I

TOPOMETER PROGRAMME SYSTEM FOR GEODESY AND PHOTOGRAMMETRY

Input: Fixed points
Output: Computed points

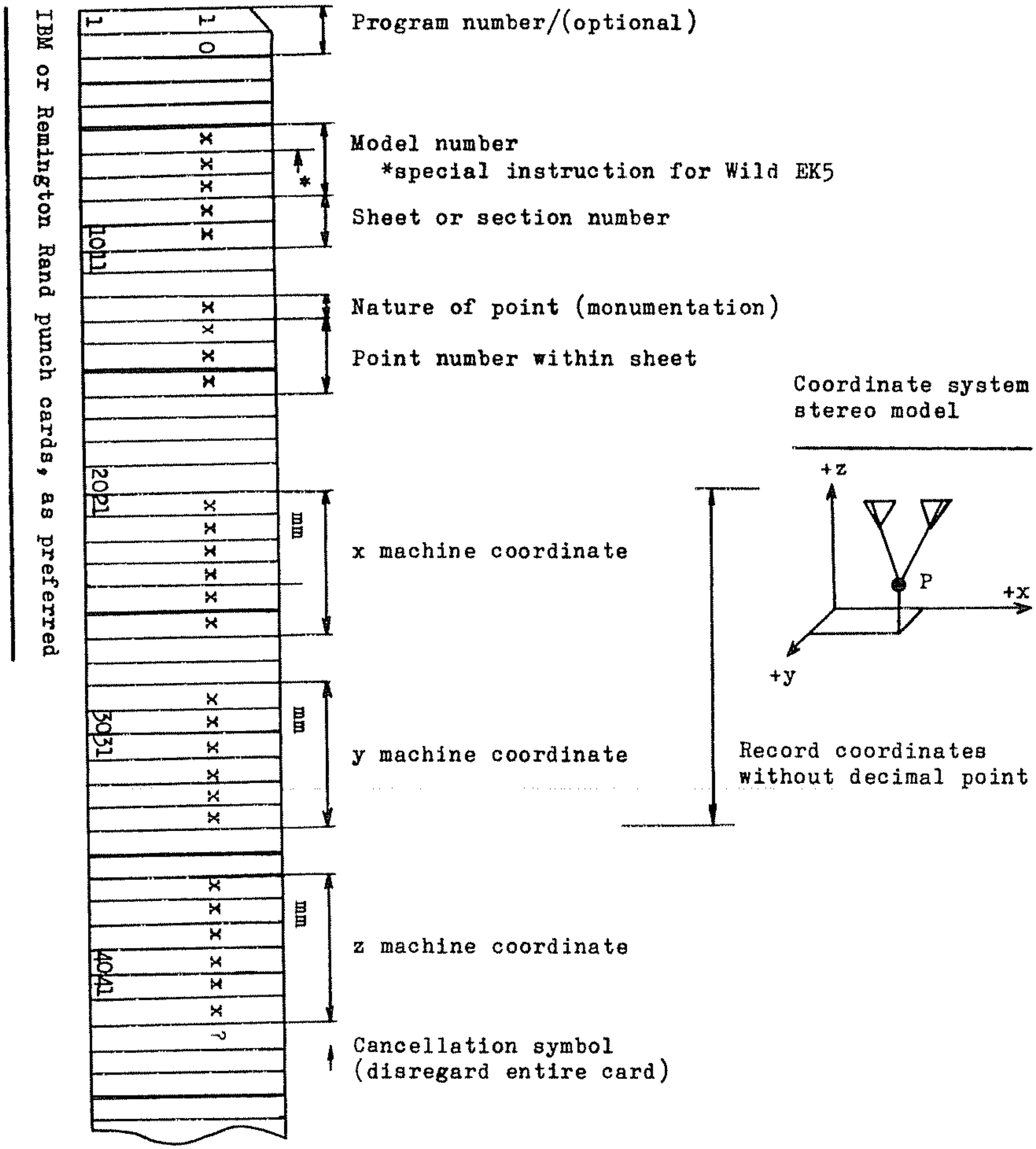


TOPOMETER AEROBLOC 3D

Input: Points of stereo model

The co-ordinate systems of the fixed points and of the model points must have the same sense of rotation.

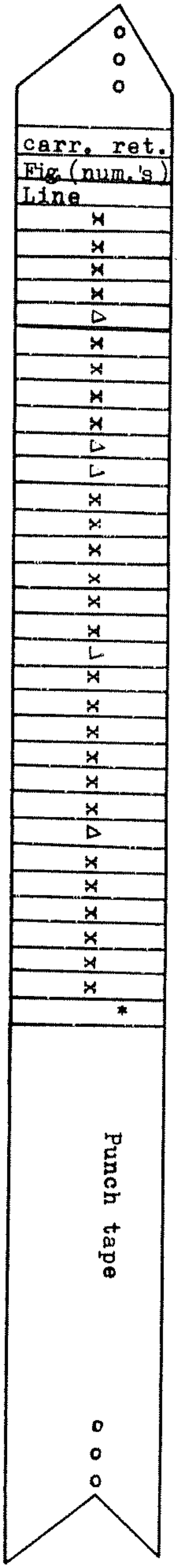
Special instruction when using the Wild EK5 Electric Co-ordinate Printer: With this arrangement, only the second and third digits of the model number can be entered when recording. If the model number has three digits, the hundreds must be pre-punched or added afterwards.



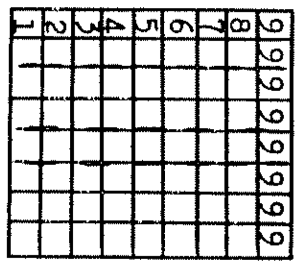
Annex III

TOPOMETER AEROBLOC

Recording of the block point on punch tape with Wild EK5 Electric Co-ordinate Printer



Wild EK5 Keyboard



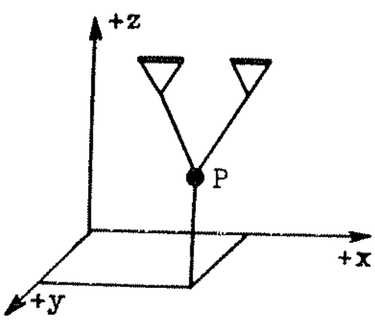
Wiring instructions for Wild EK5

Step switch No.		
1	FIG	(numerals)
2	≡	(line)
3	8	Pkt. No.
4	7	
5	6	
6	5	
7	BL	
8	4	Pkt. No.
9	3	
10	2	
11	1	
12	BL	
13	TAB	
14	6	X coordinate
15	5	
16	4	
17	3	
18	2	
19	1	
20	BL	
21	6	Y coordinate.
22	5	
23	4	
24	3	
25	2	
26	1	
27	BL	
28	6	Z coordinate
29	5	
30	4	
31	3	
32	2	
33	1	
34	A	
35	B	

Legend

x Numerals
Δ Spaces

Coordinate system Stereo model

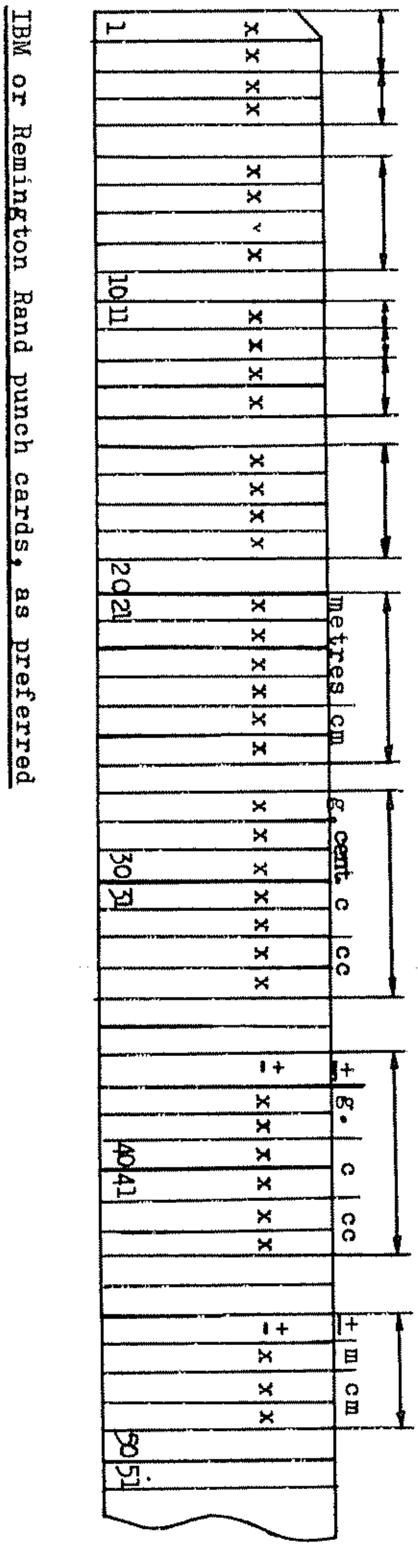


Annex IV

TOPOMETER POLAR

Input: Field measurements

Nets without sheetlines: Leave "sheet number" columns blank.
Nets without computation phases: Leave column "computation phase" blank.
Distance only: Punch measured distance, leave other (measurement) columns blank.
Direction only: Punch measured direction, leave other (measurement) columns blank.



Form No.
Sheet No. station point

Code: Station Point

No. of station point in the respective sheet

No. of computation phase
Category of point sighted
Sheet No. of points sighted

Code: Point Sighted

Point No. of point sighted in the respective sheet

Distance station point - point sighted
1 cm ⇒ distance zero

Direction station point - point sighted
400^g ⇒ Direction zero
(in centesimal degrees)

Vertical angle or tangent (see Special Instruction)
0^g ⇒ horizon

I-S (Instrument height - target/signal height)

On this card, insignificant zeros may be omitted (optional).

Annex V

PRINTED RESULTS

Feuille	Point	Code	Y	X	H	MY	MX	MH	N
5	76	1	546510.68	174547.98	758.28	0.06	0.03	0.03	3
5	77	1	546455.81	174464.47	758.60	0.03	0.04	0.02	4
5	78	1	546791.03	174977.59	754.90	0.05	0.05	0.03	4
5	79	1	546796.19	174978.24	755.25	0.04	0.05	0.05	4
5	80	1	546847.82	175056.22	759.31	0.02	0.04	0.02	3
5	81	1	546902.00	175138.04	763.70	0.03	0.07	0.01	2
5	82	6	546918.01	175162.39	765.95	0.04	0.03	0.03	2
5	83	1	546924.62	175156.16	765.56	0.05	0.04	0.01	2
5	84	1	547005.75	175082.47	767.14	0.01	0.06	0.01	2
5	85	1	547069.59	175024.35	770.12	0.01	0.06	0.07	2
5	86	1	547083.82	175010.22	771.00	0.03	0.10	0.04	2
5	87	1	547096.69	174994.97	771.85	0.04	0.10	0.05	2
5	88	1	547108.37	174978.66	772.47	0.01	0.10	0.05	2
5	89	1	547118.23	174961.28	773.06	0.08	0.12	0.07	2
5	90	1	547126.73	174942.83	774.00	0.00	0.00	0.00	1
5	91	1	547157.09	174873.02	777.33	0.00	0.00	0.00	1
5	92	6	547194.46	174786.51	779.94	0.07	0.04	0.07	3
5	93	1	547201.62	174769.80	779.87	0.04	0.02	0.05	4
5	94	1	547194.00	174773.42	779.78	0.02	0.02	0.02	4
5	95	1	547099.93	174704.70	779.15	0.05	0.02	0.05	3
5	96	1	546996.69	174629.13	778.37	0.07	0.03	0.03	3
5	100	1	546987.07	174622.06	778.26	0.08	0.04	0.04	3
5	101	1	546921.32	174573.66	775.60	0.06	0.02	0.04	3
5	102	1	546908.91	174562.01	774.59	0.06	0.03	0.04	3
5	103	1	546902.43	174552.63	774.01	0.06	0.02	0.06	3
5	104	1	546840.57	174443.38	766.16	0.04	0.03	0.02	3
5	105	1	546835.60	174434.20	765.31	0.02	0.03	0.02	4
5	106	1	546825.29	174423.38	764.41	0.04	0.01	0.02	4
5	107	1	546809.77	174414.13	763.28	0.03	0.03	0.02	4
5	108	1	546793.47	174406.12	762.23	0.03	0.02	0.02	4
5	109	1	546760.39	174391.93	760.25	0.06	0.05	0.10	2
5	110	1	546747.29	174387.13	759.60	0.03	0.02	0.02	5
5	111	1	546668.18	174362.55	757.37	0.04	0.01	0.03	4
5	112	1	546655.24	174356.42	757.17	0.04	0.02	0.05	4
5	113	1	546645.16	174346.21	756.99	0.03	0.03	0.06	4
5	114	1	546745.86	174391.97	759.66	0.06	0.01	0.03	4
5	115	1	546758.37	174396.58	760.16	0.00	0.00	0.00	1
5	116	1	546791.48	174410.76	762.16	0.03	0.03	0.04	3
5	117	1	546807.21	174418.66	763.25	0.03	0.03	0.03	3
5	118	1	546821.74	174427.96	764.30	0.02	0.02	0.05	3
5	119	1	546828.93	174435.13	765.05	0.02	0.03	0.05	3
5	120	1	546834.39	174442.82	765.74	0.07	0.04	0.06	3
5	121	1	546833.00	174448.57	765.68	0.05	0.04	0.06	3
5	122	1	546835.18	174452.03	766.09	0.04	0.03	0.02	3
5	123	1	546840.43	174453.29	766.67	0.04	0.04	0.03	3
5	124	1	546780.80	174482.89	763.04	0.03	0.03	0.02	3
5	125	1	546749.88	174503.27	761.36	0.04	0.00	0.02	2
5	126	1	546744.42	174501.90	761.02	0.08	0.01	0.05	2
5	127	1	546745.45	174511.09	761.33	0.05	0.01	0.01	2
5	128	1	546898.16	174555.33	773.76	0.02	0.03	0.06	3

Annex VI

PHOTOGRAMMETRIC CADASTRAL SURVEY OF CORREVON-CHANÉAZ, SWITZERLAND

1. Survey flight with Wild RC8 automatic film camera, Universal-Aviogon wide-angle lens $f = 152$ mm (6 inches), 23 cm × 23 cm (9 inches × 9 inches).

Flying height: $h = 900$ m (3,000 ft) above ground

Photo scale: 1 : 6,000

Longitudinal overlap: 60 per cent

Lateral overlap: 60 per cent

All boundary corners targeted with white dispersion paint, target diameter 28 cm (11 inches).

2. Enlargements for field identification at scale 1 :1,500 in the rural areas and 1 :1,000 in the villages.

3. Field completion of all hidden points for subsequent integration into the photogrammetric survey.

4. Aerial triangulation by the method of independent models in the Wild A8 Autograph, and simultaneous registration of all corner points with the Wild EK5 Co-ordinate Printer. The stereo models had thus to be set up only once in the autograph, and only one relative orientation was necessary.

5. Block adjustment with the topometric aerobloc system in the Univac III computer.

First step: computation of the block;

Second step: evaluation of results to locate and eliminate possible errors;

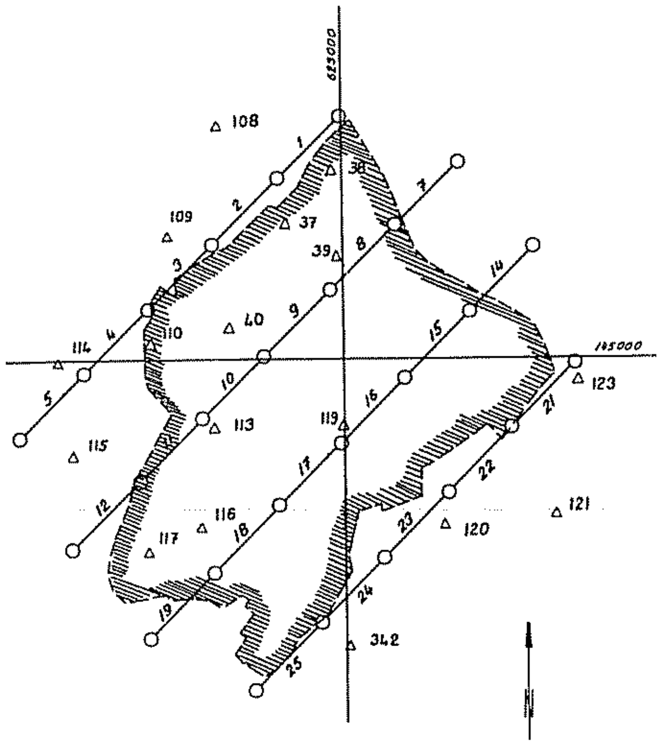
Third step: final adjustment.

6. Three-dimensional transformation of the corner and detail points into the network of adjusted pass points and computation of residual errors.

7. *Results*: number of points determined by aerial triangulation, 141; number of boundary corners measured in at least two stereo models, 1,576.

Number of models in which a point has been measured: N	*Number of points*	$\sqrt{[vv]/N(N-1)}$		
		m_{y_m}	m_{x_m}	m_{h_m}
4	169	±4.2 cm	±3.0 cm	±4.1 cm
3	631	±4.7 cm	±3.5 cm	±3.5 cm
2	774	±6.0 cm	±3.0 cm	±5.8 cm
Average	1,576	±5.3 cm	±3.2 cm	±4.8 cm

Mean square distance error, determined by checking 522 distances in the field: ±3.7 cm.



Flying height 900 m (3,000 ft) above ground

Fig. II—Switzerland: Photogrammetric cadastral survey of Correvon-Chanéaz

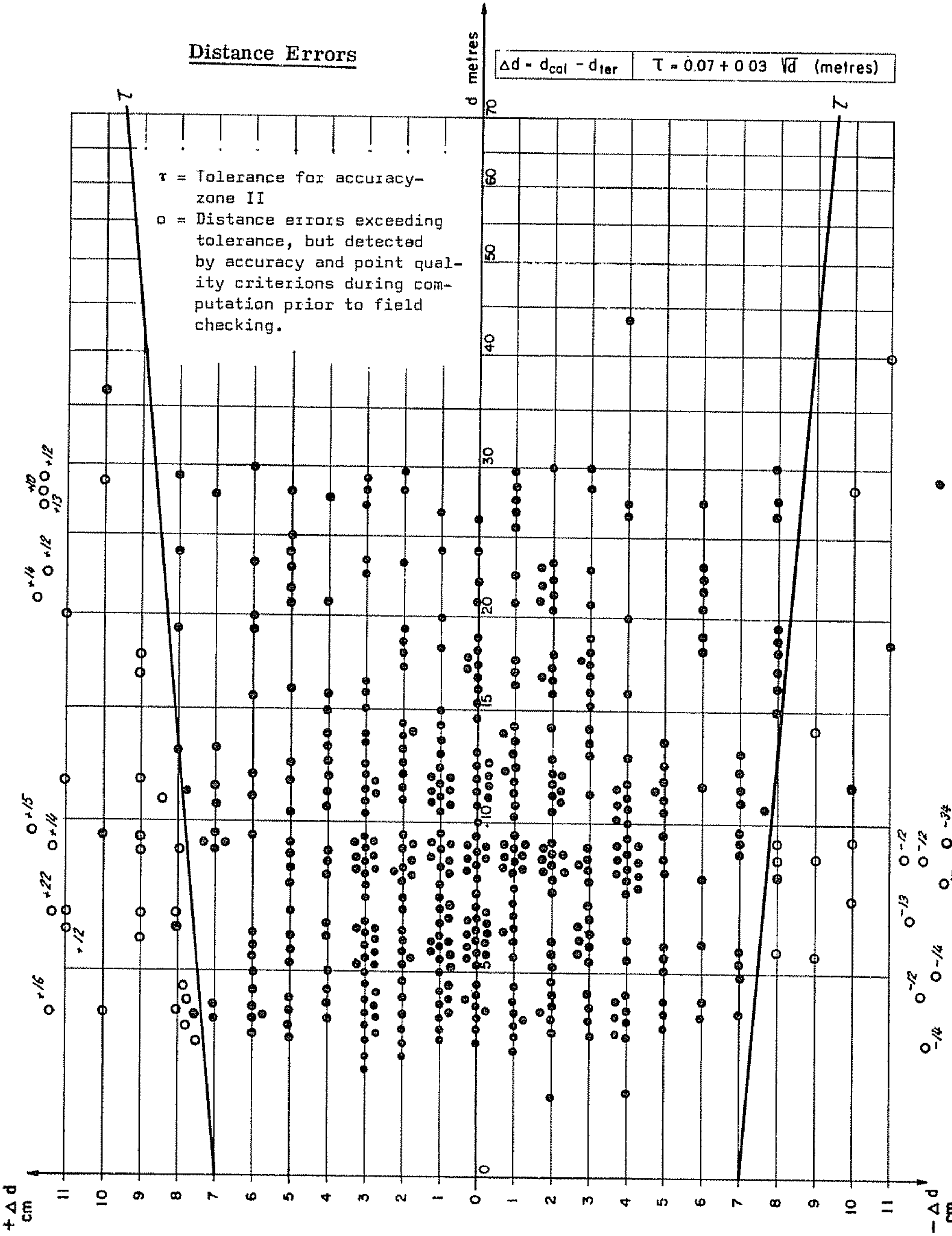


Fig. III—Switzerland: Photogrammetric cadastral survey of Correvon-Chanéaz; distance errors

*(b) Preparation of basic topographic maps**

APPLICATION OF THE STEREOCOMPARATOR TO MAPPING OPERATIONS IN TASMANIA

Paper presented by Australia[1]

Although only some 26,000 square miles in extent, much of Tasmania consists of rugged mountainous country largely covered by dense temperate rain forest.

Access to the western half, which is the most rugged part, consists almost entirely of one main road and one railway. Penetration of this country on foot in the immediate post-war years was a matter of extreme difficulty and, quite apart from lack of suitable areas, made the obtaining of ground control for aerial surveys a serious problem.

An economic solution to this situation had to be found before mapping from aerial photographs could be accepted as a practical proposition. Efforts were therefore concentrated upon analytical bridging methods, to which end a Cambridge stereocomparator was purchased.

Early attempts to bridge were based upon methods developed by Earl Church of Syracuse University, but no really satisfactory method was found to suit the condition existing in Tasmania at the time.

The development by the United Kingdom Ordnance Survey of a method of bridging for the establishment of horizontal control was therefore followed with considerable interest and carefully studied by officers of the Lands and Surveys Department in Hobart. The latter subsequently devised a method for the bridging of heights which permitted the adoption, in 1954, as standard procedure, of a suitable bridging technique based on those principles.

The ability of the stereocomparator to determine co-ordinates to a high degree of accuracy has permitted its use as a means of maintaining satisfactory accuracy, both horizontally and vertically, when bridging over long distances is required to reduce the necessity for expensive and difficult ground control surveys. That this is effective is shown by the fact that distances of up to 30 miles (or nineteen overlaps) have been bridged between ground control areas, although experience has shown that it is desirable to restrict this to about 20 miles or so wherever practicable.

A Hilger and Watts stereocomparator incorporating a punched tape output for direct operation with an electronic computer was installed three years ago and has since been used to reduce the time required for control surveys on large-scale projects, particularly in built-up areas. It has been found quite satisfactory, when plotting 5 ft contours at 1:2,400 from photography flown at 5,000 ft or plotting 2 ft contours at 1:720 from photography flown at 2,400 ft, to restrict ground control to every third overlap. The method has an additional advantage in that easily identified pass points are available, clearly pricked in the four corners of each overlap and also near the principal points. The latter are particularly useful when excessive enlargement is required from photo to plan and it becomes necessary to plot an overlap in two sections.

A further application is now being developed in the sphere of cadastral surveying. To facilitate experiments in this field, small annular floating marks have been obtained. These have already proved of great value; their use has not only improved pointing accuracy but, because of this very fact, it has also considerably increased observing speed. Prior to their use, an average of 1.1 overlaps per hour was observed, but present indications are that, using 18 points on an overlap, approximately 1.6 overlaps per hour can be observed.

The installation of a Stereocomparator would appear to offer a number of advantages:

A Stereocomparator can be bought for appreciably less than a first-order analogue machine;

A first-order analogue machine is a large-scale plotter and, if used for bridging, its usefulness in that sphere is reduced accordingly;

A Stereocomparator can be operated at much greater speed;

Any type of camera may be used for photography regardless of focal length;

Since allowance can be made for lens distortion during computation; no distortion plates are required; earth curvation and atmospheric refraction can also be allowed for in the computation;

The use of a réseau in the camera is not necessary if a modern stable base film is used and processing is carefully controlled, particularly in drying, where heat must not be used.

Probably the principal drawback to a comparator is that it is most desirable that electronic computer facilities should be available to carry out the computations. However, even this could be overcome to some extent by arrangement with an agency, perhaps in some other country if necessary, for the use of its programme and computer facilities. With modern air mail little delay would be experienced.

The last project completed consisted of seven runs of 17 to 23 overlaps controlled by three tie strips. Photography was taken with an RC8 camera $4\frac{1}{2}''$ focal length and 7×7 inches format. The film used was Kodak Plus X on Estar base exposed from an altitude 20,000 ft above sea level. The standard error in height on eighty-one check points was ± 4 ft, with a maximum error of 10 ft, while the standard error in position of 25 check points was ± 5 ft, with a maximum of 8 ft.

* An Australian paper, "Air photography and topographic mapping in Australia", submitted under this item, is reproduced under agenda item 6 above.

[1] The original text of this paper, prepared by the Lands and Surveys Department, Tasmania, appeared as document E/CONF.52/L.31.

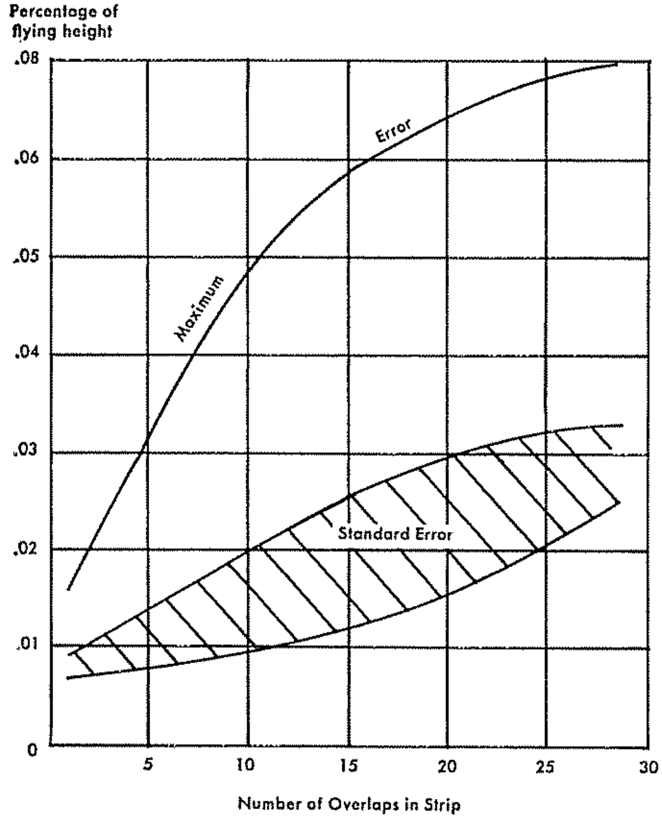


Fig. I—Australia: Height accuracy of stereocomparator

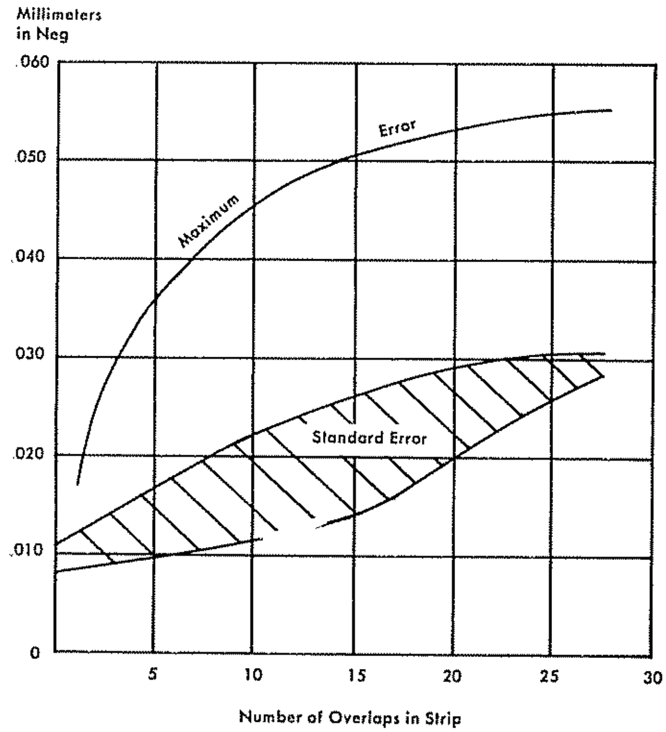


Fig. II—Australia: Planimetric accuracy of stereocomparator

PHOTOGRAPHY APPLIED TO TOPOGRAPHIC MAPPING AT 1:31,680 SCALE IN NEW SOUTH WALES

Paper presented by Australia[1]

INTRODUCTION

Prior to the Second World War, very little topographic mapping existed in Australia. The continent was largely unmapped except for isolated pockets in the vicinity of the capital cities. The Army Survey Corps was the sole mapping authority and its efforts were understandably governed by strategic requirements.

By the end of the war, a series of 1 inch to 1 mile maps covered the eastern seaboard of the continent, mostly in New South Wales and Victoria. Even so, New South Wales had somewhat less than 10 per cent of its 310,000 square miles mapped when in 1947 a New South Wales Government Mapping Investigation Committee recommended the establishment of an authority which would systematically map the State for civil purposes.

The Central Mapping Authority was set up within the administration of the NSW Department of Lands with three essential mandates: first, to complete the triangulation of the State which had been discounted in 1917; secondly, to carry out systematic photography of the State and, thirdly, to produce accurate topographic and cadastral base maps for the general development of the State's resources.

In 1952, the authority was constituted in four divisions: trigonometrical survey, computing, photogrammetry and cartography. In 1965, a research division was added and the total staff now numbers 284.

THE STANDARD TOPOGRAPHIC MAP

By general agreement, a scale of 1:31,680 (2 inches = 1 mile) was selected for the topographic maps of the eastern and central divisions of the State, with contours at 25 and 50 ft intervals. The projection was the nationally adopted transverse Mercator projection of Clarke's 1858 spheroid, with 5° zones. Three such zones covered the State. Map format was 15′ of longitude by 7½′ of latitude. The format and specifications were essentially those adopted by other states of the Commonwealth acting in concert through a National Mapping Council. New South Wales maps, however, were to have a unique feature in the form of an overprinted cadastral pattern.

National Mapping Council standards of map accuracy were adopted for the task. Based on the requirements of the United States Geological Survey, they provided for a horizontal tolerance of 0.5 mm for 90 per cent of well defined test points, and half the contour interval for an equal number of vertical test points with an additional height tolerance for horizontal shift in rugged terrain. Expressed in terms of standard deviation, the formulae are as follows:

$$e_p \text{ (position)} = \pm 0.3 \text{ mm}, \quad e_h \text{ (height)} = 0.3\, c + bt$$

[1] The original text of this paper, prepared by H. S. Rassaby, appeared as document E/CONF.52/L.32.

where b is the allowable horizontal shift in ground measure and t the slope ratio.

In practice, considerably more stringent tolerances are applied and errors in excess of $e_p = 0.5$ mm and $e_h = 0.5\ c$ are rectified by field survey or recompilation.

Photography

Prior to 1958, photography of the State was carried out by contract, mostly with Williamson 6-inch lenses. In that year, however, the Government decided for reasons of efficiency and economy to charter an aircraft and carry out its own photography. A Wild RC5a camera was purchased, and in the short space of eight years complete coverage was obtained of the State. The RC5a camera with interchangeable 114 mm and 210 mm cones is installed in a DC3 aircraft with supercharged engines for high altitude work. Flying heights range from 2,000 ft above sea level for large-scale projects to 24,000 ft for standard mapping.

Equipment and organization

In 1952 the Photogrammetric Division was equipped with two Wild A5 Autographs, seven A6 Stereoplotters, a Kelsh plotter and one 7-projector Miltiplex unit. By January 1967, the machine complement will consist of one A5, two A8, one Stereometrograph, seven A6, three B8, seven PG2 and one Hilger and Watts Stereocomparator. The Stereocomparator and one A8 are linked to IBM 026 punchcard machines. The A8 is used for stereoplotting but in emergency provides relief for the Stereocomparator on aerotriangulation.

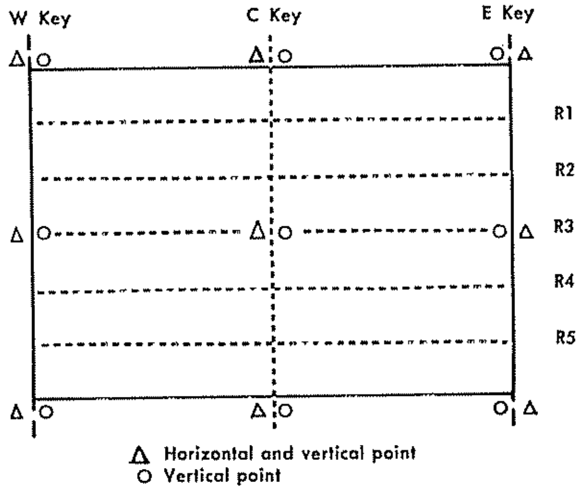
Photogrammetry is carried out in four sections each equipped with five plotters. Two machines are reserved for training. Two of these sections are wholly engaged on standard mapping, the remainder on large scale engineering and town-planning projects.

Control surveys

These are carried out by personnel of the Trigonometrical Survey Division using orthodox methods of triangulation, traverse and levelling. Considerable use is made of the Tellurometer for long-distance radiation fixing and traverses of flat terrain.

Essential control for photogrammetry is signalized using a 15 ft yellow target of Sisalkraft paper with 5 ft square black insets. Experience of the past eight years has confirmed this as an ideal non-recovery target for a wide range of country. At the scale of photography, the target measures 85 microns or a little over twice the diameter of the A5 floating mark. Current block adjustment techniques have reduced control requirements to nine horizontal points for a block of five runs, each of fifteen photographs. For height, the nine points are supplemented by an equal number of satellite height points (see figure in next column).

It is apparent that control in special locations of the map will usually involve surveys additional to those previously established by primary and secondary triangulation. With the flat western half of the State still largely devoid of primary surveys, photogrammetric and geodetic requirements can usually be combined to avoid the overlapping unavoidable in the more accidented country to the east. Some success has been achieved in extending the standard pattern of control over ten runs, but further work remains to be done in this field.



Australia: Minimum control requirements

Aerial survey

The survey is commenced as soon as possible after targeting. Four map sheets covering 30′ of longitude by 15′ of latitude, or approximately 500 square miles, are photographed as a single block from 24,000 ft. Four to five runs of east–west photography are obtained depending on terrain and three north–south key runs. The latter are positioned between pairs of control points (see figure above). Scale of photography is in the vicinity of 1:60,000.

Preparation

The assembly of source data, preparation of observation sheets, gridding of compilation manuscripts etc. are routine tasks which need no elaboration. Contact glass diapositives (18 × 18 cm) are prepared and checked for quality.

On the A8 Stereoplotter, the effects of film shrinkage are dealt with quite simply by adjusting plotting principal distances to compensate for systematic changes in interfiducial measurements. The use of stable polyester film (Kodak Estar) has meant that measurements need be made only to every fifth diapositive. Tests have shown that shrinkage, both regular and differential, seldom exceeds 1:2,700.

Again, if the A8 is used for triangulation, it is necessary to check calibration errors by grid measurements. This is done at intervals of three to six months depending on the amount of use to which the machine is put. Readjustment is aimed to reduce errors to better than ±7 microns at picture scale, corresponding to a little over 1 ft on the ground. The co-ordinates of air stations are also determined on the A8 by grid measurements. This is done for a convenient base length which is held fixed during triangulation. A commonly used base is 200 mm.

The selection of pass points and tie points on the Wild PUG device is a task to which considerable importance is attached. Experience suggests that good results are obtained with the fewest possible points. Each pricked point, including non-targeted control which is often more conveniently selected on PUG, is expected to function in as many ways as possible i.e., pass, tie, etc. Each diapositive will have from three to ten pricked points, allowing for transfer points from key runs, staggered east-west runs and points required for cadastral mapping.

Table 1. Output and accuracy performance on H and W stereocomparator

Project	Pairs	Preparation. Pairs per m/day	Observation. Pairs per m/day	RMS y-parallaxes in microns	RMS pass-over diff. in microns x	y	z
Griffith-N	70	9.1	Unreliable	4	2	8	12
Griffith-S	70	9.1	Unreliable	4	10	10	18
Ardlethan-N . . .	73	8.0	7.0	4	10	2	12
Ardlethan-S . . .	73	8.0	7.0	4	6	18	20
Katoomba-N . . .	108	5.0	5.6	4	2	8	16
Moss Vale-N . . .	180	7.3	8.2	4	8	14	18

Experience in recent years has shown that the average preparation time for standard mapping is in the vicinity of eight overlaps per man day.

Aero-triangulation

This stage deals with the formation of spatial models and connexion in the direction of flight to provide strip co-ordinates. It is convenient at this stage to deal with the techniques applicable to the Stereocomparator and A8 separately.

The end product of stereocomparator measurements is a set of Cartesian co-ordinates with origin at or near the principal point. The measuring process on the Hilger and Watts machine involves readings to nearby réseau crosses which, while slowing down measurements, will almost certainly provide more accurately reduced co-ordinates. Current performance on the comparator is of the order of eight to ten pairs observed, per 7½-hour working day. Models are formed analytically based on measurements at six to twelve points. Model rotations are determined by least squares using iterative procedures for the reduction of y-parallaxes with a fixed number of seven iterations supplied in each case. Computation of model co-ordinates is followed by that of strip formation, the final stage providing for a three-dimensional orientation and scaling to ensure smaller closure differences with adjacent runs.

The A8 method of triangulation involves the observation and measurement of independent pairs generated from fixed air stations. The model is formed by the orthodox elimination of y-parallaxes, and the co-ordinates recorded; thereafter, the process of joining models and determining strip co-ordinates is purely analytical. Models are connected together at air stations, scaled and rotated on a best mean fit at wing points. As before, a three-dimensional orientation and scaling of the strip is applied before connecting adjacent runs.

All computations associated with the Stereocomparator and A8 are carried out on a high speed Honeywell 400 computer at the Treasury's ADP centre. Table 1 sets out the accuracies of model and strip formation obtained in recently completed tasks on the Stereocomparator. Residual errors are given at scale of the photograph.

Block adjustment for planimetry

The method used is that developed in the department in 1958 by S. Bervoets and subsequently modified in 1960 by A. Zvirgzdins. While originally designed for desk computers, the method has been adapted for processing on the Honeywell 400, with the added feature of least-square computation during external adjustment.

Briefly, the method provides for the connexion of adjacent strips by second- or third-order polynomials. The parameters of connexion are used to solve strip parameters by the introduction of arbitrarily introduced condition equations. On application of strip parameters, adjacent runs are connected to form an internally adjusted block, which is finally connected to control (external adjustment) at a minimum of 9 points, using second-order adjustment surfaces.

The method of block adjustment is now in general use in Australia. Its use in the department has been confined, other than experimentally, to blocks of 5 runs by 15 photographs. Other organizations have used it successfully on blocks of 10 runs by 15 photographs and even 10 runs by 30 photographs. Its principal advantage lies in the separation of internal and external adjustment. In effect, aerial triangulation can proceed in advance of field surveys, with the internally adjusted values held in storage until mapping is required. Such mapping is not confined to areas of regular shape. Any particular segment of the block can be adjusted at any time with the only requirement that a minimum of nine well distributed control points be available to provide an interpolated solution. The method of adjustment not being conformal, care should be exercised to ensure that model shapes remain insignificantly deformed at the scale of mapping. Hence the caution exercised by the department in not extending blocks beyond 30′ of longitude by 30′ of latitude (10 runs by 15 photographs) for 1:31,680 mapping.

Accuracies of internal and external adjustment for more recent work are stated below. Residual errors are given at the scale of the photograph.

Table 2. Results for block adjustment of planimetry

Project	Pairs	Adjustment control	Test control	RMS errors at control in microns x	y	RMS differences at tie points in microns x	y
Katoomba-N 1:58,600 . .	76	25	71	26	35	41	35
Griffith-S 1:58,000	48	9	13	47	30	26	30
Griffith-N 1:58,000	48	9	20	55	52	26	26
Ardlethan-N 1:58,000 . .	48	9	26	35	42	40	31
Ardlethan-S 1:58,000 . . .	48	9	15	61	56	33	31
Moss Vale-N 1:39,000 . .	171	12	19	55	58	70	60
Oberon-S 1:54,000	65	9	67	Not available		42	48

Table 3. Results of block adjustment of height

Project	*Pairs*	*Adjustment control*	*Test control*	*Root mean square errors* *Microns at photo scale*	*Feet on ground*	*Maximum error in feet*
Bendemeer-S	64	9 × 2	54	36	7.3	15.0
Armidale-N	56	9 × 2	39	25	4.4	11.1
Moss Vale-S	70	9 × 2	38	30	5.3	9.3
Ellerston-S.	75	9 × 2	105	22	3.2	9.9

Block adjustment for height

After considerable experimentation with various methods including that of Jerie's analogue computer, the department since 1962 has adopted a simple technique involving the use of key runs. The figure on minimum control requirements shows the lay-out of key runs positioned in between the basic nine points required for planimetry and an equal number of satellite height points. The symmetry of the pairs may give the impression that considerably accurate flying of key runs is necessary. In practice the only requirement to be met is that each pair should straddle the flight time and the points may, of course, be at unequal distances from it.

Ideally, photography should be carried out after targets have been placed and before surveys commence. The balancing heights may then be established as satellites to the basic nine and field surveys are minimized. In difficult terrain, the positions of the height points may even be obtained by photogrammetry (i.e., after block adjustment) and the surveyor's task is reduced to the reading of vertical angles to identifiable photo points. If, however, the survey is to precede photography, as is currently the practice in New South Wales, satellite points are treated as separate fixations at safe distances from the targets to ensure easy key run placement.

Key runs consisting of eight pairs approximately are carefully bridged to provide adjusted heights along the axis of flight. Second-order polynomials are used in the computation. The derived heights are used to control the adjustment of east-west runs each of fifteen pairs, using the Zarzycki strip method. Tie point differences are examined and mean values adopted.

The first experiment with the method was made in 1962 on the standard mapping of Bendemeer-S (4 runs by 14 pairs). Key runs were bridged from both ends using a Wild A5. After height adjustment, axial points exhibited differences of the order of ± 3.4 ft or $\frac{H}{6910}$, with a maximum difference of 8.6 ft. Mean values were adopted and the points used to control the adjustment of east-west runs. RMS differences on tie points after a Zarzycki adjustment amounted to 8.4 ft. Following adoption of mean values, an RMS error of 7.3 ft and maximum error of 15 ft were computed from fifty-four well distributed check points established by field survey. The entire block was re-adjusted with the Jerie computer to the same control, i.e., the points derived from key runs. An RMS error of 6.3 ft and maximum error of 15 ft were obtained.

Results of more recent height adjustments in standard mapping are given in table 3.

Detail compilation

Very little need be said about this phase of work as methods are essentially those used elsewhere. The reader will be interested in output performances and the figures below reflect material savings achieved in recent years by the examination of compilations *in situ* i.e., while still in machines.

Table 4. Compilation output at 1:31,680

Project	*Vertical interval (feet)*	*Nature of terrain*	*Output in square miles per man/day*
Griffith-N . .	25	Flattish terrain, little relief	5.0
Griffith-S . .	25	Flattish terrain, little relief	5.0
Ardlethan-N .	25	Flattish terrain, little relief	6.3
Ardlethan-S .	25	Flattish terrain, little relief	6.3
Bendemeer-N .	25	Undulating country, closely settled and developed	2.7
Armidale-N . .	25	Partly open plateau, some timbered gorges	3.6
Moss Vale-S .	25	Rugged, timber covered slopes	2.5

Conclusion

In summary, it is fair to say that, while some four-fifths of this State's 310,000 square miles remain to be mapped at scales suitable for development, the emphasis will remain for a long time in the direction of speedier and more economical methods of photogrammetry. Methods currently in use in New South Wales are applicable wherever mapping problems are extensive. Representing as they do a balance between accuracy and economy they provide, nevertheless, a reservoir of accuracy for the larger scales of mapping essential to highway development, town planning, water conservation and other projects of national importance.

THE STEREO-IMAGE ALTERNATOR, POTENTIAL SUCCESSOR TO ANAGLYPHIC VIEWING

Paper presented by the United States of America[1]

Ever since the introduction of the Multiplex in the mid-1930s, direct-viewing double-projection stereoplotters with anaglyphic filters have been the workhorse photogrammetric instruments for quantity map production in the United States because of their relatively low cost and simplicity of design and operation. For example, the Topographic Division of the Geological Survey now has some 400 improved modern anaglyphic plotters (mainly Kelsh and ER-55), as compared with about forty of the more complex instruments with optical trains.

Anaglyphic instruments, however, have several inherent disadvantages, which have long been recognized. These may be summarized as follows:

1. Low light intensity in the projected model: most of the light emitted by each projector bulb is wasted by the double filtering before it reaches the observer's eye, requiring him to work either in a dark booth or in a room with a limited level of ambient light; the light loss due to filtering is most serious in the corners of the model;

2. Incomplete image separation: the combinations of filters ordinarily used are not completely effective, so that each eye sees not only the principal image but also a subdued disturbing image, intended for the other eye, which ranges in intensity from 10 to 30 per cent of that of the principal image;

3. Unequal sharpness of the filtered images: the optimum projection distances are not the same for red and blue light, so that the two images on the tracing table are almost never exactly matched in sharpness of definition; this effect is particularly important at the extreme ranges of projection distance;

4. Incompatibility with colour photographs: with the introduction of colour materials suitable for photogrammetric use, this has become an important consideration.

These shortcomings of anaglyphic stereoplotters have, of course, been overcome in the European instruments which incorporate a separate optical train for each eye, but at the penalty of greatly increased cost and complexity. Much thought has therefore been given to designing attachments which would make the direct-viewing double-projection instruments no longer dependent on anaglyphic filters. Through the years, all of us have heard of "flicker systems", which would alternately flash the left and right images of a stereomodel on the tracing table for observation, and the general principles of such a system are well understood. But no practical items of equipment have been forthcoming until recently. After the system described here was developed, I was surprised to learn of a thesis written by Rudolf Burkhardt some twenty-five years ago,[2] in which he analysed the important shortcomings of anaglyphic filtering in quantitative terms and examined the characteristics of several experimental types of what he called "alternating shutters". Although the basic objectives are the same as those which led to the present development, none of the designs described by Burkhardt have been incorporated in generally available photogrammetric equipment.

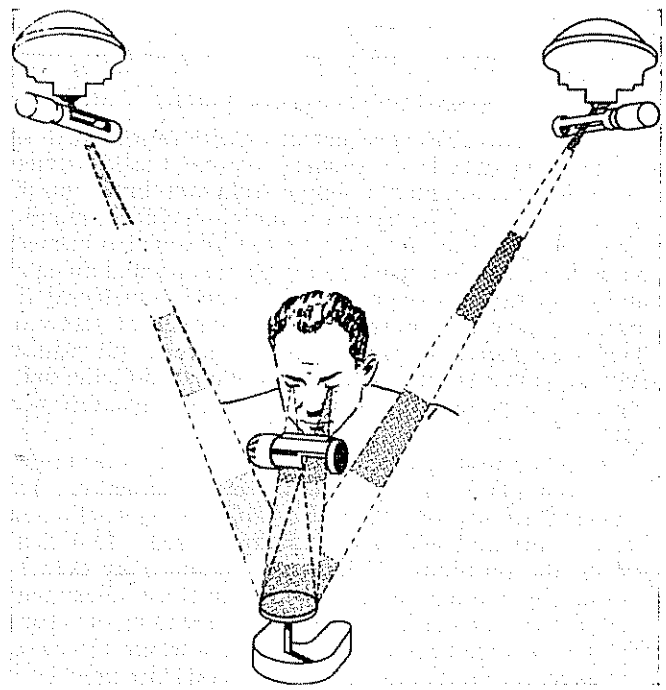


Fig. I—United States of America: Operating principles of stereo-image alternator system

Operating principles

The Stereo-image Alternator (SIA) system is illustrated diagrammatically in figure I. A rotating cylindrical shutter, with equal-area solid and open segments, is situated in front of each projection lens, so that the beam from each projector is alternately stopped and released. The two shutters are out of phase, so that one beam is stopped while the other is open, and *vice versa*. Correspondingly, the viewing shutters open and close to present the proper views to the right and left eyes of the observer. As is well known from movie theory, if the flash rate of successive images to the separate eyes is rapid enough, there is no impression of flicker but of a steady image. Although the critical flash rate for a steady image varies with the individual observer, a rate of 60 flashes per second will produce a steady image for all.

Synchronization

The central problem in designing a mechanical system of alternating projection is synchronization. That is, the relationship between the projected flashes and the images received by each eye must be exact and constant. Modern technology has provided the answer to this problem by the availability of miniature stepping motors.

These motors consist of a permanent-magnet rotor and a wired-field stator divided into four equal segments, so that each sequential pulse from the control circuitry imparts a rotation of 90° to the motor shaft. The size 11 and size 8 motors used in the Stereo-image Alternator system can respond to pulse rates of 200 and 300 pulses per second,

[1] The original text of this paper, prepared by J. William Knauf, United States Geological Survey, appeared as document E/CONF. 52/L.49.

[2] Rudolf Burkhardt, Untersuchungen zur Frage der Bildtrennung beim stereoskopischen Messen; *Luftbild und Luftbildmessung*, No. 21: Hansa Luftbild G.m.b.H., Berlin, 1941.

which means that they can operate synchronously at speeds of up to 3,000 and 4,200 rpm respectively.

The motors are physically very small, $1\frac{1}{16}$ by $1\frac{1}{8}$ inches for the size 11 motor, and $\frac{3}{4}$ by $\frac{7}{8}$ inch for the size 8 motor. Both have $\frac{1}{8}$ inch rotor shafts. The shutter components are attached directly to the rotor shafts and obviously must be of lightweight construction and dynamically balanced. Operating temperature of the motors is rather high, around 200° F, so that protection from touching by the operator is required. Life expectancy at the speeds of operation of the SIA system is predicted in thousands of hours, and the bearings, which are the only wearing components, can be replaced by the manufacturer as necessary.

Adaptation to plotters

Although the general principles of the Stereo-image Alternator are illustrated in figure I, the details of adapting it to specific plotters vary with the physical characteristics of each plotter, and usually several configurations are possible, depending on the ingenuity of the designer as well as on considerations of practicality and convenience. The examples presented here are by no means exhaustive, and further possibilities are being tested to arrive at the most useful and convenient configurations.

With Kelsh-type plotters, several placements of the projection shutters are possible: in front of the projection lens, between the lamp and the projection lens, and around the lamp. Theoretically, the first two placements are preferable as they can provide 100 per cent separation of images, whereas the third will lead to overlapping images and a disturbing image—but one that is small in comparison with those produced by anaglyphic filters, something on the order of 5 per cent instead of 10–30 per cent.

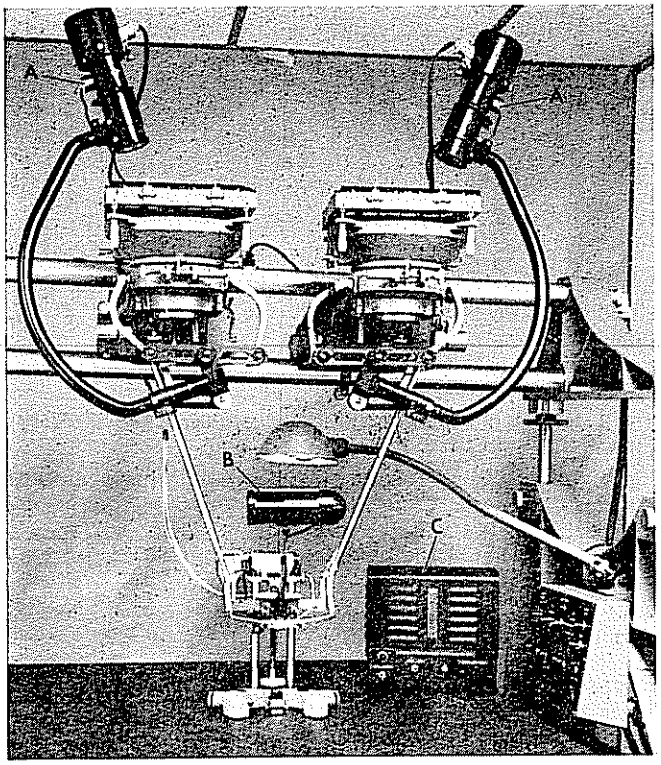


Fig. II—United States of America: SIA system installed on Kelsh K-100 plotter

A. Projection shutter motors.
B. Viewing shutter assembly.
C. Control logic unit.

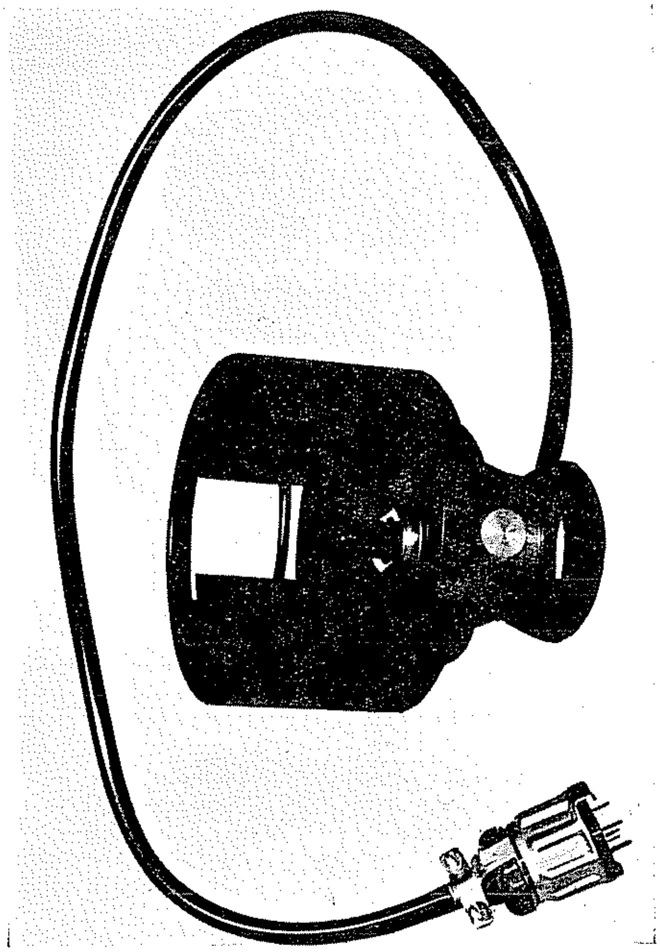


Fig. III—United States of America: Projection shutter for M-2 plotter

With ER-55 (Balplex) plotters, the only feasible placement for the projection shutter is below the projection lens. However, the lenses of these plotters project the entire model at one time over the full field of the photographs, whereas the area of interest is centred on the tracing table. A shutter capable of stopping and releasing the entire projected beam would be too large and heavy. The problem of adapting the Stereo-image Alternator to the ER-55 plotter is therefore solved by incorporating swing suspensions which allow the two small projection shutters, with their longitudinal axes aligned in the y direction, to move a limited distance in the x direction. This sort of x motion is easily controlled by metal roller tapes attached to the tracing table, and the shuttered portions of the projected beams are kept centred on the tracing table. The tapes are flexible when moved in the y direction but adequately rigid when moved in the x direction.

Viewing-shutter assembly

As shown in the figure of the SIA system, the assembly containing the pair of viewing shutters is attached to the tracing table. A close-up of the assembly is provided in figure IV. Here again the design is only one of several possibilities. Others could include spectacle frames, harnesses and head gear, with cylinder, disk, or

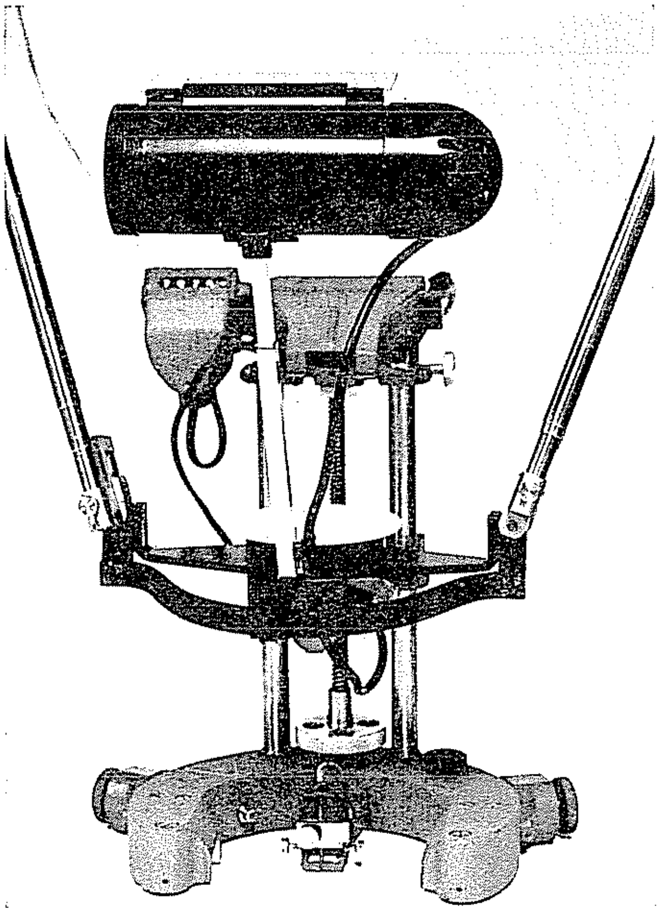


Fig. IV—United States of America: Viewing shutter assembly attached to tracing table

belt shutters. The present design, however, has served adequately for all the installations thus far. It does not require the operator to wear anything extra and avoids the problem of interference with glasses that the operator may already wear. Moreover, the viewing field is kept centred on the tracing-table platen.

A single rotating cylindrical component contains the rectangular slots and solid segments which provide the shutters for both eyes. Thus only one motor is needed for the viewer. In the mechanisms described by Burkhardt, a separate motor or actuator was required for each ocular shutter. The eye slots are made rectangular rather than circular to eliminate the need for an eye-base adjustment. An outer protective shell houses the rotating component and the motor. The motor and attached shutter can be rotated within the housing to adjust for optimum orientation, for either normal or pseudoscopic viewing. A feature shown in the close-up of the viewing shutter which has been added since the figure of the SIA system was taken is the plastic shield which can be lowered over the slot in the housing. Some operators noted that the slight fan action of the shutter tended to dry out their eyes.

The shutter assembly is attached to the tracing table by a hinge block which contains several detents so that the operator can adjust the viewing angle as needed. A small lateral swing adjustment is provided. The length of the supporting tube was selected for an average viewing distance of 10 inches from the platen, but this distance can also be adjusted.

System adjustment

As already noted, the viewing shutters are instantaneously adjustable by rotating the motor support. Similar rotational adjustments are provided in the projection shutters. With the system in synchronous operation, it is necessary only to rotate the motor mount of each projection shutter (with the other projector turned off) until no light is visible through the shutter intended for the other eye—that is, until complete cut-off is obtained. The motors can be stalled for short periods of time without damage and will realign themselves in the sequential operation when released. Once adjusted when placed in operation, the system seldom needs readjustment.

Operational evaluations

Production units of the SIA system have been in daily use since November 1965 with no appreciable down time due to malfunction of the system. All operators who have tried the SIA system report favourably on the brightness and sharpness of the models, and that they are able to compile with more assurance from models that they would ordinarily class as difficult. Suggestions for minor improvements have, of course, been received, and one of them has already been mentioned in this report: the plastic shield over the opening of the viewing shutters.

Conclusions

The SIA system is being installed on plotters in the United States Geological Survey and elsewhere as a standard accessory. Although the specific details are subject to change with further development, a patent application has been filed on the basis of the design described here. Technical details about the SIA system are not given in this report as these can be obtained on request to the Geological Survey.

Finally, it should be noted that the possibility of obtaining a stereoscopic image by alternate projection of two perspective views was first described by J. C. d'Almeida, who also invented the anaglyphic system of stereoscopic projection.

PRELIMINARY DETAIL PLOTS IN PAPUA-NEW GUINEA

Paper presented by Australia[1]

INTRODUCTION

During 1960–1961 the Commonwealth Scientific and Industrial Research Organization (CSIRO), through its Division of Land Research and Regional Survey, had an urgent requirement for base maps on which to plot the results of its field investigations in New Guinea.

The Division of National Mapping, which was responsible for this task, was faced with a difficult situation. Air photography coverage existed in isolated blocks of varying shapes and sizes with large differences occurring in actual photo scale due to extreme variations in terrain height.

[1] The original text of this paper, prepared by W. A. Thomson, Division of National Mapping, Department of National Development, Canberra, appeared as document E/CONF.52/L.55.

Survey control consisted of a few astronomical fixations, frequently poorly situated for map control purposes. Although a comprehensive survey control and air photography programme had been planned, it was not likely, at that stage, that significant results would be available for a few years and certainly not in time to satisfy the CSIRO's urgent requirements.

An evaluation of these circumstances led inevitably to the conclusion that it was not possible to approach the problem in a conventional way.

Outline of technique

The method adopted consisted of the preparation of "preliminary detail plots". Independent and uncontrolled slotted template sections, comprising eight to ten overlaps, were assembled. The mean positions as determined by several laydowns were adopted. By using any means available (existing maps, control points, and so on), the section shapes were brought graphically to an approximate but common scale. The individual sections were fitted together in groups of six on the compilation base. The top three sections were joined together at their common edges. The north edge of the centre bottom section was separated by 4 mm from the south edge of the top centre section. The remaining bottom sections were joined at their common edges.

The map detail was stereoplotted directly on to those bases using Zeiss stereotopes or Wild A6 autograph machines.

It was intended that, when suitable survey control became available, the section shapes would be block adjusted and each section plot rectified photogrammetrically to fit to corrected corner positions.

Advantages of the procedure

The advantages of the system were that working maps of quite good relative accuracy were immediately available to the CSIRO for the recording of its resources mapping investigations.

It was intended that a limited distribution would be made to other authorities actively working in the areas, such as patrol officers, missions etc. with a request for return of corrected and annotated copies. This information would be filed ready for incorporation in the final map.

Further advantages envisaged were that the plots themselves would be invaluable in otherwise unmapped country during the process of obtaining subsequent control.

Once the necessary control was available, the production of the final map on a standard format would not require additional stereo plotting.

Present situation

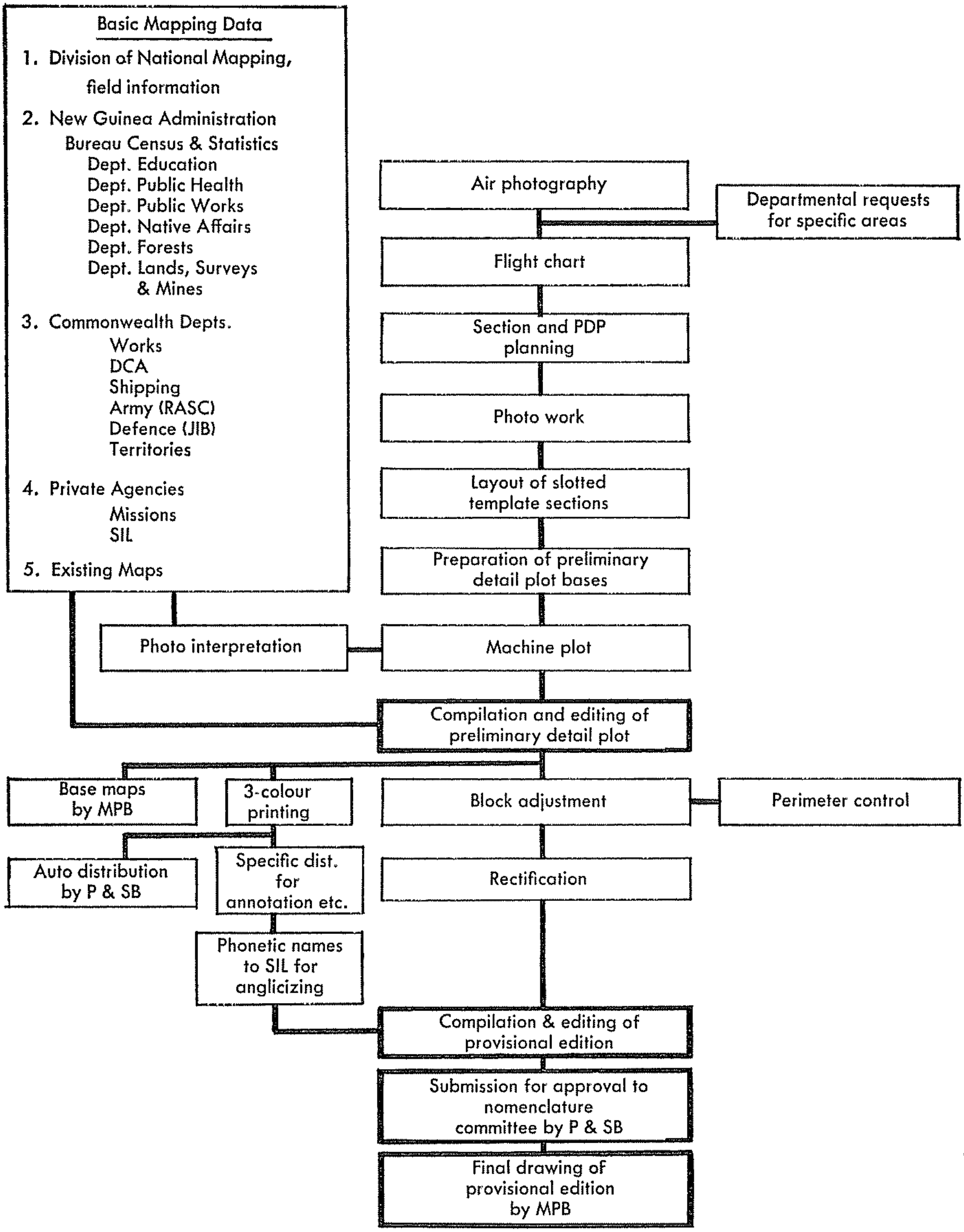
The requirements for copies of the preliminary detail plots were greater than originally envisaged, so that they were finally distributed as lithographically printed sheets with the relief shown by air brush shading methods.

As subsequent base maps required by the CSIRO were in areas suitable for standard mapping procedures, the "preliminary detail plot" methods have been discontinued by the division.

At this stage no block adjustments of sections have been attempted. Meanwhile these detail plots are fulfilling an urgent demand for topographical information in otherwise completely unmapped areas.

A sample preliminary detail plot is annexed to this paper.*

* See pocket at end of volume.



Australia: Work flow chart—New Guinea planimetric mapping

AN APPROACH TO 1:100,000 and 1:50,000 SCALE MAPPING, USING SUPER-WIDE-ANGLE PHOTOGRAPHY

Paper presented by Australia[1]

Introduction

The Royal Australian Survey Corps is primarily responsible for the production of maps and charts for the Army and Air Force, and for printing Navy hydrographic charts. It provides residual capacity for national development mapping programmes.

In 1966, the Minister for National Development announced a ten-year programme for the production of a 1:100,000 topographic series of the Australian mainland to commence in 1967, after completion of the compilation of the 1:250,000 series. The total number of maps in this programme exceeds 3,000, of which nearly 2,000 sheets will be published at 1:100,000, and the remainder compiled for this scale and incorporated in the second edition of the 1:250,000 series. The latter sheets are generally in the central desert area. Commonwealth and state mapping agencies are contributing to the programme, and the Royal Australian Survey Corps has undertaken to compile and publish approximately 850 sheets of the 1:100,000 series.

Australia has nearly 3 million square miles of country which varies considerably in type, climate and population density. There are large areas of flat, sparsely populated country of very low rainfall, including the main deserts. Timber, and in some areas jungle-covered mountains rise to a maximum of approximately 7,000 ft. The main centres of population and development are in the eastern and southern coastal plains.

A primary, homogeneously adjusted geodetic framework covers the entire country. In the south and east of the continent secondary networks provide reasonably dense horizontal control. With the exception of the far north, a framework of third-order spirit level traverses provides well distributed primary vertical control.

Wild RC9 super-wide-angle survey photography at scales between 1:70,000 and 1:85,000 covers, or is scheduled to cover, the whole programme area. From this photography it is intended to produce the 1:100,000 series and any 1:50,000 sheets required. One 1:100,000 scale map area contains four 1:50,000 scale maps and six 1:100,000 maps comprise a 1:250,000 map area. A basic unit of block photography is a 1:250,000 map area of 1° 30′ longitude by 1° of latitude.

The distribution of survey control required for the numerical adjustment of one unit block of super-wide-angle photography to provide 1:50,000 standard accuracy is no more than that required for 1:100,000 scale accuracy. It was decided to control and adjust all areas of Wild RC9 photography to 1:50,000 standards, so that no duplication of field control or aerotriangulation would occur where 1:50,000 maps were now required or would be needed in the future.

Control and adjustment of photography

Flight planning

Block super-wide-angle photography is flown in east-west strips to the format of the 1:250,000 map series graticule, at an altitude of 25,000 ft above sea level. The basic unit of block photography is a 1:250,000 area which is 1° 30′ longitude by 1° latitude. In addition, transverse strips are flown each 30′ of longitude, which reduces the field heighting commitment and provides checks on the adjustment.

Eight of nine east-west strips of approximately forty pictures are required to cover a unit 1:250,000 area. They overlap laterally by 25 per cent and have forward overlaps of 80 per cent. Whereas alternate photos which overlap by 60 per cent form the basis of the aerotriangulation for the photogrammetric adjustment, and supplementary 80 per cent overlaps provide better interpretation in steep terrain and dense vegetation at the plotting stage.

Horizontal control

The Bervoets nine points method of block adjustment for horizontal control is currently adopted for the photogrammetric adjustment, and the pattern of distribution of the nine control points is based on this method. The pattern required for the adjustment of a unit block to 1:50,000 accuracy is identical to that required for 1:100,000 accuracy, so that the absolute accuracy of the control survey remains the only variable. There is little difference, however, in the methods in use, or time factors for obtaining either order of accuracy, so 1:50,000 standards are observed. Two additional horizontal positions are fixed in the most convenient positions to provide adequate checks.

Conventional ground survey techniques normally apply, except that airborne aerodist equipment is used to break down primary control in large and sparsely developed areas such as those in northern Australia.

Vertical control

The pattern of distribution of height control is similar for either a numerical strip adjustment method, or the Jerie method of block adjustment, except that the Jerie method is less rigid in its requirement. In each case, for a unit block of approximately 6,000 square miles, approximately twenty-four control heights are required, if the transverse 30′ strips mentioned under flight planning are used in the numerical method. Without the transverse strips, about forty heights would be required. In each case, the absolute values of the controlling heights would alone determine the resultant standard of accuracy after adjustment.

Precise altimetry should meet the specification for accuracy in difficult country. However, air profile recorder (APR) equipment flown either along the 30′ longitude or along the common overlaps between the east-west runs, would reduce the field heighting commitment even further. In the latter case, the only heighting required would be for the reduction of the APR data which would eliminate the need for any photogrammetric adjustment as such. Naturally higher order vertical control is desirable where it is economical to obtain. Where third-order spirit-level traverses exist, breakdown by the ground elevation meter would be the most economical means of providing vertical control to the required accuracy.

Identification of control

The precise identification of ground control on to survey photography is very often subject to error when using any

[1] The original text of this paper, prepared by Colonel F. D. Buckland, Royal Australian Survey Corps, appeared as document E/CONF.52/L.56.

means other than pre-targeting. In an effort to eliminate these errors, all stations are identified on the existing survey photography, and also targeted and photographed separately. White plastic sheets, each 10 ft × 4 ft, laid in the form of a cross about the ground mark form the target. It is unfortunately not feasible to pre-target vast areas of proposed photography when a firm flying schedule cannot be maintained for various good reasons.

Photogrammetric adjustments

The aerotriangulation and adjustment of the photography is conducted through a Wild A9 autograph and IBM 1620 computer. The classical pass points are marked on to half size (12 cm) diapositive plates, accommodated in the A9, by means of a Wild PUG point transfer device. An IBM 026 card punch is linked to the A9 through an EK5 co-ordinate printer. Points on each photograph are transferred to adjacent runs as join-points which, although not all necessary, provide a good basis for analysis of any errors thrown up in the adjustment, and the discord of doubtful join-points.

To assess the accuracy of the method, a unit block area containing a variety of flat, steep and densely timbered terrain was chosen. Forty-one additional horizontal control points and seventy-five heights were available for independent check comparisons. After adjustment, the mean square error on the additional control was 13 yards, or approximately 0.16 mm at picture scale. This figure reflects possible mis-identifications which were not re-examined. The average residual on the check heights was ±12 ft. In the case of the vertical comparisons, similar results were obtained by means of the Jerie equipment. This result is compatible with 1:50,000 and 1:100,000 scale accuracy specifications.

After the strip adjustment of vertical data, residuals at join-points are included in the Jerie adjustment.

Times which may be anticipated for photogrammetric states in the observation of a unit block of six sheets at 1:1,000,000 scale are approximately the following: selection marking of control, pass-points and join-points, using a Wild PUG point transfer device, 8 man-days; observations through a Wild A9 autograph to an IBM 026 card punch, 30 man-days; assembly of Jerie height adjustment: 15 man-days.

Plotting and compilation

Plotting equipment

The data provided by the photogrammetric adjustment constitute the values required to determine the absolute orientation of individual models in the plotting equipment. The Wild B9 aviograph is designed to accommodate the same reduced diapositive plates (12 cm) as those which are marked and observed through the Wild A9 autograph for the purpose of the adjustment. Although the points of orientation may be transferred to another set of full-size plates for alternative plotting equipment, it is simpler to remain at the reduced size for the B9 equipment.

It is simpler to correct the Wild RC9 super-wide-angle photography for earth curvature, atmospheric refraction and nominal lens distortion by imposing a correction plate in the reduction printer at diapositive printing stage, although correction plates may be fitted to the plotter if desired.

The B9 equipment is normally oriented to the aerotriangulated data to within ±0.04 mm in height at a model scale of 1:75,000. However, the machine model scale may be varied from 1:60,000 to 1:80,000. In addition, a linear pole pantograph operating over an attached plotting table allows enlargement and reduction from 1:24,000 to 1:200,000 respectively.

From each model up to 50 square miles of terrain may be plotted, and an operator is able to plot a model in one to two days according to the density of the detail. Each 1:100,000 scale map contains approximately thirty models, so that the rate of map production to compilation stage could be expected to average one map per 45 man/machine days.

One A9 autograph can provide aerotriangulation for six B9 plotting equipments. The over-all balanced rate of production then for a unit of one A9 and six B9's would be two 1:100,000 maps each three weeks, working on a one-shift basis. There is little problem in working more than one shift on B9 equipment, but with the A9, in the interests of accuracy, one operator should observe a complete run. This takes approximately 18 hours, and an operator should not work more than ten hours in any one stretch, once again in the interests of accuracy. There is no difficulty in arranging a seven-day week roster observing the above restrictions.

Compilation

The scale of the compilation is mainly determined by the scale of publication and the density of detail. For maps to be published at 1:100,000, the compilation is normally at 1:75,000 in areas of sparse detail or 1:50,000 in areas of dense detail. There may be exceptional circumstances where the high density of detail warrants an even larger compilation scale. In all cases the compilation must be open and clear for tracing, lettering and editing, and the linework and symbolization must allow for the relevant reduction.

No attempt is made to ink or scribe a compilation sheet directly through the plotting equipment. The operator views a model which is magnified 7½ diameters from the diapositive plate scale, that is, about 1:22,000, which, although better from the point of view of interpretation, tends to induce the operator to plot more detail than can be shown at finished scale. This surplus detail is normally controlled at the tracing and editing stage.

With minor exceptions, all interpretation of detail is done in the plotters because of the high magnification factor. On completion of compilation, prints of the plotted sheets are checked in the field. This is done to the maximum extent possible by use of slow flying light aircraft, and ground checks are made where air annotation is not economical or feasible.

The drawing medium used for the compilation sheet must have a high-quality inking and erasure surface so that the subsequent impression required by the cartographer is clear and crisp. It must be stable and have characteristics similar to those of materials used in the cartographic and lithographic stages of production, so that sound registration is maintained throughout.

Conclusions

Some conclusion which may be drawn from this paper are listed below.

The flight planning of photographic cover of an area must be systematically designed in units of proposed photogrammetric adjustment.

A 1:250,000 map unit of block-adjusted super-wide-angle photography at scale between 1:70,000 and 1:85,000 is a workable unit of photogrammetric adjustment for 1:50,000 and 1:100,000 mapping standards.

It is desirable that the accuracy of the aerotriangulation of an area should be sufficient to accept higher order control so that it may become available for readjustment for larger scale mapping; alternatively, control should be established in the first instance of sufficient accuracy to meet all foreseeable requirements for larger scale mapping.

Absolute identification of control is essential in the field.

It should be noted that the conclusions drawn are intended to apply only to the particular circumstances of the Australian medium-scale mapping problem, and have not been examined in relation to other scales, conditions or areas.

SOUTH AUSTRALIA'S TOPOGRAPHIC MAPPING SYSTEM

Paper presented by Australia[1]

Introduction

Each photogrammetric organization develops its own mapping instrument system. The type and range of instruments installed are often influenced by the need for a particular map at the time of the organization's formation, by the required accuracy of the map and by the previous experience of the officer planning the section.

Once the basic equipment to produce one particular type and scale of map has been installed, it is not unusual for the photogrammetrist to be asked to produce maps at many different scales and for many different purposes. That the customers are often satisfied reflects the versatility of photogrammetry and its instruments.

South Australia's Department of Lands Photogrammetric Section was set up to prepare maps, at a scale of 1:31,680 and with a 25 ft (8 m) interval between contours, of the settled areas of the state, or approximately that area having an annual rainfall greater than 10 inches (25 cm). The mapping system has gradually developed since the first instruments were installed during 1950–1952. In 1957, a plate aerial camera was purchased, the Bervoets block adjustment system was adopted in 1960, the ITC-Jerie height adjustment equipment was first used in 1962 and automatic recording of co-ordinates was added to one of the Wild A5 instruments in 1964. The latest development has been the introduction of scribing of the compilation sheet during the plotting stage.

The instrument system now in use is as follows: Wild RC7 wide-angle plate aerial camera; Wild PUG 2 point transfer device; Wild A5 autograph with EK5 co-ordinate printer and IBM 026 card punch attached; Bervoets block adjustment system computed on an IBM 7090 computer and ITC Jerie height adjustment equipment; Wild A6 stereo-plotting instrument.

To describe the department's mapping system it might be clearer if one particular block of map sheets were to be followed through all its various stages, the planning of the photography and field control, the aerial photography, the block preparation and stereo-triangulation, the block adjustment and finally the plotting.

Planning

When instructions are received that a certain area of the state is to be mapped, the first step is to split the area into blocks of convenient size. Experience has shown that 2,000 square miles (5,200 km^2) is the largest practicable size that can be handled by the section. The size and shape of the blocks vary according to coast lines, islands etc., but, for the purpose of this paper, a block is 1° longitude wide by 0.5° latitude deep. Such a block will be covered by eight east-west strips of 25 photographs from a height of 22,000 ft (6,700 m) above the average ground level; the photography will then have a contact scale of 1:68,000. Normal overlaps of at least 60 per cent fore and aft and 25 per cent lateral are specified. The lateral overlap may often be greater than this, as it is usual practice to cover the block exactly with a whole number of strips and also make the first and last exposure exactly at the edges of the block.

Any minor variations to the mapping system must be decided at the planning stage, so that the field survey staff and the air crew may be provided with the correct information and instructions to complete their part of the work within the over-all framework of the system being used. The most convenient method of passing on the information has been found to be a scaled mosaic prepared from the latest photography of the area. The whole state has been completely covered by aerial photography, so that some is always available. The initial planning of flight lines and exposure points is carried out on any existing small-scale maps and then transferred to the mosaics. If no maps exist, then some preliminary points are surveyed and these are used to scale the mosaics. Four copies of the planning are prepared, the surveyor's copy showing exactly where all the horizontal and vertical control points are required, the navigator's copy showing the position of the flight lines to be flown, the photographer's copy showing the position of each individual exposure; the fourth copy is the master copy which shows all the planning information.

The distribution of the horizontal and vertical control points through the block must be made with a full understanding of the block adjustment system that is to be used later and of the quality and position of the existing survey data. This entails the closest co-operation with the surveyor who will be supervising the field work. Approximately twenty horizontal control points are used for a block of this size, fourteen of them being positioned along the block edges (and can therefore be used for adjacent areas); the remainder are distributed through the centre. All horizontal points are premarked on the ground with a 24 ft (7 m) square marker or a cross with 30 ft (10 m) arms, each arm 6 ft (2 m) wide, made either of plastic or a strong coarse paper. All trigonometrical points in the block are also marked, as this assists in the identification of the points for record purposes and plotting.

Vertical control points are usually considered separately. This is partly due to the department's policy of carrying out third-order levelling concurrently with the mapping field work. Again, after discussion with the surveyors, the

[1] The original text of this paper, prepared by R. G. Roberts, Supervising Photogrammetrist, Department of Lands, South Australia, appeared as document E/CONF.52/L.57.

distribution of height control is planned in accordance with the results obtained from tests and experiments carried out by the section in 1962 (see annex I).

For a standard block, four or five chains of height control, one point in each lateral overlap, the chains being at right angles to the flight lines, are sufficient to maintain the contouring accuracy, provided additional heights are measured on every other model along the top edge of the first strip and along the bottom of the last strip. The relative positions of the height-control chains may be varied to suit the topography, accessibility and method of field measurement. Height-control points are not usually marked. If, however, the mapping is urgent and there is no time to complete the control surveys and levelling before photography and stereotriangulation must begin, then all points are premarked.

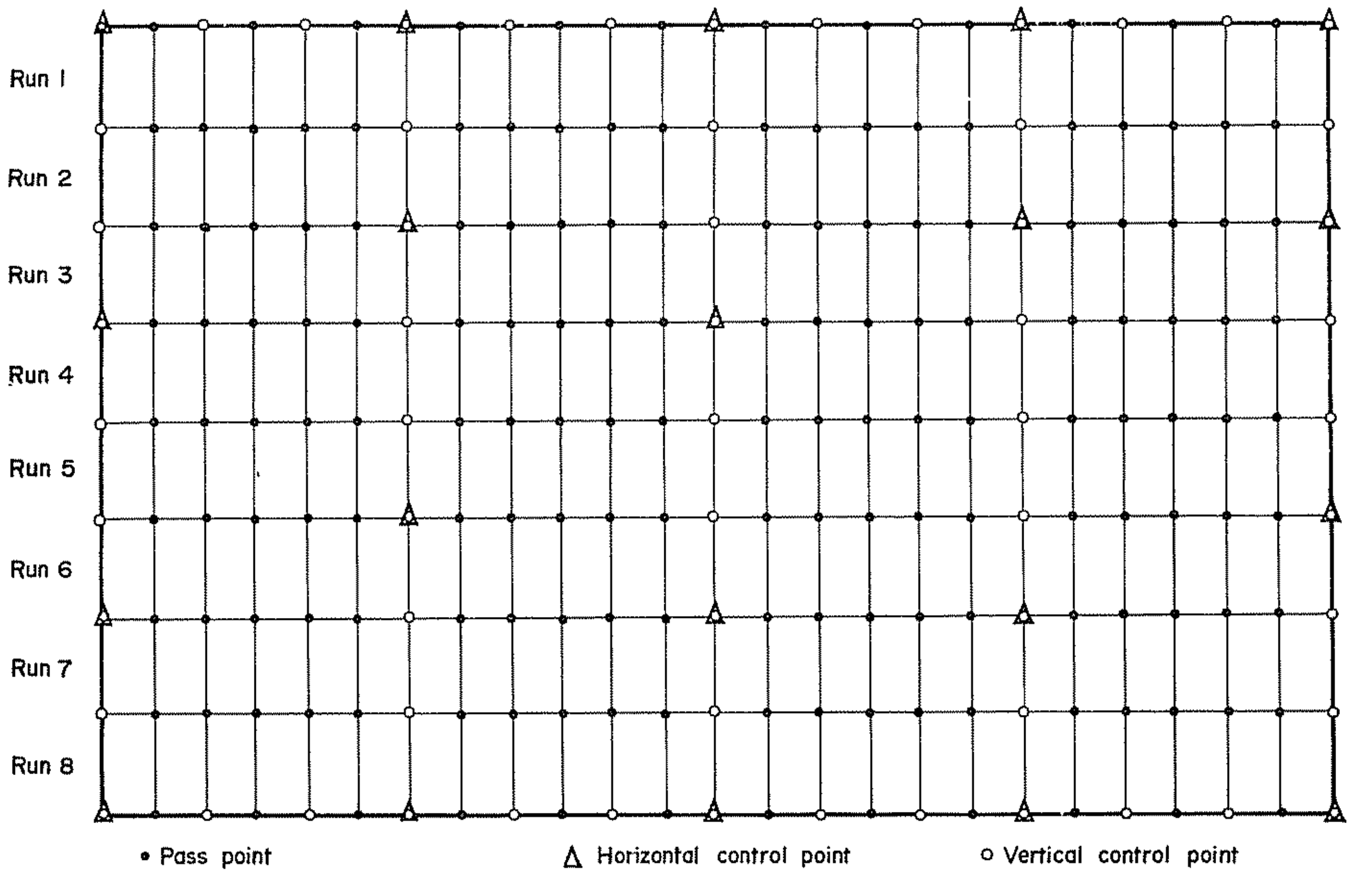
All ground marking must be completed before photography and it is desirable that photography be completed as soon as possible after the markers have been laid. A delay of one week may mean the loss of a marker and the ruin of the photography.

are Agfa Gevaert ultra-flat 15 cm^2. The need for the plate camera, since the advent of the Estar and Cronar film bases, has decreased. No problems of residual parallax in models has arisen that could be attributed to the camera or plates and this ensures trouble-free plotting, which in turn means greater production as well as a slightly higher accuracy.

The photography is carried out under a system which, it is believed, is used only in South Australia. This is called the predetermined exposure point system, or PEP. Every exposure on every strip or run of photography is manually made over a point identified on the ground by the photographer from the scaled mosaic prepared at the planning stage. The time interval between exposures at 22,000 ft (6,700 m) is some 40 seconds and this permits the photographer to identify his position and make the exposure. To safeguard against becoming "lost", the second photographer monitors the time interval between exposures with a stop watch. The PEP system has the following advantages:

It covers a block with the minimum number of photographs;

A single exposure can be repeated, if needed;



Australia: Control distribution for a standard block

AERIAL PHOTOGRAPHY

The department's aerial photography is carried out by a DC3 aircraft, especially modified for aerial survey work, chartered from trans-Australia Airlines, with a pilot and first officer. The department provides the remaining crew members of at least one navigator and two photographers, making a crew of five.

All mapping photography is done with the Wild RC7 plate camera using the 10 cm lens cone. The plates used

It permits control to be placed in the "supralap" (that portion of a photograph which is common to the two adjacent ones in a strip and three photographs in the adjacent strip);

It simplifies the preparation for the block adjustment;

It minimizes the number of points to be observed in the stereotriangulation;

It eliminates the need for adjacent blocks to overlap;

It makes all control at block edges effective for the adjacent blocks.

Care must be taken in the planning to ensure accuracy of position and the surveyor has to place the control exactly where indicated.

The main disadvantage of the method is that the air crew need a "look-see" run over a strip before photography. This is usually made as the plane returns to the same end of the block for the beginning of each strip. A strong westerly air stream persists over most of South Australia, at heights of 15,000 ft (5,000 m) and above and it has proved of some advantage to fly against this wind when actually photographing. It is also an advantage to have the flight lines in the east-west direction to avoid excessive drift settings.

The exposed plates are processed in the normal developing tanks provided, but these are mounted in another tank in which water at 70°F (21° C) is continually circulating. The plates are left in the racks in which they are developed until dry. The negatives are then immediately inspected to see that they are of suitable photographic quality, that they have been taken over the correct points and that any ground markers that should be visible, are visible. If satisfactory on these three counts, they are accepted and numbered and prints prepared from them.

Topographical photography covering 10,316 square miles (26,500 km^2) was flown in 91.6 flying hours. The flying time includes the time taken in flying to and from the area of photography.

At the current rate of aircraft hire, crew salaries, overheads etc., of $A450.00 per hour, the cost per square mile is approximately $A4.00 ($A1.54 per km^2).

Block preparation and stereotriangulation

At this point in the mapping system another practice has been adopted which, perhaps, is peculiar to South Australia. The original glass negatives are used in the stereotriangulation and plotting. The quality of the negative is utilized to the full by the use of the original plates in the plotting machines. That the operator sees a negative image is no handicap to the interpretation of the photographs for mapping purposes. It is interesting to note that the breakages that might have been expected have not actually occurred. Over 10,000 plates have been used during the past eight years and fourteen plates were broken when one box of plates fell off a shelf in the store. The plates are stored vertically, each plate in an open clear plastic bag, in boxes of twenty-four.

A block diagram is prepared showing the positions of all points to be observed in the triangulation. On this diagram is also put the model number, the run or strip number, point classification and the unique number under the Australian Mapping Council resolution No. 274 of 1964 on a numbering data processing (see annex II), Only the three points down the middle of each plate are drilled on the Wild PUG II and where a marker occurs a pass point is not marked. The upper and lower pass points are transferred stereoscopically to the adjacent runs. No other permanent marks are made on the negative plates. The complete number for each point drilled on each plate is recorded on a corresponding contact print for the machine operator's guidance.

Triangulation, at present, is by the dependent pairs method (continuous bridging), but as soon as the computer programme has been modified the method will be changed to that of independent models. This method is quicker and produces results at least as accurate.

The output of data from the Wild A5 autograph with EK5 co-ordinate printer is in the form of a typed list; in addition, a single computer card for every point is punched on the IBM 026 card punch. Errors in the recording of data have shown a remarkable decrease since the installation of this equipment.

Section statistics show that, in three years, 1,013 models were triangulated for topographical mapping in 1,330 hours. The average time per model was 1 hour, 20 minutes, which, at present section charges, would have cost $A13.00 per model or $A1.30 per square mile ($A0.50 per km^2). Using the independent model method of triangulation, a time of less than one hour per model can be expected.

Block adjustment

The block adjustment system is, basically, that designed by S. G. Bervoets, now of Melbourne University. It has been programmed for the IBM 7090 computer; a detailed description of the programme is given in annex III, the main features only being discussed here.

The three principal stages of the adjustment for the planimetry are, first, to check the consistency of the data, secondly, to join together all the strips in the block into the co-ordinate system of the first strip and, finally, to adjust the block co-ordinate values to obtain the best fit on to the geodetic control points supplied. If required, a further stage may be introduced to bring the height values of each strip in the block into close agreement with the control supplied, as a preliminary to obtaining the final corrected values from the ITC-Jerie analogue height adjustment equipment.

The check on the consistency of the input data is carried out by transforming each model of a strip into the co-ordinate system of the first model. This may seem, at first sight, to be a duplication of the work done by the triangulation instrument, but it is considered that several advantages accrue from this stage. Any erroneous data is immediately found and highlighted by the programme, before the computer has entered the more complicated second stage. It assists in eliminating those small but troublesome changes in scale and azimuth which occur from time to time during the stereotriangulation of a strip. It also permits the independent model method of triangulation to be used when heights on every model are provided from the field.

Next the programme joins the top edge of the second strip to the bottom edge of the first strip, then the third strip to the second, the fourth to the third, etc., until the whole block is in the co-ordinate system of the first strip. The join is calculated from the cubic curve which best fits the differences in co-ordinates between the same pass points appearing in adjacent strips.

The third stage of the block adjustment involves computing and applying the corrections necessary to bring all points into the geodetic co-ordinate system by the comparison of the values of known points in the block co-ordinate system and the geodetic system. This is done simultaneously for X and Y co-ordinates.

Throughout the whole adjustment system, the principle of least-square fit is applied. Every point suitable for use as a control point is used as such. The accuracy of the system has been evaluated from the residual vectors remaining at all control points after adjustment.

Summarizing only topographical blocks, 1,013 models in four blocks were controlled by 69 planimetric control points and resulted in an average residual vector of 50 microns at the scale of the negative or approximately 11 ft (3.5 m) on the ground.

PLOTTING

The unit of plotting is the quarter sheet, 15′ longitude by 7½′ latitude deep for maps at a scale of 1:31,680; for mapping at a scale of 1:50,000 it will be a single map sheet 15′ longitude by 15′ latitude. Each machine operator is given one unit of mapping to complete at one time. The control for every model in the sheet is plotted on to three pieces of scribing film, one for each of the three detail colours: black, blue and brown.

Through the planning and the PEP system of photography, twelve models exactly cover a quarter sheet at a mapping scale of 1:31,680 and twenty-four models exactly cover a whole sheet at 1:50,000. There are no part models to plot on any of the sheets of a standard block. This speeds production and simplifies the preparation of sheets for plotting.

With care, it has been found practicable to scribe on the stereoplotter most of the detail needed to appear in brown on the final printed map. As the contour or brown sheet contains about 90 per cent of all line work in a map sheet, there is a considerable saving in work by adopting a direct machine scribing system.

The black sheet is often subject to amendment and is liable to interpretation errors; this sheet is therefore not scribed directly but the information is recorded on the scribe-coated film in pencil and ink. The blue sheet detail is similarly compiled. The contours of the brown sheet are scribed on the plotting machine. The contours are not joined model to model nor are ring contours completed, but a small gap is left for the draftsman to complete them by hand. A green sheet is not prepared for the preliminary edition of the map and the red sheet is prepared by the draftsman from other sources.

The scribing stylus or tool is held in a normal pencil holder chuck and, after testing for the verticality of the stylus, scribing can proceed, using 0.1 mm and 0.2 mm line-widths, when the appropriate number of weights have been added. The surface of the plotting table has been improved by placing a sheet of glass upon it. This system has been quite successful on Wild A6 stereoplotters and has been used on productive work for six months. The rate of plotting from the Wild A6 machines in the section dropped initially when the method was introduced, but it returned to normal after three months.

Production from the instruments varies according to the density of detail to be plotted and the complexity of the terrain; over a period of three years the rate has been approximately 1 square mile (2.6 km^2) per machine-hour worked. A total of 8,404 hours has been spent on machine plotting and 8,615 square miles (20,100 km^2) of mapping has been compiled.

Annex I

RESULTS OF TESTS CARRIED OUT BY THE PHOTOGRAMMETRIC SECTION FOR THE ACCURACY OF THE ITC JERIE ANALOGUE HEIGHT ADJUSTMENT EQUIPMENT

Three tests were made with control points distributed in five, four and three chains across a standard Block. The results appear below.

	Five-chain pattern	*Four-chain pattern*	*Three-chain pattern*
Control used	43	34	29
Number of check points	140	145	152
Error classification (in feet)			
14	0	1	2
12–14	3	3	3
10–12	4	6	6
8–10	4	4	15
6–8	14	16	24
4–6	25	19	28
2–4	32	40	38
0–2	58	56	35
Mean square error (in feet)	4.5	4.8	5.8
Percentage of flying height	0.020	0.021	0.026

The stereotriangulation was carried out by a Wild A5 with the Z column set at about 400 mm. The flying height of the photography was 22,000 ft taken with a Wild RC7 plate camera with 100.10 mm focal length lens, using Agfa Gevaert ultra-flat glass plates.

Annex II

SYSTEM OF PHOTOGRAMMETRIC POINT NUMBERING

A ten-digit system of reference is used, 0–9.

Working from left to right, the digits are allocated as follows: digits 1 and 2, run number; digits 3 and 4, common run number; digits 5 and 6, photo number; digit 7, point classification number; digits 8, 9 and 10, unique point number.

The run number is the flight strip number in which the point is observed.

The common run number is the strip number to which the point is common. If a point is not common to two strips or runs the run number is repeated at digits 3 and 4.

The photo number is the last two digits of the left hand photograph of a pair of photographs being observed.

The point classification system is as follows: 0 represents a tie point; 1, a top pass point; 2, a centre pass point; 3, a bottom pass point; 4, a horizontal control point; 5, a vertical control point; 6, test points; 7, 8, 9 represent supplementary points.

A tie point is a point used to tie together two adjoining strips, while a pass point is used to link two models together in the same flight strip.

Annex III

DESCRIPTION OF BLOCK ADJUSTMENT DESIGNED BY S. G. BERVOETS AND PROGRAMMED IN FORTRAN II FOR THE IBM HIGH-SPEED COMPUTER NO. 7090

The programme is divided into four parts.

Part I

This part of the programme accepts the machine co-ordinates of each model and transforms the second and subsequent models into the co-ordinate system of the first model. The transformation is calculated by a least-square fit on the X and Y co-ordinates of the three common points, thus forming strip co-ordinates. Any scale change is applied to the Z values also.

The output from this part prints out, model by model, the linear transformation parameters A, B, C and D and the scale factor. For each point used in the transformation, the residuals in X, Y planimetric vector and Z are printed out against each point number. If any residual exceed RMAX or HMAX, which are set in the programme at 0.20 mm, the word "excess" is printed against that point (RMAX and HMAX may be varied by a parameter card).

This part of the programme ensures that the data is consistent between models and helps to remove small changes in scale and azimuth.

Part II

The strip co-ordinates computed in part I are now formed into one co-ordinate system. The co-ordinates of the second and subsequent strips are transformed into the co-ordinate system of the first. This is done by comparing the co-ordinate values of points common to two adjacent strips and computing the least-square cubic correction curve that will bring the values of strip $n+1$ to those of strip n. If, after transformation, the residual vector at any point in strip $n+1$ is greater than DMAX (which is present in the programme at 0.30 mm), "point number ... is bad fit error is ... " is printed out by the computer. (DMAX may be varied by a parameter card.) All points in the strip-join are then listed giving the X value and the residuals in X and Y after a linear transformation only has been applied. The point which has the greatest residual greater than DMAX, after the application of the cubic correction, is deleted from the computation and a new correction curve computed. This process is repeated until DMAX is not exceeded. If only three points remain during this stage the computation is stopped.

If a point has been rejected, both values are carried forward through the rest of the computation as two separate points and are printed out after final transformation, one having a negative point number.

Finally, the linear and cubic join parameters for each strip are printed together with the average Y values.

Part III

The average value of the cubic correction parameters is computed from the cubic join parameters and printed. The geodetic points are listed; the chosen adjustment parametric terms for the final block adjustment are listed and a comparison of the map and ground values for each horizontal geodetic point is printed out after a linear transformation has been computed. This allows any large discrepancies between map and geodetic values of a point to be located before final adjustment. It is possible to select the number and order of the terms in X and Y to be used in the final block adjustment. If no instruction is given, the following order is adopted:

$$x, y, xy, x^2, y^2, x^2y, y^2x, x^2y^2, x^3, x^3y, x^3y^2, y^3, y^3x, y^3x^2, y^3x^3.$$

If the number of horizontal geodetic points is less than the number of terms, the computer will use one term less than the number of geodetic points.

The final adjustment matrix is solved in several stages and at the end of each stage the X and Y residuals at the control points are computed. These are printed as the sum of the square of the residuals at their control points, with the number of degrees of freedom remaining. Thereafter the final transformation parameters are listed.

Part IV

The final transformation is now applied to every point in the block and the result printed out. During this part of the programme a sub-routine can be called for a preliminary height adjustment to prepare heights for final adjustment on the Jerie analogue height computer. Corrections are computed using the following terms in the correction equation:

$$x, y, x^2, xy,$$

if sufficient height control points are available. For every control point less than six in the strip, one term is omitted from the equation.

The adjusted height value for a point and the adjusted value from the adjacent strip, together with the difference between them, is printed out alongside the adjusted X and Y co-ordinates.

Feet or metres may be used as the unit of height. A rejection criterion HMAX is set at 50.0 units to delete widely discrepant geodetic height data. This sub-routine can be omitted if not required for a particular job. HMAX may also be varied by a parameter card.

The programme will accept up to and including twenty strips with 240 points in each strip, with no more than 100 tie points. Eighty geodetic points is the maximum number allowable, with not more than twenty height geodetic points per strip. A single strip cannot be computed by this programme.

USE OF HIGH-ALTITUDE PHOTOGRAPHY TO CONTROL LARGE-SCALE MAPPING IN NEW SOUTH WALES

Paper presented by Australia[1]

Recent years have seen extensive progress in photogrammetry procedures, particularly in the field of analytical photogrammetry. Such developments, while necessary and applicable in this modern age, tend to give the impression that there is very little that can be done in more simple practical procedures. An examination of any professional journal discloses that most articles are concerned with theories of errors, adjustments or some specialized application of photogrammetry in a restricted field. Very little is written on practical applications at a level between the text book and the most sophisticated modern techniques.

This paper attempts to fill a little of this gap by examining the problem of producing large-scale maps where control is scarce. It outlines a practical approach of attaining a sufficient degree of accuracy without incurring the cost of extensive field survey.

The basic technique is to make use of points derived from the adjustment of high-altitude photography as control for large-scale mapping with low-altitude photography. The technique does not involve any new concept but is simply a particular application of methods that any photogrammetrist is expected to handle from day to day.

The Photogrammetric Division of the Central Mapping Authority has made use of the technique with variations for two separate projects, details of which will be given later. In each case the ratio of large-scale to small-scale photography was in the order of three to one. Triangulation of the high-altitude flights was carried out and adjustment based on an adequate number of targeted control points. Tie points previously selected in suitable positions on both sets of photography were then used for the necessary treatment of the low-altitude photographs. It is obvious that the technique involves a number of special problems. Not only must the degree of accuracy of the final map be met, but the matter of control density and distribution of tie points must also be clarified.

First, the technique is not intended to be used for precise mapping calling for accurate horizontal positions, although it is by no means sure that, with refinements, application in this field is not possible. It is mainly intended for large-scale mapping for engineering purposes, town planning, road design etc., where the main requirement is relative accuracy at least in position. It is also particularly applicable where existing control is inadequate for conventional methods at larger scales, but sufficient for a rigorous adjustment of a high-altitude flight.

The area to be mapped must be reasonably extensive, as it will be realized that in small areas the technique would be uneconomical. The amount of control necessary using normal methods would, in such a case, be seldom more than required to control the high-altitude flight.

[1] The original text of this paper, prepared by K. J. Stokes, Department of Lands, New South Wales, appeared as document E/CONF.52/L.58.

An important point to consider is the altitudes and scales of the two sets of photography. The altitude of the low-level flights will mainly be established from the normal considerations of contour interval, map scale and instruments available. The altitude of the high-level flights will depend on the required degree of accuracy, both relative and absolute. While a ratio of three to one is suggested, this is not fixed and may be revised to meet the circumstances.

The density and distribution of control will also be dictated by circumstances, but, in view of the reliance placed on high-altitude flight, it would be advisable to achieve somewhat more than minimum control requirements to reduce as far as possible the effects of accidental errors in the strip. Certainly the targeting of horizontal control is strongly recommended.

However, accuracy will be the question that will cause most concern with this technique. While it is emphasized that, for horizontal position, relative accuracy is the most important consideration, this does not necessarily apply to heights. It must also be noted that, while an error of a few yards in position may not be very significant even on a large-scale map, errors of this magnitude in elevation cannot be tolerated on maps dealing with sewerage surveys, dam storage, etc. We must therefore examine the matter of accuracy in position and elevation separately.

With regard to horizontal accuracy, it is obvious that residual errors in the triangulated strip, even though small at the scale of the photography, are significant at the scale of the map. Provided, however, that all systematic errors have been removed in the adjustment, it can be expected that these errors will be random in nature. Even if some systematic effects still remain, the relative errors between points will be random. It is therefore not the absolute accuracy of the adjusted strip which concerns us, but the magnitude of the random errors. It seems reasonable to assume that these will be closely associated with pointing accuracy. Any other causes of error will, in the main, contribute a systematic effect.

Whatever random errors of this nature exist, it is probable that they will be exceeded by errors resulting from the incorrect identification of tie points. It is obvious that, when dealing with photography at vastly different scales, the problem of accurate identification of common features involves a number of difficulties. Even if a stereoscope with zoom-type lenses, that is, with variable magnification factors, is available, fusion is not always possible. The fact that the photography may have been taken at different times, under different lighting conditions and even at different seasons, makes for extreme difficulty in the transfer of points. There is some question as to whether tie points should be pricked on the plates of one or both sets of photography or whether identification should be based on description and sketches. From experience it seems that, in developed and cleared areas, identification by description and sketches is most reliable, but points should be pricked in timbered, undeveloped areas. Since accuracy will largely depend on the correct identification of these tie points, only the most experienced operators should be used on point transfer.

One matter which arises from the analysis so far is that, in setting up large-scale models for plotting, use will be made of points containing random errors of significant order. However, if a sufficient number of tie points are available on each model, then the best mean fit would result in a reasonably accurate scale and orientation being established. The greater the number of points, the greater the probable accuracy. With a suitable number, it is reasonable to expect that any inaccuracies will be of lesser magnitude than the random errors that exist on the points. It seems advisable, therefore, that four or more points should be selected for each model, depending on the certainties of identification.

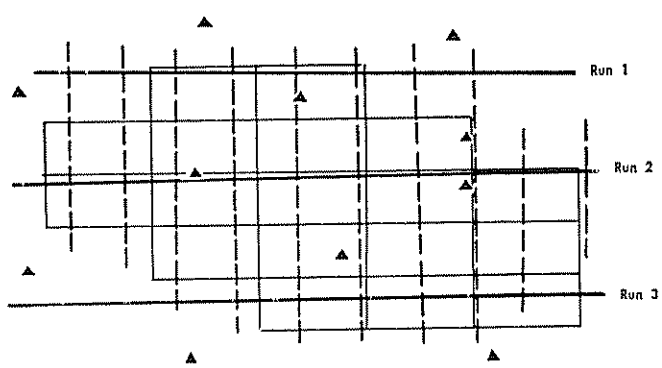
In examining the problem of vertical accuracy, a completely different approach is necessary. While an engineer is usually more concerned with the accuracy of measured distances than about position on the earth's surface, he will generally require a reasonable degree of absolute accuracy with contours. It is seldom the case that sufficient absolute accuracy is obtained by using adjusted elevations from high-level photography, even though more than the minimum were provided to ensure correct orientation and best mean fit. It may be necessary, therefore, for sufficient vertical control to be established to suit the requirements of the large-scale runs. Vertical control can be more easily established than horizontal control, and is less costly.

However, one approach which may be able to overcome the problem is to triangulate the low-altitude runs as well as the high-level flights. The vertical adjustment of the whole strip to give the best results on all the tie points could mean that a suitable degree of absolute accuracy was obtained. Furthermore, a very strong relative position between points would thus be established, and a horizontal adjustment to obtain the best over-all fit to the tie points should give quite an accurate answer. A least-squares adjustment would, of course, give the best results. Refinements such as the weighting of tie points based on the ease of identification would further control the errors.

There is no doubt that further variations of this technique are possible to meet particular circumstances and requirements.

Readers will, of course, be interested in the application of the technique and whether the analysis outlined is verified in practice.

Of the two projects undertaken in recent times, the most challenging from the point of view of horizontal accuracy is the compilation of 1:4,000 basic cadastral sheets in the Newcastle area. A large number of detail and topographical maps at various accuracies and scales, produced by a large number of organizations, existed over the area. It was considered that basic cadastral maps at a suitable scale should be produced to act as a base for all these maps. The use of the technique to compile the framework for the full cadastre was a major challenge, as it was realized that extra care would have to be taken.



Australia: Relationship of two sets of photography

The relationship of the two sets of photography as seen in the figure shows that the area is covered by three runs each of eleven pairs of high-altitude photography. This was flown with a Wild RC5A from 16,000 ft, using a lens of 115 mm focal length. Sixty-six low level photographs were flown from 5,900 ft with the same camera and lens cone to cover the area. The figure also shows the control available of which only four points were not targeted.

In view of the development of the area and the large number of identifiable cultural features, tie points were selected during triangulation with a brief description, and in some cases a location sketch. Triangulation of the high-level flights was carried out on a Wild A5 autograph and the Zarzycki method of adjustment was applied.

The following results were obtained after adjustment:

Mean square error of differences on tie points between runs:

$x = 1.44$ yards (0.028 mm at photo scale);
$y = 0.95$ yards (0.019 mm at photo scale).

Mean square error on control:

$x = 1.19$ yards (0.024 mm at photo scale);
$y = 1.03$ yards (0.020 mm at photo scale).

For the large-scale plotting of the area, approximately 230 special tie points were selected. Plotting was done on a Wild A8 stereoplotter with a model scale of 1:8,000 and a map scale of 1:4,000.

In setting up the large-scale models, some residuals on tie points were to be expected. Although 10 per cent of the mapping has yet to be completed, the accuracy of the results so far have exceeded expectations. The mean square error of the residuals is ± 0.3 mm at map scale, representing ± 1.3 yards. It would seem that the relative accuracy obtained is as good as the absolute accuracy of the high-altitude flight.

All horizontal control was targeted. It can be seen that only a single high-altitude run of nineteen pairs is involved, with eleven horizontal control points available for adjustment. Triangulation and adjustment were carried out in the same manner as the first project, although the method of selection of tie points was somewhat different. Over most of the area, the points were identified during triangulation. However, parts of the area were undeveloped and fairly heavily timbered. In such areas, tie points were selected and pricked on each set of photography by separate stereoscopic inspection of the two sets. Because of the great difficulty of establishing accurate transfer, as many as eight points were selected for each large-scale model. The difficulty of transfer was further increased by the fact that most of the low-altitude photography was taken at mid-morning, while the high-altitude was taken early in the afternoon, giving different orientations for tree shadows.

With regard to vertical accuracy, it was realized that reliable contours at 10 ft intervals could not be obtained using elevations from the high-altitude run. The large-scale models were therefore controlled for height with four field points per model.

Since the mapping of the area is not complete, a full analysis of the results is not available. However, the results so far appear satisfactory, although not quite as good as on the Newcastle project. The absolute accuracy of the adjustment of the high-altitude run cannot be fully established, since all control was used. With respect to relative accuracy, it has been established that, over the developed areas, residuals on tie points after orientation were in the order of 0.5 mm. Larger residuals were experienced in the timbered areas, with a few cases of residuals greater than 1 mm.

In spite of this, it is felt that sufficient accuracy has been obtained to meet the requirements of the project, emphasizing that these residuals are not a direct indication of the accuracy of the mapping, but a measure of the magnitude of the random errors on the tie points.

The division has not yet seriously considered the use of elevations from high-altitude photographs for large-scale mapping, although it is hoped that tests will be made in the future. Certainly the technique will continue to be applied with suitable projects, and, as greater experience and understanding of the advantages and limitations is obtained, eventually develop into a standard procedure.

PREPARATION OF TOPOGRAPHIC PLANS FOR LARGE-SCALE DEVELOPMENT PROJECTS AND THEIR USE AS PROVISIONAL MAPS

Paper presented by the Federal Republic of Germany[1]

In order to prepare topographic plans from aerial photographs, we have performed test plottings dealing with the application of direct coat scribing. These scribing tests were concerned mainly with the plotting scales of 1:25,000 and 1:50,000 as the copies obtained by reproduction of the conventional pencil manuscripts did not reflect the clarity of the original plottings and therefore necessitated expensive complementary work. By direct coat scribing, however, plotting originals may be obtained from which perfectly legible copies may be prepared by means of contact processing.

The application of direct coat scribing for the preparation of topographic plans may become particularly important for developing countries which rarely possess adequate documents for planning and development purposes in the various fields. Therefore it is suggested that, in the case of large-scale development projects, the initial emphasis should be exclusively on the preparation of topographic plans by direct coat scribing. Such plans are of high quality, and the low cost of their production is of decisive importance for their use in developing countries. The plans are prepared by means of photogrammetric survey and plotting only, without subsequent cartographic treatment of the plotted manuscripts; consequently no experienced cartographic personnel is required at first. A few days after the completion of the plottings, it is possible to distribute the plans to the planning engineers and to all institutions participating in the development projects of the country concerned. It is well known that cartographic operations for the preparation of printing plates for the reproduction of a topographic map at 1:25,000 are far more expensive than the preparation of a plotting manuscript by photogrammetric survey. The time required for the preparation of topographic plans by direct coat scribing is some 10 to 15 per cent longer than that required for the preparation

[1] The original text of this paper, prepared by H. Kretzchman, Institute of Applied Geodesy, Frankfurt, appeared as E/CONF.52/L.82.

of pencil manuscripts. These topographic stereoplots like all photogrammetric plotting manuscripts are incomplete from the cartographer's viewpoint and may contain mistakes due to misinterpretation of the aerial photographs. However, we are of the opinion that local reconnaissance for the purpose of correcting and supplementing the stereoplots is decidedly uneconomical and indeed superfluous at first. Only within the framework of special, detailed development operations or some other purpose for these topographic plans in developing areas would it be necessary to gather all data needed for subsequent map production. For the time being, a cartographic treatment of the topographic plans is required neither for planning work nor for the execution of development projects. It should be performed at a later date, when, *inter alia*, skilled staff and sufficient financial means are available.

Depending on the dimensions of the region to be developed, the topographic plans should have a scale suitable for the execution of various preparatory planning and development operations; the scale should also be such as to make it possible to represent and evaluate large areas as a whole. For this purpose, the scales of 1:25,000 and 1:50,000 are particularly suitable. So that the plans should be easy to read and thus of the most far-reaching utility, they should additionally be provided with coloured overprints for woodland, meadows and hydrography. They should furthermore have uniform sheet lines, a uniform grid, and a sheet identification or sheet number. Finally, a legend should give information on all symbols and colours used, which should be standardized on all plans as far as possible. Plans prepared in such a manner will for many years be a sufficient basis for all planning and construction activities occurring in developing countries. They should therefore be designated as provisional editions of maps.

All stereoplotters equipped with spindle-drive and plotting table are suitable for plotting by direct coat scribing. Plastic foils covered with a scribing coat serve as drawing bases, on which the plottings are scribed by means of a steel scriber. A colourless and transparent intermediate coat applied between coat base and scribe coat prevents the scribed features from being affected by remaining particles of the scribe coat. In order to scribe different line weights, steel scribers are used with points of different width. Lines which have been scribed incorrectly by the operator can be opaqued by corrective varnish and scribed anew. Coated foils should be used within approximately half a year. On separate coated foils, we prepare one scribed stereoplot each of culture, hydrography and contour lines, which are subsequently combined for the production of a topographic plan in three colours. A grid, also scribed on the plotting table, can be superimposed on the topographic plan in a fourth colour. Before copies are prepared, the coating within the symbols whose outlines have been scribed on the culture foil is removed with a scraper, so that the symbols are represented on the printed copy in the usual way. Contour line numbers and spot elevation numbers are added on the scribed stereoplots either manually by a scriber, or they are printed on thin film, as is the case with lettering and often with symbols of topographic plans too; the film is then pasted on the positive obtained from the scribed originals. The copies required for the coloured overprints for vegetation, hydrography etc. are prepared from the corresponding film diapositives and negatives by simple retouching.

The two test sheets described below, chosen from areas at different stages of development, show the results of direct coat scribing, as well as the possibilities of presenting and arranging topographic plans.

The topographic plan at 1:25,000, based on aerial photographs at 1:38,000,* was compiled from four single scribed stereoplots, making possible the coloured representation of culture (black), hydrography (blue), contour lines (brown), and grid (grey).

The black lines—scribed in different line weights—indicate roads (thick lines), paths (medium dashed lines) and boundaries of cultivated farmland with dry ditches and dikes (thin lines). Water features, with the exception of water reservoirs (blue tint), are represented by thin dashed lines as they are only seasonal (rainy season). Contour lines are scribed in two different line weights (50 m contours are represented by thick lines, all other contours by thin lines); 5 m contours by long-dashed, 2.5 m contours by short-dashed lines. For special studies, contour lines have been scribed without particular difficulties at 1.25 m intervals (lines with shorter dashes) for insignificantly inclined regions of cultivated farmland. Contour line numbers and spot heights are printed; symbols for vegetation and desert areas are scribed manually.

The topographic plan at 1:25,000, based on aerial photographs at 1:22,000,* was prepared from one scribed stereoplot each of culture (black), hydrography (blue), contour lines (brown), grid (grey), supplemented by three coloured overprints for woodland (dark-green), meadows (light green), water tint (light blue); all areas without coloured overprint (white) are in this case cultivated farmland. For the scribing of roads and tracks, three different line weights were used according to their classification as primary roads, secondary roads and field and forest tracks. Footpaths are shown as dashed lines. Railroad lines and dual highways are represented by double lines, the railroad lines being additionally marked by a manually drawn symbol. For high-tension power lines, the poles were first plotted, then connected manually. Symbols for wooded areas and meadows are superfluous with coloured overprints. For the representation of dikes, cuts, embankments, marshland etc., the conventional symbols have been used.

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* See pocket at end of volume.

LARGE-SCALE SURVEYS IN THE UNION OF SOVIET SOCIALIST REPUBLICS

Paper presented by the Union of Soviet Socialist Republics[1]

In the USSR, topographical surveys at 1:5,000 and larger scales are carried out for separate parts of the national territory in connexion with the current needs of the national economy; for instance, detailed geological surveys are made of a selected area, or preliminary investigations are carried out for some construction project.

A considerable part of the large-scale surveys very soon became obsolete; therefore it is inadvisable to demand a uniform degree of accuracy of all of them. It is more advantageous, both from the point of view of economic efficiency and from the point of view of speeding up the work, to execute such surveys with no more than the accuracy needed for the work in question. For instance, surveys executed for irrigation or improvement require a relatively high accuracy in the representation of topography and detail (contour interval 0.1 m and 0.5 m), whereas planimetry may be surveyed with much lower accuracy. Again, urban surveys make more stringent claims on accuracy in the planimetry shown on a topographic map.

At the same time, the tolerances should not be such as to render impossible utilization of a large-scale survey for the compilation of topographic maps of smaller scales, such as 1:10,000, corresponding to standard requirements of accuracy.

In the USSR, accuracy requirements for topographic maps at scales ranging from 1:10,000 to 1:100,000 have been standardized. The accepted errors must not exceed:

In planimetry: mean error 0.5 m, maximum admissible error 1.0 m in flat country; and 0.75 m and 1.5 m in mountains (at the scale of the map);

Errors of spot heights plotted on the map must not exceed 1/3 contour interval in flat and rugged country, and 1/2 contour interval in mountains.

Where a large-scale representation is required for some work, but without a corresponding increase in accuracy, it is permissible to compile plans at a larger scale. As regards accuracy, such plans will satisfy the standards accepted for a smaller-scale survey; thus, for instance, a plan at 1:2,000 will be compiled with an accuracy corresponding to a survey at 1:5,000.

Experimental work on large-scale stereotopographic surveying has shown considerable advantages in stereotopographic surveying as compared with ground-survey methods. A great volume of engineering surveys at scales 1:5,000 and 1:2,000 has been done by a number of USSR agencies, using stereotopographic methods. The scales of photography and the aerial surveying cameras used are shown below.

Table 1. Scales and cameras used in stereographic surveying

Scale of plan	*Contour interval (m)*	*Focal distance AFA (f in mm)*	*Scale of photography*
1:5,000	2	100	1:7,500
1:5,000	1	70	1:10,000–1:5,000
1:2,000	1	100	1:3,500–1:4,000
1:2,000	0.5	70	1:3,500–1:4,000

In certain cases, mosaics were obtained by means of special aerial surveys executed with aerial cameras of a narrower angle (f = 200 or 350 mm) than was strictly necessary for stereoscopic plotting of relief (topography). In most cases, the scale of photography chosen was between 1½ and 2 times smaller than the scale of the plan under compilation. Field control points were distributed in pairs at intervals of two to three bases in the direction of flight. In some cases, the available data of smaller scale surveys have been used. For instance, plotting of photo-plans at 1:5,000 was done from aerial photographs at 1:15,000 to 1:17,000, and aerial photographs at 1:5,000 to 1:7,500 were utilized to construct plans at 1:2,000. In these cases, each photograph had been provided, as a rule, with no fewer than four (and in most cases five) geodetic fixed points.

According to available control data, the accuracy of mosaics in planimetry is characterized by a mean square error ±0.25–0.30 mm for image magnification up to 2.0×, and 0.35–0.40 mm for 2.5–4.0×.

When aerial photography is taken to obtain large-scale plans of populated centres, and there is a large quantity of green vegetation and dense shadow that obscure a considerable part of the ground surface, then as much as 30 to 40 per cent of the features to be surveyed are not represented on the aerial pictures. Therefore aerial survey of populated centres, and more especially of those characterized by large built-up areas, is now executed during the morning or evening hours, when the shadows are more transparent, or in diffused light in cloudy weather. Photography of large green plantations is carried out in spring or autumn when the trees are leafless.

In 1965–1966, the Central Scientific Research Institute of Geodesy, Aerial Surveying and Cartography conducted several investigations of accuracy of measurement of height points in universal stereo-plotters from single models; the said investigations were undertaken with the aim of choosing optimal scales for large-scale surveys. The following table gives a comparison of photogrammetric heights of points (unmarked) obtained from aerial pictures taken with an aerial camera of *f* = 70 mm, with corresponding heights of geodetic points.

Table 2. Relative photogrammetric heights

Scale of photography	*Number of stereo pairs*	*Number of control points*	*Mean square error (m)*	*Maximum error (m)*
1:20,000	3	143	±0.29	0.74
1:15,000	18	464	±0.26	0.71
1:10,000	20	497	±0.21	0.60
1: 5,000	18	359	±0.13	0.38

The figures given above show that, using super-wide-angle cameras, it is possible to obtain spot-heights on the ground and to plot the contours with sufficient accuracy. Therefore it is planned, at present, to increase the volume of stereotopographic large-scale work, especially in flat regions. It would not be expedient to use too large scales of photography, as the relative height errors increase proportionately to the scale of photography. The causes are errors of identification of points on the ground and on

[1] The original text of this paper, prepared by the Department of Geodesy and Cartography of the USSR Ministry of Geology, appeared as document E/CONF.52/L.101

the picture, the natural roughness of the ground surface, increased blurring of the image, etc.

Experimental work at the institute has shown, for instance, that the relative accuracy of pointing on a stereo-model decreases as the scale of photography increases, especially if the scale of photography is larger than 1:8,000. Therefore, the optimal scale of photography for a stereo-topographic survey in flat areas at scales 1:5,000 and 1:2,000 (with contour interval 0.5 m) will apparently be 1:6,000–1:8,000 (AFA, f = 70 mm).

Where a 1 m contour interval has been chosen, and plotting is done at 1:2,000, the scale of photography may be 1:8,000 with f = 70 mm and f = 100 mm; for plotting at 1:5,000, the scales of photography may be 1:10,000 (f = 70 mm) and 1:8,000 to 1:10,000 (f = 100 mm).

Plotting from surveys of built-up areas must be executed in accordance with the type of building and topography of the area. If the building pattern is complicated, then it will always be preferable to have photo-plans, as that essentially simplifies the plotting of planimetry. Construction of photo-plans is sometimes conveniently done with the help of an additional aerial survey executed with a narrow-angle camera.

In large-scales surveys, problems of photogrammetric control extension are of considerable importance. At the present time, surveys at 1:25,000 are executed, with wide application of photogrammetric control extension, in universal plotters, or by the method of analytical photo triangulation; thanks to the utilization of statoscope data for levelling stereomodels along the strip, both the horizontal and height control points are, as a rule, determined at 6–10 models intervals. However, for small contour intervals the statoscope indications are not sufficiently accurate.

Therefore, for plotting with contour intervals 0.5 m and 1.0 m, it is intended to adopt photogrammetric height control extension solely for the insertion of single points. At the same time, photogrammetric horizontal control extension will be applied, in full measure, by analytical methods or in universal plotters, the intervals between geodetic control points being every six to eight stereo models.

At the present time, it is intended to provide geodetic height control for each section consisting of three to four stereo-pairs when plotting is executed with a 2 m contour interval and for each section consisting of four to six stereo-pairs when plotting is done with a 5 m contour interval.

For plotting at 1:2,000 with a contour interval of 2 m, it is preferable to take photography with an aerial camera of f = 140 at the scale 1:8,000; plotting at 1:5,000 with the same contour interval, as indicated above, should be done from aerial photographs 1:15,000 to 1:19,000, taken with an aerial camera of f = 100 mm or 70 mm. If the contour interval is 5 m (scale of the map = 1:5,000), then the aerial survey should be executed at a scale of about 1:18,000, with cameras of f = 100 or 140 mm. Geodetic plane control points may then be spaced every six stereo models as in a flat-country survey.

In mountains and alpine regions, large-scale work is executed by photo-theodolite surveying, or combining photo-theodolite and aerial surveying. The area under survey is photographed with a photo-theodolite from some medium-height summit providing a wide view of the terrain. Pictures obtained with a photo-theodolite are subsequently plotted in a stereo-autograph, so that not only planimetry and contours are plotted, but at the same time control points are determined for orientation of photographs. All the details that cannot be plotted from photo-theodolite survey are then filled in from aerial pictures. Aerial pictures may also be utilized, if necessary, to extend the net of control points by means of a spatial photo-triangulaton net consisting of from two to five models. This combination of aerial surveying with ground photo-theodolite survey achieves considerable economy of time and costs, for the following reasons:

There is no need to apply ground methods to survey "dead zones", which may constitute up to 10 to 15 per cent of conventional photo-theodolite surveying;

The volume of field work is considerably reduced (by not less than 40 to 50 per cent as compared with a conventional photo-theodolite survey);

The image quality on the topographic map is improved because it is much easier to make measurements of steep slopes on photo-theodolite pictures; at the same time mapping of relatively flat areas is more conveniently done from aerial photographs.

The greater economic efficiency of large-scale surveying, a number of measures must be taken.

First, it is necessary to improve the quality of aerial pictures as regards both their geometrical and their photographical properties.

Secondly, methods of plotting and adjusting spatial photogrammetric nets must be improved in such a way that the amount of necessary geodetic control may be reduced and geodesists released from the obligation of adhering to rigid schemes of control points location. The methods now available cannot provide a fully satisfactory solution of this problem. Here, principal attention should be directed towards a further development of analytical methods of plotting and adjusting blocks of spatial phototriangulation.

A further improvement of stereo-photogrammetric devices is necessary to ensure higher labour productivity and better accuracy of obtained results. What is of great importance here is the possibility of obtaining a larger degree of magnification of the image on the plan as compared with the scale of aerial pictures; automatic control of systematic errors of photographs; design and construction of devices for differential restitution. The last-mentioned point is of special importance in surveying built-up areas and areas where complex engineering investigations are carried out, as the photo-image contains, as a rule, more information about the topography than can be derived from a corresponding topographical map.

PHOTOGRAMMETRIC CONTOURING FROM AERIAL COLOUR PHOTOGRAPHS

Paper presented by Switzerland[1]

Introduction

After a lengthy interruption, aerial colour photographs were taken in 1964. The purpose was to compare the performance of Kodak ektachrome, false colour and panchromatic Cronar films. The experiments, in which several interested parties participated, including the Swiss Federal Topographic Service, had the following aims:

To gather new information and experience in the taking and processing of aerial colour films;

To find out whether it was possible to produce from the original photograph duplicates on film or glass, colour paper prints and enlargements with existing laboratory equipment;

To assess the quality of the photographs as regards contrast range, sharpness, colour rendition, brilliance, resolving power, etc.;

To determine the suitability of colour photographs for vegetational and glaciological studies as well as for forestry investigations.

The results turned out to be so satisfactory that a continuation of the experiments in 1965 could be considered: an investigation into the possibility of plotting colour films directly in the autograph.

Purpose and objectives

The objectives of the experiments were the following:

To expose and plot commercially available (Kodak) aerial colour films;

To test photogrammetrically plotted contours by visual comparison with contours obtained in plane-table surveys;

To represent contour accuracy and quality pictorially through the standard position error band M_L, in accordance with the tolerance standards of the Swiss general cadastral map 1:10,000 (the theoretical development of this process is treated by E. Imhof in his book, *Kartographische Geländedarstellung* (Cartographic Terrain Representation), p. 37, para. 7);

To carry out contour plotting at the scale of 1:10,000 by direct scribing on coated glass plates.

Source material

As source material, a general plan at 1:5,000 of the Swiss Cadastral Survey was used. This plan had been established in 1928 by a private surveyor, and was verified by the Swiss Federal Topographic Service as conforming with the following tolerance standards:

For position of contours:

$$m_L = \pm (3 + \cot \alpha) \text{ m}$$

For elevation of contours:

$$m_L = \pm (1 + 3 \tan \alpha) \text{ m}$$

Here α represents the terrain slope.

In flat terrain with gradients of less than 5 per cent, a positional error of the contours of up to $\pm$ 30 m will be tolerated.

According to the verification report, the general plan at 1:5,000 used in this comparison represents a most meticulous survey in every respect. The standard error of the contours amounts to 32 per cent of the tolerance [$\pm (1 + 3 \tan \alpha)$], computed from 170 check measurements taken from fourteen stations.

Choice of area

The test area chosen is a terrain of approximately 100 hectares in area, approximately 1,000 m (3,000 ft) above sea level, located between Appenzell and Gais. Topographically this is a hilly and only slightly wooded old moraine region at the foot of the Alps. The greatest elevation differences are around 100 m (300 ft). Terrain gradients range from 5 to 40 per cent.

Flight and photographic data

Photography

Because of continually poor weather, the photographic mission could not be carried out as planned in the month of July, but only on 12 October 1965.

Because of ground fog and strong haze during most of the day, only the time between 15.00 and 17.00 hrs was available for photography—a rather unfavourable time of day and season for colour photography with its well-known narrow exposure latitude.

Aircraft

For the mission, the Twin Pioneer of the Swiss Federal Directorate of Cadastral Surveys was used; this high-wing twin is equipped with two camera ports, permitting the simultaneous installation of two air survey cameras.

Photographic cameras

To permit the taking of the required photographs under identical meteorological conditions and at the same time, two cameras were installed in the aircraft: a Wild RC5a and a Wild RC8. The cameras were synchronized for simultaneous release and both were equipped with Universal-Aviogon objectives (UAg) $f = 152$ mm, picture size 9 × 9 inches.

Films

In order to obtain as many photographs as possible for comparison, the following film material was exposed: Kodak ektachrome aerial film process E3; Kodak special-ektacolor aerial safety film; Du Pont Cronar aerial safety film, type 136, rapid processing, panchromatic.

Table 1. Shutter speeds, diaphragm apertures and filters

Film type	*Shutter speed (seconds)*	*Diaphragm aperture*	*Filter*
Ektachrome reversal colour film	1/175	f/5.6	Sandwich AV 2.2 plus CC 05 Y
Ektacolor negative colour film	1/250	f/6.8	Sandwich AV 2.2
Cronar panchromatic film	1/175	f/5.6	500 mμ

[1] The original text of this paper, prepared by J. Denzler, Swiss Federal Topographical Service, appeared as document E/CONF.52/L.119.

Flying height, picture scale, longitudinal overlap, and base height ratio

The photographs were taken at a flying height of approximately 2,100 m (7,000 ft) above ground. The picture scale was approximately 1:14,000; the longitudinal overlap, 70 per cent; the base/height ratio, approximately 1:2.

Meteorological conditions

Light cumulus clouds were forming; there was a strong haze; the horizontal visibility was 10 to 15 km. In addition, there was a paucity of light and a preponderance of long shadows due to the adverse season and hour of day.

Development

The exposed films were developed in the photographic laboratories of the Swiss Federal Topographic Service. Since the photographic mission was flown under unfavourable light conditions, under-exposed photographs were to be expected. With black and white photography it is easy to exert a corrective influence on under-exposed pictures during development, but that is not so with colour photographs. These must be processed with the greatest care and precisely in accordance with manufacturer's instructions if the best results are to be obtained. In spite of these difficulties, the material appeared to be suitable for plotting.

General observations on plotting results

Plotting was done in the Wild A7 autograph. Every picture pair was plotted twice: one plot was done with 8.5 × eyepieces, the other with eyepieces of 10 × magnification. With the under-exposed colour photographs at our disposal, we were hopeful that the choice of the weaker magnification would result in an improved stereoscopic impression. Touching-down of the floating mark seemed to be surer than with the 10 × enlargement, where the apparently coarser grain of the emulsion was in itself a handicap. Even before discussing the evaluation of the individual plottings, it can be said that the results failed to show a proportionate improvement.

For absolute orientation of the models, no targeted points were available. The photogrammetric models were fitted into the general map or plane-table sheet. Of the six trigonometric points partly located in the test area or in its vicinity, and whose position could be determined from the records, the residual error in elevation amounted to a maximum of ± 0.4 m; in horizontal position, referred to planimetric detail (roof-tops, house corners, road intersections, etc.), $\pm 1/10$ mm at map scale.

Contouring was rather difficult, especially on the southern hillsides (sunny slopes without details: dull and spongy image).

Plotting of colour photographs leads to eye fatigue sooner than black-and-white pictures; this is probably caused by the increased frequency of change from dark to bright multicoloured areas within a stereogram throughout the plotting process. In the author's opinion, this is a matter of habit.

When the pictures were centred on the picture-carriers on the lightbox, the colour films (with the exception of the prints) were found to be practically free from shrinkage.

Evaluation of the individual plottings by visual comparison

General

The plotted contours are characterized, on steep slopes as well as in flat terrain, by satisfactory-to-good planimetric correspondence with the contours of the general map. They are, however, even more detailed and thus represent the terrain with greater fidelity as to its shape and geomorphological characteristics.

Exceeding of tolerances is encountered in nearly all plottings in the same places, but not at the same magnitude.

In plotting from the prints, an additional and more pronounced exceeding of the tolerance becomes evident, especially in the flat portions of the terrain.

In table 2, the exceeded tolerances are shown by areas.

Table 2. Areas outside the planimetric error band*
(in m^2)

Ektacolor	*Cronar*	*Ektachrome*	*Print*
82.26	137.86	357.36	479.06

* Determined by planimeter measurements in plottings made with 10 × eyepieces.

There is practically no difference in exceeded tolerances between the plottings made with 10 × eyepieces and those made with 8.5 × magnification; the sum of the error areas is approximately equal.

The presumed causes of exceeded tolerances are the following:

Small horizon differences with respect to the plane-table survey;

Influence of grass cover;

Man-made terrain changes after completion of the plane-table surveys, due to road building (cut and fill etc.);

Suppression, for lack of sufficient surveyed points, of minor terrain form details in the general map;

Uncertainty in the plotting of contours about sudden changes of contrast or colour.

Subsequent field checks of the doubtful spots resulted, predictably, in most cases in the confirmation of the newly plotted contours.

The plottings satisfy the demands to be made on a general map at the scale of 1:10,000.

Had it been possible to take the photographs under more favourable meteorological conditions, the results would doubtlessly have been better.

Evaluation of contour plottings

Ektacolor (negative) film (comparison 1)

For the plotting of Ektacolor photographs, denser green filters were inserted in the filter holders of the picture illumination of the A7 autograph, and more powerful light bulbs were used. Thereby the colour negatives looked very much like black-and-white negatives; an operator accustomed to the plotting of black-and-white films will find this a great help in contouring. This procedure may well be taken as one of the reasons for the very close correspondence in horizontal position of the plotted contours with those of the general map. The "grain" is finer than that of the Ektachrome film, and the contrast with the print films is even more pronounced, but it is coarser than the grain of the Cronar film.

Ektachrome (positive) film (comparison 2)

Correspondence of horizontal position is better with 8.5 × than with 10 × magnification, especially in the flat portions. The "grain" is distinctly coarser than that of the Ektacolor or Cronar films.

Print (positive) film produced from Kodak Ektacolor film (comparison 3)

There is a marginal correspondence in horizontal position with the contours of the general map in both plottings, especially in the flat portions. The diapositives are dull and spongy. There is no comparison with those made from good Ektacolor film. Tolerances are exceeded far more frequently than with the Ektacolor, Ektachrome and Cronar plottings, especially in flat areas.

Cronar black-and-white negative film (comparison 4)

If the plotted curves are compared with those of the general map, a good correspondence in horizontal position is found, with the exception of some details not shown in the general map but which are actually there (as observed during a subsequent field check). The curves greatly resemble those plotted from the Ektacolor photographs.

EXAMINATION OF THE NATIONAL LARGE-SCALE MAP

Paper presented by Japan[1]

Introduction

Recently there has been great demand by the public for large-scale maps and aerial photographs. The major problem in meeting the large demand is how to maintain good quality maps within the cartographic agencies in Japan. Most of the maps made available are published by private firms and the quality of such maps varies considerably from firm to firm. Although the Geographical Survey Institute produces many large-scale maps and aerial photographs each year to meet demands, it is dependent upon private firms. The Institute is responsible for examining all the maps produced but, since production has been so great, only a sampling method, spot-checking the uniformity and standards of the maps, can be used.

Specifications for the national large-scale map

In 1961, in order to define the standards necessary for a national large-scale map, specifications were prepared for ground-control surveys, aerial photography, and compilation and preparation of maps. These are briefly outlined below.

Control survey

The control survey needed for the production of such a large-scale map would be at the fourth-order triangulation and the sides would have a length of about 1.5 km each, with an accuracy within 10 cm. The closures of the traverses should be less than 1:5,000. Instruments such as the Geodimeter and Tellurometer may be used.

Aerial photography

Aerial photography should be taken by using a wide-angle camera (size 23 cm × 23 cm; focal length 15.3 cm). The overlap and sidelap should be about 60 per cent to 30 per cent respectively. As a rule, the aerial photography should be at a scale of 1:20,000.

Large-scale maps

The scale of the maps is 1:5,000. The following is an outline of the specifications of the maps: size, 80 cm × 60 cm (or 4 km × 3 km); contour interval 5 m; planimetric precision, ± 0.7 mm (on the map); altimetric precision of contour lines, ± 1.0 m ∼ ± 1.5 m; minor controls less than 1.0 m.

The maps should be plotted by using the first-order or second-order plotting instrument and finally drawn on plastic sheets, shrinkage of which is less than 0.05 per cent under ordinary conditions.

There should be a sufficient number of ground control points for the orientation of the map models.

Examination

The maps produced by the various private firms are examined in conformity with the specifications. An example of how the examination of the large scale map and aerial photography is done is outlined below.

Examination of large-scale map

The sampling methods of checking on the precision of the map and its contents are examined by using random tables. Usually about 10 per cent of a group of maps is selected for such an examination.

The selected sheets are replotted to determine the map's precision, using first- and second-order instruments. The replotted sheets and original sheets are then compared for discrepancies.

Sampling inspection tables of the Japan Industrial Standards (JIS) are used. If the results of the selected sheets are unsatisfactory, the whole group must be checked again. In addition, the selected sheets are also examined by using aerial photographic enlargements and available field data. The errors found on these sheets are classified in three categories: heavy, median and light errors. Heavy errors, such as the omission of important planimetric features and poor matching of adjoining sheets, are not acceptable, even if only one such error is found. The omission of building symbols, errors of annotation or symbolization are considered as median errors and there are limits of allowance for such errors. If these limits are exceeded, then all sheets of the group must be examined. Since at times it is difficult to differentiate between a light and median error, such differentiation is left to the examiner.

Air-photo taking

Where aerial photographs are mainly used in the mapping process, it is very important to take into consideration the accuracy and quality of the photographs. At the present, we have no method of precisely examining photographic quality and we are now studying this problem, which proves to be very complicated and difficult, by using the densitometer. Photographs are being "eye balled" when examining haze or mist, shadows of clouds, snowfall, etc. Therefore, the sampling method for examining large-scale maps is not used. We use the readings printed on the photographs, which indicate records of altimeter, level of

[1] The original text of this paper, prepared by Seizo Kakishita, Geographical Survey Institute, Tokyo, appeared as document E/CONF.52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

camera, etc., to examine the geometrical quantity of the photographs, including inclination of camera, altitude of flight etc. We realize, of course, that readings of records attached on a camera may not be reliable because of the irregular acceleration of an aircraft. We also use inexpensive plotting instruments and are now in the process of constructing a simple instrument for this purpose. When the examination results are poor, we use the more sophisticated plotting instruments.

Precision of the national large-scale map

The following table briefly summarizes the precision of the national large-scale map.

Year	*Scale*	*Minor control (m)*	*Contour line (m)*	*Road railway (mm)*	*Vegetation boundary (mm)*	*Construction (mm)*
1964	1:2,500	± 0.60	± 0.64	± 0.52	± 0.49	± 0.73
1964	1:5,000	± 0.91	± 1.27	± 0.35	± 0.37	± 0.49
1965	1:5,000			± 0.33	± 0.34	± 0.50

Precision of large-scale map

The table shows standard deviations calculated by using the discrepancies mentioned in the previous paragraphs. In the case of minor controls, the values in the table exceed the limits of our standards, but all the others are sufficient for our requirements.

Recently, since levelling surveys are always carried out in densely-mapped areas, the altimetric precision of minor controls has been greatly improved. The results of field checking are not contained in the table.

Conclusion

We still have many technical problems to solve in the proper examination of maps. In addition, it must be pointed out that many times several examinations are not possible because of a huge backlog of work by many firms. Nevertheless, maps are being gradually improved by our examination. We are also studying the possibility of applying the sampling methods to the examination of control surveys. We also hope to apply this method to the examination of public surveys (cadastre).

NEW SPECIFICATIONS FOR 1:25,000 TOPOGRAPHIC MAP SERIES BY THE GEOGRAPHICAL SURVEY INSTITUTE

Paper presented by Japan[1]

In Japan, medium-scale topographic map series consist of sheets on the scale 1:25,000 and 1:50,000. The 1:25,000 map sheets cover the major lowlands of the country, while the sheets on the scale 1:50,000 cover the whole country. In 1964, the Geographical Survey Institute undertook a ten-year project to prepare new sheets on the scale 1:25,000 to cover the whole country. Photogrammetric methods are being used for this project. The old 1:50,000 map sheets are revised whenever the new 1:25,000 sheets are completed and published. A set of new specifications was prepared for this project so that the new 1:25,000 series would be suitable for general usage. Since this project is relatively new, the specifications are constantly reviewed and, where necessary, changes are made. The specifications of the older 1:50,000 series are also being revised closely, relating them to the 1:25,000 map series. In order to facilitate production procedures, the specifications of the new series were simplified as compared with previous specifications, and the number of map symbols were decreased in number; the details from field surveys necessary to complete the new series were considerably reduced; the line weight and the design of map symbols were simplified.

The legend and all pertinent result material for this map series will be sent to the Map Information Office in Bangkok, Thailand.

[1] The original text of this paper, prepared by Eiji Gojo, Geographical Survey Institute, appeared as document E/CONF.52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

MAPPING OF INTERNATIONAL BOUNDARY AREAS

Paper presented by Thailand[1]

Border mapping problems, particularly where long border lines are involved, can be quite difficult.

At previous conferences Thailand has asked for discussion and resolutions to resolve these problems. No solution to the problem has so far been found. It is proposed that all member countries at this conference should aim at a resolution that will enable countries with common borders freely to exchange technical data to assist in border mapping.

This paper is not intended to touch upon problems associated with the marking or delineation of border lines. The sole aim is to secure the inclusion of as much detail as possible in the map sheets on both sides of the border, perhaps with an understanding that specified detail in the neighbouring country's area be eliminated.

Consideration of this matter should take into account not only the military aspect but also developmental problems of the countries involved.

The following proposals are therefore submitted:

(1) That a method of reaching agreement between neighbouring countries be specified for each particular area to be mapped to facilitate exchange of maps and mapping data;

(2) That, if no agreement is reached as in (1), an alternative be found to facilitate such exchange of maps and mapping data.

It is stressed that the proposals as in (1) and (2) should not be restricted to the area along a specified "border strip"

[1] The original text of this paper appeared as document E/CONF.52/L.128.

but should cover the complete rectangles of each map sheet.

If agreements as in (1) or (2) are reached, consideration should be given to allow photographic flights from the neighbouring country beyond the specified "border strip" which will require clearance by the Governments concerned. To cover an area stipulated in an agreement, photographic aircraft must of necessity fly a little beyond its limits.

As for the problem of delineation of the border line upon the map when there is no reliable data for determination of the border or when no joint committee has been formed to clear the way for agreement on the map delineation of the border, it is recommended that a note such as: "The delineation of international boundaries on this map must not be considered as authoritative", should be printed on the margin of the map by the producing country.

It is further proposed that the lack of accurate information to permit exact delineation of a border on a map should not hold up the mapping of the border area, in view of the continuing need for maps to aid development.

The Thai delegation asks for earnest consideration of this problem at this conference and seeks knowledge from countries which have had experience in overcoming such problems.

(a) Control surveys;

(b) Preparation of basic topographic maps

EVALUATION OF STEREOMAT IV (AUTOMATIC STEREOPLOTTER)

Paper presented by the United States of America[1]

INTRODUCTION

During the early and middle 1950s, there were many rumours concerning the automation of the stereophotogrammetric compilation process. In fact, before it was commonly known that it could be accomplished, this electronic possibility had been discussed by Army Map Service (AMS) compilers. There was little time for the possibility to be ridiculed, for within a few years the mapping community became aware that the development of electronic correlation of photographic imagery was a reality.

Many papers have been written, published and presented describing the design of the various stereomat systems. This paper will concentrate on an operational test which was designed to determine the accuracy, reliability, speed of operation and limitations of the Stereomat IV, as incorporated in the Wild Aviograph B-8.

This presentation will be divided into three phases. The first will describe the background and previous investigation. The second will describe the equipment, modifications, test procedures and test results. The third will be an analysis of test results, the electronic engineers' contribution to the over-all operation, and the present use of the Stereomat IV in the production of orthophotographs. The paper will conclude by showing how this automatic process has the promise of easing and speeding the task of map compilation.

BACKGROUND AND PREVIOUS INVESTIGATION

The system of electronic correlation of similar photographic images was first demonstrated by G. L. Hobrough of Canada in 1958. This method was referred to as the "Auscor". The first photogrammetric compilation instrument to accommodate the new system was the Nistri photo-mapper, and this combination was designated as the Stereomat II. The instrument was designed with a single cathode ray tube (CRT) for scanning and two photomultipliers for the production of the electrical signals. This instrument was delivered to the United States Army Geodesy, Intelligence, Mapping Research and Development Agency (GIMRADA) for test and evaluation in April 1960. Upon completion of the acceptance testing, AMS personnel were given the opportunity to familiarize themselves and operationally evaluate the instrument.

The next development, the Stereomat III, was delivered to the AMS in March 1961 for test and evaluation. The instrument was basically the same as the Stereomat II, except for the addition of another CRT as a source of light for scanning. Instead of viewing the platen to check the instrument's floating mark, the operator viewed the stereomodel on the two CRT surfaces through a set of binoculars. Upon completion of the testing and evaluation of the Stereomat III in early 1964, it was concluded that the speed of automatic contouring was three times that of manual contouring with some reduction in accuracy and that the unit could contour slopes from 2 to 40 degrees and profile slopes up to 42 degrees. It was further concluded from the evaluation that the Stereomat III would have to produce more than contours automatically before it was suitable as a production instrument.

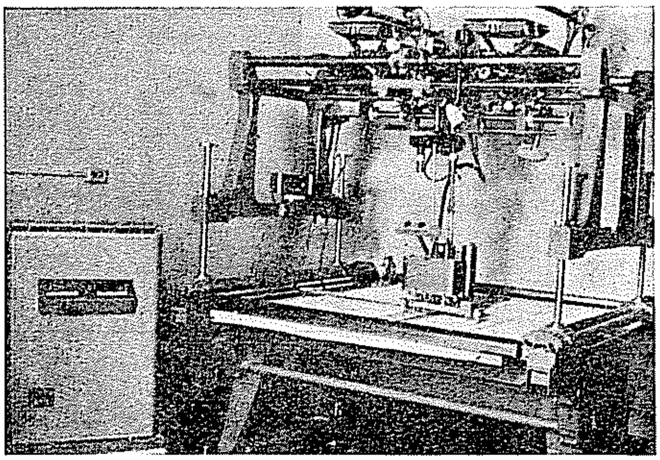

Fig. 1—United States of America: Stereomat III

[1] The original text of this paper, prepared by Charles H. Lawrence, Cartographer, United States Army Map Service, appeared as document E/CONF.52/L.21.

The Stereomat III was considered the forerunner of the Stereomat IV. The use of the two CRTs was necessary because of the proposal, at that time, to mount the stereomat system on a mechanical-projection-type plotting instrument. The 2-tube system also permitted changes in the shape of the scanning rasters for better correlation of slope detail. Since the Stereomat II did not possess this feature, it would only contour slopes up to 20 degrees. The mechanical projection instruments were used because of their inherent superior accuracy over the anaglyphic projection equipment, and because they could be easily modified for the additional capability of the orthophotoscope. Instrument designers were of the opinion that the system could be mounted on the first-order instruments; however, further study revealed that the mass to be moved on this equipment was too great for the electronic circuitry. A lighter, more compact instrument was chosen; the Wild Aviograph B-8. The new Stereomat was designed to produce an orthophotograph of the stereo-model. All other mapping detail, excluding contours, would be extracted from the orthophotograph. The Stereomat IV was delivered to the AMS for evaluation in March 1964.

EQUIPMENT, MODIFICATIONS, TEST PROCEDURES AND TEST RESULTS

The Stereomat IV is composed of two basic portions, the Wild B8 and the Orthophotoscope. The figure is a front view of the instrument. The important parts of the basic instrument marked on this figure, A_1 and A_2, are the cathode ray tubes; B_1 and B_2 are the photo-multipliers; C_1 is the tracing unit; D_1 is the Z counter system and the Y parallax indicator. E_1 contains the correlation circuitry with the instrument control panel. F_1 and F_2 are the plate-holders, with G being the viewing binoculars.

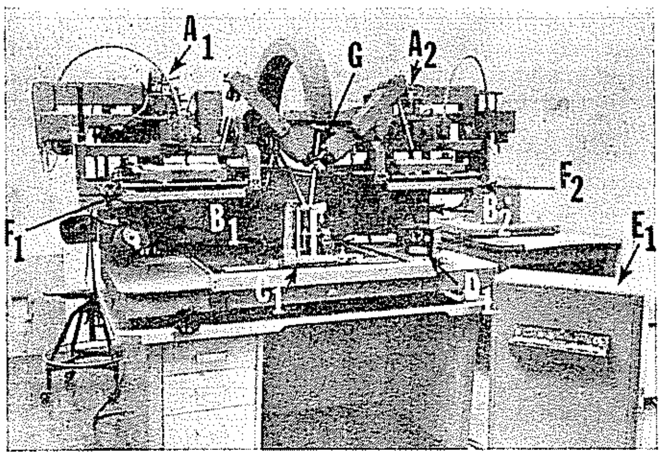

Fig. II—United States of America: Stereomat IV

The Orthophotoscope shown in figure III is located directly to the rear of the B8. It is mechanically linked to the B8 through wire banding with X and Y bars. These bars ensure that the CRT of the Orthophotoscope moves simultaneously with the tracing unit. A_1 shows the vacuum bell with the film cassette pulled forward ready to accept the film. The three switches visible in this slide are, left to right: the pump, vacuum and vacuum release. The film is held in place by a vacuum for the exposure of the orthophotograph.

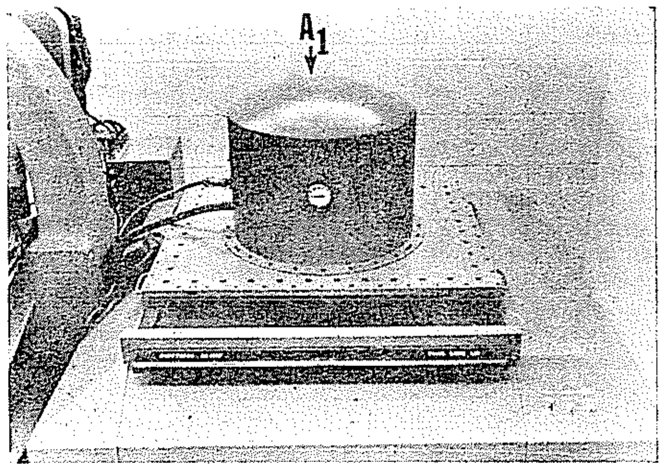

Fig. III—United States of America: Orthophotoscope

Figure IV shows the vacuum bell removed with the CRT and the exposing lens system.

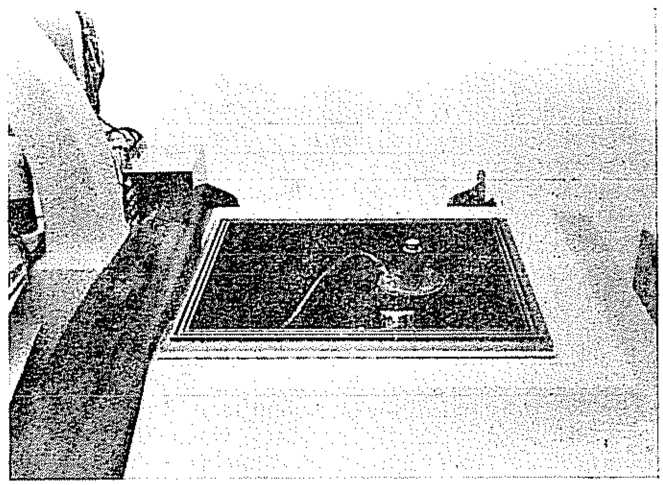

Fig. IV—United States of America: Orthophotoscope CRT

In the figure of the Stereomat IV the tracing unit is shown. A close-up of this unit is shown in figure V, below. The

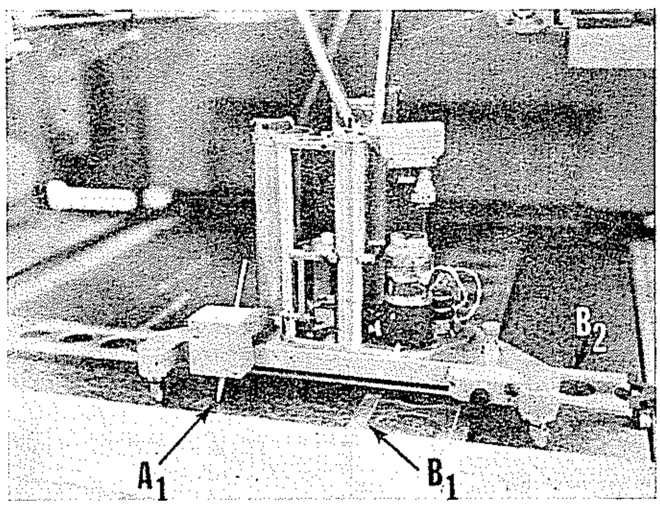

Fig. V—United States of America: Tracing unit tracing pencil (A_1) operates only when the correlation is within 20 microns. The X and Y bars can be seen (B_1,B_2). The Y bar is 74 inches long and runs from the front of the B8 to the end of the slate of the Orthophotoscope. It controls the X motion of the tracing unit and the CRT of the Orthophotoscope. The X bar shown is duplicated on the Orthophotoscope slate. These bars are 31 inches long. The steel drive tapes are driven by X-Y servo-motors which are contained in the Orthophotoscope unit. The servo-motor for the control of the Z counter is mounted on the tracing unit. This unit is the heart of the Stereomat IV operation.

The Z counter system is shown in figure VI. The counter can be read both to 0.1 inch and 0.1 mm. The knob's purpose is to make indexing changes on the counter. The

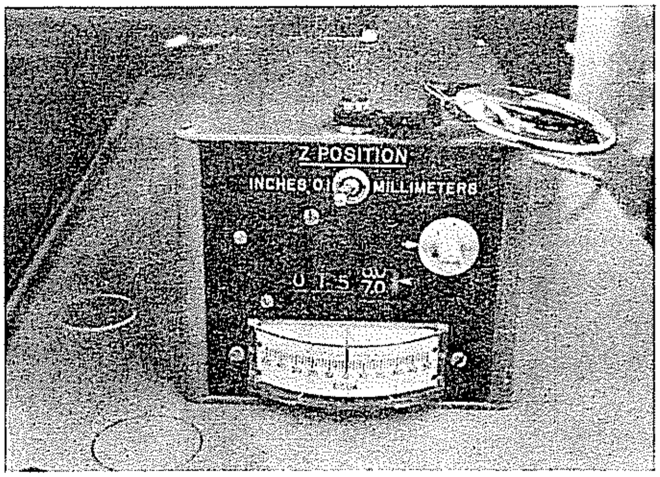

Fig. VI—United States of America: Z counter

meter in the lower part of the box is the Y parallax indicator, which is divided into 2 micron increments. The magnifying glass is used for operator assistance in reading the Z counter.

Figure VII shows the control panel for the operation of the Stereomat IV. The control panel is self-explanatory. The standby mode gives the operator freedom of manual movement when this becomes necessary. The manual mode allows the operator manual manipulation of the X and Y motions; however, the Z motion remains as an automatic electronic movement. The instrument has the capability of automatic profiling, contouring and relative

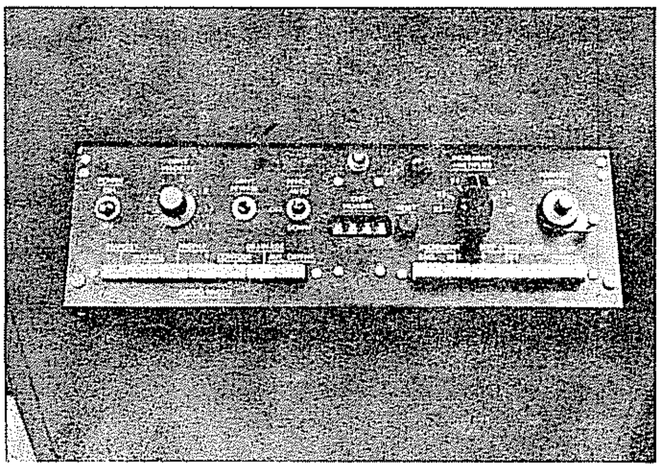

Fig. VII—United States of America: Control panel

orientation. The instrument was designed for the automatic tracing of drainage, but the Stereomat IV would not perform that task. The left side of the control panel shows that the instrument can operate in increments, for profiles or contours, of the English or metric systems. The step direction can be programmed to increase in direction or value for both the contours and profiles. This can also be accomplished with the step manual control. The position-adjust allows the operator to adjust his Z setting in the contouring mode, or the X or Y position in the profile step-over. The gear settings for contour intervals or profile settings are 0.125 or 0.25 mm. The profile spacings and contour intervals are multiples of these gears. The pencil can be programmed to be in contact with the drawing material continuously or it can be automatic so that it draws when the system is correlating. The drive reverse controls the direction of the profile or contour. These controls are quite simple and can be handled by a new operator with minimum explanation.

At this point, it would be appropriate to discuss the inputs and outputs of the system. The inputs to the instrument are: overlapping distortion-free glass positives; ground co-ordinates of three or more photo-identifiable points. The glass positives are preferred because of their stability. The outputs of the system are the contoured manuscripts and orthophotographs.

The instrument can be used in both the profiling and the contouring modes. Briefly, the operation is as follows: (*a*) interior orientation has to be accomplished manually; (*b*) relative orientation is automatic, semi-automatic or manual and (*c*) absolute orientation is manual. Once the orientation process is complete, the instrument is used automatically in either the contouring or the profiling mode, with a provision for manual override. In both the profiling and contouring modes, the operation is described as the translation of correlated photographic imagery to electrical signals. This is accomplished by scanning the images with rapidly moving, interrelated spots of light, produced on the face of each CRT. As this light passes through the overlapping input photographic imagery, photo-electric cells detect the changes of light intensity resulting from the image densities of the areas scanned. These changes of light intensities cause a variance of the electrical output of the photo-electric cells. When this operation is properly correlated, electrical signals are generated to drive the rotational and translational servos within the system. The orthophotograph is produced by reproducing the signal from the right photo-electric cell (facing the instrument) on the CRT in the orthophoto unit. The signals produce an image which has been completely corrected for scale and relief displacements through the profiling operation. As stated earlier, the CRT of the Orthophotoscope is tied mechanically to the X and Y position of the tracing unit. The Orthophotoscope exposes the area being scanned and viewed in the instrument proper.

The Stereomat IV was originally installed in Erskine Hall of the AMS. Preliminary testing indicated that the vibration of the building (fourth floor) was so severe that the instrument would not function. A vibration study was conducted of the AMS facilities and it was determined that the first floor of the Emory Building had the desirable stability. The instrument was dismantled, moved from Erskine Hall and reassembled in the Emory Building. The new location, however, was not ideal, for it was soon discovered that there existed an erratic temperature and humidity condition.

The pre-testing difficulties were numerous. The output of the CRTs appeared weak, so improved CRTs were installed in the system. This required different designs of electronic circuits, and some overhauling of the system for the acceptance of the new tubes. The metal bands controlling the X and Y bars broke quite frequently, causing further loss of time before the test proper could be initiated. As can be expected with any prototype instrumentation, these were the major problems. However, there were many other difficulties which caused numerous false starts of the project. Often considerable time was required to correct the operation of the instrument. This can be explained by the fact that 90 per cent of the failures were in the electronic field, and the AMS electronics personnel were not familiar with the prototype electronic designs. Furthermore, an adequate maintenance manual for their guidance did not exist. The AMS personnel did not start the actual evaluation until June 1965. Although the instrument operated fairly well during the testing, failures still plagued the operation and caused the original plan of test to be altered considerably.

The testing was accomplished in three parts. The first part consisted of the reading of grid models at the optimum, minimum and maximum projection distances (PD). Single terrain model orientations were planned for the second part of the evaluation. Reading difficulties and poor correlation confined the terrain model observations to the optimum PD. As the third part, four terrain models of varying terrain slopes and density were to be contoured and orthophotographed. The contoured manuscripts were to be compared with published maps of the area. The orthophotographs were to be carefully checked for positioning of map detail as well as the photographic quality of the exposures.

Before the initiation of the test, AMS testing personnel were faced with the problem of determining the proper *f*-stop settings for different exposures in the production of orthophotographs. Originally, it was planned to use the entire Orthophotoscope unit and make a series of different *f*-stop settings on a piece of film. However, after the exposure was completed, the film processing followed, and it was found that the processing required the minimum of eight hours. This was a serious time delay before orthophotographs could be exposed.

Figure VIII shows the top portion of the orthophotoscopic unit with the vacuum bell removed and a plywood board platform (A_1) holding a polaroid back (B_1). This platform was levelled and the surface of the polaroid face was set the same distance from the exposing lens as the vacuum frame. When the polaroid orthophoto unit was exposing, the black cloth (C) was pulled over the platform. This solved the processing time delay. Trial exposures could be made on the polaroid film to determine the best setting for the commercial sheet film. The minimum time delay of eight hours was reduced to a matter of minutes.

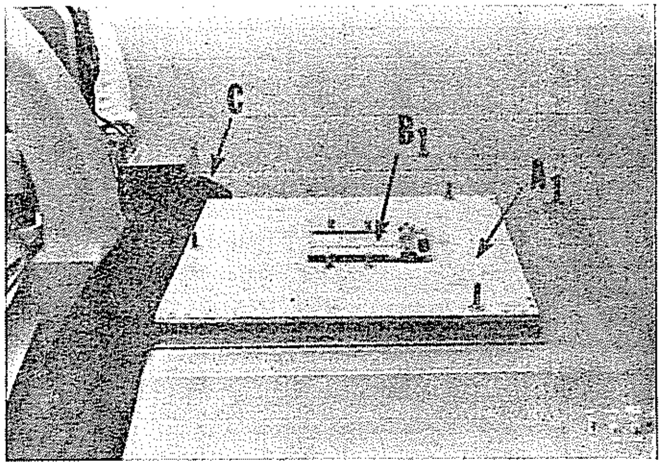

Fig. VIII—United States of America: Polaroid attachment

The vertical accuracy of the Stereomat IV was tested with a stereoscopic grid model. The grids used were Wild precision 240 × 240 mm with a 20 mm interval. The 23 point grid model was measured at the optimum (262 mm), maximum (311 mm) and minimum (213 mm) projection distances. The grids were absolutely oriented at a base-height ratio of 0.6. The orientations required 10 to 15 minutes to accomplish; they were repeated three consecutive times in both the manual and the automatic modes. The instrument failed to correlate in the automatic mode at the minimum PD, therefore no test data exist for this mode. The test results are shown in table 1. The average root mean square error (RMSE) accuracies manually were as follows: minimum PD 1:11,210; optimum PD 1:11,909; maximum PD 1:7,585. The average

Table 1. Grid accuracy (in mm)

Projection distance	*RMSE* *Manual*	*RMSE* *Automatic*	*RMSE/Projection distance* *Manual*	*RMSE/Projection distance* *Automatic*
213	±0.020	No correlation	1:16,650	No correlation
	±0.018	No correlation	1:11,833	No correlation
	±0.020	No correlation	1:10,650	No correlation
Average	±0.019		1:11,210	
262	±0.022	±0.012	1:11,909	1/21,833
	±0.023	±0.013	1:11,391	1/20,154
	±0.021	±0.013	1:12,476	1/20,154
Average	±0.022	±0.013	1:11,909	1/20,154
311	±0.048	±0.025	1:6,479	1/12,440
	±0.039	±0.034	1:7,974	1/9,147
	±0.037	±0.033	1:8,405	1/9,424
Average	±0.041	±0.031	1:7,585	1/10,032

RMSE's in the automatic mode were as follows: optimum PD 1:20,154 and maximum PD 1:10,032.

The revised plan of test specified that the terrain model flatness was to proceed in the same manner as the grid check. At the minimum PD, however, no correlation could be achieved and, at the maximum PD, correlation was difficult. The plan of test was further revised so that the terrain flatness tests were conducted at the optimum PD only. The first model was absolutely oriented to five control points, and 50 points within the model were read for elevation. The scale (1:13,500) was compatible with the optimum PD of 262 mm. When the first model was finished, it was disturbed and reoriented. All points within the model were read again. Each point was read three consecutive times, in the manual mode. This operation was repeated for three successsive orientations in both the manual and automatic modes. This same photography was used on the evaluation of the Stereomat III.

Since every model was absolutely oriented, a post adjustment was not considered necessary. The differences between the mean instrument elevations and the elevations of the panel points were recorded. These differences were used to determine the RMSE flatness in both the manual and automatic modes of operation. Table 2 shows these results. It should be noted that the manual operation recorded slightly less than the automatic; the manual RMSE was 1:4,946 of the altitude, compared to the 1:5,648 for the automatic.

Table 2. Terrain model accuracy (RMSE/altitude)

Orientation	*Manual*	*Automatic*
1	1:5917	1:5626
2	1:3030	1:6015
3	1:5891	1:5305
Average	1:4946	1:5648

The contour comparison test was conducted immediately following the terrain model flatness. There were four models altogether, absolutely oriented, contoured and then profiled for the exposure of the orthophotographs. The models had a wide variety of terrain conditions, as well as an acceptable production density range. The contour manuscripts of the models were compared with completed maps of the area. The stereomat manuscripts were reduced to the scale of the map for comparison purposes. Six arbitrary profiles were drawn through each contoured manuscript and the finished map sheet and comparisons were made wherever the contours of the manuscript crossed the profile. The number of points for comparison ranged from 352 to 481. The results of the contouring phase were not in agreement with the ability of the Stereomat IV to profile or read individual points. All the RMSEs, upon completion of the comparisons, were quite large.

The Orthophotoscope testing was conducted to determine the production speed, as well as the quality of an orthophotograph. As stated previously, the polaroid back was used to determine the proper speed and *f*-stop setting for the orthophotograph production. The average acceptable speed was determined to be 6 mm/sec for a satisfactory exposure. The *f*-stop setting was dependent upon the density of the plates. It was determined, through a series of test exposures with the polaroid and commercial film, that a conversion factor of 2 had to be applied to the *f*-stop when transferring from the polaroid to the 18 × 22 inch film used for the orthophoto negative. This size is specified in order to have a precise fit in the vacuum frame. If this size film is not used, the vacuum pressure decreases and a faulty orthophotograph is produced.

The time required to produce the test orthophotographs ranged from 1.7 to 2.6 hours with the average of 2.2 hours. The *f*-stop settings for the best exposures were from *f* 5.6 to *f* 11, with the majority of exposures at *f* 8. Random checks for comparison were made between the original photography and the orthophotograph. The deterioration of image quality of these models was determined to be a maximum of approximately 20 per cent. The photography used for this test had a maximum resolution of 26 lines/mm, and the loss of resolution reduced this to 21 lines/mm. Even with this degradation all the orthophotographs were of suitable quality, so that planimetric detail could be extracted without any difficulty. At the present time a separate project is being conducted involving the capability of the Stereomat IV for production of orthophotographs. Additional information will be available when this task is complete.

The Y parallax indicator of the Stereomats III and IV had never been correlated. In fact, the relationship of the scale of the meter and the actual amount of Y parallax in the model had not been determined. This was a phase incorporated in the final plan of test. A precision microcator was positioned on the drafting surface and placed in contact with the plate-holders. Minute changes were introduced in the tilt direction of an absolutely oriented model. These changes were recorded on both the microcator and the Y parallax indicator. This was repeated for positions throughout the model and it was determined that the value of each interval of the Y parallax indicator was 2 microns. These determinations concluded the formal testing for this evaluation.

Analysis of Test Results and Present Use of the Stereomat IV

During the evaluation, a great deal was learned concerning the operation of the Stereomat IV. The grid testing indicated that the best performance could be expected from the optimum projection distance. At the minimum PD, the operation of the instrument was so erratic that vertical readings could not be made. Improved operation was observed at maximum PD, but the constant oscillation made readings very difficult. The instrument operated properly at the optimum PD. It should be explained at this point that these operational problems at both the maximum and minimum PD were mechanical. The counter-weight was at the extreme lower and upper position of the Z column. In these positions it is difficult to operate the instrument manually. This indicates that the instrument will operate efficiently at the optimum PD with approximately ± 40 mm from the optimum of 262 mm. Because of the results of the grid test, an optimum acceptable plotting scale is 1.7 times the photographic scale. This test further indicated that at the optimum PD, with grids, approximately a 2× superior vertical accuracy could be achieved using the automatic mode over the manual.

This superior accuracy factor was not reflected in the terrain flatness portion of the investigation. The average RMSE flatness indicates that the automatic mode is superior to the manual mode. However, if the second orientation of the manual models had followed the RMSE pattern of the first and third orientations, the manual mode with the terrain model would have been superior or at least equal to the automatic mode. Since the difference is slight, it could be concluded from these results that the accuracy of the automatic and manual modes on the reading of individual Z observations in a single model is approximately equal. The vertical accuracy results of the Stereomat IV are superior to those of the Stereomat III by a factor of 2.3. The Stereomat III read the same model as had been used in the Stereomat IV model-flatness test. The automatic mode of the Stereomat IV is comparable to the AMS M-2 plotter which produced an RMSE flatness of 1:6,024 h with the same model as had been used in the Stereomats III and IV evaluations. This task has shown that the Wild B8 is a very fine compilation instrument and its modification to accommodate the stereomat system has not appreciably deteriorated its over-all accuracy.

The Stereomat IV was a disappointment in the contouring mode. In fact, on a comparative basis, the Stereomat III had a considerably smaller standard deviation, when compared to maps, than the IV. Also, with the III, the speed of contouring was faster and the necessity for human intervention was much less. The exact reasons for this superiority are not known. Two facts are known: the scan (size and shape) was optimized in the Stereomat III for the contouring mode; in the Stereomat IV, the scan pattern served several purposes: contouring, profiling, as well as part of the image transfer for the production of orthophotographs. If the same optimization could be designed for the IV in contouring as exists in the III, there is the possibility that the IV could out-perform or at least equal the III in the contouring mode. This has been suggested to the manufacturers of this system as a modification for the next prototype stereomat.

What position does the electronic engineer maintain in a mapping system composed of stereomats? He becomes an important individual because his knowledge and skills are needed to produce a cartographic product. The experienced cartographer is quite familiar with the mechanical adjustment of photogrammetric equipment; however, the addition of the electronic circuitry is a recent innovation, which requires the specialties of an electronic engineer. Therefore the operation, adjustment and maintenance of a system, such as the Stereomat IV is dependent upon the combined efforts of the electronics engineer and the cartographer. The cartographer describes to the electronic engineer that which is desirable in the operation of the equipment for the production of the final product; and the electronic engineer, in turn, either repairs, adjusts or redesigns the circuits to produce satisfactory results.

Modern technology has dictated to the cartographer that part of the map production which will be automated. The electronic correlation of photographic imagery is one step towards automating the compilation process. As a result, the Stereomat IV investigation has produced a working partnership between the electronic engineer and the cartographer.

As noted earlier in this paper, many months passed after the installation of equipment before the evaluation was started. A very high percentage of this period was spent in electronic repair and redesign of the circuitry. Even after the equipment was placed in operational condition, 20 per cent of the evaluation time was spent in electronic adjustments. The electronics engineers with their oscilloscopes, various testing meters and other adjustment and repair gear, became familiar personalities to the cartographers; for without the services of these specialists the evaluation would have been impossible to conduct.

It should be further noted that electronics engineers are working in co-operation with the cartographer for the improvement of the stereomat system. The future is quite promising. AMS testing personnel are working closely with other government agencies and private industry to develop a more sophisticated stereomat system. The Stereomat V, with many mechanical and electronic improvements, is now in existence. The Stereomat VI is in the design stages. What the AMS has learned from the evaluation and present use of the instrument has been passed on to the designers. AMS has also recommended that certain features be included in the new designs. The later instruments can be constructed in such a manner that the cartographer could make certain electronic checks on the system as well as the necessary adjustments which follow these checks. Although this would decrease the present dependence on the electronic engineer for adjustments and calibration, he would continue to be a necessity for maintenance purposes.

The Stereomat IV is presently producing orthophotographs for the AMS study on the use of orthophotographs in topographical mapping. When the analysis of the results of the AMS evaluation of the Stereomat IV was completed, the basic conclusion was that the instrument operated more efficiently in the profiling than in the contouring mode. Orthophotographs are produced in the profiling mode. It should be noted that all the orthophotos of this evaluation were of acceptable quality. Therefore the Stereomat IV was chosen to produce the orthophotos for the latest AMS orthophotography study. This study will be completed at the end of this year and it is entirely possible that a report on this project could be submitted to the mapping community at the annual meeting of the American Congress Surveying and Mapping and the American Society of Photogrammetry in the spring of 1967. This project will increase our knowledge of the techniques, procedures and materials to be used for the compilation of map detail from orthophotography.

The Stereomat IV is being modified by Army Map Service testing personnel to produce a line-drop manuscript while operating in the profiling mode. This is the same type of device that had been attached to the service's integrated mapping system. A contour interval would be drawn for every other interval along an individual profile. This would be repeated for every profile, which would produce a line-drop manuscript. Contour information would be sketched by connecting the ends of these contour interval lines. The average production time for the profiling and production of the orthophotographs with the Stereomat IV was two and one-half hours. This means that the contoured manuscript and the orthophotograph can be produced simultaneously in this period of time, thereby saving many man-hours and substantially reducing the cost of map production.

It is envisaged that, in the future, one operator could handle two instruments of the stereomat type and produce, in three hours, the stereophotogrammetric compilations that now take two men twenty hours each to produce. The possible savings are tremendous.

ANALYTICAL AEROTRIANGULATION SYSTEMS FOR PHOTOGRAMMETRIC MAPPING IN THE UNITED STATES GEOLOGICAL SURVEY

Paper presented by the United States of America[1]

The Topographic Division of the Geological Survey is applying methods representing two general approaches to aerotriangulation: the fully analytical technique, in which both the triangulation and the adjustment procedures are carried out computationally, beginning with the measured photo-co-ordinates of pass and control points; and the semi-analytical technique, in which the computational input consists of model, section, or strip co-ordinates determined with plotting instruments. In both procedures, the end product is pass-point positions and/or elevations for use in orienting stereo models in topographic map compilation.

THE FULLY ANALYTICAL METHOD

Description of the system

The completely analytical system developed by the Geological Survey is known as the direct geodetic constraint method. It may be described as an iterative, simultaneous adjustment of exposure-station space positions and camera orientations in a least-squares solution in which constraints are applied to the projective image rays. It is a modification and extension of the method originated by Paul Herget at Ohio State University. The method was developed as a joint endeavour of Cornell University, the United States Army Engineer Research and Development Laboratory, and the United States Geological Survey, under the direction of Arthur McNair.

Bundles of projective rays for each photograph, defined by the perspective centre and the measured photo-co-ordinates of pass and control points, are caused to assume optimum positions and attitudes in space by forcing common pass-point rays to intersect and control-point rays to pass through the ground locations of the control, or to intersect upon geodetically defined surfaces containing the control points. All constraints are enforced simultaneously and repetitively until no further worth-while improvement results.

The system, which has been programmed for the Burroughs 220 computer, is capable of solving problems in units of as many as twenty-two photographs. The photographs may be arranged either as a single strip or as a block. For larger problems, contiguous twenty-two-photograph blocks can be fitted together after they have been solved and adjusted internally.

Tests have shown that the method permits a sufficient reduction in the amount of required ground control to enable it to compete economically with methods presently used in the Geological Survey, in which two elevations are established for each photograph by field survey methods. Theoretically, the system can provide a perfect solution for a block of any size containing only two horizontal control points and, for vertical control, three elevations on any one strip and one elevation on each of the remaining strips. Although, in practice, several times these minimum amounts would always be specified (normally, all available points are used), these vertical control requirements represent, nevertheless, a considerable reduction from current requirements.

Tests of the system

The system has been tested with both fictitious and real problems. It is now being fitted into map-production operations.

One series of three tests was made using a seven-photograph strip flown at 10,000 ft above the McClure, Ohio, test area. In the portion of the test area covered by the strip were about eighty horizontal and vertical control points of first- and second-order accuracy, targeted on the ground by circular concrete platforms 6 or 8 ft in diameter. The photographs, borrowed from the United States Coast and Geodetic Survey, were exposed on Mylar-base film in a Wild RC8 camera. Photo-co-ordinate measurements were obtained with a Wild stereocomparator.

In the first test, diagrammed in figure I below, the strip

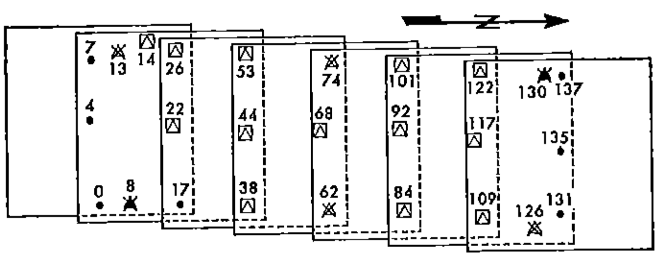

Fig. I—United States of America: Diagram showing vertical control (crosses), horizontal control (solid triangles), test points (open squares and triangles) and pass-points for McClure test 1

[1] The original text of this paper, prepared by Morris L. McKenzie and Robert C. Eller, United States Geological Survey, Washington, D.C., appeared as document E/CONF.52/L.22.

Table 1. Summary of results of McClure, Ohio, tests

	Test 1	Test 2: Phase 1 (before adjustment)	Test 2: Phase 2* (after adjustment)	Test 3
Vertical RMSE (ft)	0.6	2.2	0.5	0.7
Maximum vertical error (ft)	1.2	3.8	1.0	1.8
Horizontal RMSE (ft)	1.1	1.3	—*	1.3
Maximum horizontal error (ft)	2.3	2.6	—*	2.7
No. of horizontal control points	2	2	2	2
No. of vertical control points	6	3	6	6
No. of horizontal test points	17	17	17	78
No. of vertical test points	13	16	13	75

* The phase 2 adjustment in test 2 involved only the vertical dimension, hence no horizontal error values are given.

was controlled with two horizontal and six vertical control points. As the figure shows, seventeen horizontal and thirteen vertical points were used as pass-points in the solution to provide test points. The results of this test are summarized in the left-hand column of table 1. The tabular values are the errors at the test points. It is important to point out that the exact values after convergence depend upon the particular cycle or iteration at which the problem is terminated. Convergence usually occurs after four or five cycles; after that point is reached, the subsequent solution values oscillate a few hundredths of a foot around some value. Therefore the reported results have been rounded to the nearest tenth of a foot to render the oscillations insignificant.

The discrepancies in relative orientation for test 1 are given in table 2. Here, the first line gives the average and the maximum amounts by which the two rays for each point, as defined by successive photographs, fail to intersect. To emphasize the extreme smallness of these discrepancies, the values are given in inches at ground scale. The second line gives the separation in space between the positions of common points, as defined by the two models.

Table 2. Summary of discrepancies in relative orientation at all points, McClure test 1

	Average (inches)	*Maximum (inches)*
Amount by which rays fail to intersect .	2.98	6.71
Amounts by which models fail to join. .	4.30	8.42

The conditions for test 2 were identical with those for test 1 except that the solution was divided into two phases: first, the problem was solved to convergence with minimum control, that is, two horizontal and three vertical points as shown in the figure above; then the strip thus derived was adjusted vertically by a second-degree equation to the same six vertical control points as had been used in test 1. Eliminating redundant control in the initial solution allowed the photographs to come to a best possible relative orientation, free of the encumbering effects of the control. The results of both phases of test 2 are given in table 1. That test 2 produced slightly better results than test 1 is not considered significant. What is considered significant is that the tests indicate considerable promise for both these approaches.

Test 3 was identical with test 1 except that the number of test points was increased severalfold, as indicated in table 1.

A second operational test of the system involved the solution of two adjacent 7.5′ quadrangles—Middleburg and Arcola, Va. These particular quadrangles were chosen because they contain an abundance of high-order control to serve as test points for evaluating results.

The test area contains about 1,100 ft of relief, varying from low rolling hills to low mountains. The Arcola quadrangle was to be mapped with a 10 ft contour interval and the Middleburg quadrangle, containing the Bull Run Mountains, was to be mapped with a 20 ft contour interval. The photographs for the area consisted of fifty glass-plate negatives in four east-west strips at 12,000 ft above mean ground.

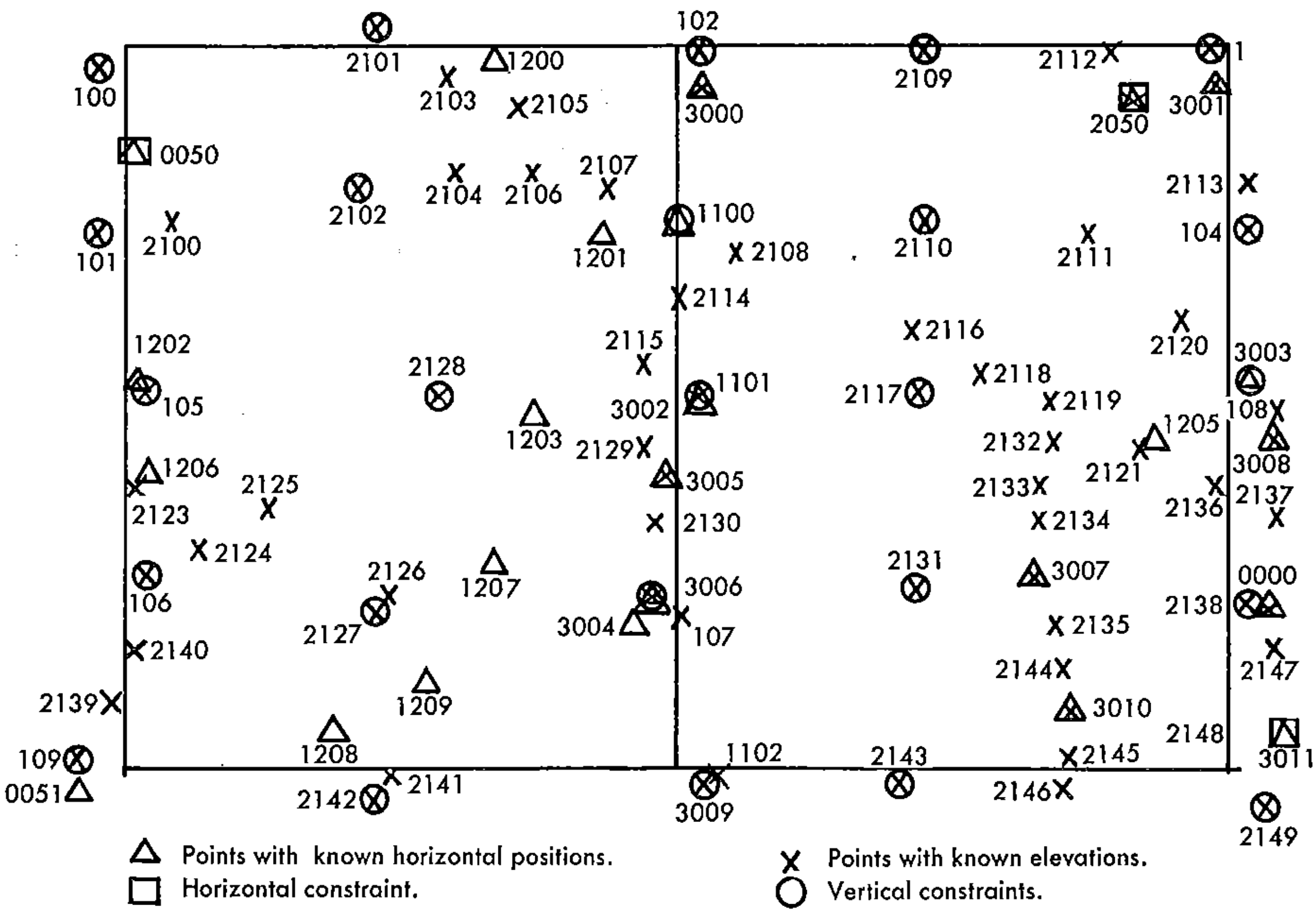

Fig. II—United States of America: Distribution of ground control, Middleburg and Arcola quadrangles

There are twenty-three horizontal control points well distributed over the two quadrangles to serve as control and test points. Therefore no additional horizontal control was needed.

Level lines were run to establish elevations on twenty-five targeted points scattered over the area, bringing to seventy-five the total number of targeted points with near third-order or better elevations. Four horizontal and twenty-five vertical points were used as constraints (see figure II). All ground control and test points were marked on the ground with 6 ft, white circular targets of pliable plastic.

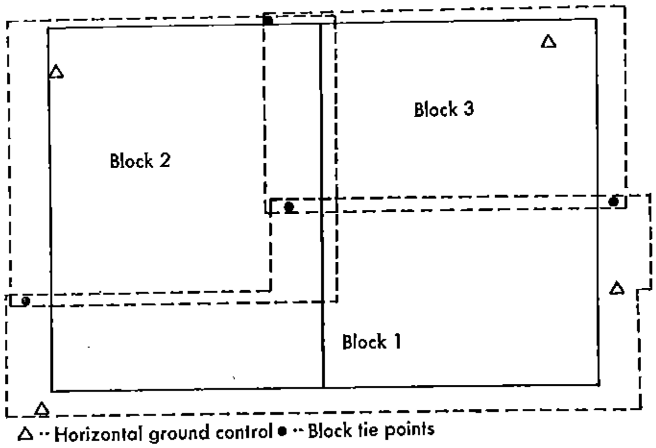

Fig. III—United States of America: Block configuration for Middleburg-Arcola test

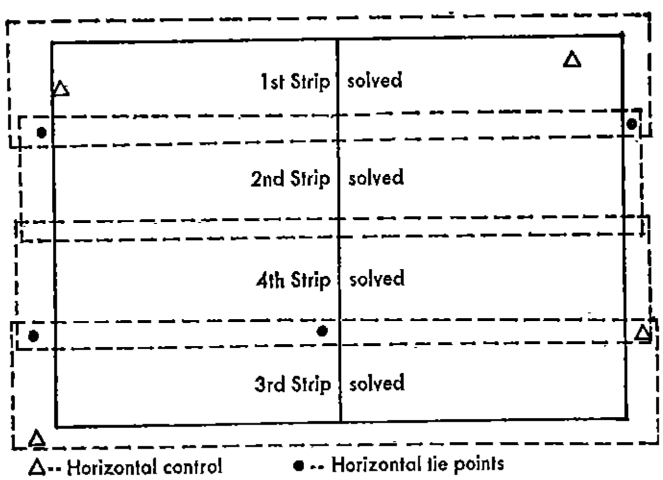

Fig. IV—United States of America: Sequence of strip solutions for Middleburg-Arcola test

The solution was conducted twice, first as three blocks, then as four strips, as shown in the following two figures.

The results of the block solution and the strip solution are summarized in table 3.

Table 3. Summary of results, Middleburg-Arcola test

	Block solution (in feet)	*Strip solution (in feet)*
RMS vertical error	1.40	1.06
Maximum vertical error	4.26	2.50
RMS horizontal error	3.9	4.2
Maximum horizontal error	7.5	8.0

It will be seen that there is not much difference in the accuracies of the two solutions. However, the strip solution requires only about half as much computer time and is preferred on that basis.

Semi-analytical methods

The development of highly accurate devices for converting mechanical motions to digital form has made it possible to combine instrumental and mathematical aerotriangulation. Thus advantage can be taken of the expediencies to be found in projection-type stereoplotting instruments and the conveniences and accuracies associated with electronic computations. Interior and relative orientations of overlapping photographs are performed with stereoplotters; absolute orientation and the final adjustment of pass-point positions are performed on electronic computers.

The Geological Survey is presently applying several of these semi-analytical methods, some to obtain horizontal pass-point positions only, others to obtain both horizontal and vertical data for map compilation.

Horizontal adjustment by weighted-mean transformations

One of the horizontal adjustment methods is known as the weighted-mean method because, in the adjustment of strips to each other, weighted-mean line lengths and angles are used. In one adaptation of this method, model co-ordinates are read out from ER-55, Kelsh or Wild A8 plotters. The models are joined into strips by linear transformations on the model co-ordinate points. In another adaptation, the strips are generated directly on universal plotters such as the A7.

In joining the strips to form a block, the weighted-mean rotations, translations and scale factors needed to fit the pass-points of one strip to those of the adjoining strip are determined by computing these factors from the various combinations of corresponding line lengths and line azimuths that can be formed from as many as twenty tie points common to two adjoining strips (see figure V below).

The second strip is fitted to the first, the third to the second and so forth, to form a block of strips. Normally, the block will be a 7.5′ quadrangle. The block is fitted to control at the four corners of the quadrangle in two steps.

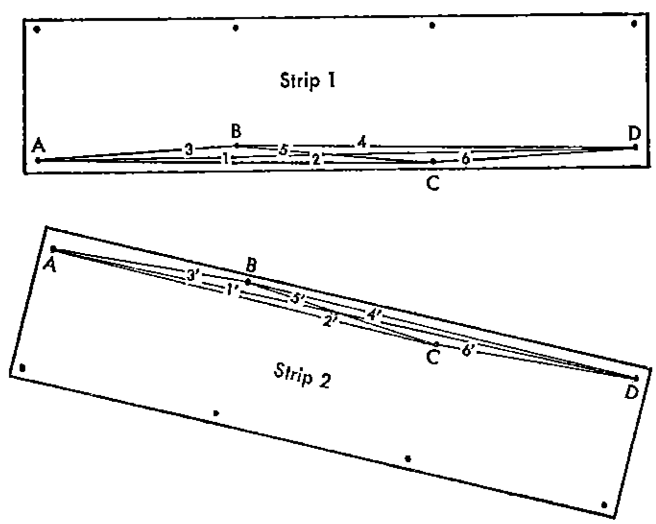

Fig. V—United States of America: Six combinations of corresponding lines formed from four tie points

First, a linear transformation is performed for gross fit in which parameters are determined in the same way as for tie points—by computing factors to force the adjusted line lengths and azimuths defined by adjusted control-point positions to agree with the true line lengths and azimuths. The second step is a nonlinear fit to the same four points patterned on the method used by the United States Coast and Geodetic Survey for correction of film distortion.

This method has been programmed for the Burroughs B5500 and is in full operational use. The solution of a 7.5′ quadrangle takes about 25 seconds of computer time. About 600 quadrangles a year are handled by the system in the Topographic Division.

Horizontal block-adjustment of models or sections

Two versions of a method have been tested that adjust horizontal pass-point co-ordinates obtained from either individual models or multiple-model sections.

In one version, written for the Burroughs 220 computer, all units (models or sections) are brought to a common co-ordinate system and then fitted to the ground co-ordinates system in preliminary transformations. These transformations are made by fitting unit to unit with pairs of tie points and finally by fitting the resulting sub-block to two horizontal control points (see figure VI below).

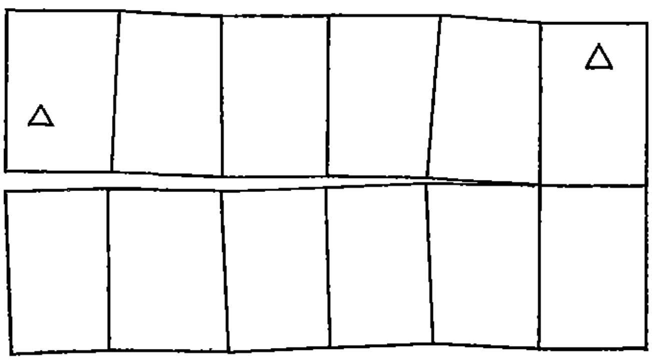

Fig. VI—United States of America: Models joined by linear transformations to form a sub-block

In the main adjustment, the units are adjusted to each other and to all ground control, each unit undergoing a linear transformation in which transformation parameters

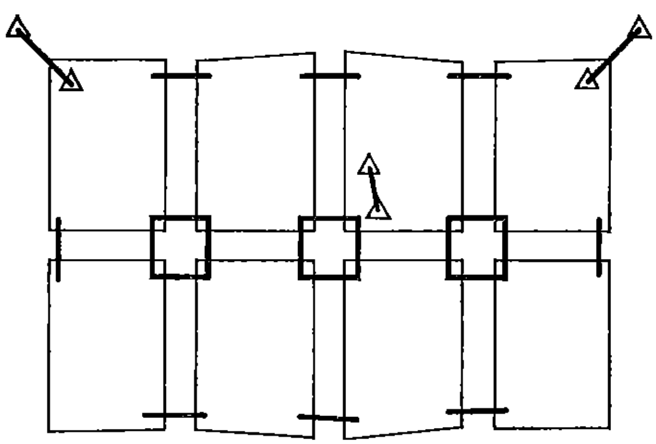

*Fig. VII—United States of America: Simultaneous adjustment to fit models to each other and to control**

* The adjustment involves each of the connexions indicated with heavy lines.

are determined by the method of least squares (see figure VII). As many as twenty-four units may be used to form a sub-block and as many sub-blocks are generated as are needed to cover the project area up to a limit of twenty-four.

Finally, the sub-blocks are adjusted to each other and to all control in another simultaneous linear transformation involving both sub-block tie points and control points.

The second version, designed for use with a small computer, is written for the IBM 1130 computer. Two- or three-model sections are used as the basic units to form each sub-block so that a project area can be covered with fewer sub-blocks. Artificial images on the diapositives, created by printing through a glass stage plate containing etched crosses at standard pass-point positions, are used as tie points for joining the models into the sub-blocks and the sub-blocks into larger blocks.

Schut-NRC method

A method of adjusting pass-point co-ordinates developed by G. H. Schut of the National Research Council of Canada is being evaluated for compatibility with existing USGS instrumentation. Although the procedure is designed to perform both vertical and horizontal adjustments with the same data decks, the Geological Survey is evaluating only the horizontal adjustment capability of the procedure.

The Schut system as applied by the Geological Survey consists of two parts: first, a linear join of models into strips and a linear fit of the strips to an approximate ground co-ordinate system; secondly, a simultaneous block adjustment of strips to each other and to ground control. The degree of adjustment (linear or nonlinear) and the type of adjustment (vertical or horizontal or both) can be specified.

Alternated models method

The Topographic Division has developed a system that uses a "swing-around" technique in the Kelsh plotter whereby a strip of disjointed models (or multi-model sections) is formed with alternate models or sections rotated 180°. All models or sections are referred to a common vertical datum through common vertical pass-points along the centre of the strip.

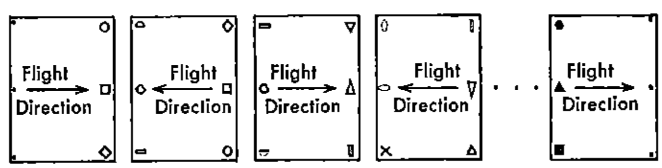

*Fig. VIII—United States of America: A strip in which alternate models are rotated 180°**

In the computational adjustment, the alternative models are first rotated back to their proper orientation and then joined with the others to form strips through a linear least-squares transformation based on the three points common to each model or section. The strips are then adjusted into a block and simultaneously fitted to control through a second-degree conformal transformation, such as described by Schut. Normally, six points will be used to tie each pair of strips together.

All horizontal aerotriangulation in the Pacific area is being done by this method—about 600 quadrangles a year.

* Corresponding pass-points are shown with identical geometric figures.

Two computers are used. An RPC-4000 is used for model-to-strip transformations and for final conversion of output co-ordinates to the state plane co-ordinate system. The simultaneous adjustment of the block is carried out on an IBM 7040/7094 through a remote terminal.

Combined horizontal and vertical block adjustment

A method for adjusting both the horizontal positions and the elevations of points in a block of bridged photographs has also been programmed for the Burroughs 220 computer and tested. In this method, the horizontal positions of a block of strips, generated on the A7, are adjusted simultaneously in a least-squares solution based upon Schut's equations. In the vertical adjustment which follows, the Z co-ordinates of pass points are adjusted mathematically by determining elevation error surfaces for all strips in the block from the errors at known elevation points along the strips, and correcting all the points in each strip in accordance with the error surface of the strip. The strips are adjusted simultaneously to control and to each other in a least-squares second-degree solution.

The 10,000-word memory of the 220 computer will allow the solution of up to fourteen strips.

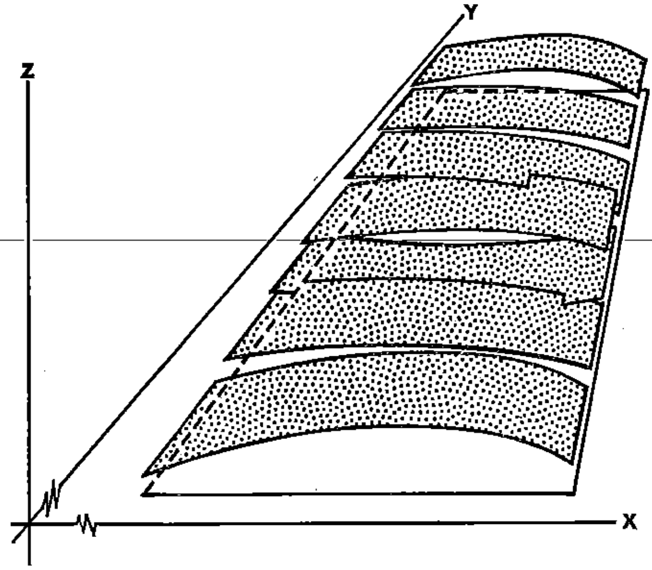

Fig. IX—United States of America: Vertical error surfaces for seven bridged strips

THE CHALLENGE OF THE NEXT DECADE TO SURVEYORS AND MAPPERS

Paper presented by the United States of America[1]

In his memorable speech before the United Nations in 1961, the late President Kennedy hailed the 1960s as the "decade of development". From the vantage point of 1967, we can recognize the great scope of this development, and begin to sense the far greater advances and challenges in the 1970s and beyond.

The surveying and mapping community is very much a part of this accelerating tempo, as we apply the methods of modern science to our age-old task.

We have been engaged in mapping for a long time. Cartography antedates the art of writing. The capacity to understand the nature of maps is possessed even by peoples whom we are in the habit of describing as savages. Cadastral surveys for purposes of taxation existed in ancient Babylon, 2100 B.C. The Incas of Peru had relief maps at the time that the Crusaders were trying to liberate the Holy Land.

In the centuries since then we have progressed far, but we have even farther to go. New areas, rich in natural resources, have become accessible by modern aircraft and susceptible of development for the benefit of their peoples and the growth of their nations. Most of these areas, by their very nature, are largely unsurveyed and unmapped, and would probably remain so were we to be limited by the methods and equipment of the not-too-distant past. Fortunately, this is not the case; and advances in technology are making it possible to provide the surveys and maps which are so essential even to the initial planning phases of development.

Today the challenge facing the mapper, in terms of the sheer volume and variety of mapping requirements, staggers the imagination. Despite the tremendous mapping accomplishments of the past twenty-five years, approximately 80 per cent of the earth's land area lacks adequate topographic map coverage at scales required for general planning; and an even greater percentage lacks coverage at the larger scales. And topographic maps are only the beginning for emerging nations. Geological maps and other surveys of physical resources—in thrity-five to forty inventories—and cadastral surveys, for example, are all needed for comprehensive, planned growth and progress.

Similarly, military requirements encompass a broadening spectrum. The needs of the artilleryman, special forces, the tank commander, the aircraft pilot or the infantryman differ one from the other and from the needs of the strategic planner or the armed forces commander. Altogether, the magnitude and scope of world-wide requirements for surveys and maps for the foreseeable future will continue to tax our finest research and development brains and our best operational efforts.

There are large areas of the world, ranging from nations which have shaped history to some which have only recently become independent political entities, which lack adequate topographic coverage. The untapped resources of these areas must be opened up for their contribution to the increasing needs of the world and its exploding population. Mapping these areas poses a tremendous challenge to the ingenuity and improved technology of modern surveying and mapping. Since many of these areas are plagued with inhospitable climates, difficult access, debilitating diseases and other obstacles, successful mapping and inventories of resources will require methods utilizing very little on-the-ground effort. Of course, the construction projects to follow still must be laid out by conventional survey processes. It is still difficult to drive a stake in the ground from an aircraft.

It is encouraging to see that the newly emerging nations are demonstrating a growing awareness of the need for

[1] The original text of this paper, prepared by Major General T. J. Hayes, Director of Topography and Military Engineering Office, Department of the Army, Washington, D.C., appeared as document E/CONF.52/L.25.

basic mapping as a point of departure in planning for socio-economic development. In some of these nations the cartographic capability is inadequate for the task. These nations look to us for guidance, assistance and training. As their capabilities expand they will increasingly share our interest in better, more economical methods of maintaining the initial investment in basic mapping. At the same time, they too will encounter rising demands for specialized and even more detailed mapping. Techniques, equipment, materials and practical know-how will find a ready but highly competitive market. Meeting the challenge of this competition will require our best technical efforts.

The awareness of the need for basic mapping is coupled with the need for inventories of natural, economic and sociological resources. The emerging countries require these inventories, at small and large-scale map treatments, to plan for their agricultural and economic development from the inception of ideas to the establishment of individual projects. United States Government agencies, private industry and collaborating countries are producing such inventories in Latin America, South-East Asia and other areas. These inventories are proving to be valuable tools for decision-making at all levels. However, we need to accelerate the production of these inventories to assist national and international groups in making their decisions where regional projects are involved, and to assist countries in playing their part in the world-wide effort for economic and sociological progress. We must use every technological advantage to produce the required data in the next decade, and to provide systems and techniques for rapid acquisition and maintenance of new information.

In the United States, we are approaching a significant milestone on the road to our goal of complete and adequate topographic coverage. A decade from now the basic large-scale topographic mapping by the United States Geological Survey will be nearing completion. The emphasis will then change to maintenance and refinement of that coverage. To do this economically, we must find efficient methods of acquiring and exploiting new information. Nothing in our present inventory of techniques truly gives us the flexible responsiveness that we need in this important area.

Another area of effort concerns the increasing need for new and improved systems for amassing, presenting and maintaining a growing body of precise information about the earth and its resources. We need more accurate, timely and detailed information on man's use of the terrain if we are to plan and operate an efficient and highly industrialized society, with due regard to the development of suitable recreational and cultural facilities and proper attention of suitable recreational and cultural facilities and proper attention to the aesthetic aspects of social progress.

We can foresee that the increasing needs of such vital forces of social progress will require full utilization of the unique technical services offered by surveyors and mappers. Only a few years ago housing developments were constructed as individual projects, and many transportation facilities were designed on a compartmented basis to serve the limited needs of the immediate community. Today we cannot afford this, and the trend is towards planning of entire communities and construction of transportation networks designed to serve efficiently the enlarging areas which are interdependent. Such a trend dictates a much more comprehensive approach to surveying and mapping requirements.

In a global sense, the next decade should see the completion of a world-wide geodetic net, achieved through the use of satellite geodesy. The United States Government is pursuing an active and highly successful satellite geodetic programme, involving electronic ranging and ballistic camera techniques. From this programme, a joint effort of Government and industry, we shall improve our knowledge of the shape and size of the earth. These accomplishments illustrate the increased capability of the surveying and mapping community to cope with the challenges and capitalize on the opportunities presented by the rapidly evolving electronic and space technologies. But even these impressive achievements are only a transitory stage in our efforts. New demands and new technology will lead us to pursue even more sophisticated methods, such as those involved in extra-terrestrial mapping.

Down through the ages, men have been enchanted with the heavens. Today that enchantment is nearing some measure of fulfilment. Within this decade we expect man to journey to the moon. To prepare for this journey, more effort has been expended on lunar mapping in the past five years than had been expended throughout man's history. The results are impressive, but are still only a beginning. To complete the mapping required to select a landing area and permit lunar exploration by the astronauts will require more than double the total effort already expended. There is a current programme of a series of unmanned space vehicles designed to orbit the moon and transmit photography of pre-selected sites back to earth. These data will give us detailed information regarding more of the lunar surface than has ever before been available. Initial mapping from these data will lead to geological studies and resources interpretation to assist in the search for construction materials, water, oxygen, fuel and other elements which could facilitate the establishment of a lunar base and contribute to interplanetary exploration. The surveying and mapping community must provide the cartographic support required for these endeavours.

In the past twenty-five years we have made impressive progress in our equipment and techniques, moving from the relatively simple, optical-manual systems of survey and photogrammetric measurement to the faster and more precise electronic ground and airborne surveying and analytical photogrammetric systems. The import of this may be better appreciated in the light of a few outstanding examples of change and accomplishment.

1. We are all well aware of the current importance of electronic computers to mapping and geodesy. We accept and appreciate their worth as a tool essential to our operations. This, in itself, represents a distinct change in thinking which has occurred in a relatively short time. When the United States Army Map Service acquired the UNIVAC-1 in 1952, the requirement for a computer of such capacity in mapping and geodesy was questioned by some. In fact this computer was considered primarily as a means of saving personnel rather than as an instrument for meeting otherwise impossible requirements. UNIVAC very quickly demonstrated its essentiality in such projects as the European Geodetic Adjustment; and before long both personnel and computer were unable to keep pace with the growing requirements. Since then, UNIVAC has been superseded twice by computers of greater capacity and application; and today additional computer facilities are urgently required to meet the demands for solutions to increasingly complex problems.

2. The AN/USQ 28 mapping and surveying system, developed by the United States Air Force, comprises the most advanced group of equipment specifically integrated to collect accurate raw data for mapping purposes. It is specifically designed to acquire photography suitable for 1:50,000 scale topographic mapping in areas of insufficient ground control. The system is configured in the RC 135A aircraft and consists of precision mapping cameras, a precise inertial navigation system, electronic distance measuring equipment, a terrain profile recorder and ancillary equipment. All auxiliary data will be recorded on magnetic tape for direct input into digital equipment to speed the data reduction process.

3. Also, in the area of control surveys, the Topographic Division of the United States Geological Survey has worked with industry to develop the helicopter-borne ABC system of airborne control. The system has the advantage that it permits rapid acquisition of mapping control in areas where difficulty of access precludes economic employment of ground surveys.

4. Another example is the progress that has been made in compilation equipment. Government-sponsored contracts with industry have produced extremely accurate, automated, photogrammetric compilation equipment. Two outstanding examples are the UNAMACE and the AS-11C stereoplotter. These computer-drive machines use image-sensing and correlation techniques to produce orthographically correct images while simultaneously detecting and recording terrain relief. It is expected that this equipment will reduce map compilation time by as much as 75 per cent.

5. Another development of significant interest is the "semi-automatic co-ordinate reader". This equipment is designed to measure stellar co-ordinates on photographic plates in connexion with the data reduction processes for optical satellite tracking systems. The instrument has a pre-programming feature which moves a detecting head to the approximate location of each required stellar image. The detection head then centres itself precisely over the stellar image. At this point the co-ordinates are measured and recorded on punch cards for input to the computer programme.

In the next decade even greater technological progress will take place in the mapping profession. Geometrically accurate, all-weather, space-borne sensors; automated data banks with national and international results in either graphical or digital form—these are some of the components we can look forward to in the topographic information systems of the future. Much of the necessary technology and equipment is already in being. More is in the conceptual and developmental stages. The United States military and civil mapping agencies and private industry have all co-operated in this tremendous research and development effort since the beginning of the Second World War. We can take pride in the excellence of the results.

Although detailed descriptions of future developments are hardly within the scope of this paper, there is one important area that should be mentioned. With computers affording the means of automating data reduction, storage and retrieval, and advanced instruments automating the compilation process, there remains the time-consuming cartographic phase of mapping which is still predominantly manual. Analyses have been conducted to determine the technical feasibility and economic desirability of automating the manual operations involved in colour separation, names compilation and data manipulation. These analyses have indicated that a phased development programme would provide definite advantages from the standpoints of cost reduction and a more rapid response capability. Research and development efforts are currently under way to create this capability.

The rapidity and profusion of developments such as the few mentioned emphasize the very real challenge posed by the necessity of keeping abreast of technological advances and applying them to improve the survey and mapping processes. This implies timely interchange of knowledge on such advances and continuous training programmes to permit their effective utilization. Hence it is gratifying to see the extent to which the professional journals dealing with surveying and mapping have highlighted significant technological advances and have urged incorporation of modern procedures in formal educational curricula.

The subject matter in these professional media in itself suggests an altered profile for the typical mapper of the next decade. Certainly he will need more mathematics, physics and electronics than are expected today. We can foresee reduced emphasis on the traditional manual talents of cartography. The future geodesist will need increased emphasis on some aspects of astronomy and celestial mechanics. Preparing ourselves and our successors for the demands of the new technology is a challenge we must conscientiously face. Compounding the problem is the fact that in many fields progress is so rapid that the lifetime of technical knowledge is only five to six years.

It has been said that human effort is becoming less and less an exercise of slowly acquired skills and more and more an application of versatility in the operation of new machines and processes. Two important changes thus appear; we must educate some of our youth to be the developers of the gadgets of our new society and we must train others to be more versatile operators. In our new society, the computer and its handmaiden, the automaton, will perform the drudgery and there will be ultimately left only those operations requiring human judgement.

Certainly, in our mapping operations the sheer volume of the data which requires processing dictates the use of expensive computers and other automated equipment systems. These new systems are costly, complex but highly productive, and will help us to revolutionize the capabilities of the mapping community. However, there will be certain side-effects. The initial investment cost of the new systems, with their substantial research and development efforts, will require organizations and relationships keyed to the efficient use of these very powerful tools.

The technological evolution we are witnessing, and of which we are a part, has three principal objectives: accomplishment of tasks hitherto impossible; more rapid satisfaction of the large volume of unfulfilled requirements; reduction of unit costs.

Unfortunately, the magnitude and urgency of the tasks still to be accomplished preclude early reductions in gross expenditures. On the contrary, the increasing awareness of our potential has caused our society to augment its contributions for our work. In keeping with that trust, we bear the burden of ensuring the application of cost-consciousness in all our efforts.

These, then, in very broad terms, are the challenges and the opportunities that can be seen for our mapping community in the coming decade: a proliferation of requirements in terms of volume and types; the creation of highly complex, costly, but very productive data systems capable of presenting results rapidly in a variety of forms and of providing a wide range of services to the entire community; a parallel evolution in the educational, organizational and managerial aspects of our mapping community in order to capitalize on the capabilities of these new automated systems.

We of the surveying and mapping community are at the threshold of the opportunity to apply our ever increasing knowledge and capabilities to the unfulfilled needs of our modern society. The multi-disciplined nature of modern surveying and mapping places us in an enviable position. We shall be able to apply our activities to those broad areas where the full benefits of our potential have not been realized. The environment of this conference, the progress displayed in the exhibit hall, and the information exchanged here, illustrate the possibilities which exist for contributing to the progress of the society of mankind. It is up to us, as members of the surveying and mapping community, to meet the challenge and ensure that potentiality becomes reality. I am confident that we are equal to the tasks which lie ahead.

PHOTOGRAMMETRIC RESEARCH WORK ON THE GULF STREAM

Paper presented by the United States of America[1]

Introduction

The gathering of data and publishing of information on tides and tidal currents are an important part of the Coast and Geodetic Survey's responsibility to maritime commerce and to the safety of navigation in the territorial waters of the United States and its possessions. Consequently, the bureau has been making surveys of tidal currents since about 1850.

The rapid increase in population and the growth of cities, with their attendant industries, in our harbours and along our coastline have brought increasing federal response to the necessity for more detailed information about the circulatory pattern of currents in harbours and bays. This information is needed to support a wide variety of programmes designed by the Congress and the President to ease the congestion in our busy harbours, to promote the economic well-being of citizens in urban centres near the sea, to conserve the nation's water resources and protect the public health by learning to control and retard pollution of our rivers and estuaries.

Through interaction with national programmes in oceanography, current measurement contributes to our prospects for tapping the vast resources of the global ocean—a matter now under extensive study at the highest governmental levels. Thus, the tidal current and related oceanographic efforts of the Coast and Geodetic Survey and the Environmental Science Services Administration reflect programmes very close to the heart and mind of the President, the Congress and every private citizen: clean water, healthy commerce, bright prospects for our great cities and acquisition of the great potential resources of the sea.

As a result of the increasing need for more detailed information on currents, Coast and Geodetic Survey personnel experimented with aerial photography and photogrammetric measurements as a means of supplementing conventional current surveys by use of meters. It was found that photogrammetric methods provided a ready and reasonably economical means of obtaining a synoptic view of the circulatory pattern in an entire harbour area and thus provided more detailed information than could practicably be obtained with observations by current meters alone.

Our first use of aerial photography specifically for the measurement of tidal currents was at Lituya Bay, Alaska, in 1959, following the disastrous earthquake of the previous summer. There the objective was to measure currents in the narrow entrance to the bay. The success of the project gave impetus to plans for making a photogrammetric current survey of a complete tidal cycle for an entire harbour area. This was first done at Charleston Harbour, South Carolina, in April 1962, in conjunction with a conventional tidal current survey using the Roberts current meter. That project was followed by a survey of currents at Ocracoke Inlet, North Carolina, in October 1962 and at Tampa Bay, Florida, in April 1963, combining the use of photogrammetry with current meters. At present, current surveys of Long Island Sound are being conducted by photogrammetry.

The photogrammetric method used on these surveys includes, principally, the seeding of the area with suitable floating targets, the use of aerial photography taken at intervals throughout the tidal cycle to record the movement of these targets, and the derivation of the current velocities

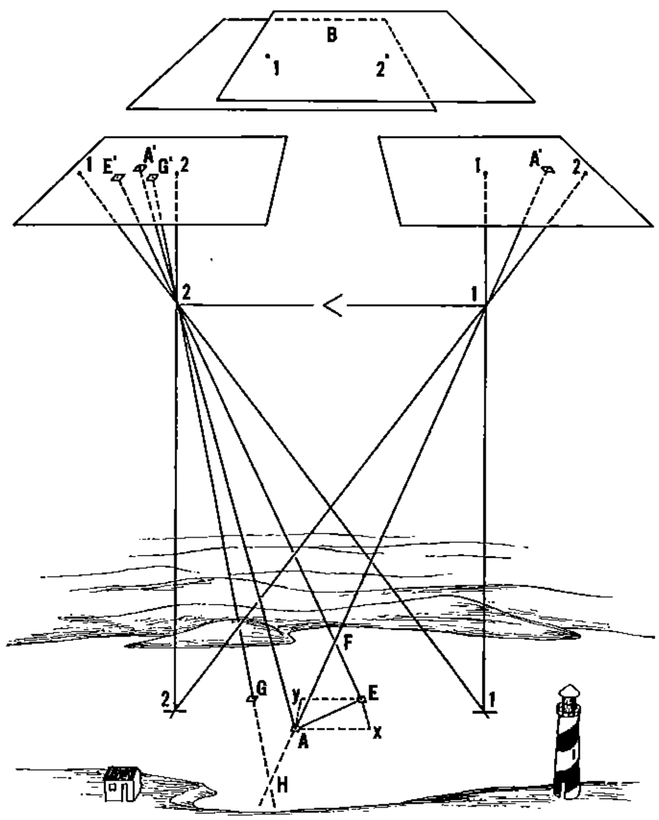

Fig. 1—United States of America: Photogrammetric current measurement

[1] The original text of this paper, prepared by Rear-Admiral J. C. Tison, Director, Coast and Geodetic Survey, Environmental Science Services Administration, and submitted under items 8 and 16, appeared as document E/CONF.52/L.29.

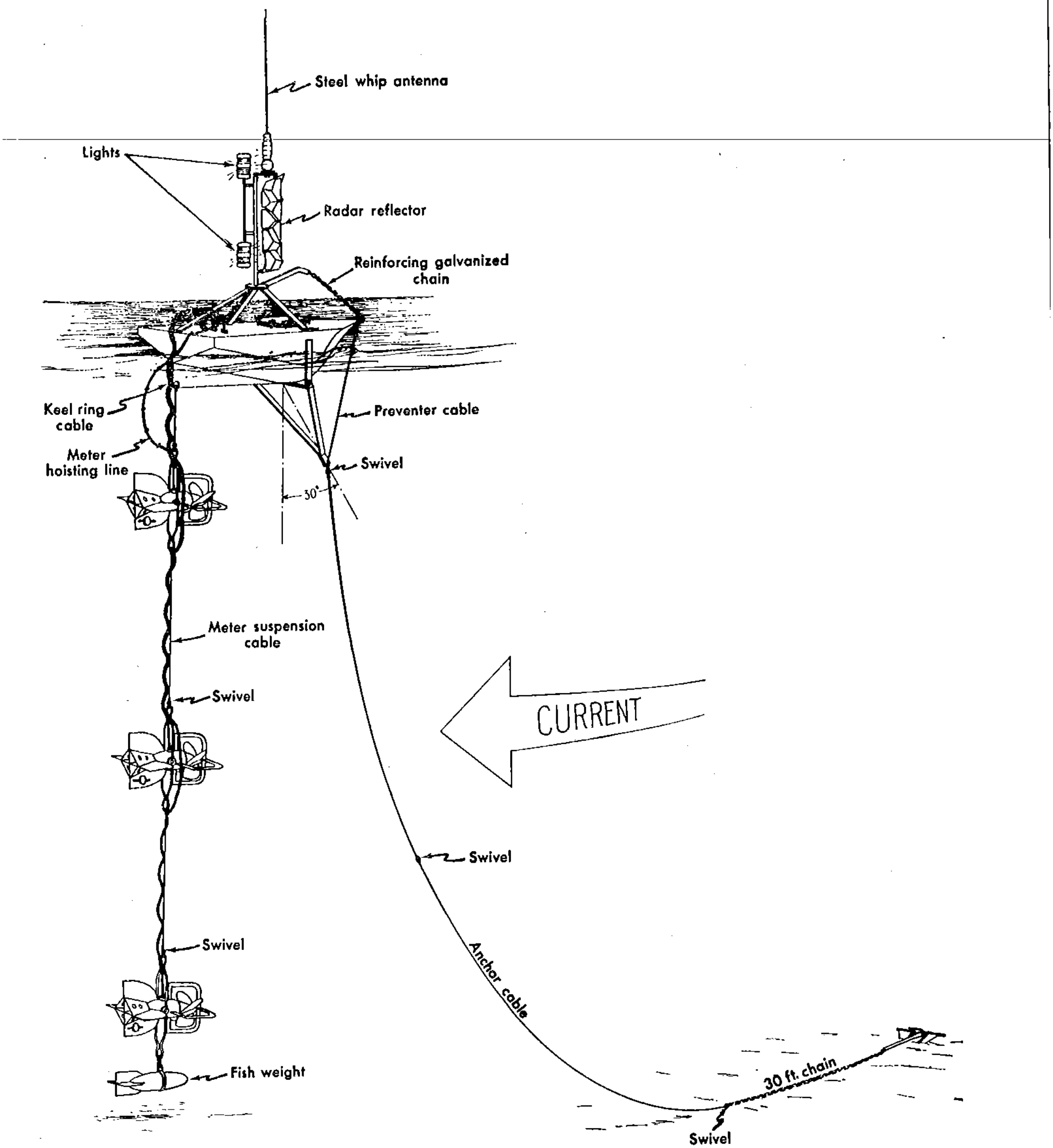

Fig. II—United States of America: Roberts radio current meter installation (buoy with three meters)

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from parallax measurements of the targets on stereoscopic plotting instruments.

The diagram (figure I) on photogrammetric current measurement illustrates the method used in past surveys. The diagram shows a pair of photographs numbered 1 and 2, taken with 60 per cent endlap as illustrated at B. The floating target moved from point A to point E in model space. Thus it is readily apparent that the distance AE can be derived from measurements of X parallax and Y parallax, once absolute orientation is achieved; and when this distance is multiplied by the scale number and divided by the time interval between exposures, we obtain the velocity of the moving target.

By distributing numerous floating targets in our survey area, it is possible to obtain much data on current velocities. With conventional current surveys, each metering installation must be anchored and monitored in some way (see figure II) on Roberts radio current meter installation. The economics of a high-density distribution of such installations make it, of course, prohibitive. Moreover, the measuring of velocities at the surface by this means is difficult. Thus photogrammetry is an important adjunct to current measuring.

Following upon the photogrammetric measurement of the target motion on the stereoplotting instruments, it is possible to interpolate additional current velocities between the target positions. The presence of surface markings gives the water surface a texture such that if a model of moving water is examined stereoscopically, the water exhibits a relief effect depending on the velocity of the current. By comparison with the relief shown at the measured targets, other intermediate current velocities can be interpolated.

By use of photogrammetric and current meter observations, a series of current charts are compiled to show the circulatory patterns of currents of the area for the entire tidal cycle. This requires, as a minimum, observations at and near the times of maximum ebb and at maximum flood. The graph of the currents, much like that of tides themselves, is generally sinusoidal in shape and only observations to show the changes in the curves are required. In compiling the final currents chart, corrections are made for local meteorological conditions and for known astronomical effects. The next two figures (III and IV) show currents at maximum ebb and maximum flood for Ocracoke Inlet.

It has thus been demonstrated that stereoscopic photogrammetry can serve a very important role in synoptic current surveys for rivers, bays and harbours. For this application of photogrammetry, the basic requirement is that sufficient control (usually on the land mass) be available to obtain absolute orientation for each stereoscopic model. The stereoscopic model is the basic unit from which current velocities are derived by measuring the movement of floating targets between successive photographic exposures.

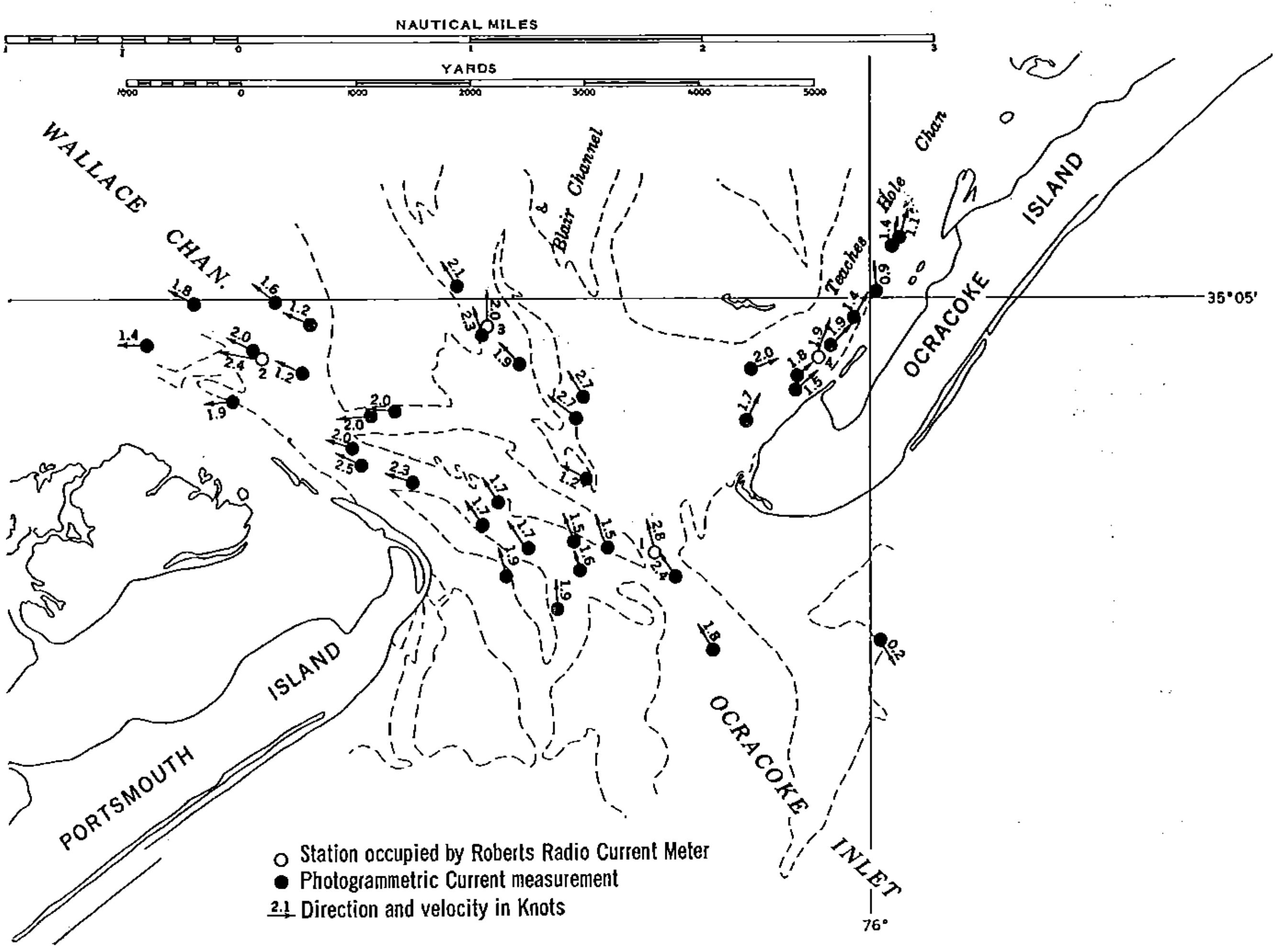


Fig. III—United States of America: Ocracoke Inlet, N.C., maximum flood at meter 1 (14 October 1962, 07.25 h, EST)

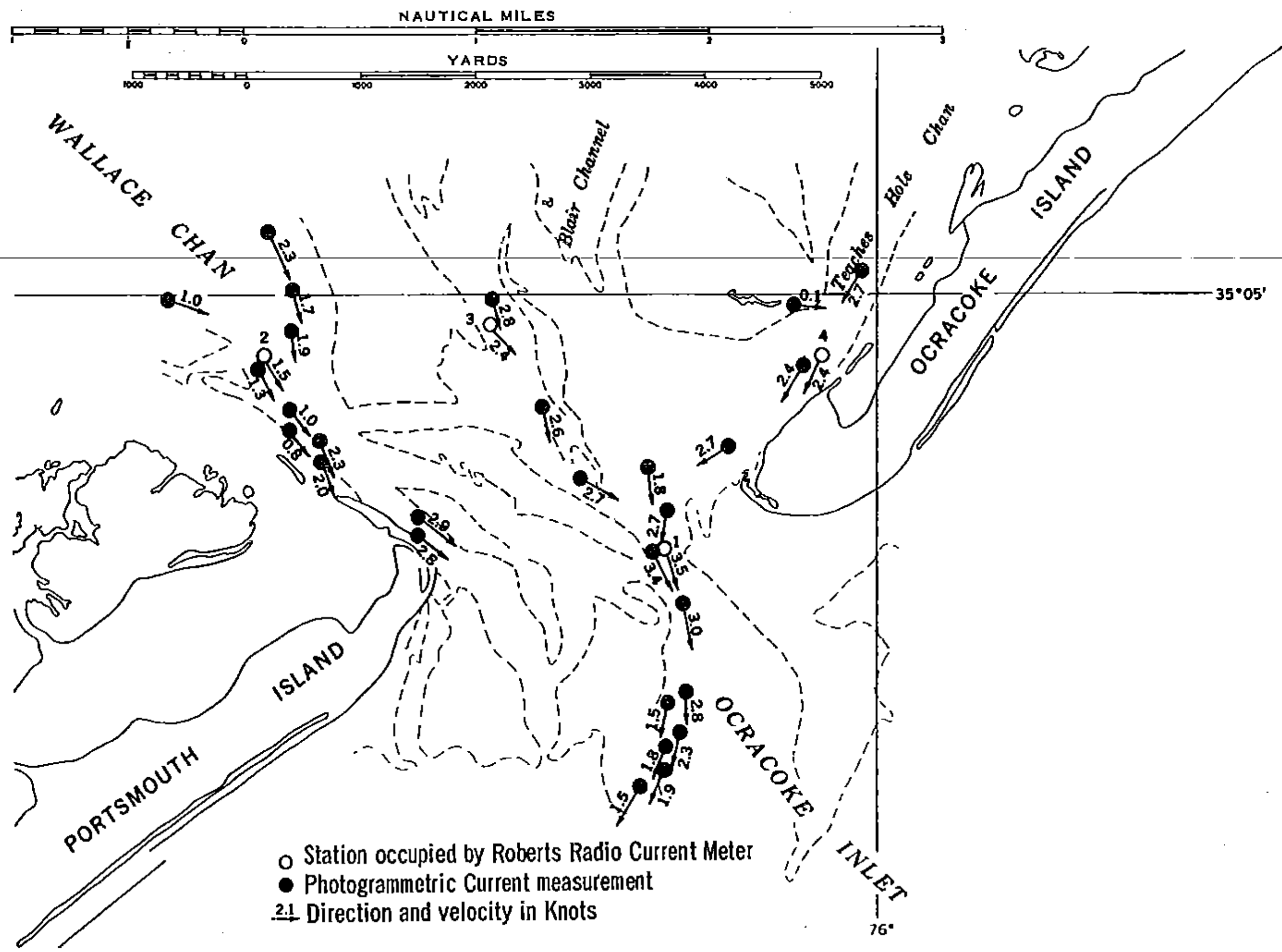


Fig. IV—United States of America: Ocracoke Inlet, N.C., maximum ebb at meter 1 (14 October 1962, 13.18 h, EST)

1965 Gulf Stream Survey

With stereo-photogrammetry, already a proven tool for current measurements, personnel of the Coast and Geodetic Survey studied the problem of using aerial photographs for the measurement of off-shore ocean currents in such a way that the photography would not touch the land mass. The first experiment was attempted on 27 October 1965, as part of an extensive scientific study of the Gulf Stream. Use was made of a one-photograph method with time-lapse photography (as suggested by C. A. Whitten of the Coast and Geodetic Survey). Control requirements with this method are quite different from those with the two-photograph (stereoscopic) method as described previously. Here it is necessary to rely on the aircraft and the ship to furnish control data for each photograph.

The area of this survey of about 9 square miles is at the approximate position of latitude 32° N and longitude 79° W—a seaward distance of approximately 60 miles from the coast of South Carolina. The chart of Cape Hatteras to Straits of Florida (figure V) shows the location of the survey and the positions of the two HI-FIX stations used to position the vessel.

The survey covered a strip 3 miles in length parallel to the direction of the Gulf Stream and to the westward or shoreward edge. The survey combined the efforts of the oceanographic ship *Peirce* and the C&GS Air Photographic Mission.

The data used in the analysis comprised five flights of colour aerial photography at 1:20,000 and 1:30,000. Positional and azimuthal control were furnished by the ship using HI-FIX electronic distance-measuring equipment for positions and compass headings for azimuth. The flights of photographs covered the area in which floating surface targets had been placed and were taken at half-hour intervals.

Fifteen surface targets were used in this survey. They were distributed by the ship at about 0.3 mile intervals along a line approximately perpendicular to the Gulf Stream boundary. Nine of the targets were rectangular wooden panels with a mast and a signal flag. These were painted either red or white so as to be distributed in the water in alternate colours for ease in identification on the photographs. The other six targets were formed by using aluminium powder. An intermittent trail of red Rhodamine dye was used to mark the entire line of targets and to furnish another type of target for measurements.

Control data were obtained for each flight of photography. This was accomplished by having the ship positioned at the middle of the line of targets (figure VI). At the actual time of photography, the ship determined its

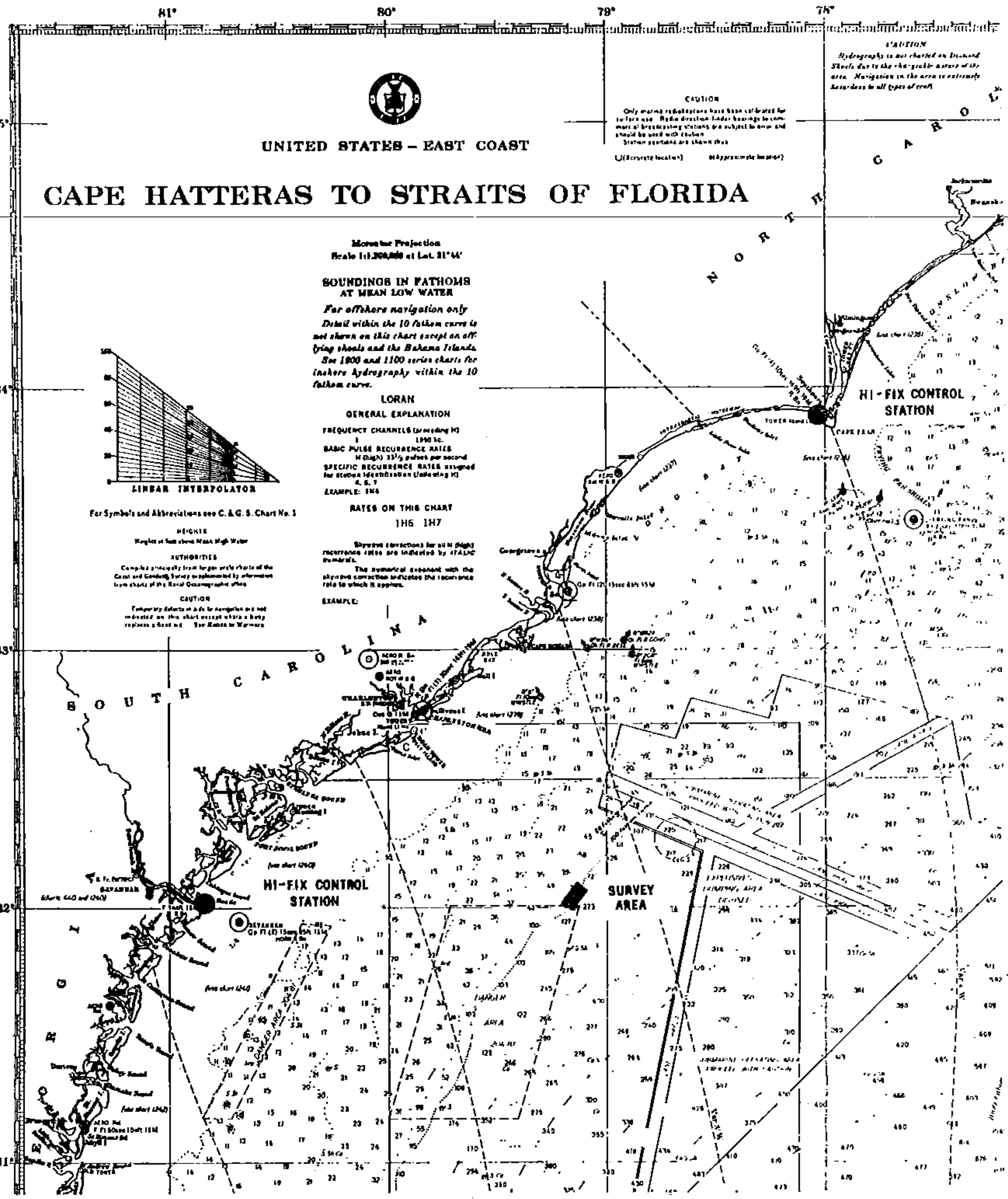


Fig. V—United States of America: East Coast, soundings

position by HI-FIX and observed compass directions to one or more of the masted targets. Thus, by imaging a point of known position (the ship) and a line of known azimuth (ship to masted target) on each photograph, the position and orientation of the photograph was obtained. The scale of the photography was controlled by maintaining a prescribed flight altitude by barometric altimetry. For this, the ship's barometer was used as a base station to correct for pressure changes.

The objective of the survey was to furnish current velocities. This was done by determining positions for targets for successive flights of photography. Then, with exposure times of the two flights known, the velocity vector (in knots) could be computed as $v = s/t$ where s is the difference in

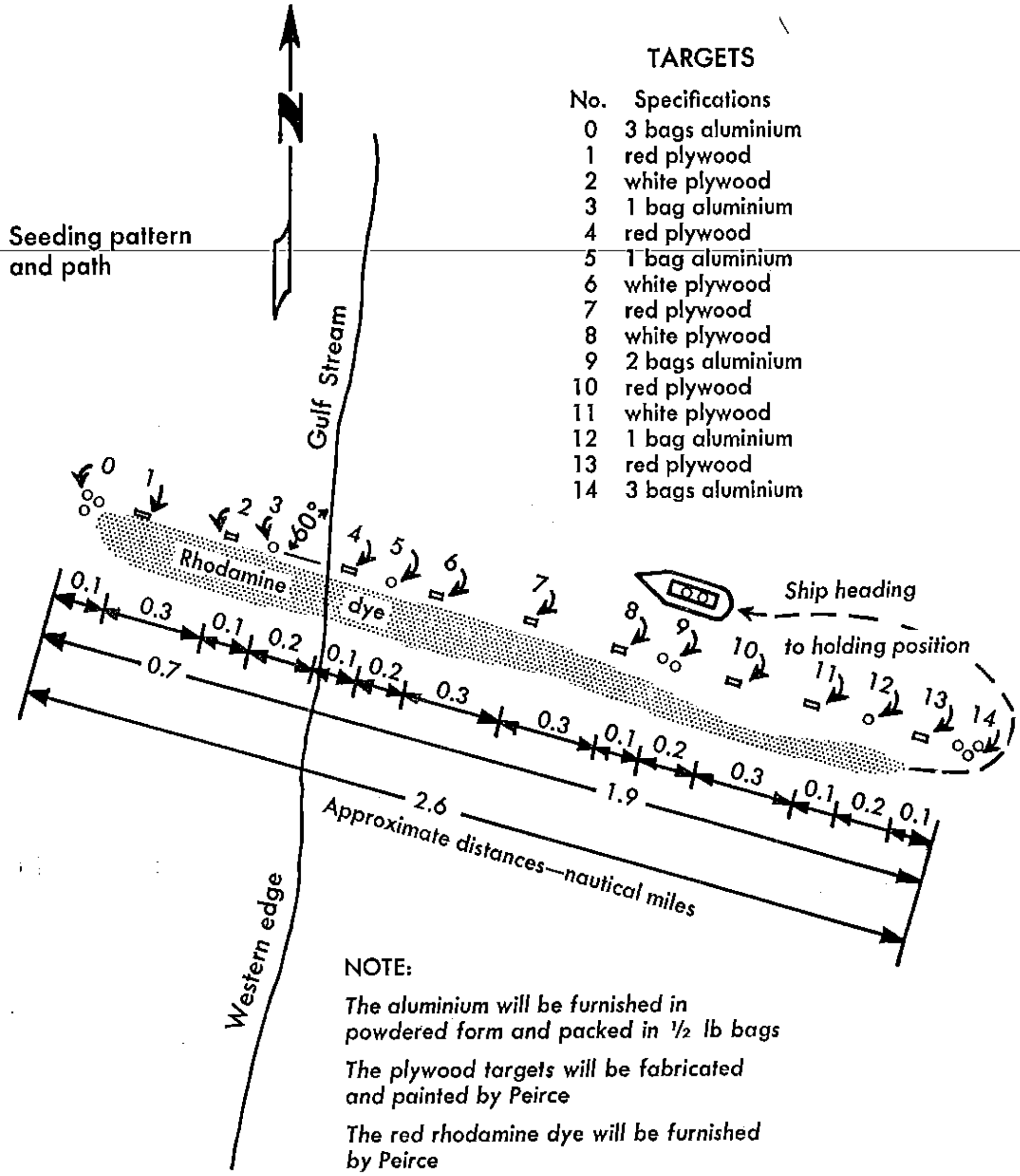


Fig. VI—United States of America: Target distribution sketch

position in nautical miles and t is the increment in time in hours. When this equation is stated in terms of millimetres at a photograph scale of 1:20,000 and in minutes for time between photograph exposures, it becomes

$$v\ (\text{knots}) = 0.649\,\frac{s\ (\text{millimetres}).}{t\ (\text{minutes})}$$

Absolute positions were not required to determine the velocity vectors for this survey. The relative positions using HI-FIX lane data were instead plotted at a scale of 1:20,000. The absolute position by HI-FIX is subject to some error, whereas the relative position between two fixes is very good. An absolute position was computed only for the general geographic location of the survey.

The aerial photography was flown with 80 per cent overlap so that the plotting of each target for each flight time was obtained separately from more than two photographs. This redundancy provided some compensation for the effects of tilt and scale errors in the photogrammetric measurements. As previously mentioned, the plot for each flight was controlled by using the ship's image for position and one or more lines from ship to targets for azimuth. Except for one flight, which had a single azimuth, three or more azimuths were given to orient the flights and thus provided a check in each case. The resulting data, consisting of target positions and current velocities, are shown in figure VII. This illustration shows the wooden panels (squares), aluminium powder (circles) and the dye (octagons). Current vectors are shown with arrows and velocities in knots.

The final accuracy of the current vectors are determined by the accuracy of the exposure times, the precision of the photogrammetric measurements and the accuracy of position and orientation of the photographs. Exposure time for an individual photograph was recorded to the nearest second. The time factor is not critical with time-lapse photography of one-half hour interval and is not even required to this accuracy of one second. Thus, with the

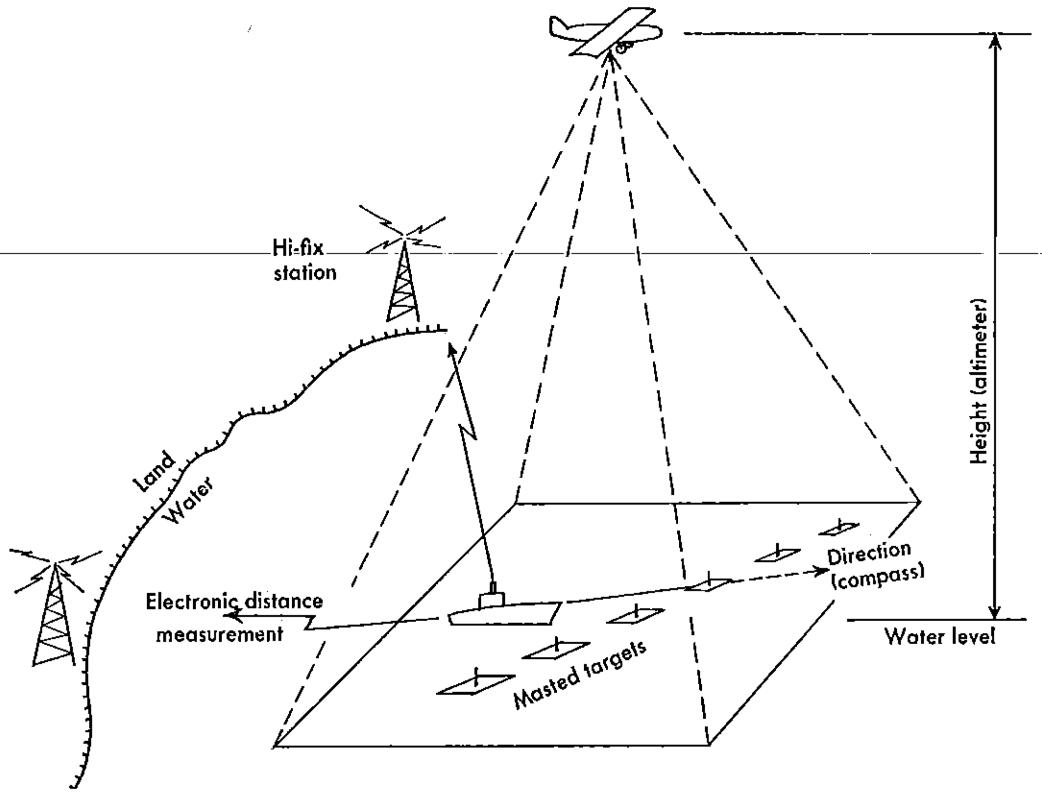


Fig. VII—United States of America: Target positions and current velocities

current velocities of about one knot, for this survey, the mean time of each flight was used for all photographs in the flight.

To achieve a measuring accuracy of 1 mm for photograph positions, sources of error had to be considered and corrections applied, including: ship position, azimuth determination and scale and tilt of photography. Determination and correction of these error sources are discussed fully in an issue of the *Coast and Geodetic Survey Technical Bulletin* to be published at a later date.

For this survey, accuracy in positioning targets was indicated as within 1 mm and accuracy for measuring time interval within 30″. This may appear to be extremely poor measuring from the standpoint of photogrammetry but it is good enough to yield current velocities to an accuracy within 0.05 knot. Other aspects of the survey and results achieved deserve some comment.

Of the three types of targets used—panels, aluminium powder and dye—only the panels gave an absolute point for measuring. The aluminium powder dissipated or changed shape as the survey progressed. By the end of the two-hour period, the dye was almost completely dissipated in some areas. Moreover, the points along the dye path were generally rather indistinct and were not well defined for targets.

The colour code used for the panels is a convenient and worth-while tool for identification. Colour photography was selected for this project instead of panchromatic or infra-red photography because of its advantages in the identification of targets. However, white targets are not always easy to detect against white foam. Perhaps orange and dark red would be a better selection of colours. A natural consideration is the use of geometrical patterns of two or more colours but tests reveal this to be impractical because much larger targets are required for the photographic resolution of patterns.

Owing to the photographic flare of the panels, the rectangular shapes of the targets were not very evident on this photography. For these scales—1:20,000 and 1:30,000—the sizes of the targets were adequate for identification: seven were 4 × 4 ft and two were 4 × 8 ft. The 4 × 8 ft was the preferred size and shape.

The panels were spaced at approximately 2,000 ft intervals. This was adequate for measuring the currents in the area. In the two-hour period of this survey, the targets had dispersed from approximately three miles in extent to five miles. A wider spacing would have presented problems of coverage and identification.

The wooden panels with a small mast surely offer some wind resistance, although they were designed to minimize that effect. It might be feasible to determine, experimentally, wind factors for different target designs. Thus, if wind velocity was observed during the survey, the effect on the target could be computed.

1966 Gulf Stream Survey

Another area of the Gulf Stream has been selected for an experiment in oceanographic study during 1966. It is approximately 8 × 15 miles and is to be covered by wide-angle photography at 1:40,000 scale. For this survey, it is anticipated that the ship can furnish horizontal control comprising positions on about eight anchored floats. The pattern selected for control permits coverage of the area by two parallel flights of photography (see figure VIII).

The logistical problem of supplying targets over such a large area of fixed position is perhaps the most difficult aspect of the survey. The ship and launches will lay down

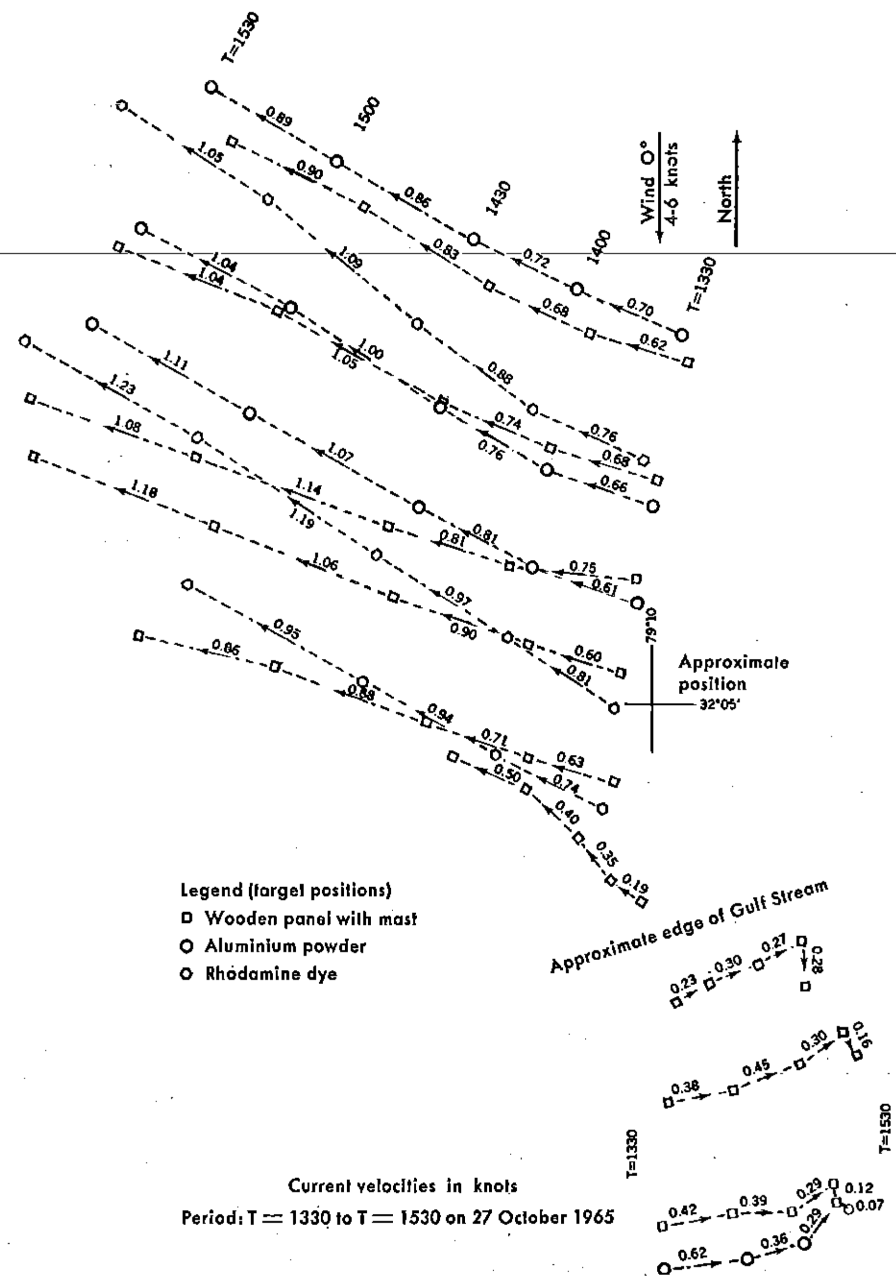


Fig. VIII—United States of America: Photogrammetric current survey of Gulf Stream

two lines of eleven targets at $1\frac{1}{2}$-mile spacing, four drogue targets and seven panels. The aircraft will disperse aluminium powder targets at $\frac{1}{2}$-mile intervals on seven separate flights during a two-hour period, requiring a total of approximately 200 targets.

Based on the experience of the last survey, 4 × 8 ft panel targets will suffice for identification at the 1:40,000 scale. For more positive identification, larger aluminium targets will be used. Because directions are not required by the ship to the targets, masts are not needed on the targets; there will thus be a lesser wind effect on the targets.

The planned flight axes for photography coincide with the lines of fixed targets to control sidelap—a critical factor. This problem will be further aided by equipping the terminal targets with smoke signals for the entire period of the survey to assist the aircraft both in photography and in distributing targets.

As in the previous survey, in order to have greater redundancy for target location, an in-flight overlap of approximately 80 per cent will be maintained. This will require a total of approximately 125 photographs for two hours of the survey.

The pattern of distribution for control and targets will permit applying radial plot methods for control of scale and position. The use of radial plotting will eliminate most of the tilt effects—perhaps the most troublesome error source. The resulting plot will be an unusual one in that it has some built-in error resulting from the drift of targets with the currents. However, drift will be fairly small because the flights will require only about eight minutes (approximately 31 mm at 1:40,000 scale for a velocity of 5 knots).

The drift effect can be corrected at the time of compilation. The effect is shown in simplified form in figure IX. In this case, scale within the flight will be nearly correct with

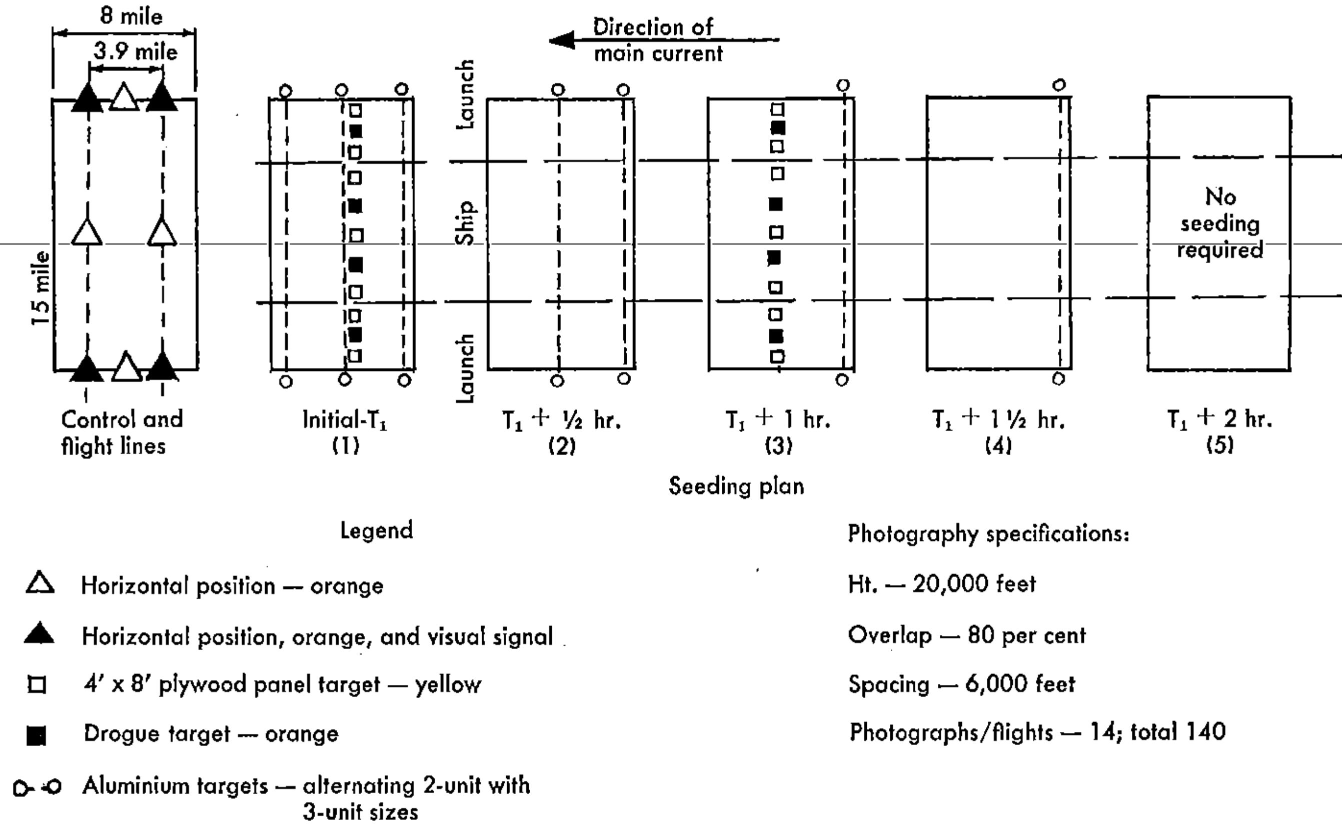


Fig. IX—United States of America: Plan for fixed control, flight lines and distribution of targets

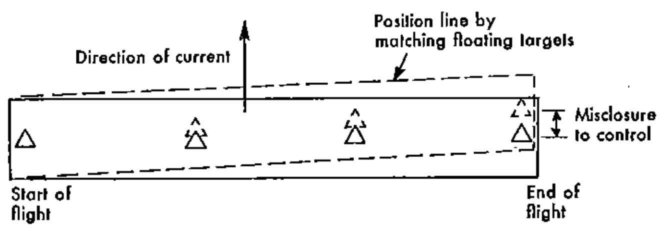


Fig. X—United States of America: Current drift effect in plotting of targets

only the azimuth of the flight being in error. This requires corrections to plotted positions which vary with the current velocities and the time increments of exposures within the flight. The current velocities can be closely approximated by a preliminary plot of successive flights. Using these values, the photograph centre will be shifted in position accordingly for the time interval between exposures. After these corrections are applied, the adjustment of anchored or fixed terminal control targets is made conventionally.

With optimum conditions, the use of radial plotting to control scale and positions for this experiment will furnish higher accuracy than the small survey discussed earlier. With moderate care, positions should be within 1 mm. Also, by using the actual time of the exposures to 1 second, much better accuracy for the time factor can be achieved. The effects of scale errors and tilt errors are mostly eliminated by using the radial plotting method. The error in scale introduced by the use of altimetry, applicable to the earlier survey, will be eliminated with this plan.

A potential source of error is introduced in this plan: that of position errors in the anchored targets. The anchorages may be difficult and some drift may occur during the survey. To control this factor, these control positions will be determined when installing and again when removing the targets.

The plan for this survey demands good teamwork between marine and aerial units. Altogether, slightly more effort is required than with the previous experiment, but the plan offers greater potential to do a larger and more accurate survey.

Summary

Both the two-photo (or stereoscopic) and the one-photo methods have been successfully employed in the measurement of ocean or tidal currents. With the stereoscopic method, the intervals of time and space are very small. Thus, precision photogrammetry should be undertaken only with precision stereoscopic instruments. With the longer time lapse, as employed with the one-photo method, precision photogrammetric measurements are not required. Each method has its advantages and its limits in application. For areas contiguous to the land mass such that the models can be absolutely controlled, the stereoscopic method is preferable. For models away from the land mass, the control required becomes prohibitive for some areas by the two-photo method.

An experiment is now in progress in Long Island Sound. Here a study is being made to determine whether the 20-plus mile width of water area can be spanned without anchored floats for control, or at least with very few. Scale and position corrections will be made by using lines between floating targets; it might be called a "floating base" principle.

Another aspect of this experiment is the use of simultaneous photography with two aircraft. This offers the advantage that the model can be levelled, thereby eliminating an important error source. Also, the coverage can be increased by the base length between aircraft.

The use of smaller scales has proved to be practical for current surveys. It is possible to detect floating targets, if increased in size very slightly, on super-wide-angle photography at 1:70,000 scale. The smaller scale is compensated by the increase in time interval. Another advantage of such photography is obvious: each exposure covers almost 100 square miles of surface area.

The Coast and Geodetic Survey has much work to do in measuring currents along the bays and harbours of our coasts. The need for better techniques is great. We shall continue to explore new methods. Photogrammetry is very likely to play a more prominent role in oceanography.

COMPUTATION OF CADASTRAL SURVEYS IN NEW SOUTH WALES

Paper presented by Australia[1]

General

Cadastral surveys in New South Wales

Following the foundation of the colony of New South Wales in 1788, the necessity of utilizing the agricultural possibilities of the land was early recognized by Governor Phillip. The first grants of land were made to the military and later to convicts as they became free. The first free settlers arrived in 1793 and grants were issued to them.

In the process of settlement, it was necessary that the boundaries of lands granted and leased by the Crown should be determined by survey and that each survey should be indexed on maps.

The first surveys of land for settlers and townships were made by H. Dawes of the Marines, assisted by David Burton. From 1803 to 1822, practically all the surveys of the early grants in Cumberland county were made by James Meehan, a transportee, who had been assigned to Charles Grimes, the Surveyor-General from about 1802.

From the earliest days, cadastral surveys have depicted the lengths and bearings of lines and boundaries which are the foundation of the subsequent construction of cadastral maps. Nearly all the earlier surveys were performed with the circumferenter and Gunter's chain. During the first forty years at least, of land settlement in New South Wales it is recorded that there were only two theodolites in the equipment of the Surveyor-General's office. The use of the latter instrument became mandatory in about 1870. The major limiting factor of a circumferenter is the open sights as opposed to the optical telescope of the theodolite. The accuracy is not usually depicted to more than 10′ of arc. The Gunter chain consisted of 100 main links connected with 300 smaller links of wrought iron or steel. The excessive wear and distortion resulting from this was liable to cause changes in use, and measurements have been found to be as much as 30 links in one mile in error. It would appear that wrought iron or soft steel banks of 1 or 1½ chains long and about half an inch wide were introduced in the early eighteen-sixties. The long steel band or wire and the practice of hypotenusal chaining is believed to have been first used in 1872.

The compass has also been occasionally used in modern times for measurements in rough country to be held under leasehold tenures, not intended for alienation from the Crown.

Cadastral surveys in New South Wales are almost invariably referred to the magnetic meridian, either directly as with the circumferenter, or indirectly, as when the azimuth has been derived from adjoining surveys. The regulations governing surveys in the state of New South Wales occasionally provide for the determination of the magnetic variation of a survey by astronomical observation, which is most valuable in the process of map compilation.

The Department of Lands now holds over 500,000 plans of surveys of land alienated from the Crown, held under the various forms of tenure and dealt with in many different ways under the provisions of the Crown Lands Act and kindred legislation. In addition, the various types of plans of survey held by the Registrar-General are of great value in cadastral map compilation. This applies particularly where the original Crown surveys are of an early date. Plans of various leases, etc., held under the Mining Act are also frequently used.

Methods of compiling cadastral maps

The "parish" map forms the basis of the administration of the Department of Lands, providing as it does an index to record all dealings with and surveys of the Crown estate, and in addition showing such lands as are acquired by government bodies by purchase or resumption for public purposes. Private subdivision of alienated lands is frequently shown as far as practicable.

By direction of the Secretary of State, the colony of New South Wales was divided into counties, hundreds and parishes in 1824. The division of the eastern part of the colony into nineteen counties, fixed by Governor Darling as the limit of settlement, was accomplished by 1830. Further subdivisions into counties and parishes was completed in the following decades. The state of New South Wales now contains 142 counties and 7,422 parishes, of which 5,300 parishes are mapped.

Prior to the recent commencement of "basic cadastral mapping" on the national grid, most parish maps were compiled independently of the adjoining parishes, each plan being regarded as representing a survey on a plane surface; the surveys were adjusted to the azimuth of one portion and fitted together by plotting one on to the other. The resulting distortion would not be appreciable over the extent of a single parish.

The desirability of commencing a recompilation of the complete cadastral system of the state is set out in the report of the Government Mapping Investigation Committee of 1945 (section II, paragraph (15)). The report states:

"A substantial number of the existing parish map compilations prepared in the Department of Lands were first made many years ago, when land settlement in rural areas had not progressed beyond isolated groups of holdings. These groups were rarely connected to one

[1] The original text of this paper, prepared by B. Purins, Chief Computer, and J. R. Hutchinson, Senior Computer, Department of Lands, New South Wales, and submitted under items 8 and 9 (*g*), appeared as document E/CONF.52/L.35.

another and their relationship in the parish compilation was, of necessity, only an approximation. In the course of time, as settlement expanded and intervening surveys were made, it was found that the final key surveys would not fit accurately into their places in the map in true relationship to the other surveys.

"This was not due to faulty survey work, but to the original fault in the map. If the discrepancy was not excessive, the key surveys were adjusted into position as well as circumstances would allow, and the map accepted for reference purposes as a matter of expediency. If, however, the discrepancy was intolerable, a recompilation was made. It was intended that in due course more accurate compilations would be prepared to replace the faulty ones, but in the mean time the officers aware of the position were transferred or retired, and the existence of the faulty compilations was unknown to their successors. Nor were the discrepancies discernible by cursory inspection. Later, when the preparation of a new standard map was unavoidable, and in ignorance of the inaccuracy of the dilapidated compilation, a tracing of the latter was made, thereby perpetuating the faulty map. It is inevitable that all the faulty map compilations will have to be replaced by accurate ones."

Reference is made to the necessity of completing the trigonometrical survey, begun about 1867, as a preliminary to such re-compilation. In a few regions the parish maps were, in fact, based on the triangulation, and are excluded from the above remarks. These were plotted on what was in effect a grid on the Cassini-Soldner projection. A separate projection was allotted to each county, or in some cases more than one, with a centrally situated trigonometrical station as origin.

Following the recommendations of the above-mentioned committee, a new compilation of basic cadastral maps was commenced by the newly created Central Mapping Authority. The aim was to provide an accurate base map at a scale of 20 chains to 1 inch which might be used for the preparation of other cadastral maps at various scales, but more particularly the parish maps at a scale of 40 chains to 1 inch.

The compilation was controlled by the main triangulation stations of first and second order, which had been connected to the cadastral system. Lower order control stations were interpolated between the main stations, by intersection, resection or Tellurometer radiation, such stations being also connected to the cadastral system.

The methods adopted did not differ basically from the procedures to be discussed in the present paper. The principal differences lie in the systematic procedure now adopted of breaking down the control by means of polygonal circuits or the design of direct traverse routes, with suitable checks, between control points. The analysis and mitigation of errors where possible was not normally undertaken. At that time, also, the advantage of electronic computation was not available.

Advantages of a computational system

The process of compiling cadastral maps will be seen to have developed from a purely graphical one, as with the original parish maps, to an intermediate stage where a certain amount of computation is done, as with the procedure adopted for the first basic sheets.

It is evident that the use of the co-ordinatograph for precise plotting of co-ordinates has advantages on the score of accuracy over the plotting of successive traverse lines with scale and protractor. Obviously, the use of co-ordinates for plotting will necessitate some form of computation; on the other hand, determination of co-ordinates of the whole network of surveys is scarcely practicable. The computation of co-ordinates of a sufficient number of points to enable the remainder to be plotted by protractor and scale without risk of error accumulating is the desirable compromise.

The cartographer's task is simplified, as he is freed from the necessity of carrying out any computations himself; he is supplied with a list of co-ordinates which he may plot with precision, and fill in the remaining cadastral detail without difficulty.

By the methods to be outlined in this paper, the given control, by triangulation or other means, may be broken down by selected traverses through the cadastral surveys, giving co-ordinated points wherever they may be required. By arranging traverses to follow sheet boundaries as closely as possible, difficulties of edge-comparison between adjoining sheets may be avoided.

If control is scarce over considerable areas of the sheet for any reason, it is frequently possible to break up the area by computation of a network of traverses sufficiently accurate for the graphical plotting of the intervening detail. Computations for a map sheet may be organized as a complete, separate task, to provide the cartographer with the data he needs and, at the same time, to permit the utilization of modern techniques such as automatic data processing. Finally, the computation results may be preserved, and are frequently useful for other purposes such as control for photogrammetry and topography in certain cases.

Relationship of cadastral to topographic mapping

It will be appreciated that much of the detail of the cadastral pattern will also appear in the photogrammetric plot of topographic detail, if the two forms of mapping proceed concurrently, which is normally the case. If boundaries are fenced, the latter will appear on the topographic compilation. In addition, various features are accurately located on the cadastral surveys, especially watercourses which intersect the line of traverse. Comparison of the respective compilations yields a valuable check on both.

Survey plans and maps available

Existing cadastral maps are essential for the planning and execution of a basic compilation. The principal maps used for this purpose are the county, parish and town maps already published by the Department of Lands.

County maps are published at a scale of $\frac{1}{2}$ inch to 1 mile. The average area covered by a county is about 2,200 square miles. Generally, a graticule of meridians and parallels is shown, but not invariably. The maps show the complete cadastral pattern as at the date of publication and such other information as is appropriate to the scale. The county map functions as an index to the parish maps covering the same area.

County maps are used in the form of a rectangular composite at a scale of 1 inch to 1 mile, which conforms to the National Map Index, to form a working sheet. These sheets are used to indicate the position of existing control points, or any further control which may be required, for action in the field. The sheets are also used to depict the final network of traverses which have been computed and adjusted, for submission to the cartographer.

Parish maps are essential, as they provide an index to the plans of survey of all portions shown on the map, as well as roads, mountain ranges, where traversed, and various miscellaneous plans, such as connexions to trigonometrical stations. The area covered by a parish map varies considerably, and may amount to 150 square miles or more. The scale of the maps is normally 40 chains to 1 inch, but 20 chains to 1 inch is used in closely developed areas. Each surveyed portion has its own reference number, the sequence being confined to one parish; the numbers are roughly chronological, with the oldest surveys having the lowest numbers. In addition to much information concerned with administration, the registered numbers of the original plans of surveys throughout the parish are tabulated and references to other plans of survey appear on the face of the map.

Town maps show details of surveys within towns and villages. The office copy of parish and town maps should be consulted for the latest information.

Registered plans will be available for virtually all portions shown on the parish map. In the eastern and central divisions of New South Wales, the scale is usually 20 chains to 1 inch for the plotting of the surveys, or 40 chains to 1 inch for larger portions. In the western division, with its large holdings, 80 chains to 1 inch is commonly used.

The great majority of plans of portions are of foolscap size (13 × 8 inches) but double foolscap rolls are common. Larger rolls, especially for road surveys, and "large flats" are also frequently met with. A system of paired numbers with an initial letter is used for catalogue purposes except for miscellaneous plans. The first number is the serial number; the initial letter and second "small number" normally indicate the county (for example, C 697.2030 and C 697.1507 are located in the counties of Cumberland and Cook respectively).

In addition to the registered plans of survey held by the Department of Lands, a wealth of information is available at the Land Titles Office (Registrar-General's Department), especially in the older, more closely settled areas of the state. Most commonly met with is the "deposited plan" (DP), which is actually a plan of the subdivision into five or more lots of land held under the Real Property Act ("Torrens title"). Various other plans which show bearings and lengths of boundaries, connexions and descriptions of marks are also held by the department, which may assist in the compilation. Such plans of survey may replace the older Crown surveys in many cases.

Copies of plans of various holdings under the Mining Act may be obtained from the Department of Mines. These may prove helpful in linking up other surveys in difficult areas. Leases for gold dredging along certain main rivers are a case in point.

Partial surveys will frequently be encountered. These are normally used for leasehold tenures not intended for alienation from the Crown. Surveys of adjoining portions are adopted where available and new surveys applied only to define the remainder of the boundary.

Plans of connexion to trigonometrical stations conform to the specifications laid down for cadastral surveys. Bearings to other trigonometrical stations are referred to the adopted magnetic meridian.

Diagrams of connexion to minor control points are similar, but not registered. Bearings in this case refer to the central meridian of the projection. Both forms of connexion normally depict connexions to one or more cadastral corners together with a comparison of bearing which enables the grid bearings of the original survey to be established.

Numerous gaps will appear in the pattern of surveyed portions. These may occur when such portions are adjacent to travelling stock reserves and other unsurveyed areas such as State forests and vacant Crown lands. Frequently, however, connexions will be found which enable computations to be extended across these gaps. These will be searched for on the plans; similar connexions across major streams will be searched for.

Information shown on plans

Plans of survey will normally indicate the bearings and distances as determined by the surveyor in the field. The bearings may be omitted along cardinal directions. Where the scale does not permit the direct entry of the bearing and distance along the appropriate line, the values are shown on a separate schedule on the face of the plan. A diagram may also be used to clarify details not otherwise clearly shown.

Official directions published for the guidance of surveyors will be of assistance in using the plans effectively, especially in connexion with instructions for placement of marks and preparation of plans. Particulars of older corners and reference marks are of particular importance, as the accurate transfer of azimuths between adjoining surveys is an essential feature of the computation methods to be discussed. If both corners at the ends of an existing boundary are identified as "peg found", a more reliable transfer of azimuth will obviously be possible than in a case where only a line of blazed trees has been found. Recovery of the corner reference tree, lockspits or other identifying marks will also be noticed.

Details of the connexions to corners from the various reference marks are tabulated on the face of the plan. These will also be helpful in identifying with certainty apparently identical corners appearing on different plans.

The datum line for azimuth which has been adopted, usually from an adjoining survey, is indicated on the plan. If astronomical observations for azimuth have been made, the data used to determine the variation of the plan azimuth from true north is tabulated.

It should be noted that, although cadastral plans are often stated to be referred to magnetic north, this is strictly true only of the original surveys by compass from which subsequent azimuths have been derived. These may have been made possibly upwards of a century or more earlier.

Mention should be made of the subject of excess lengths. It is on record that, in marking out large grants in the early days, an extra link was sometimes added to the chain for better accuracy, in order to avoid the usual corrections for slopes. Fortunately, by far the greatest number of surveys dealt with today date from about 1870 onwards. It is noted, however, that, when adjusted to triangulation control, there is a marked tendency towards a positive correction to lengths. By comparison with later work, it is sometimes possible to determine a correction factor.

Accuracy

The computed control for cadastral mapping should be free of plottable error at the scale of the proposed map. Assuming that the actual plotting is to be correct to 0.01 inch and the basic sheet is to be at a scale of 1:15,840, the error in the easting and northing of co-ordinates should not exceed 5 yards. The 5-yard tolerance is also useful in the assessment of closing errors in polygons or traverses between control points. When mapping is to be compiled on other scales, the density of the control and desirable accuracy of computation would be appropriately varied.

Computations for basic cadastral mapping are at present designed for the following plotting scales:

1:4,000: this scale is designed for developing urban areas of the state;

1:15,840 (20 chains to 1 inch): this is the normal scale for compilation for standard mapping in the eastern and central divisions of the state;

1:63,360 (80 chains to 1 inch): this scale has been employed for the computations of map sheets in the western division.

Assembly of available information

Working sheets at the scale of 1:63,360 (1 mile to 1 inch) are prepared from existing county maps and mounted on linen. Copies of parish maps are obtained and up-dated from the original copy.

Copies of plans available in the Department of Lands are obtained by Xerox equipment (foolscap size: $8\frac{1}{4} \times 13\frac{1}{4}$ inches) or by usual photographic techniques (large-size rolls). Copies of real property surveys are obtained from the Registrar-General's office and the surveys are noted on the parish maps.

Selection of ground control

The only existing ground control consists of established trigonometrical stations in the area. In the selection of additional control, topographical control requirements are satisfied first. For this purpose, control is arranged evenly along the edges of the sheet (8 points) and one point in the centre of the sheet. In addition, some 5 check points are selected in the area so that we have, say, 15 control points already available for cadastral control also, the maximum distance between control being approximately 15 miles.

The extension of the control is then planned according to the requirements of control traverses by careful study of the working sheet and noting the following factors: general density of the cadastral pattern of boundaries; expected accuracy of the plans; layout of rivers, streams and railways; areas for which no plans are available, unsurveyed areas and isolated portions in those areas. Generally available river crossings are inspected first to make sure that a reasonable traverse system may be established in the area. The positions of river crossings are marked on the parish maps.

If plans of estimated reasonable accuracy and reliable river crossings with azimuth comparison are available, normally no additional control is required for a distance of up to 10 to 15 miles.

However, for up to 90 per cent of cases, control points are to be selected 5 to 10 miles apart. In some cases, additional connexions across rivers or railways only are required without the establishment of position.

The actual routes of control traverses are not selected at this stage. Control is marked on a copy of the working sheet with coloured pencils.

Control point folders are prepared containing copies of all the surrounding plans required for the connexion of the control point to portion boundaries. All the above information, with an attached schedule, is handed over to the field staff. In the field, the actual control points, established by resections or tellurometer radiations, are connected to boundary pegs or reference markers, if found. Fence corners are selected if there is no evidence that the fence has been erected off the boundary. As a rule, both ends of a line or any two identified points on the portion boundaries are connected for following purposes: verification of the connexion, and to establish the portion survey on grid bearings.

In the case of connected fence corners, the accuracy of the grid bearing must be taken into account, and the longest line of the portion survey is accordingly preferred for comparison of bearings.

Methods of computation

Point-to-point method

Three or four control points are selected in the area and control traverses run between them by the shortest possible route through a common point or points. As a rule, the method may be applied under the following conditions only: the expected accuracy of the plans along the route is considered to be sufficient; if obstacles mentioned under the heading "Selection of ground control" above cannot be avoided, reliable crossings with azimuth comparisons should be available.

For further details, see the sections under the headings "Selection of traverses for the point-to-point method" and "Co-ordination for point-to-point method" below.

Polygon closure method

A system of closed polygons is formed between the control points so that, by the inspection of individual misclosures, unreliable traverses may be detected and errors isolated and dealt with separately. This is also the method generally used for computations in cases where satisfactory results cannot be obtained by the point-to-point method.

Least-squares method

As a rule, an adjustment by the method of least squares is not justified for the following reasons: if the accuracy of the plans is reasonable, the required plotting accuracy is usually obtained by the methods just described; in areas where the plans are unreliable, sufficient accuracy cannot be obtained by any adjustment. An attempt is usually made to isolate these areas and establish an interior polygonal system with a view to obtaining the best fit possible. Additional field control is usually necessary if the affected area is sufficiently extensive.

There may be cases, however, when plans of reasonable accuracy are available for considerably larger areas, even including several map sheets. In these cases the possibility of computing without the establishment of additional ground control may be considered even if trigonometric control is available at the border of the area only. Under these conditions, an adjustment by the method of least squares may be justified and carried out as follows: a system of closed polygons is established; errors in control traverses may be isolated by an analysis of the polygon misclosures; two condition equations are formed for each polygon and between each pair of control points, the absolute terms being the misclosure in both co-ordinates; a least-squares solution is obtained and corrections applied to the corresponding control traverses to obtain adjusted values; co-ordinates of junction points are computed; traverses between junction points are adjusted. The method has been used once only in the Department of Lands in an area containing larger sized land units.

Programmes for automatic data processing

The programmes described below have been designed for the computation of control traverses.

Computation of a missing line

Bearings with provision for an accuracy to the nearest second and distances to 0.1 or 0.01 of the unit are punched on Hollerith 80 column cards: 6 lines per card. A blank co-ordinate card with identification number is attached as the last card. The programme supplies a print-out showing all punched data and the bearing and distance of the missing line between the end points. The programme may be used for the computation of the vector of the misclosure for a closed polygon and it may be extended to include the application of the projection scale factor.

Traverse adjustment programme

The same cards are used for the computation and adjustment of co-ordinates of the traverse between end points. Co-ordinates are punched on the last data card left blank above. The computer evaluates the bearing and distance of the missing line from data punched and the same from the given co-ordinates. The comparsion of the results indicates the difference between plan and grid bearings and the scale factor of the traverse. The difference in bearings is added to each punched bearing and the length of each line is proportionally altered by the scale factor. The adjusted results are used for the computation of the co-ordinates for each traverse point, starting from one end of the traverse and computing also the co-ordinates of the other end for comparison purposes. Only the length of the lines is changed, the angles remaining the same.

Two types of print-out are available, both showing the adjusted bearings and adjusted length in the units used for punching. One print-out shows co-ordinates in yards only, the other includes the corresponding values in millimetres at a certain scale for plotting purposes. This method of adjustment was introduced at an early stage of programming and has been found to yield sufficient accuracy for cadastral mapping. For the method of plotting adopted, only a certain number of points are established by co-ordinates, and the traverses between them are plotted by adjusted bearings and lengths. The adjusted bearings are also required to establish the neighbouring plans on grid bearings. The adjusted length is useful for the estimation of a scale factor for these plans, especially in the case of older surveys. The main advantage of this method is that the adjusted bearings and lengths are obtained directly in the simplest possible way before the computation of adjusted co-ordinates. Other methods would normally require either the determination and application of corrections of varying magnitude and sign (as in a least-squares adjustment) or the computation of these values for each line from co-ordinates (as in the case of an adjustment of Bowditch's rule). The programme may be extended to include the application of projection scale factor as computed from the mean values of the co-ordinates of the end points before the adjustment (see section under the heading "Assembly of source material and data" below).

Selection of junction points and control traverses

General problems in the selection

The purpose of the control traverses is to provide sufficient control for the plotting of the cadastral pattern of boundaries by a protractor and scale. Before commencing the selection of control traverses, the distribution of control points should be studied on the working sheet to determine whether any junction points are required for the formation of polygons. It may be possible to provide sufficient control in an area by direct traverse routes between control points as in the point-to-point method.

Normally junction points are selected in the central part of the area surrounded by control points. The following principles are adopted for the selection of junction points and control traverses: they should be evenly distributed, without large differences in the length of the traverses joining them to other junction points or control points; these traverses will form closed polygons the size of which should generally depend upon the area covered by individual portion plans, and more junction points and smaller polygons should be required as portions become smaller; the first attempt at selecting control traverses is made at this stage in conjunction with the selection of junction points.

The following rules should be studied and applied:

(*a*) The best use should be made of the boundary surveys available, as follows: areas with most reliable and extensive plans, especially extended road surveys and real property surveys, should be inspected first; areas with unreliable surveys may be avoided by choosing traverse routes along the boundaries of such areas; traverses should be run close to plans for which grid corrections are available from astronomical observations; the positions of the crossings of obstacles noted on the parish maps should be taken into account;

(*b*) At the sheet edges, routes are selected outside the sheet but as near to the edge as possible;

(*c*) The most suitable positions for junction points are at the intersection of the routes selected, as above;

(*d*) To avoid excessive accumulation of plotting errors, control traverses should be arranged so that in no cases more than ten lines are to be plotted without available control. The only exceptions are river traverses, because these normally are not plotted and tracing methods are used for transferring the river from plan to map;

(*e*) Small polygons should be avoided; if additional traverses are required for the isolation of errors or for plotting purposes, interior traverse routes may be designed later.

Selection of traverses for the point-to-point method

Three or four control points are selected in the area and the most direct routes taken in a diagonal direction. It may be practical to choose a common line or lines instead of a common point if nothing is gained by an additional route. The same may be applied at the central part of both traverses. The advantage is that direct comparison of grid bearings as produced by the two routes on the common lines is available in addition to the comparison of co-ordinates without the examination of the plans. Some saving of time is also achieved by the repetition of a part of the traverses. The rules set out above apply in the selection of traverse routes.

Method of co-ordination

The method used for the co-ordination of traverses is described below.

(*a*) Preliminary corrections are obtained for the magnetic or other bearings shown on the plans along the traverse routes, so that plan bearings may be converted into the grid bearings on the projection.

(*b*) The bearings and distances of the traverse lines along portion boundaries are listed, and cards are punched for automatic data processing.

(*c*) Each traverse is replaced by a missing line computed by an electronic computer for the polygon closure and least-squares methods. In the case of the point-to-point method, traverses between known co-ordinates of the end points are co-ordinated directly. The same procedure may be applied for the other two methods, if the traverse is run between the control points, especially if the bearing comparisons at both ends indicate satisfactory agreement. However, the time spend on computations by desk calculators to obtain a comparison of co-ordinate differences is negligible and we have one advantage, namely, that the punched data are shown on the print-out of results instead of the adjusted data as shown for co-ordinated traverses, so that a final check of any errors in the listing or punching may be effected more conveniently. Experienced punch operators very seldom make errors, especially if the punching is verified. The listing is also checked either by the same computer or by another one, but accidental errors cannot be avoided. If the listing is checked by another computer, the reliability of the source data would depend mainly upon the experience of the computers. However, an independent check generally doubles the time required for the listing.

(*d*) Co-ordinate differences at the end points of traverses are computed from the bearings and distances of the missing lines by a desk calculator. Thus the differences of co-ordinates as obtained by source data are available for all sides of the polygons. A direct comparison of co-ordinate differences as computed by the source data and by control points may be effected for traverses run between the control points. An automatic data-processing programme is available for the computation of a bearing and distance from the co-ordinates of any two points. However, desk calculators are generally used for the computation. The discrepancies found by these comparisons are investigated before the formation of polygon misclosures.

(*e*) Polygon misclosures are calculated and investigated and attempts are made to minimize existing discrepancies as far as possible.

(*f*) The co-ordinates of the junction points are evaluated from the known co-ordinates by the formation of a weighted mean.

(*g*) Final co-ordinates are added to the data cards already used and traverses are adjusted by an electronic computer.

(*h*) Final representation of co-ordinated control traverses is prepared.

Establishment of preliminary grid corrections for plans

The main problem in the computation is the establishment of reliable grid corrections for the plans along the traverse route. As far as the time required for the listing of source data for a traverse is concerned, the solution of the problem requires most of the time, followed by the joining of plans by common lines or corners and some other problems as discussed below ("Assembly of source material and data"). The actual corrections are evaluated and noted on plan copies in pencil for comparison purposes only. The differences between the grid correction as adopted for the traverse and the grid correction of a plan are considered in the process of the listing of traverse lines. Generally all plans are on approximately the same magnetic bearing and these corrections are small as compared with actual grid corrections, which may exceed 10°. It is expected that more errors would occur in the arithmetical process of addition or subtraction of these substantially larger quantities. Generally the grid correction required for the plans with the most lines is adopted as the grid correction for the traverse and corrections, if any, are applied to the lines of the rest of the plans. Traverse routes running directly between control points are treated first. A working diagram is prepared noting the location of control points, junction points, traverses and astronomical azimuth stations. Numbers are allocated for the traverses in consecutive order.

The process begins with the establishment of grid correction for the plan at one end of the traverse from a control point diagram. The next plan is then compared with this plan on a common line or lines to establish the difference in plan bearings. If the neighbouring plans are surveyed by the same surveyor at different times or by another surveyor, these plans are also inspected for general agreement by the closure of angles around a point common to all of them or by comparison of grid corrections of all plans around the point. The identity of corner positions should always be checked. Most reliable comparisons can be obtained if pegs or reference markers are found at both ends of the common lines. Where later surveys do not provide satisfactory connexions, older surveys may provide more reliable comparisons, especially if these are extensive and several surveys were done by one surveyor at about the same time. Thus "cancelled" plans may provide better comparisons than plans showing new surveys of the same area.

The length of the lines of comparison should also be considered; comparison is more accurate on longer lines. In the case of a long common traverse containing short lines, several longer lines should be compared. If agreement is not satisfactory, the common traverse should be computed by both plans to compare length and bearing thus obtained. This should also be done if comparison is needed along a large number of short lines. For the crossings of obstacles as noted in "General problems in the selection" above, especially in the case of river crossings, bearing comparison is obtained by running traverses on both sides of the obstacle between the common points at two crossings. Thus the reliability of the crossing is also obtained by the comparison of the lengths of both missing lines.

The grid corrections for the plans of a traverse may be verified through plans joining a plan with an astronomically observed azimuth to which grid convergence is applied. The reliability of the astronomical observations should also be considered. If the latitude has not been observed, the adopted approximate latitude should be checked. Approximate grid co-ordinates of the point of observations may be obtained with sufficient accuracy on the parish maps graphically. Grid north line is established by known grid corrections to plans and drawn through the point of observations by a protractor. A perpendicular from any close point with known co-ordinates is dropped to this line and the differences of co-ordinates measured graphically. The northing of the point is converted into latitude and from the easting the grid convergence is computed and applied algebraically to the observed astronomic azimuth or magnetic declination as noted on the plan or corrected. If the latitude is in error by more than 30″, the observed values should be corrected, especially if observations have been effected less than two hours before the culmination.

Thus moving from plan to plan along the traverse route, the successive preliminary grid corrections for the plans are derived until a comparison of corrections is available: (*a*) at the other end of the traverse where observed grid bearing is available; (*b*) at any other plan for which a correction has been obtained previously or astronomical observations are available. If the misclosure in case (*a*) is less than 3′, no further investigation is required at this stage and assembly of source data, described in "Assembly of source material and data" below, may be effected. If the 3′ limit is exceeded in (*a*) and (*b*), the corrections obtained on the route are checked by a larger block of reliable plans, if possible. If comparisons and surveys are reliable, the accuracy of astronomical observations in (*b*) and that of observed bearings in (*a*) is checked and noted on the working diagram, together with remaining misclosures at control points and astronomical stations.

The areas containing unreliable plans which cannot be avoided may also be noted. Treating one polygon between three or more control points at a time, grid corrections are now obtained for the plans of other traverses between control points followed by traverses to junction points (interior traverse routes). Thus the main polygon and interior polygons are closed and preliminary grid corrections are available for plans along the perimeter of the polygons. Additional interior routes may need to be chosen for the comparison of grid corrections only in difficult areas. The signs and magnitudes of the remaining misclosures may be compared. The comparison may indicate systematic errors (of the same sign) or unreliable areas (opposite sign). If everything possible has been done to eliminate errors and uncertain comparisons, traverses are listed as indicated in the next section, and further analysis of bearing corrections may be effected by the comparsion of the bearings as adopted for the traverse from plans with the corresponding bearings obtained from co-ordinates of control points. It should now be possible to make a decision as to whether certain traverse routes are unreliable and whether an observed grid bearing at a control point is reliable. If there is evidence that the observed bearing is unreliable, other traverses from this control point in the neighbouring polygons should be processed to verify the assumption, so that the observations may be disregarded.

The misclosures in the neighbouring polygons should also be considered for any errors which cannot be eliminated in traverses between control points. Remaining misclosures may be adjusted in stages of 1′ between plans at points where connexion is weakest, preserving the best general agreement of closure of polygons and closure with control. Thus the adopted preliminary grid corrections have been noted on all plans, and listing of source data for the punching of cards may be effected.

Assembly of source material and data

The bearings and distances for each traverse are listed on special forms. As far as the bearings are concerned, the listing may be effected by: (*a*) adopting the grid corrections for a traverse from the plan with the greatest number of lines so that the bearings of this plan are listed directly from the plan (other traverses will generally require a different grid correction); (*b*) adopting a constant grid correction for a number of traverse lines. Thus, for the computation of co-ordinate differences from source data, all bearings of missing lines will require the same grid correction. However, for longer traverses with a great number of lines, system (*a*) is adopted. When the grid correction for the traverse is thus adopted, this correction is compared with the grid correction of the plan. The difference, if any, is applied with the correct sign to all plan bearings and noted with pencil on the plan and on the form. It should be remembered that, if the grid correction required for the plan is smaller than that required for the traverse, the plan bearings should be made smaller by the difference and *vice versa*. The correction should be checked on the bearings of common lines. Strict attention is to be paid to the direction of the line and 180° should be added to or subtracted from the plan bearing, if required. For checking purposes, the two first figures would add up to the same number (218 and 38: $2+1=3$; 336 and 156: $3+3=1+5$ etc.).

Rules for connexion of traverse lines between plans

The same general rules concerning the identification of markers, surveys done by different surveyors, etc., as mentioned in the previous section may be applied for the connexion of traverse lines; in some cases the selected traverse routes may require local changes.

If no common point on neighbouring plans is available, connexion is done on the line of the neighbouring plan, the distance to the nearest corner being obtained by the comparison of distances from a common point on the plans or, if not possible, by extending the comparison to other plans. For checking purposes, a second common point on the other side of the traverse should be treated in the same way. Thus unnecessary diversion of the route is avoided.

Traversing both sides of parallel reserves, such as roads, should be avoided. Roads may be crossed by computing the bearing and distance between two opposite corners at an angle on the road. If the other side is surveyed by a different surveyor, the length between two angles on the road as measured on the one side and computed by crossings on the other side should be compared.

Road width in the direction of the previous or next traverse line is added to the length of that line.

If there is evidence (comparison with later surveys, other plans of the same surveyor requiring length correction) that the plan lengths require the application of an enlarging scale factor, the numerical value of this factor should be obtained by a comparison of the plans of the same surveyor at approximately the same time with later surveys at various locations. The reduction to mean sea level and scale factors on the projection generally are not applied to the plan length. The combined corrections may be applied to the plan distances in the form of a scale factor, the value of which may be assumed to be constant for a certain area according to the accuracy required. In the adjustment of traverses between co-ordinates by the method used, however, the same results will be obtained without the application of this scale factor as far as co-ordinate values are concerned. Only the scale factor as supplied on the print-out is affected and a more realistic value is thus obtained for the analysis of the misclosures between co-ordinates. If another method of adjustment is used, such as Bowditch's rule, the effect of the above scale factor on co-ordinates will generally be negligible. The starting and end points of a traverse are described on the listing form; e.g., NW corner of Por. 81, 100 links south of most easterly corner of Por. 85, etc. The required grid correction for the traverse is also noted on the forms. The data is then punched on cards by a machine operator.

Preliminary computations

The results of automatic data processing are supplied on a print-out sheet in the form of a bearing and distance between the end points of a traverse. For traverses between control points only, the corresponding values are also computed from the co-ordinates of the control points on a desk calculator. The relative error of the length should normally be better than 1:5,000 for modern plans, 1:2,000 for older reliable plans, and 1:1,000 for other plans. The relative accuracy of the position of a control point is normally $\pm$ 1 yard. For the product (length of the missing line $\times \sin \mu\, dA$), the same accuracy is expected (dA is the difference between the adopted and calculated grid corrections). If sufficient accuracy is not obtained, traverse routes are checked by a comparsion of punched data supplied on print-out sheets with plan values. If no errors are found, the reliability of plans is examined further. If for a part of the traverse plans of reasonable accuracy are not available, another route is selected or an attempt is made to isolate the unreliable area by junction points on the traverse to form separate polygons. If no comparison of grid corrections is available at a crossing of an obstacle on the traverse, a junction point may be selected at the crossing with or without forming polygons. In the latter case, the co-ordinates of the junction point are computed by the application of independent grid corrections to the corresponding bearings of the missing lines, and co-ordinates are calculated as described below ("Co-ordination of junction points"). If sufficient accuracy if obtained, further analysis of grid corrections is effected as noted above ("Assembly of source material and data"), if required. Any remaining excessive discrepancies are noted on the working diagram for further investigation when polygon misclosures are available.

Co-ordination for point-to-point method

The following results are available on the print-out sheet: length and bearing between control points as computed by source data and from co-ordinates, the relative scale factor in the form of grid-length/plan-length and the adjusted co-ordinates. The co-ordinates of the end points should be checked first for punching errors. The co-ordinates of the common point or points are compared next, followed by a comparison of grid corrections for the plans at the common point and at control points and the examination of scale factors. If the expected accuracy is not achieved, discrepancies are investigated. Considering the scale factor and the difference in the grid corrections at control points, the length and direction of the error vector may be estimated. If the former is close to 20 yards (the width of roads is normally 22 yards) or the latter tends to be perpendicular to the direction of certain roads on the traverse, omission or duplication of roads may cause the discrepancy. If no error is found in the listing of traverses, an attempt is made to isolate the error by computing misclosures between control points through the common point, using different combinations of routes. The computations between the common and control points are effected on a desk calculator. The resultant bearing is corrected by the difference in bearings and the length by the scale factor. Thus results from source data are obtained for a combination of routes different from that used in the adjustment. If some of the combinations give satisfactory results, the error is isolated and investigated further, if necessary, by additional traverse routes between the control points, thus forming closed polygons.

Formation of polygon misclosures

At this stage, satisfactory grid corrections should be available for most of the traverse routes, and in doubtful cases the best judgement should be exercised in considering the over-all discrepancies. The corrections are applied to the bearings as obtained by source data and using plan lengths. The differences of co-ordinates are calculated on a desk calculator for all traverse lines forming closed polygons. These are noted on the working sheet with corresponding signs in the direction indicated by an arrow. Proceedings clockwise, the misclosures of each polygon in both co-ordinates are derived and noted on the working sheet, showing also the length of the route to the nearest 100 yards. Polygon misclosures are then investigated, assuming that the direct routes between control points have already been checked. This stage is restricted to the elimination of gross errors only, postponing the dealing with smaller errors by the consideration of misclosures in co-ordinates at the next stage. Misclosures of neighbouring polygons are compared first. Similar misclosures of an opposite sign would indicate error in the common traverse. Any suspected routes are checked and, if plans are doubtful, a check traverse is run. No attempt is made to adjust the polygon misclosures.

Co-ordination of junction points

Using the differences of co-ordinates as obtained by source data and noted on the working diagram, the co-ordination of control points follows. If there is more than one junction point in the area between control points in a polygon, the more centrally situated one is treated first. The co-ordinates as computed by different routes are tabulated, noting also the length of the traverses or missing lines if the traverse runs approximately in one direction. All previously computed junction points should also be included. The results are examined and, if no unusually large differences are evident, a weighted arithmetic mean is formed from the individual results directly obtained, taking the weights inversely proportional to the length of the traverse. The weight thus obtained may be decreased for doubtful traverses.

The residuals formed by the differences between the arithmetic mean and the actual values are investigated. If the accuracy as mentioned above ("Preliminary computations") is not obtained, differences in co-ordinates not exceeding 5 $\times$ 5 yards are generally acceptable, considering the plotting accuracy on 1:15,840 scale; 2 $\times$ 2 yards may be permissible for 1:4,000 scale, in which case the control points are normally situated at closer intervals. For larger discrepancies, all the information now available is used to localize and eliminate errors. The choice of another route may be required to check at least the misclosure of the polygon between the previous and new traverses.

If no reasonable agreement can be obtained for a particular traverse, additional ground control may be considered. In some cases it may be possible to identify boundary fence corners on aerial photographs which may be co-ordinated by photogrammetrical methods. If the comparisons of grid corrections in certain areas indicate that satisfactory agreement cannot be obtained, the easting value of a junction point may be evaluated from traverses running from control points in the east-west direction and the northing value from traverses in the north-south direction. If the lines of the traverse, with the exception of short lines, are approximately on the same bearing, then the more closely the general direction of the traverse satisfies the above requirements, the smaller is the effect of the errors in grid corrections on the corresponding co-ordinates.

If junction points cannot be positioned according to the above requirements, the adjustment of co-ordinates by the length of the "missing lines" from control points may be considered. The graphical method used in trilateration may be applied in these cases, and reasonably straight traverses may be run in any direction. After the adoption of final mean value for the junction point, other junction points are selected and computed until co-ordinates are available for all points selected in a group of polygons.

Final co-ordination of control traverses

Co-ordinates are punched on the last data card (left blank previously) of the corresponding traverses, and the traverses are adjusted by automatic data processing. A final check is now effected. Significant discrepancies should not occur at this final stage. If they do, the corresponding residuals at junction points are checked.

Representation of computations

The records described below are kept up to date as the work proceeds.

The final routes of the traverses are marked on a work sheet in red pencil as soon as they are completed. The work sheet for the mapping at 1:15,840 scale covers an area of 15″ latitude and 30″ longitude (approximately 500 square miles). This area is sub-divided into eight sub-sheets and for each of these units a basic cadastral map will be drawn. Therefore records are prepared for each unit separately as far as possible. Thus in the numbering system adopted for the traverses the first figure indicates the number of the sub-sheet (1–8) and the following two figures the number of the traverse in the sub-sheet. For large-scale mapping (1:4,000) the individual sheets cover an area of 4,000 × 2,500 yards only and traverses are numbered continuously through the sheets because the separate areas are small.

A work diagram is prepared for a group of polygons only. Traverse numbers indicate to which sub-sheet a particular traverse belongs. Final co-ordinates are entered on the diagram as soon as computed or adjusted.

The forms containing the final listings of traverses and final co-ordinates of the end points are kept in a folder prepared for each sub-sheet in the numerical order of traverses. The same applies to the results of automatic data processing. On these result sheets the description of starting and end points of the traverses are added as well as the plan numbers in the order in which the plans have been used. Cancelled computations are marked "cancelled" and kept until the work is completed.

The punched cards are kept in special card cabinets allocated to each computer. The first card of each traverse is a parameter card with a coloured top. On this card the number of the traverse is noted and cards are stored in the numerical order of traverses. The cards for the final traverses only are kept until the map sheet has been plotted, so that, for later minor alterations, if required, the punching of cards may be limited to that part of the traverse where alteration is necessary.

A list of traverses for each sub-sheet is prepared on a special form showing the analysis of results as follows: (*a*) the grid correction for a certain plan at both ends of the traverse as adopted or observed and as computed; the same plan is used for the other traverses with the same end point so that consistent comparisons are available at each junction or control point; (*b*) the difference (observed correction minus computed correction) as obtained from the final results sheets; (*c*) displacement in yards caused by the above difference; (*d*) length of the traverse from plans and from co-ordinates; (*e*) difference in both; (*f*) scale factor.

The records described below are prepared for the submission of the computations.

Two copies of the work sheet are prepared in ink, one for computing records, the other for submission to cartographers. Separate diagrams for submission only are prepared for each sub-sheet, showing the traverses of the sub-sheet only on tracing paper. The map scale is punched on each parameter card, and cards are processed again. The print-out obtained contains the co-ordinates in millimetres in addition to the co-ordinates in yards, so that plotting machines graduated in millimetres may be used. These result sheets are submitted in folders prepared for each sub-sheet separately. The same information is added to these sheets as that indicated earlier.

In addition to the above, the following records are submitted to cartographers: list of control points; diagram showing grid co-ordinates of sheet corners; control point diagrams; copies of plans and parish maps.

MODERN TECHNIQUES AND INSTRUMENTS FOR SURVEYING AND MAPPING

Paper presented by the United States of America[1]

Introduction

Orderly evaluation and efficient utilization of any country's resources require certain geographic and topographic information in the form of reliable maps based on ground and aerial survey data. In those countries where existing surveys and maps are meagre, the initial task may be the preparation of temporary map substitutes, or small-scale maps of a reconnaissance nature, based almost entirely on aerial photography and other air-survey data. In those countries where national surveying-mapping programmes are already in progress, and a surveying-mapping establishment already exists, the initial task may be rapid expansion and modernization of the programme and the establishment. In any case, the use of some of the modern techniques and instruments that have become available during recent years will be involved. It is the purpose of this paper to describe briefly some of these modern developments, and to indicate in general terms when they might be used to advantage.

Although the emphasis in this paper is on modern techniques and instruments for surveying and mapping, a

[1] The original text of this paper, prepared by G. D. Whitmore, Chief Topographic Engineer, United States Geological Survey, appeared as document E/CONF.52/L.48.

word of caution should be stated at the outset: a technique or instrument will not necessarily be universally applicable, or best satisfy all needs, simply because it is the most modern. To determine, for any specific mapping programme or local surveying project, which of several applicable procedures is most advantageous, whether old or new, requires a thorough understanding of the available procedures, the users' requirements, and the conditions that tend to limit the choice of procedures. Among the most important of the requirements and conditions that must be considered are the type of survey or map needed; the map scales to be used; the degree of accuracy required for control surveys and mapping the size and shape of the area to be covered; the time schedule; the available funds; any unusual characteristics of terrain, climate or forest foliage; and the technical competence of available personnel.

The following paragraphs deal with specific techniques or instruments that might be included as elements in any over-all surveying or mapping procedure. For convenience, these items are grouped under three principal headings: control surveys, photogrammetry, and preparing maps for reproduction. Although no procedure would include all techniques and instruments mentioned, it is likely that any over-all procedure which might be adopted would include some of them.

Control surveys

For control surveys of any degree of accuracy or for any purpose, there are now available new instruments and techniques that were unknown a generation ago and that, under certain conditions, will result in the work being done faster, more accurately, and at lower cost.

Distance measurement

New instruments which exploit the techniques of electromagnetic wave transmission and electronics are in general use for measuring distances in control surveys. These instruments can be used to advantage whenever there is a continuing control-survey programme involving numerous precise measurements of triangulation base lines or traverse courses.

The Geodimeter is a Swedish instrument that directs a modulated light beam from an instrument set up at one survey station to a reflector set up at a second station. The distance between the two stations is determined as a function of the speed of light and the phase relationships between the emitted beam and the reflected beam at various modulation frequencies. The operation of the geodimeter requires clear weather and an unobstructed path between the two stations. Several different models are available, the smallest being suitable for distances as short as 100 ft, while the largest can be used for precise base lines as long as 30 miles. Some can be used in daylight, if the measurements are short; others require darkness.

The Tellurometer, developed in South Africa, transmits a modulated continuous-wave radio signal from a master unit at one survey station to a remote unit at a second station, where it is, in effect, received and retransmitted to the first unit. The distance is the product of the measured transit time and the known speed of radio waves. The Tellurometer can be operated in daylight or darkness and can penetrate haze, smoke, fog, clouds, light rain, and a limited amount of foliage. Its operation is affected by reflections from nearby moving objects, such as waving grass or moving vehicles. The Tellurometer is best used for measurements in the range of 0.5 to 25 miles, although, under good conditions, it has been used successfully on distances up to 40 miles, and, if great accuracy is not necessary, it can be used to measure distances as short as 100 ft or so.

The electrotape, an American development, operates on the same basic principle and has the same applications as the Tellurometer, although it differs in details. Accurate measurements of distances as short as 0.2 miles are possible with this instrument.

Other instruments for measuring distances by electromagnetic techniques are continually being developed. The latest experimental instruments use laser light as the measuring beam, but such instruments are not yet generally available.

Angle measurement

For the measurement of angles, the standard instrument today, by almost universal acceptance, is the optical-reading theodolite, an instrument which has ultra-precise graduations on glass circles that are read to a fraction of a second of arc by means of a special optical micrometer. These theodolites are fully as accurate as the older, heavier, more cumbersome instruments. The use of optical-reading theodolites is therefore generally regarded as advantageous in all types of surveys involving measurement of angles.

Some theodolites are equipped with a multiple-wire reticle which contains five equally spaced marks for horizontal measurement and three for vertical measurement. With this reticle, up to five readings can be taken for a single instrument direction. The multiple-wire method of angle measurement saves an appreciable amount of target-searching time, especially in high-precision surveys where redundancy is required.

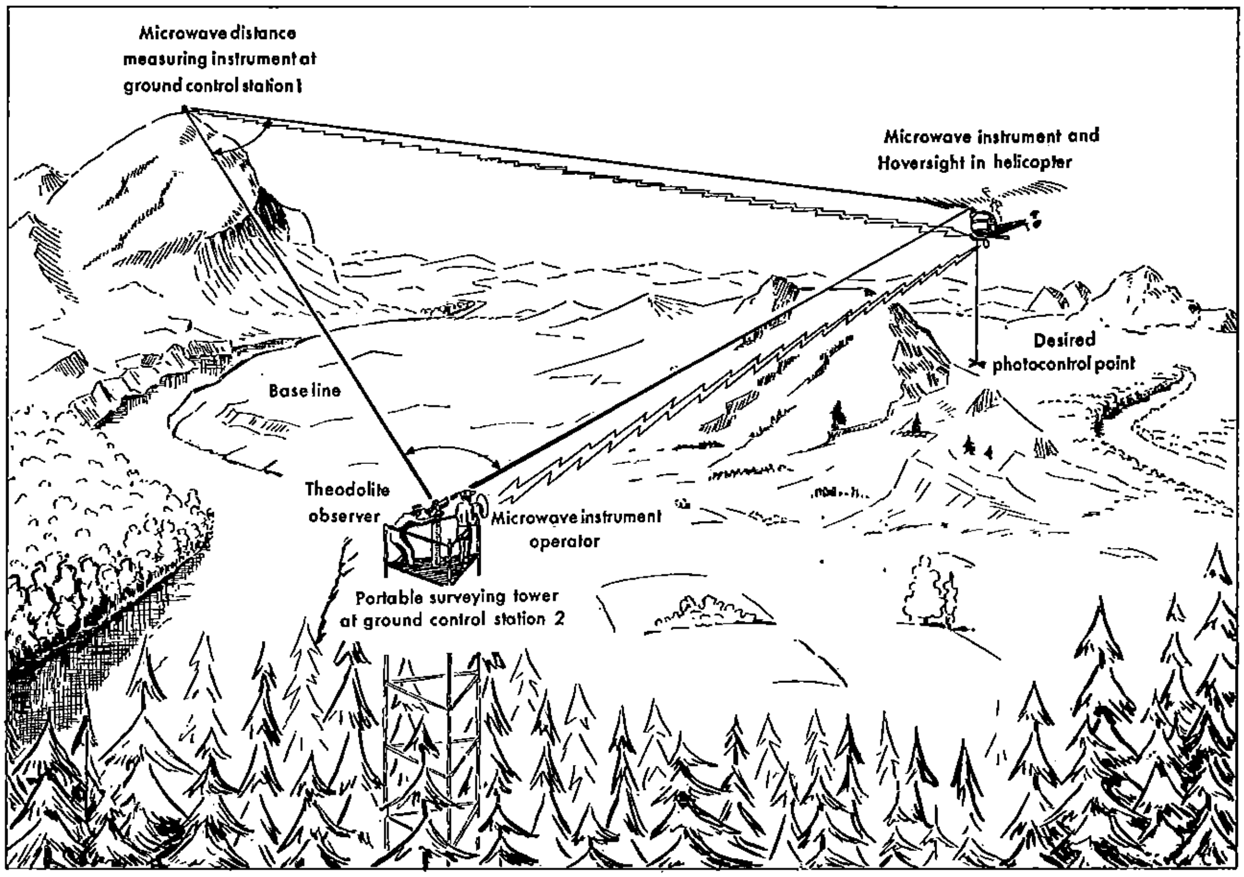
Levelling

For the accurate determination of differences of elevation, the most up-to-date instrument is the automatic or self-compensating level. After the instrument has been levelled only approximately, the collimation axis is automatically made exactly level by a gravity-sensitive compensator, similar in principle to the pendulum. This feature speeds operations by reducing the need for great care in instrument set-up and by eliminating the need for frequent relevelling. The new level is particularly effective for the levelling of second- and third-order accuracies. For plane-table surveys, self-levelling alidades, called pendulum alidades, are also now available.

On projects covering large areas, when elevation differences of fourth-order accuracy will meet requirements, the use of a Geological Survey instrument called the "elevation meter" may sometimes be economical. The equipment is mounted in a four-wheel-drive, four-wheel-steer automotive vehicle. As the vehicle proceeds along the road, an electromagnetic field acts on a very sensitive pendulum to generate an electrical signal whose strength is proportional to the sine of the angle of slope of the road. An encoder connected to a special fifth wheel generates an electrical signal which is an increment of the distance travelled. By means of an electronic integrator, the two signals are automatically combined into a continuous computation and record of the difference of elevation from an initial starting point. Proceeding at moderate speeds, the elevation meter can produce about 50 to 100 miles of fourth-order levelling per day. It can be used for the rapid determination of approximate elevations (accurate within 10 to 30 ft) on long, cross-country lines, but it can also provide elevations accurate to within 1 or 2 ft, if all lines are within closed circuits, if some main lines are double run, and if all closures are properly distributed mathematically. This machine, however, is economical only on projects that cover relatively large areas and which have a network of suitable roads.

Airborne control survey system

The Geological Survey has developed and is using a technique and equipment known as the airborne control (ABC) survey system, for establishing control for mapping by ground-to-air measurements. The technique involves distance measurements and horizontal and vertical angle measurements from at least two, and preferably three, strategically located existing control stations to a helicopter as it hovers vertically over each desired new control point. Accurate hovering is facilitated by a newly developed Hoversight which indicates the plumb point to the pilot so that he can see when he is directly over the ground point.



United States of America: Airborne control survey system

The helicopter hovers at a height just great enough so that its flashing beacon can be seen from the occupied ground stations, and a special plumb-line cable and drum are used to measure the hovering height. When the pilot signals by radio that he is over the point, horizontal and vertical angles are measured to the target light on the helicopter from the theodolites at the ground stations. At the same time, electronic distances are measured with an electronic instrument at each ground station to a remote unit in the aircraft. This technique is advantageous for establishing control in forested and other difficult-access areas where third-order positions and fourth-order elevations are adequate.

Portable surveying tower

A new truck-mounted surveying tower has been developed by the Geological Survey for elevating distance-measuring instruments to any height up to 70 ft above the ground. It is used for both horizontal and vertical control surveys. The tower consists of two independent units made from tubular aluminium—an outer one for the observer, and an inner one for the instrument. The lower 30-ft section of the tower is mounted on a frame on a flat-bed truck and can be raised by a hydraulic lift powered by the truck battery. Additional 6-ft sections can be attached to the tower units, as needed, before raising. Outriggers are mounted at the two rear corners of the truck for stability, especially while raising and lowering the tower and for use in plumbing the tower. The bottom section of the inner unit contains a 110-gallon tank that can be filled, after the tower is raised, with an ethylene glycol solution from drums on the truck; the 1,000 pounds of weight thus added to the base of the tower serves to stabilize it, eliminating the need for guy wires except when tower heights over 42 ft are used. Gravity feed is used to fill the tank as well as to return the fluid to the drums. The weight of the tower is about 10 pounds per foot of height, including both inner and outer units. It can be erected and plumbed, ready for observations, in 10 to 30 minutes, by one man if necessary.

Survey computations

The use of modern electronic digital computers can remove much of the drudgery from repetitive survey computations. Furthermore, the work can be produced very rapidly and often at large savings in costs. Once a computer programme has been prepared for a given type of computation, it is necessary only to change the input data for each particular project; the same programme can be used again and again. Computer programmes have been prepared for such survey tasks as computation and adjustment of traverse, triangulation and levelling, as well as for calibration of various instruments. The possible economy or other advantage of using such a computer should always be carefully investigated when several man-years of work would be required with the older procedures. While it is true that very few surveying programmes by themselves would justify the high cost of full-time lease or purchase of an electronic computer, it may often be profitable to hire the service on an hourly basis.

Photogrammetry

Many photogrammetric techniques and instruments are available for converting aerial photographs and other source data into maps or survey data. These range from simple procedures for obtaining results of relatively low precision to elaborate systems for obtaining products of high accuracy. In any case, the combination of aerial source data, photogrammetric equipment, and operational procedures must be compatible in every respect. As the well-established procedures are fully described in an extensive body of literature, only certain recent developments will be noted in this paper.

Aerial cameras

In the United States, the two types of aerial camera lenses currently in most common use are the 210 mm normal-angle (65°) and the 153 mm wide-angle (90°). Recently, there have become available new 88 mm super-wide-angle (120°) cameras which, in comparison with the wide-angle camera, offer more economical coverage at a more favourable base-height ratio. The larger coverage per model reduces ground-survey control requirements, and the more favourable base-height ratio gives better angles of ray intersections, which improves the accuracy of height determinations. A possible disadvantage, however, is that super-wide-angle photography at the same altitude would be at a much smaller scale. Also, if the terrain is covered with dense forests, the ground between the trees is visible less frequently than in the narrower-angle photography. Likewise, there are likely to be more invisible areas in rugged terrain. Nevertheless for many mapping requirements super-wide-angle photography may offer important advantages.

Aerial photography

Aerial photographs and other air-survey data are available in a variety of forms, each of which has its uses, depending on the kind of product desired and the conditions pertaining to the particular project at hand. Aerial photography should be specially designed for each different area or individual project; for example, in some cases, two or more different types of photography, at two or more different altitudes, may be required. In every case, the planning should provide for all air-survey data to be fully useful, not only for the desired long-range products, but also for any temporary products that may be necessary, and for all data to be fully compatible with the available photogrammetric equipment and techniques.

There are now available several types of dimensionally stable film bases produced from either polycarbonate or polyester plastics, which, in comparison with acetate film, have only about one-third the humidity and thermal coefficients of linear expansion, and far less differential distortion. For ultra-precise work, such as analytical aerotriangulation, a reseau may still be required with the new film base, but for most purposes the distortions due to film instability can be ignored.

Infra-red photography has been improved recently with the development of better emulsions and new camera lenses specifically designed to achieve optimum photographic quality with infra-red film. An important advantage of infra-red photography is its ability to penetrate atmospheric haze. It is also well known that water features, tree types, vegetation classifications and soil-structure differences are more readily distinguishable on infra-red photographs than on conventional black-and-white. It may therefore be economical, in some instances, to procure infra-red photography as an aid in interpretation, in addition to the usual black-and-white mapping photography.

Colour photographs have been shown to be useful for mapping underwater details, for photo-interpretation of planimetric features, and for contouring areas, such as prairies and woodland, where colour contrast improves stereoscopic image correlation. Recent developments in colour photography include techniques for applying colour emulsions to stable-base film and for processing the film directly to a colour negative. Photographic prints and diapositives can be made in either black-and-white or colour from this film.

Other remote sensors

During the past few years there has been intensive development of various all-weather sensing devices, including PPI (plan position indicator) radar, SLR (side-looking-radar), and the infra-red sensors. The primary advantage of these sensors is that they are operative day or night and in all weather. An important advantage of PPI is its ability to establish a uniform horizontal scale with an accuracy acceptable for reconnaissance charting purposes. PPI photography is at a very small scale and its resolution is weak, while SLR strip photography is at a much larger, though less uniform scale with much better resolution; hence PPI and SLR are best used jointly to obtain the best combination of scale and resolution. The sensor devices make it possible to get fast, economical coverage for large expanses of territory, so that small-scale planimetric maps can be rapidly produced for preliminary planning or for flight maps for standard photography.

When approximate elevations of the ground trace of the flight line would be helpful, use of the radar altimeter should be considered. This is a terrain-clearance instrument, entirely airborne, which continuously determines height of aircraft above the ground by "bouncing" a radio beam off the ground beneath. An automatic recorder then plots the profile of the ground along the aerial flight path with respect to the isobaric surface. The difference between aneroid elevations and the official vertical datum for the area, such as mean sea level, may be determined by having the aircraft fly over a suitable feature of known elevation, such as a body of water or an airport, whenever convenient. This method can yield ground elevations with accuracies in the range of from 5 to 50 ft.

An airborne profile recorder (APR) incorporating an extremely precise gas-laser ranging device and an atmospheric pressure transducer is being developed in the United States. Correlation between the flight line and profile beneath is effected by a strip photograph containing calibration marks. Although the system has not yet been completely tested, preliminary results indicate that data produced by this system may be useful for mapping control.

Navigation aids

When aerial photography is required for an area having suitable flight maps, flight navigation usually is carried out by visual comparison of the ground and the flight map. If there are no suitable flight maps, a navigation system based on certain electronic and wave phenomena may be used. Any one of several electronic tracking methods (including SHORAN, HIRAN, RAYDIST, DECCA, or the latest development SHIRAN) can be used to obtain the position of each photographic exposure station with respect to two or more fixed ground stations, or to keep the aircraft on a predetermined flight path. These methods are feasible when ground stations can be occupied without excessive difficulty. The Doppler system, which is entirely airborne, is suitable for air navigation over extensive areas where the difficulty of access makes establishment of ground stations impractical or too costly.

Stereoscopic plotters

Stereoscopic plotting instruments have been improved tremendously through an endless series of inventions and modifications that has now been going on for some thirty years. Although there are wide differences in the mechanical details, practically all stereoscopic mapping instruments are composed of three principal elements: a projection system for orienting and projecting photographs stereoscopically; a viewing system to give the observer the impression of a miniature model of the terrain; and a measuring system for determining horizontal and vertical distances in the model. In western Europe there has been much emphasis on the so-called "first-order plotters", which are generally of an extremely complex design and capable of very high quality work, but which are also quite costly. American emphasis has been on the more economical, although somewhat less accurate and less versatile plotters of the anaglyphic type, which operate on the principle of simple optical projection and direct viewing. The original multiplex itself, with its small-size diapositives and inferior illumination, is now outmoded and has largely given way to its successors which use larger diapositives and improved lighting systems. The selection of stereoscopic plotting instruments for a photogrammetric facility should be based on the nature of the long-range surveying-mapping programme. In many instances, a diversity of instruments is required. For this reason, some surveying-mapping organizations are equipped with both first-order and lower-order instruments, although the emphasis may be on one or the other.

Several kinds of stereoscopic plotters designed to utilize super-wide-angle photographs have been produced, both in Europe and the United States. The American instruments are based on general principles of the multiplex, but have improved projectors such as the ER-55 and the Kelsh types. In Europe, both multiplex-type and autograph-type plotters for super-wide-angle photographs are now available. One of the autograph-type instruments accommodates both wide-angle and super-wide-angle photographs.

Automatic plotters

A number of automatic photogrammetric systems for generating map data have been developed and are being continually improved in both the United States and Canada. In some of the instruments, relative orientation of the projectors and sensing of the surface of the optical stereomodel are done automatically. In others the model is developed in a mathematical sense and an electronic computer is required to co-ordinate scanning and image matching. The output of the different systems varies, but most can produce orthophotographs and either profiles or line-drop charts from which contour lines may be drawn. Some, however, produce contours directly.

One type of automatic stereoplotter combines a stereocomparator, an electronic digital computer and an electronically controlled co-ordinate plotter to form a system which can be utilized for high-precision stereoplotting or for aerial triangulation. Each component can be used separately or all can be combined to preform various photogrammetric operations. A fully automated version of the system produces contoured orthophotographs.

Orthophotoscope

A recently developed Geological Survey instrument, the Orthophotoscope, is used to convert perspective photographs into equivalent orthographic photographs. In this process, image displacements due to tilt and relief are removed and therefore all imagery on the orthophotograph is of uniform scale and is in correct relative position. The orthophotoscope utilizes the anaglyphic projection principle to form an optical stereomodel of the terrain. Photographic film, sensitive to only the blue light, is exposed incrementally through a narrow slit in a viewing screen upon which the model is projected. The instrument operator raises or lowers the film platen to maintain the scanning slit in continuous contact with the surface of the model. Useful map substitutes may be made by forming mosaics of individual contiguous orthophotographs, at the same scale, in map format. Orthophotographs, either as prints of single models or as mosaics, have already been successfully used by geologists and other scientists in field investigations, as preliminary planimetric maps or map substitutes, as a medium for checking the relative horizontal accuracy of existing maps, and as a means of facilitating certain map-revision operations.

Aerotriangulation

Several techniques and instruments for aerotriangulation have been developed during recent years. The aim is to devise more effective and economical means of providing positions and elevations of pass points for use in orienting stereomodels for map compilation.

One of the proven techniques is the stereotemplet method for extending horizontal control. It differs from conventional radial triangulation techniques in that the stereotemplet is representative of the horizontal plot of a stereoscopic model rather than of a single photograph. Hence the points represented in the templates contain no displacements due to relief or tilt. This has proved to be an effective and economical procedure for horizontal control extension for maps that are intended to conform to standard accuracy requirements.

Much effort is being devoted, both in this country and abroad, to the development and perfection of analytical methods of aerotriangulation. Many different kinds of techniques have resulted from this work. In semi-analytical techniques, computational procedures are used to adjust individual models, multiple-model sections, or bridged strips of models, formed on conventional stereoplotting instruments, into strips or blocks and to fit them to existing control. In the fully analytical approaches, co-ordinates of pass points and control points, measured directly on the photographs, are used to form mathematical representations of the bundles of light rays which are then mathematically fitted to one another and to the existing control. The development of these analytical techniques is being continually given new impetus as larger, faster and therefore more efficient computers become available and as new equipment for point measuring is developed. Photo-point transfer devices for marking pass points on glass plates are being marketed, stereocomparators are available for measuring point co-ordinates, and analogue-to-digital conversion units have been devised for recording co-ordinates of points measured in stereomodels. As improvements in instrumentation and techniques for gathering and processing data are continually being made, further developments in analytical aerotriangulation are expected to come rapidly.

Preparing maps for reproduction

After the photogrammetric and field-survey operations are completed, the compiled map manuscript is prepared for multicolour reproduction. Mapping agencies usually produce large numbers of copies of their maps and charts. The techniques employed for making copies have, therefore, always been important. Early maps were prepared for reproduction by engraving the colour separation on copper plates from which map images were transferred to pressplates. This process was gradually replaced by photolithography, in which colour separations inked on stable mediums were photographed to obtain negatives for contact exposure to sensitized pressplates. Techniques now in use eliminate much of the tedious work previously required and thereby offer economy in production operations without sacrifice of quality.

Colour-separation scribing

One of the greatest gains to be realized in preparing maps for reproduction has resulted from the procedure of scribing on coated plastic sheets. The scribing medium is a thin, transparent plastic sheet coated with a translucent but photographically opaque paint, on which a facsimile of the original map is reproduced photographically by means of a special emulsion that is applied directly on the coated surface. Map detail is engraved, or scribed, by cutting the required map lines and symbols through the coating, each separate colour of the final map being represented as a separate scribed plastic sheet. Each scribed sheet is, in effect, a negative, from which a pressplate can be prepared directly by contact printing. The scribing technique is also used on plane-table sheets in the field and on photogrammetrically prepared map drawings.

It is noteworthy that the negative-scribing process facilitates production of certain useful byproducts and interim materials. For example, a positive composite film is readily made by successively contact-printing each of the scribed colour separates plus the names overlay on a transparent film, and this in turn can be used to reproduce any number of diapositive-type monocolour prints. These are useful for checking and editing and also as a provisional edition for map-users until the final reproductions are press-printed. For final editing and proofing, a colour composite is prepared by making a series of contact exposures from each scribed separate, in turn. An appropriate colour-producing emulsion is applied on the sheet prior to each exposure and is completely processed before another emulsion for another colour is applied. This photoprint, in colours similar to those of the final published map, serves well as a low-cost substitute for a press-printed proof when only a few copies are required.

Map-finishing instruments

A variety of instruments are available for scribing on coated plastic sheets. The points and blades of these instruments are precisely ground to cut cleanly through the coating yet glide smoothly over the surface of the supporting plastic base without digging in. Depending on the type of symbol to be scribed, different instruments are used, ranging from the pen-type gravers for scribing single line symbols to the swivel gravers fitted with special blades for scribing double- or multiple-line symbols.

Stick-up lettering of high quality can now be provided quickly by photographic type-composing machines, which produce positive film copy of the desired lettering from a wide variety of available type sizes and styles. The copy may be used as produced; but for normal use, copies are reproduced on stripping film. Because these machines require a substantial investment, they are probably not economical, in comparison with conventional hand-set type and press-printed stick-up, except for large operations.

Photomaps

For many types of terrain, a new map product called a photomap provides a wealth of information not available on a conventional line map. Either rectified photographs of flat terrain or orthophotographs of areas containing significant relief can be used to prepare a controlled mosaic as a foundation for a photomap. The photo-image base, thus provided, is processed into two negatives: a phototone negative, which shows all imagery in a subdued tone; and a photo-line negative, which shows only the edges of images and is similar in appearance to a line drawing. The images on these two negatives are suitable for preparing lithographic pressplates without the use of half-tone screens. Masking techniques allow selected portions of the photographic imagery to be printed in distinct colour tones. The photo-image base may be overprinted with names, labels, and selected line symbols, such as roads and contours.

Conclusion

Many modern instruments and techniques for surveying and mapping have been described in a general way in the foregoing pages. Administrators who are responsible for the planning of mapping programmes must decide which of these to use for the specific tasks at hand. It would be useful if a tabulation could be prepared to show which instruments and techniques should be applied to any given mapping programme, and the cost of each phase of the work. However, for unprecedented mapping operations, schedules of procedures and costs are not reliable because the operations are affected by varied and complex factors, such as the availability of money, equipment and trained personnel and the type and extent of terrain to be mapped.

Technologies that support surveying and mapping are undergoing significant change and improvement. There is reason to expect that in the near future some advances will be made that will cause some of the instruments and techniques herein outlined to become outmoded. Through the sharing of knowledge of new developments as they occur, we can all increase the quality and efficiency of our surveying and mapping activities and thereby help to bring about a better life for people all over the world.

ANOMALOUS LAND DEFORMATION IN THE NIIGATA AREA BEFORE THE NIIGATA EARTHQUAKE AND IN THE MATSUSHIRO AREA REVEALED BY PRECISE LEVELLING

Paper presented by Japan[1]

INTRODUCTION

It is well known that appreciable crustal movements have been found after the great earthquakes. As the relation of such crustal movements to the earthquakes is not clear, it seems necessary to carry out a precise land survey for the purpose of detecting the crustal deformation and investigating the relation between deformation and earthquake. Such a survey is also important in that the detection of considerable crustal deformation seems to be one of the means of predicting major earthquakes.

As a first-order levelling net covers the whole of Japan, frequent precise levelling surveys will be a powerful means of checking land deformation. The Earthquake Research Institute of the University of Tokyo and the Geographical Survey Institute of the Ministry of Construction have repeated precise levelling surveys in the affected regions. The present report contains the results of these surveys and their relation to the earthquakes.

PRECISE LEVELLING SURVEYS IN THE NIIGATA AREA

On 16 June 1964, a major earthquake of magnitude 7.5, known as the Niigata earthquake, occurred in the northern area of the central part of Japan along the coast of the Sea of Japan. It so happened that levelling surveys had been frequently made by the Geographical Survey Institute during the ten years preceding the earthquake for the purpose of clarifying the degree of ground sinking caused by the pumping of natural underground gas. Since 1958, levelling surveys had been repeated two or three times a year along the route on the alluvium area in and near the city of Niigata. Furthermore, for the purpose of checking the change of height of local reference bench-marks, surveys had been extended every three years or so to the neighbouring tertiary areas and connected the two mareographic stations, Kashiwazaki and Nezugaseki.

Ground sinking in the alluvium area is extremely large (up to 45 cm annually), caused chiefly by artificial factors, and may therefore not indicate the crustal deformation relating to the origin of the earthquake. However, height change of bench-marks in tertiary areas may be considered to have some relation to the pre-seismic crustal deformation. Figure I shows the results of levelling along the route connecting the two mareographic stations.

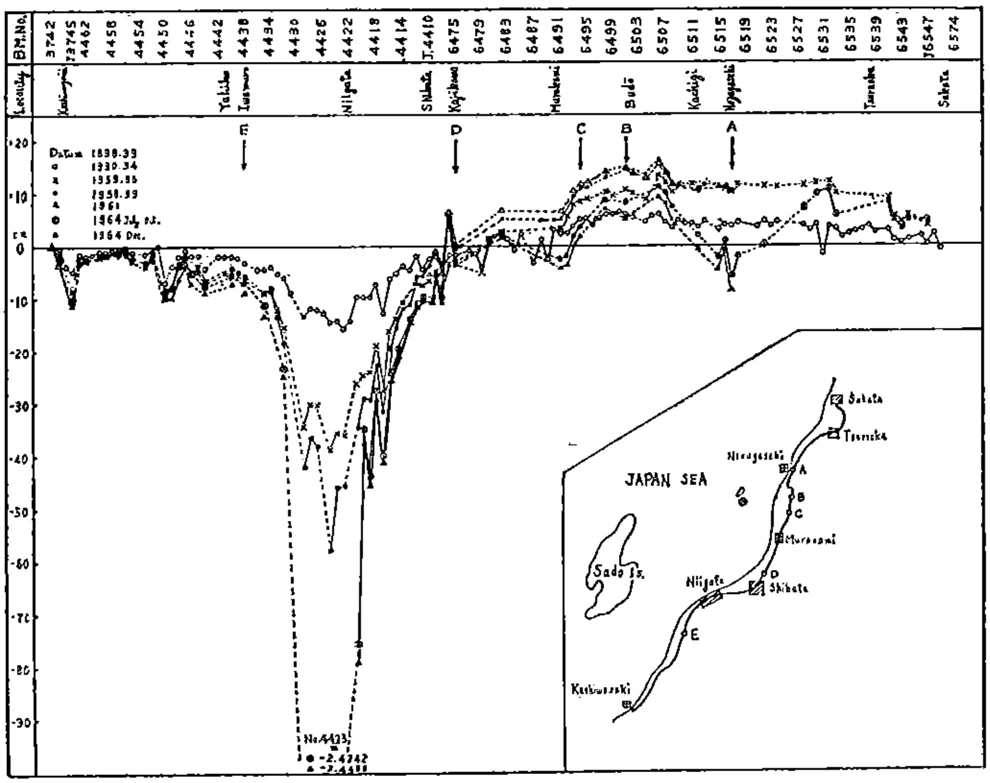


*Fig. I—Japan: Results of levelling along the route connecting the mareographic stations of Kashiwazaki and Nezugaseki**

After 1955, the interval of revision was shortened and revisions had been made more than three times before the earthquake. Although during the three years before the earthquake no survey had been made connecting the

[1] The original text of this paper, prepared by Ietsune Tsubokawa and Ko Nagasawa, Earthquake Research Institute, Tokyo, appeared as document E/CONF.52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

* Taking heights in 1898 as bases and assuming height of bench-mark No. 3742 near Kashiwazaki station to be constant.

mareographic stations, we may infer the general tendency of crustal movement from the data of frequent revision on the alluvium area and the tidal records.

Figure II shows the height changes of five representative bench-marks along the route during the period from 1898 to 1964. In all curves, the marks on the right side show the values of the revision carried out several months after the earthquake.

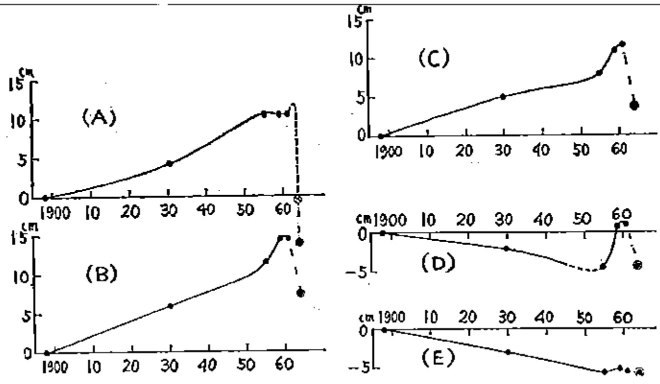


Fig. II—Japan: Changes in the heights of five representative bench-marks along the route shown in previous figure

⊗ Shows the abrupt depression of the ground accompanying the earthquake which is confirmed by the tidal records at Nezugasaki mareographic station.

⊙ Shows the values of revision carried out several months after the Niigata earthquake.

As shown in the figure, the general aspects of crustal movements in the area concerned during the period 1900 to 1950 are almost vertical upheaval in the northern part, which is near the epicentre, and almost vertical subsidence in the south-western part. After the earthquake, the mode of deformation of the land is somewhat complicated, as shown in the figure, except for bench-mark E, which seems little affected by the earthquake.

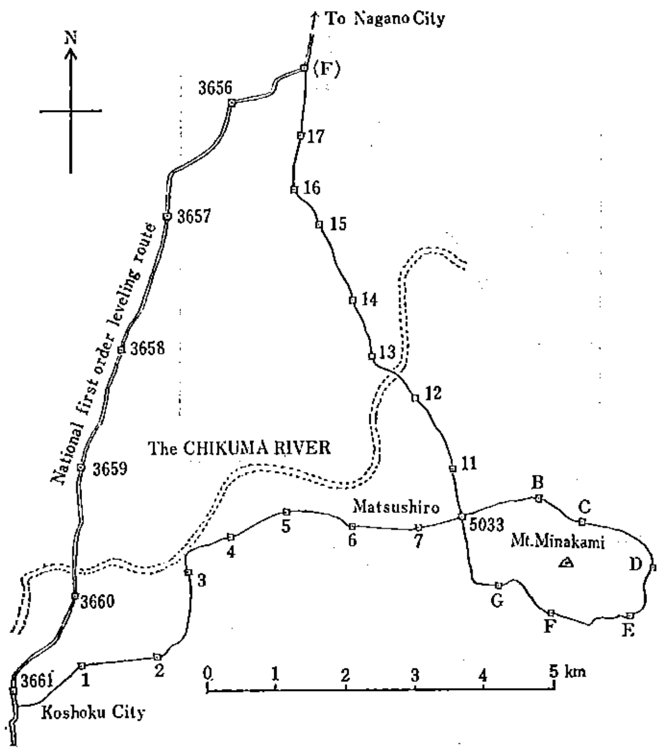


Fig. III—Japan: Levelling route map in Matsushiro area

Generally speaking, it may be said that the deformation of the land in the neighbourhood of the epicentre changed its mode some ten years before the occurrence of the earthquake and showed somewhat unstable features.

Precise levellings in and around the Matsushiro area

Since August 1965, earthquake swarms have attacked in and around the region of the town of Matsushiro, in the northern area of Nagano prefecture in the central part of Japan. They have continued for over a year, changing their activities, and are now gradually declining (November 1966).

As the national first-order levelling route runs along the highway some 6 km distant from the town of Matsushiro, the Earthquake Research Institute established a new levelling route from national bench-mark No. 3661 to bench-mark No. 3656 through the town of Matsushiro shortly after the occurrence of the earthquake swarms. This new route and a part of the national route form a triangular-shaped closed levelling route 23 km in length. The route map is shown in figure III.

For the purpose of obtaining data on the relation of the crustal movements to the earthquake swarms, the Earth-

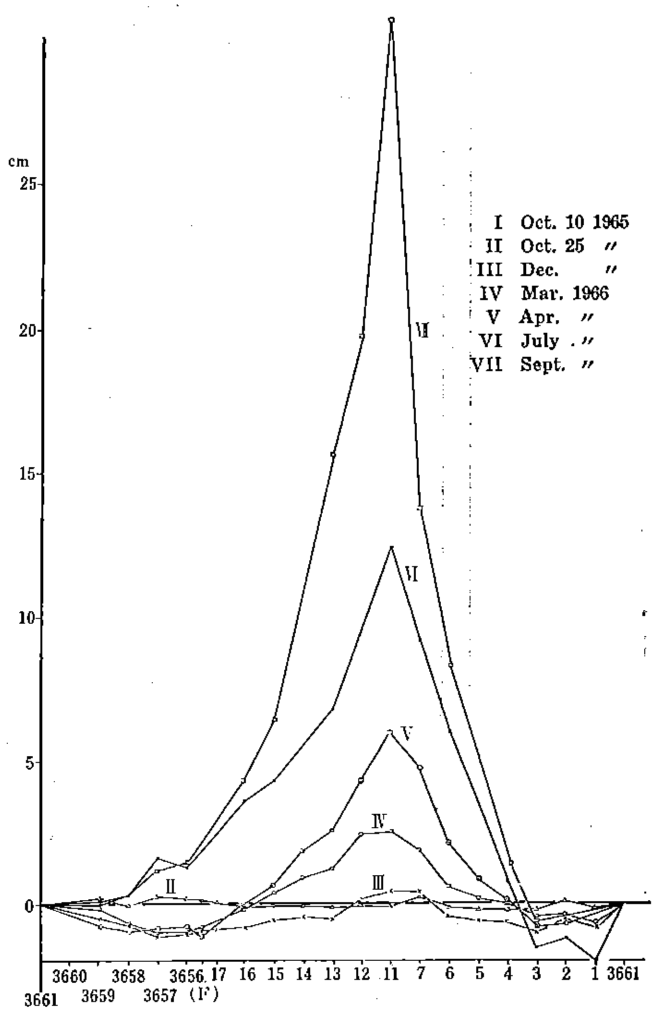


Fig. IV—Japan: Height changes in bench-marks in Matsushiro area quake Research Institute, co-operating with the Geographical Survey Institute, carried out a precise levelling survey along the route several times after the first survey in October 1965. The height changes of these bench-marks from the height in the first survey are shown in figure IV with the dates of the surveys. The height of bench-mark No. 3661 in Koshoku city is taken as the standard throughout all these surveys in the figure.

The results of these surveys clearly show that the vertical crustal deformations have been progressing all along the route. The most remarkable feature revealed from the surveys is the considerable upheaval of the ground around the town of Matsushiro which has been accelerated. For example, at bench-mark No. 11, located near the central part of the town, showing the maximum upheaval of about 30 cm, the daily vertical change gradually increased and came to about 3 mm in September 1966, although that rate decreased afterwards. On the whole, it is clear that the north-west part of the levelling route was sinking and the south-east part rising. The rates of height changes seem to some extent to correspond to the seismic activity.

Although these surveys revealed the vertical movements of the ground, we could not tell where the central point of upheaval was owing to the absence of a levelling route in the eastern part of the town of Matsushiro. The Earthquake Research Institute therefore established new bench-marks around Mount Minakami to the east of Matsushiro in April 1966 and carried out the levellings. This route is shown in the levelling route map above. The height changes of the bench-marks from the first survey are indicated in figure V, assuming bench-mark No. 5033 to be constant.

As expected, the surveys showed that the centre of upheaval lay near Mount Minakami. It is worthy of special mention that abnormally great height changes were detected on the route. The change was so great that bench-mark C rose about 30 cm during three weeks from 19 August to 10 September 1966. This corresponds to a daily upheaval of about 15 mm. Total upheaval of this bench-mark was about 50 cm from the first survey in April 1966.

From these levelling surveys, it is certain that anomalous land deformation occurred around the Matsushiro area. This fact is supported by other surveys; more widespread levelling surveys and triangulations carried out by the Geographical Survey Institute, precise distance measurements using the Geodimeter and the observation of tiltmeters by the Earthquake Research Institute.

Considering these results, it is certain that repetition of geodetic surveys, especially of levelling, may shortly be one of the best means of predicting earthquakes.

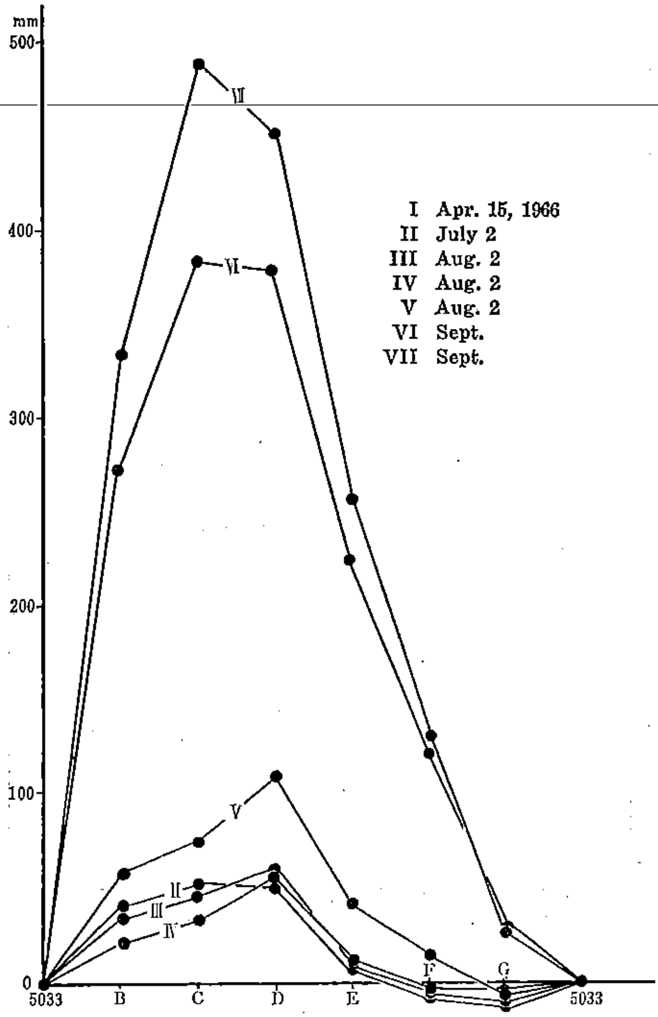


Fig. V—Japan: Height changes in bench-marks near Mount Minakami

GEODETIC SURVEYS IN THE AREA OF THE MATSUSHIRO EARTHQUAKE SWARMS

Paper presented by Japan[1]

OUTLINE OF GEODETIC SURVEYS IN THE MATSUSHIRO DISTRICT

Earthquake swarms have been threatening in Matsushiro, Nagano prefecture, in the central part of Japan, since August 1965. Over 400 earthquakes in one day were felt during the period of maximum seismic activity. After the second peak of activity, in August 1966, it became gradually weaker.

The Geographical Survey Institute has carried out geodetic surveys covering the areas considered to be affected by the crustal deformation accompanying the earthquake. To warn of the progress of crustal deformation and other geophysical anomalous changes, levelling, triangulation, geomagnetic and gravity surveys were repeated several times, as shown in the table below.

[1] The original text of this paper, prepared by Tetsuro Hayashi, Geographical Survey Institute, Tokyo, appeared as document E/CONF.53/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

Table 1. Levelling, triangulation, and geomagnetic and gravity surveys

Levelling	
Period	*Amount of work*
17 Nov.–20 Dec. 1965	123 km
12 April–27 June 1966	540 km
5 Sept.–13 Dec. 1966	472 km
Base line measurement and triangulation	
Period	*Amount of work*
9 May–23 June 1966	5 sides
21 Sept.–5 Nov. 1966	4 sides and 12 triangulation stations
Geomagnetic survey	
Period	*Amount of work*
9 May–18 June 1966	1st order-5 stations; 2nd order-15 stations
20 Oct.–10 Dec. 1966	1st order-7 stations; 2nd order-15 stations
Gravity survey	
Period	*Amount of work*
26 Sept.–2 Nov. 1966	2nd order-217 stations

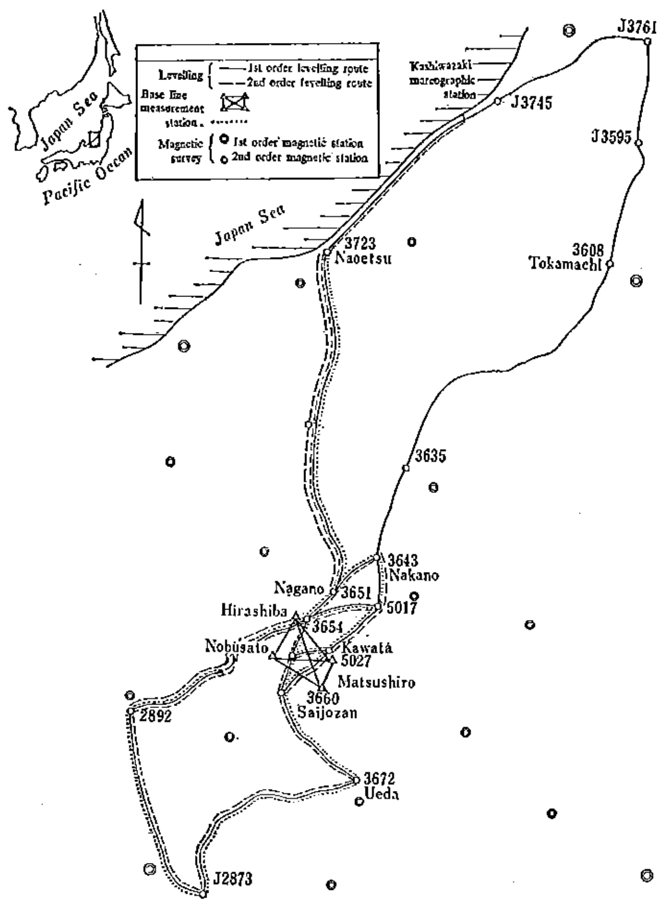


Fig. I.—Japan: Levelling routes and base line measurement stations

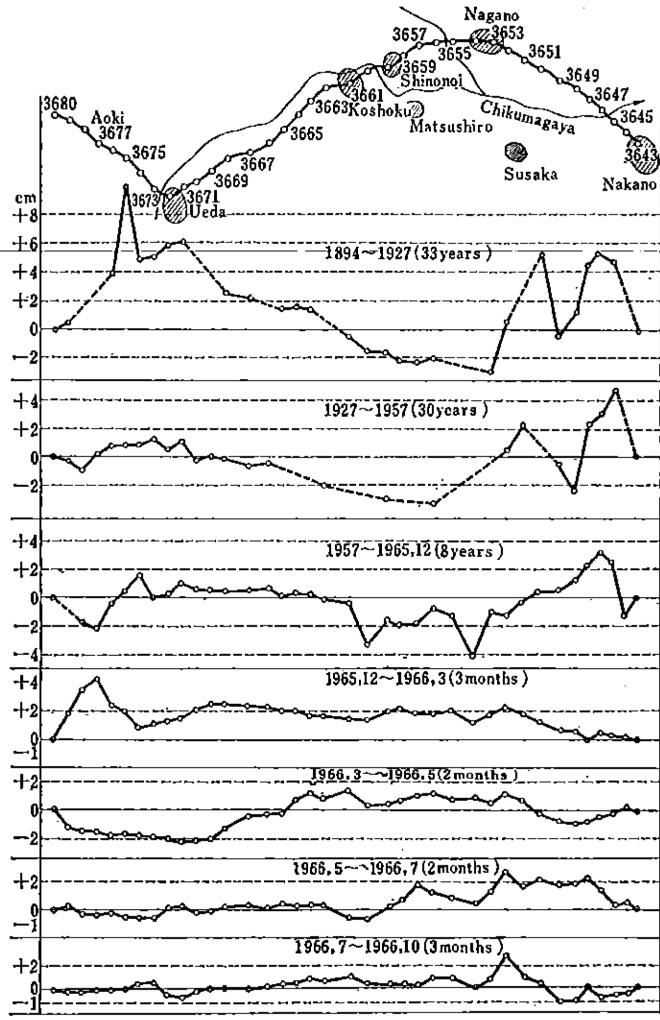


Fig. II—Japan: Vertical deformation along the first-order levelling route between Nagano and Ueda

Levelling

First-order levellings were carried out in 1894, 1927 and 1957. To detect the crustal deformations in detail, second-order bench-marks were newly established in the area near the epicentre, Matsushiro town, and surveyed repeatedly every month by the GSI and the Earthquake Research Institute, University of Tokyo. Levelling routes are shown in figure I. Vertical deformation along the first-order levelling route near the Matsushiro districts is shown in figure II.

From that figure we see, first, that post-seismic crustal deformations were the reverse of pre-seismic patterns (for example, subsidence along the route between Nagano and Kosyoku city changed to upheaval after the earthquakes) and secondly, that the velocity of the vertical deformations was about 10 mm per month during the earthquakes, while the mean velocity up to the occurrence of the earthquake was only 2 or 3 mm per year.

Triangulations and distance measurements

Third-order triangulation and electronic distance measurements have been carried out in the vicinity of the

Matsushiro district to detect horizontal crustal deformation. Rhombic base lines were newly established and measured by means of the Geodimeter IV once a week. Of the twelve triangulation stations, three have been equipped by the warning parties with T2 theodolites, and the horizontal and vertical angle observations were repeated simultaneously every week. Combining these data, horizontal displacements were tracked during about two months. Discontractive horizontal displacements were detected along the dislocation directed WNW-ESE. Relative displacements crossing the line of dislocation amount to about 1 m in the vicinity of Mount Minakami. However, from the results of the repetition surveys, it may be said that the horizontal displacement at each station gradually changed in the opposite direction. These data are shown graphically in the next two figures.

Geomagnetic survey

The Geographical Survey Institute has repeated the first- and second-order magnetic surveys over the whole of Japan since 1952. The typical variations of the geomagnetic components were detected before the Niigata earthquake in 1964. The anomalous change of 20–30 gammas is a significant magnitude from the viewpoint of accuracy, because the repetition surveys have been carried out at exactly the same station.

As the depths of the swarm earthquake of 1966 were of only one to several kilometres, it was supposed that the

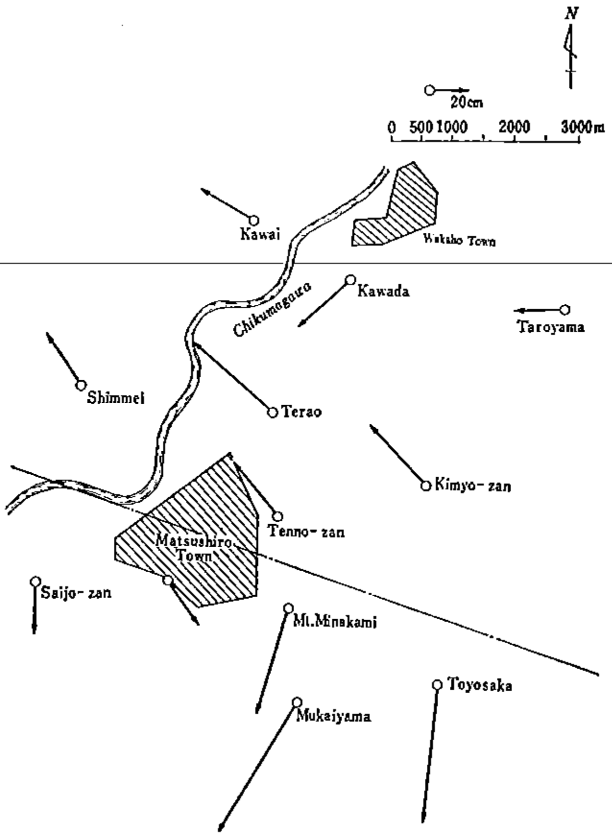


Fig. III—Japan: Horizontal displacements in the vicinity of the Matsushiro district obtained from triangulations in 1964 and 1966

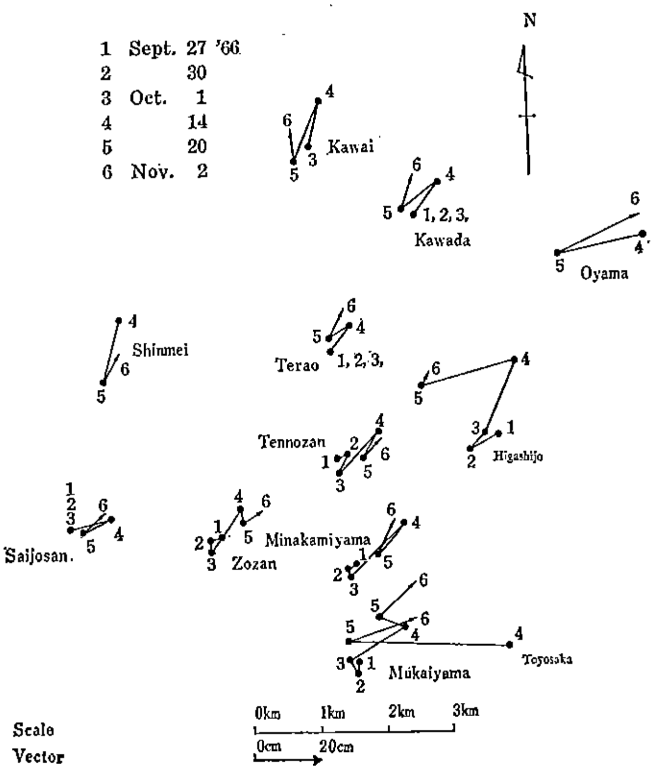


Fig. IV—Japan: Horizontal displacements obtained by repetition surveys

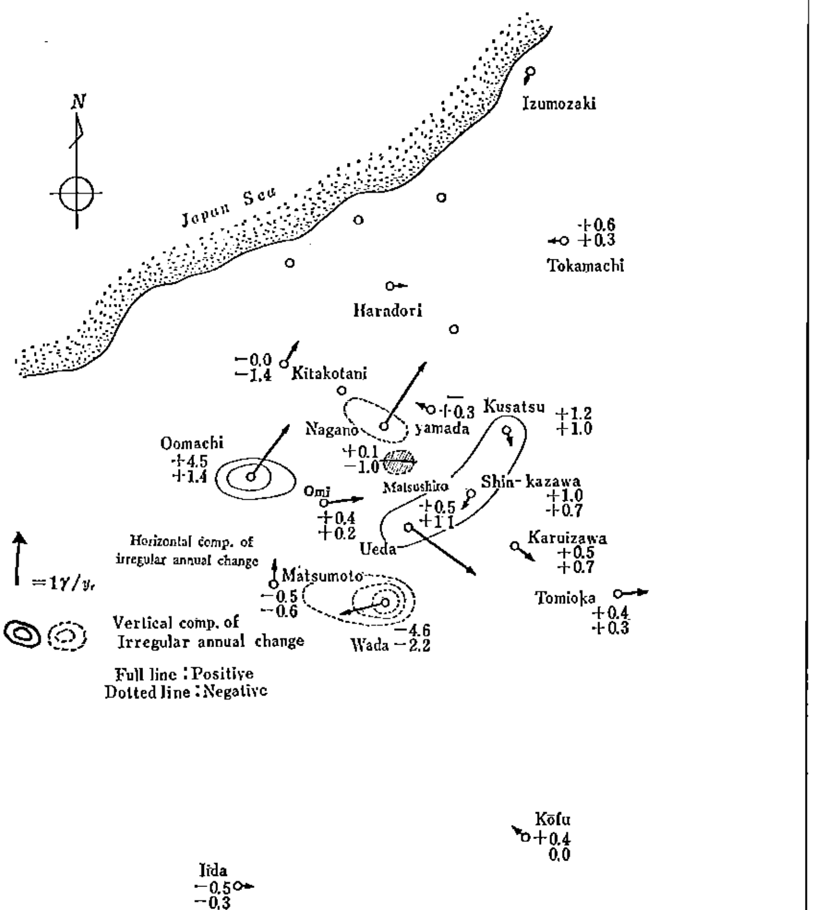


Fig. V—Japan: Irregular changes in geomagnetic values in the Matsushiro district anomalous geomagnetic changes might be accompanied by Matsushiro earthquakes. In the final figure, anomalous changes are shown in the broad area covering Nagano, Omachi and Ueda cities. Anomalies amount to about 20 gammas in the horizontal and about 40 gammas in the vertical components. Owing to the sparseness of the stations, the relation between the geomagnetic variations and the crustal deformations cannot be analysed. The study may be continued for purposes of earthquake prediction.

THE GRAVITY STANDARDIZATION PROGRAMME IN THE WESTERN PACIFIC REGION

Paper presented by Japan[1]

In order to standardize the gravimetric network of the world, the establishment of four calibration lines—Euro-African, North American, Central Asian and Western Pacific—was planned by the International Association of Geodesy. Two calibration lines—Euro-African and North American—have already been approved. The establishment of the Western Pacific calibration line (WPCL) was investigated and planned by a special study group, T. Okuda being the chairman. The plan proposed by the study group was adopted by the conference of the International Gravity Commission in 1962 and was also supported by the fourth United Nations Regional Cartographic Conference for Asia and the Far East.[2]

Acting on the adopted plan, the Geographical Survey Institute, in close association with G. P. Woollard, who conducted the gravity observations with the Gulf-Wisconsin pendulum apparatus at stations located along the WPCL during approximately the same period as that of the observations made by the GSI gravity team, has planned a series of observations with the GSI pendulum apparatus which has been used in several international gravity tie observations for the past ten years. Recently, some parts of the GSI pendulum apparatus were modified so as to obtain a constant high accuracy during the long-term observation tour and also to minimize troubles during oversea transportation. Using the modified apparatus, a test observation was carried out to determine the gravity value at Sapporo in Hokkaido, which is one of the supplementary fundamental stations in Japan.

The first step of the plan for WPCL was scheduled as a part of the Japan-United States scientific co-operation programme. So far, the following three series of pendulum observations have been carried out: March to May 1965: Tokyo, Honolulu, San Francisco, Denver; June to August 1965: Tokyo, Fairbanks; March to May 1966: Tokyo, Manila, Singapore.

In the first series, Denver, which is a hub point on the North American calibration line (NACL), was not contained in the original schedule. Following Mr. Woollard's suggestion, and upon assurance of financial support, however, the GSI gravity team extended its observation tour to that station, so that the WPCL was directly connected with the NACL.

Preliminary results obtained from the above-mentioned observations are described below.

Station	
Honolulu, Hawaii Institute of Geophysics, University of Hawaii	978.9587 ± 0.0003 (SE)
San Francisco, National History Museum, Golden Gate Park	979.9858 ± 0.0003
Denver Electronic Physics Laboratory, University of Denver	979.6114 ± 0.0004
Fairbanks, Geophysics Institute, University of Alaska	982.2460 ± 0.0003
Manila, Clark Air Base	978.3955 ± 0.0002
Singapore, Department of Geography, University of Singapore	978.0806 ± 0.0004
Tokyo, Geographical Survey Institute	979.7770

The above measurements are a part of the whole project of establishing the WPCL. Further measurements with pendulums and gravity meters on this line should be made as soon as practicable. Under the resolution adopted at the conference of the International Gravity Commission in 1965, it is expected that the Cambridge pendulum apparatus will take part in this work, so that the first stage of this project should be completed in a few years.

Our deep appreciation is due to all members, institutions and organizations concerned in this work and further support is cordially invited for the completion of the Western Pacific calibration line.

[1] The original text of this paper, prepared by Hiromiti Suzuki, Geographical Survey Institute, Tokyo, appeared as document E/CONF.52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

[2] *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 1 (United Nations publication, Sales No.: 65.I.16), p. 10, resolution 6.

AEROMAGNETIC SURVEY OF JAPAN

Paper presented by Japan[1]

Under the World Magnetic Survey, the Geographical Survey Institute and the Hydrographic Office conducted an aeromagnetic survey over the land and the adjacent Sea of Japan during the period 1961–1965. Results of the survey are being summarized and geomagnetic charts will be compiled and published by the World Data Centre in Kyoto, Japan, in the near future. The present report covers the technical features of the work by the Geographical Survey Institute concerning mainly the land survey.

The aircraft used for this survey is a twin-engined Beechcraft 65, "Queen Air", belonging to the institute. It has a maximum cruising range of 1,000 km and a speed of 250 km per hour. The crew consists of two pilots, a navigator and two observers.

Three geomagnetic components, total force F, horizontal force H, declination D, were measured with the GSI airborne magnetometer. Observation was made every 15

[1] The original text of this paper, prepared by Naomi Fujita, Geographical Survey Institute, Tokyo, appeared as document E/CONF. 52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

seconds in the order of F-H-F-D, so that a sequence was completed in one minute, corresponding to about 5 km in distance. Summarizing these data, we obtained values of the three components at about 5,000 stations in total. Flight altitude is, in general, about 3,000 m above sea level but varies according to the topography.

The GSI airborne magnetometer used has the following characteristics:

(*a*) Each of the three components is measured by the proton precessional method; to measure H and D, two coils, outer and inner, which generate bias magnetic fields, are installed in the magnetometer theodolite;

(*b*) To minimize the total weight of the equipment to be loaded on a light aircraft, the magnetometer theodolite is not stabilized at horizontal automatically but is fixed to the body of the aircraft; the tilt of the aircraft is detected by a horizontal gyroscope; the azimuth is obtained from the record of a solar camera and the horizontal position of the observed station from aerial photographs 35 mm in size;

(*c*) The output signal from the sensing head of the magnetometer is recorded on a magnetic tape together with standard frequencies and time mark; most operations are automatically controlled by a clock mechanism; the record obtained is analysed after landing.

Final accuracies of the observed three components are estimated at $\pm 20\gamma$, $\pm 100\gamma$, and $\pm 0.2°$ respectively. The accuracy of the position decision of observation stations is 200 or 300 m on land where aerial photographs are used, and 1 km at sea, where position is determined from the record of cruising time and speed on the flight course.

NEW MEDIUM-SCALE PLOTTER

Paper presented by Japan[1]

Introduction

A prototype of the medium-scale topographic plotter, is made by the Geographical Survey Institute in close co-operation with Nippon Kogaku Co., Ltd., which is going to play an important role in executing the ten-year project of producing about 4,000 sheets of the new base maps at 1:25,000 covering the whole area of Japan.

The new plotter is a one-man instrument with mechanical projection and is made for medium-scale plotting.

The ratio of the photo-scale to the plotting-scale is preferably less than 1:3 and usable photographs are taken with a wide-angle camera whose focal length is about 15 cm.

One of the characteristics of the instrument, compared with similar types of instruments such as Wild B8, Kern PG2, is that we adopt a co-ordinatograph system for plotting instead of a pantograph system.

In the instrument, a model of an object is made in the manner which we shall now describe. Photographs are laid in a horizontal plane in the instrument and photo-co-ordinates are measured on the photograph. The measured photo-co-ordinates are converted into exact vertical photo-co-ordinates. With the help of these exact vertical photo-co-ordinates, a resection in space is split into two resections in plane, namely X-Z plane and Y-Z plane. In this sense, it can be said that the new plotter is an analogue computer.

Principle of the instrument

In the instrument, the transformations from photo-co-ordinates x and y to model co-ordinates X, Y and Z are solved step by step as follows (where x'' and y'' are the exact vertical photo-co-ordinates):

$$\left.\begin{aligned} x' &= x\cos\kappa + y\sin\kappa \\ y' &= y\cos\kappa - x\sin\kappa \end{aligned}\right\} \qquad (1)$$

$$\left.\begin{aligned} x'' &= \frac{x'\cos\varphi - f\sin\varphi}{(f\cos\varphi + x'\sin\varphi)\cos\omega + y'\sin\varphi} \\ y'' &= \frac{\{y'\cos\omega - (f\cos\varphi - x'\sin\varphi)\sin\omega\}f}{(f\cos\varphi + x'\sin\varphi)\cos\omega + y'\sin\omega} \end{aligned}\right\} \qquad (2)$$

$$Z = \frac{b \times f}{x''_1 - x''_2} \qquad (3)$$

$$X = \frac{Z}{2f}(x''_1 + x''_2) + \frac{b}{2} \qquad (4)$$

$$Y = \frac{Z}{2f}(y''_1 + y''_2) \qquad (5)$$

Formula (1) is solved simply by the rotation of the photograph around the principal point in a horizontal plane.

Formula (2) is solved by projecting the point in the mechanical photo-plane on to the exact vertical photo-co-ordinates plane, which is inclined at ω and φ by central projection.

These exact vertical photo-co-ordinates (x''_1, y''_1) and (x''_2, y''_2) are transferred to the resection device by synchro-servo-system.

In the resection device, the model co-ordinate Z is computed mechanically according to formula (3).

The model co-ordinates X and Y satisfy formulae 4 and 5.

Absolute orientation is carried out in a similar way as in the other restitution instruments. The scale of the model is determined by changing the bx value. For the levelling of the model, φ_1, φ_2, and bx are used in X-direction and both ω_1 and ω_2 in Y-direction.

Mechanical structure of the instrument

The instrument consists of the following four main parts: projection device; resection device; drawing table and optical system.

Each part of the instrument will now be explained in detail.

Projection device

The structure of the projection device is shown in figure 1.

A photograph is oriented on the plate-holder with the attached light box. The plate-holder with a photograph is set on the top of the device. The plate-holder can be rotated around the centre at ± 15 g.

Underneath the plate-holder, there is an optical system. The optical system moves along the X and Y axis guided by parallel guide rails. Plate-holders are not inclined in X- and Y-direction, thus simplifying the optical system.

[1] The original text of this paper, prepared by Takeshi Hirai, Geographical Survey Institute, Tokyo, appeared as document E/CONF. 52/L.121. Additional papers bearing the same symbol were submitted under items 6, 7, 8, 9, 10, 12 and 13.

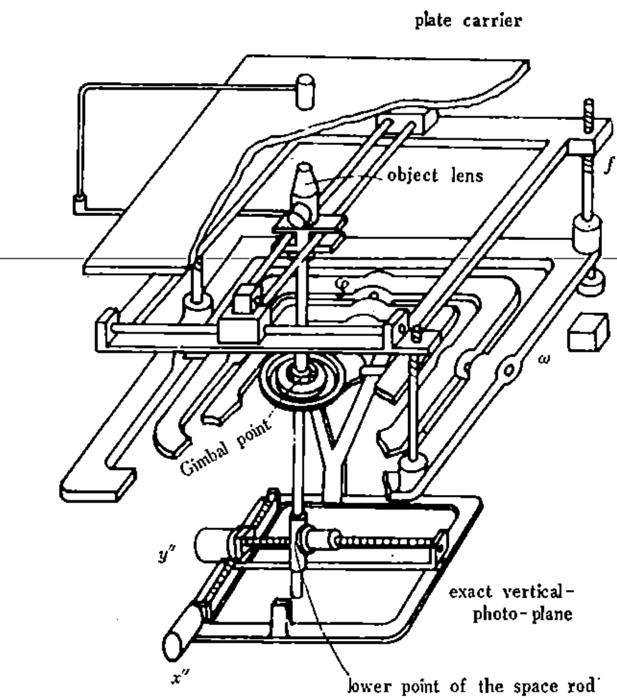


Fig. I—Japan: Projection device of medium-scale plotter

Under the optical system, there is a gimbal point which plays the role of the projection centre. The distance between the mechanical photo-plane and the gimbal point can vary from 149 mm to 155 mm.

The lower plane is an exact vertical photo-co-ordinates plane. It rotates around the gimbal point.

When this exact vertical photo-co-ordinates plane inclines at ω and φ, formula 2 is solved.

The exact vertical photo-co-ordinates plane should be small enough to rotate around the gimbal point easily and exactly; on the other hand it should be large enough to fulfil the accuracy required. Therefore the distance between the exact vertical photo-co-ordinates plane and the gimbal point is fixed at 10 cm. The size of the plane is determined in such a way that the whole stereoscopic parts of the photographs can be scanned when the photographs incline at $\kappa = \pm 7g$, $\omega = \pm 5g$, $\varphi = \pm 5g$ and the overlap of the photographs is between 55 and 74 per cent.

The movement of the lower point of the space rod in the exact vertical photo-co-ordinates plane is given by a servo-motor.

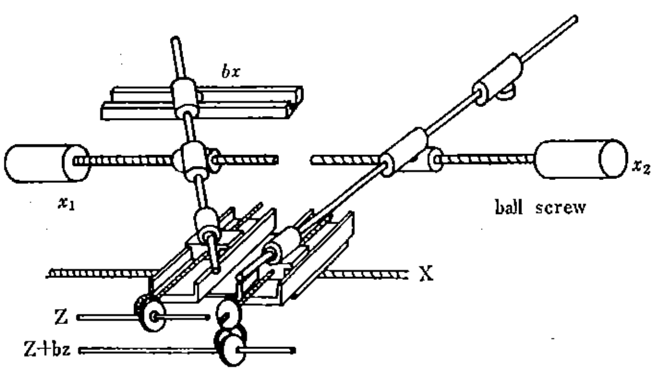


Fig. II—Japan: X-Z *plane of resection device*

The servo-motor is controlled by a control transformer which receives the signals from a control transmitter of the resection device.

Resection device

The resection device consists of the *X-Z* plane and *Y-Z* plane, as shown in figures II and III.

The power which moves the resection device is given by the *X*-handle, *Y*-handle and *Z* foot-disc. The power transmission system is shown in figure IV.

The *Bz* movement is added to the *Z* co-ordinate of the resection point from the right-hand-side photograph with the help of the *Bz* adding system.

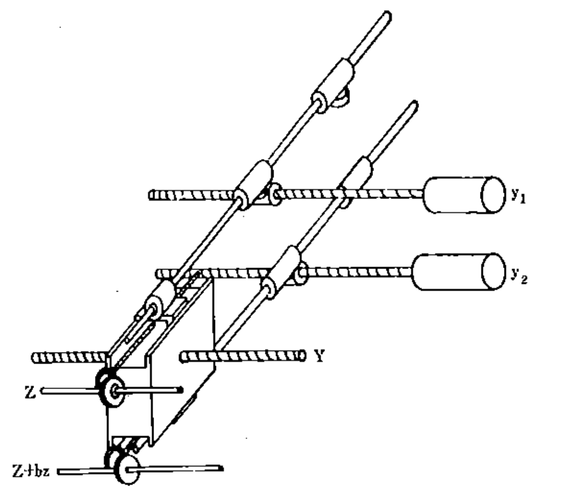


Fig. III—Japan: Y-Z *plane of resection device*

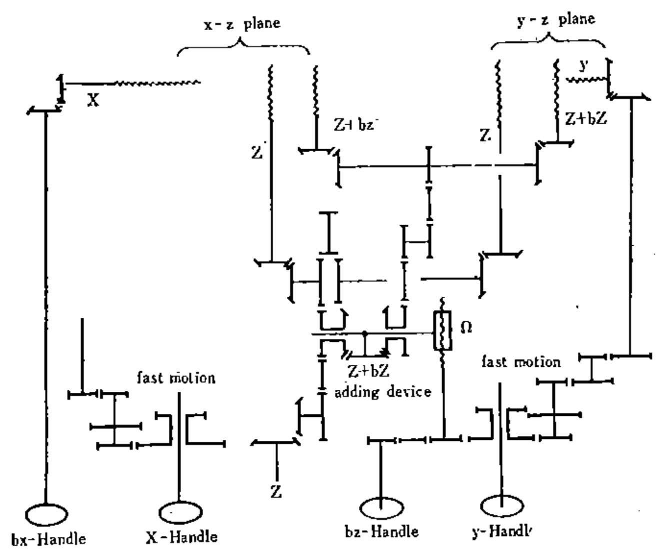


Fig. IV—Japan: Power transmission system

The movement of the resection point is transmitted to the nut of the ball screw through a steel rod and the signal corresponding to the exact vertical photo-co-ordinate is sent to the projection device from the control transmitter of the synchro-servo-system.

The distance between the projection centre of the resection device and the ball screw is fixed at 15 cm and the distances between the projection centres and *X*, *Y* spindles are fixed at 30 cm respectively.

Drawing table

One of the characteristics of the new plotter is that it has a drawing table which can be used as a co-ordinatograph. It is therefore possible to plot a whole sheet without dividing the area of the sheet into models and putting them together in one sheet after plotting. Production procedures can thus be simplified.

The ratio of model scale to plotting scale can be fixed variously by changing gears. Usable gear ratios are 4:5, 7:10, 3:5, 1:2, 2:5 and 1:1. It is sufficient for the plotting of a map at 1:25,000 scale.

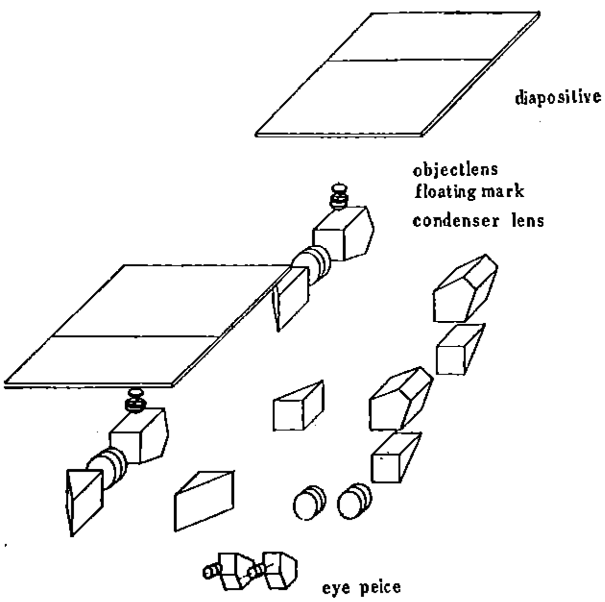


Fig. V—Japan: Optical system

Optical system

A diagram of the optical system contained in the new plotter is shown in figure V below.

The diameter of the field of view on the photograph is about 40 mm and the magnification is 4×.

GENERAL FEATURES

Type	Medium scale plotter
Projection	Mechanical projection
Ranges:	
Principal distance	152 ± 3 mm
Picture size	23 cm × 23 cm
Lateral tilt	= ± 7 g
Longitudinal tilt	= ± 7 g
Swing	= ± 15 g
bx	90 ± 20 mm
bz	±50 mm
X	−60 mm +240 mm
Y	±250 mm
Z	±60 mm
Dimensions:	
Height	143 cm
Length	150 cm
Depth	103 cm
Size of drawing table	60 cm × 80 cm
Weight	about 800 kg

The instrument is currently being tested for accuracy and economy. It is hoped to be able to publish the results in the near future.

AGENDA ITEM 9

Practical application of cartographic techniques

(a) Location and development of mineral resources

MAPS FOR THE DEVELOPMENT OF PHILIPPINE MINERAL RESOURCES

Paper presented by the Philippines[1]

INTRODUCTION

A mineral resources map series is among the sixteen types of economic map series which have been given priority by the Governing Board of Technical Surveys and Maps. Before discussing what source material is needed for the compilation of and specifications for a mineral resources map, it is well to consider the relevant cartographic and technical material involved in the development of mineral resources. This material may be subdivided as follows: different types of maps needed by the mining industry; aerial photographs and other survey data; mineral resources maps; government maps available.

Different types of maps needed by the mining industry

Without maps and mineral land survey operations it would not be possible to operate a mine profitably. The first step in the establishment of mining operations is to procure an approved plan or map of the area leased for mining development. The next step is to procure the largest scale topographical map available covering the area to be mined as well as the immediate vicinity in order to plan for the location of office buildings, roads, shafts and tunnels, plant sites, necessary drainage, and housing facilities for its personnel, electric power plant sites, water supply installations, etc.

A smaller-scale map to indicate air, water and land transport and communication facilities, sources of supplies for the mining operation, as well as the community for the workers, is also needed. A geological map of the area is needed for more comprehensive information of the possible extent and amount of the mineral being mined and any other minerals that may be present. It is also needed as technical information on the location and design of engineering structures required in the development site; for example, structures should not be constructed on faults. Foundations of plants, buildings and other structures are controlled by the geological formation of the vicinity. With respect to water supply, surface water resources and underground water resources maps would be of great help to the engineering department of the company.

Aerial photographs and other survey data

Aerial photographs, mosaics from aerial photographs, cadastral plans, Bureau of Lands index and boundary maps are also needed in getting pertinent vegetation information and other data not available from other sources.

Large-scale aerial photographs are sometimes needed by a development company because maps available in the area are not on a scale large enough for the purpose. A new set of aerial photographs could be requested or existing photographs could be enlarged to any scale desired. In view of changes in vegetation the latest topographical map that has been compiled may not show the actual vegetation covering. In this case aerial photographs are required.

Mineral resources maps

If a map as compiled by the Bureau of Mines, is not already available to be used in planning and programming the development of any mineral resources, a new map should be prepared. For a new map, maps and survey data available in the Government should be made available to the mining company, but in all cases a new survey supplementing existing government surveys is necessary for the location of outcrops and veins and for other relevant information.

It is also necessary to locate monuments already established by government agencies such as the Bureau of Lands, the Bureau of the Coast and Geodetic Survey and the Bureau of Mines.

Government maps available

*Topographical maps**

The Philippines is now covered by topographical maps as follows: on the scale 1:50,000, 974 sheets; on the scale 1:250,000, 55 sheets, and on the scale 1:1,000,000, 6 sheets.

Large-scale topographical maps are also available for special areas. The 1:1,000,000 and 1:50,000 maps are available at the Board of Technical Surveys and Maps, while the 1:250,000 maps are available at the Bureau of the Coast and Geodetic Survey. Topographical maps of special areas are available at the Bureau of Mines, the National Power Corporation and the Bureau of Public Works.

The large-scale map series at 1:50,000 scale is published by the Board of Technical Surveys and Maps in co-operation with the Chief of Engineers, Armed Forces of the Philippines. The chief source materials of this series are military reproduction negatives compiled from aerial photographs

[1] The original text of this paper, prepared by Marcelino S. Tabin, Vice-Chairman and Executive Director, Board of Technical Surveys and Maps, appeared as document E/CONF.52/L.8.

* See pocket at the end of volume for "Index maps of 1:50,000 scale topographical maps".

taken from 1949 to 1953 by the United States Air Force, using photogrammetric methods.

Geological maps

The 1:1,000,000 geological map of the Philippines, available at the Bureau of Mines, consists of six sheets in colour; it was produced in 1963. There are, in addition, ninety-four sheets of geological maps of special areas at scales ranging from 1:550 to 1:83,000; ten at medium scales (1:100,000 to 1:250,000); and seventeen at scales smaller than 1:250,000. These are also available at the Bureau of Mines. The geological map at 1:1,000,000 has superseded all geological maps of the Bureau of Mines at 1:1,000,000 or smaller. While these geological maps are produced by the Bureau of Mines, the Board of Technical Surveys and Maps' library has copies of them for immediate reference and consultation by interested parties.

Geological maps on large scales (1:550 to 1:83,000) cover the following areas:

Napisian and Sia, Bulalacao region, Mindoro Oriental;
Coal district of Catanduanes;
Camp Ermitaño (coal), Paganiban, Catanduanes;
Cancalbon-Naglobog, Catanduanes;
Batan island;
Hitoma-Manambrag Region, Catanduanes;
Ube-Malabog, Catanduanes;
Gatbo Peninsula, Sorsogon;
Semirara island;
Argao-Dalaguete region, Cebu;
Bayabas-Bañaas (coal), Cebu;
Gransina-Mantalongan (coal), Cebu;
Butung-Deplahan;
Malangas-Kabasalan Region, Zamboanga del Sur;
Lalat;
Hixbar gold mine, Rapu-Rapu Island, Albay;
Botolan copper mine;
Botolan-Cabañgan, Zambales;
Barrio Giwang, Guindulman, Bohol;
Anda peninsula, Bohol;
Manganese ore reserves;
Sitio Tawid, Barrio Cogtong, Candijay, Bohol;
Kabulayon, Negros Occidental;
Tababoy Negros Occidental;
Calatrava-Toboso region, Negros Occidental;
Macasilao, Negros Occidental;
Bogonbon, Negros Occidental;
Bislig-Lingig region, Surigao;
Lobo copper mine, Batangas;
Sibalom, Antique, Panay Island;
Cansi, Tuburan, Cebu;
Carawisan Mine, San Remigio, Antique;
Mindanao Mother Lode Mines Inc., Zambales;
Matugan, Toledo, Cebu;
Media Once, Toledo, Cebu;
Pansol, Toledo, Cebu;
Ancheta Copper Mines, Santa Cruz, Zambales;
Bato Hayao Prospect, San Remigio, Antique;
Carmel Mine, Lunocan, Patnongan, Antique;
Diamond Sawa-Sawa and Malabog, Lanuza, Surigao;
Lutopan Mine, Lutopan, Toledo, Cebu;
Maypay, Toledo, Cebu;
Mipicu Group Claims, Kayan copper district, Bontoc, Mountain Province;
Pilar copper deposit, north-eastern Panay;
Santa Cruz Poly Mines, Eguia and Dasol Pangasinan;
Southern Antique;
Binulig Ridge Copper, Sipalay, Negros Occidental;
Bongbongan Mine, Sibalom, Antique;
Malobog, Lanuza, Surigao;
Copper deposit of La Perla Empire Mining Corp., Pangasinan;
Kayan copper district, Bontoc, Mountain Province;
Lepanto Mine, Lanuza district, Surigao;
Nonoc Island, Surigao;
Sipalay copper deposit;
Cagrary and Batan islands;
North-western Cotabato Province;
Barili, Cagayan Province;
Part of Iloilo;
Camalaningan Iron Prospecting and Gumanongong Ridge, Camalaningan, Cagayan.

Medium-scale geological maps (1:100,000 to 1:250,000) cover the following areas:

North-western Cotabato Province;
North-western Leyte;
Camotes island;
Central Cebu;
North of San Carlos, Negros Occidental;
Southern Mindoro Oriental;
Southern Zamboanga;
Marinduque;
Western Davao;
Surigao iron ore reservation.

Other small-scale geological maps, including distribution of geological age units, cover the following areas:

North-eastern Luzon area;
Samar Province;
Sulu Archipelago;
Northern Zamboanga Province;
Zambales and central plain of Luzon;
Cebu;
Panay;
Masbate;
Burias Ticao;
Leyte;
Camotes Island;
Bohol;
Agusan.

Mineral maps

The Bureau of Mines has twelve small-scale mineral maps of the Philippines (at scales 1:4,000,000 to 1:6,500,000) in black and white print.

The minerals indicated on these small-scale maps are chromium, coal, lead and zinc, iron, gold and silver, copper, manganese, chromite, guano phosphate, limestone, petroleum and radioactive minerals.

There are seven large maps at scales 1:1,500,000 to 1:2,500,000 indicating the following minerals: iron and ferro-alloy metals, base metals, precious and rare metals, ceramic and refractory minerals, mineral and fertilizer, copper.

There are thirteen smaller areas covered by large-scale maps ranging from scales 1:1,000 to 1:29,400 as follows:

Botolan copper mines of Botolan, Zambales;
Binulig Ridge Copper of Sipalay, Negros Occidental;
Bituloc copper deposit of Nueva Ecija;
Milagros copper deposit of Masbate;
Pauli Copper-Molybdenum Property, Marinduque island;
Nickel ore in zones 1, 2, 3 and 4, Awasan islands, Surigao;
Nickel ore in zones 1, 2, 3 and 4, Nonoc islands, Surigao;
Nickel ore in zones 1, 2, 3 and 4, southern Dinagat, Surigao;
One distribution map of the explored islands of Nonoc-Awasan, southern Dinagat, Surigao;
Bagacay copper deposits of the Marinduque Iron Mines, Inc., Samar;
Ore bodies of Malolos area, Lanuza, Surigao;
Kayan copper district, Bontoc, Mountain Province;
Contour map for laterite ore, Nonoc and adjacent island, Surigao;
Contour map for Serprentride ore, Nonoc and adjacent island Surigao.

Conclusion

The specifications for the compilation of mineral resources maps is in the hands of Co-ordinating Working Group D-(4) of the Board of Technical Surveys and Maps, with representatives from the following offices: Reforestation Administration; Bureau of Mines; Bureau of Forestry; Philippine Fisheries Commission; Bureau of Soils; Parks and Wildlife Office; Board of Travel and Tourist Industry; Bureau of Lands; Bureau of Agricultural Economics.

This working group is responsible for utilizing any source material available and for drafting a format that would conform with international specifications and requirements and yet not be inconsistent with national practices and standards. As soon as it has concluded its deliberations, the resulting recommendations will be given to the governing board of the Board of Technical Surveys and Maps, which in turn will make final decisions on the national standards and specifications for mineral resources maps which should be followed by all agencies concerned.

PHOTOGEOLOGICAL STUDY OF PHILIPPINE DIORITES

Paper presented by the Philippines[1]

Introduction

The advent of the aerial photograph in geological studies brings into focus a new approach to the study of rocks. In the not too distant past, there were two main arenas in which rock studies were conducted: the field, where rocks were studied *in situ*, and the laboratory, where they were examined under the microscope. Rock classifications now used are based on data gathered from these studies. Photogeology is a most welcome innovation, for it adds a new dimension in which rock study can be carried further. It is slowly gaining importance as an aid in the search for a less confused system of rock classification and as an improved method in geological mapping in general.

Diorites, quartz diorites, granodiorites and all other intrusive igneous rocks of intermediate composition (which will be referred to as the diorite group in this study) are perhaps among the most extensively studied rocks in the Philippines. The primary reason is that this rock group is genetically related to the formation of most of the mineral deposits that have so far been discovered in the archipelago. The Lammin iron deposits in Ilocos Norte, the Lepanto copper deposits in Mankayan, the Baguio mineral district, the Sipalay copper mines in Negros Occidental, the sulphide mineralization zones of Zamboanga del Sur and scores of other mineralized areas can be spatially correlated near to or on the border zones of large intrusives of the diorite group.

To date, however, there have been very few photogeological investigations and studies made of the diorite group in the Philippines. Although photogeology has long been used in the Philippines, particularly by the Bureau of Mines, there have been very few attempts at formally studying these rocks as they occur in the Philippine morphogenetic environment. Except for a brief mention in a report published by the Bureau of Mines summarizing the photogeological work done in that bureau between the years 1960–1963, no other studies are known to exist. Because of this, the photogeological identification of diorites has not developed much beyond the unscientific matching method, where data are mostly based on those developed in environments entirely different from that of the Philippines. The present study was undertaken on the underlying premise that the photogeological interpretation of this rock group, as well as other types of interpretations, must be based on local morphogenetic conditions before references to other countries are made. The archipelago lies in a unique geographical location and the geomorphic behaviour of rocks must necessarily be different in more ways than one to have evolved their own characteristic landforms.

Bearing these considerations in mind, the diorite rocks in the Philippines offer a favourable opportunity for the study of important photo-interpretation problems in geology and provide a test as to the applicability of photogeological techniques in the country.

The following specific questions are especially pertinent:

How successfully can air photographs supplement and improve field methods in the location and mapping of diorites?

Do these rocks develop distinct photographic characteristics which may help in their identification from air photographs?

How far may the photographic criteria used in the identification of these rocks in other countries be applied to local conditions?

How do geographic location, climatic conditions and erosional stage affect their geomorphic development?

To what extent may photogeological technqiques be used to aid in the discovery and study of mineralized zones in or around diorites?

A thorough study of vertical aerial photographs of areas underlain by diorite masses with corresponding minimum field checks shows that diorites develop characteristics which enable an experienced photogeologist to distinguish them readily from other rock types. Nevertheless, these rocks should be considered independently of those located in other countries; and even within this region itself, each locality must be given special attention. Caution must, however, be exercised when the aerial photograph is the sole source of data, because lithologic characteristics alone become unreliable in passing from one locality to another. Climate and physiographic conditions combine with the geological setting and become the all-important controlling factors. Problems of quality and scale of the photograph come into play in connexion with the use of photography in the location of ore deposits. It is precisely because of these two variables that the extensive use of aerial photographs for this purpose is deemed unwise at this stage of development of photogeology in the country. The role of photogeology in mining will grow as more specialized studies are made, the quality of photography improved, and the choice of scale widened. Until then, field survey will remain the only reliable method.

Conduct of study

To suit the limitations and purposes of the present work, investigations were conducted on the assumption that every particular locality required special treatment,

[1] The original text of this paper, prepared by Arthur Saldivar Sali, Training Centre for Applied Geodesy and Photogrammetry, University of the Philippines, appeared as document E/CONF.52/L.9.

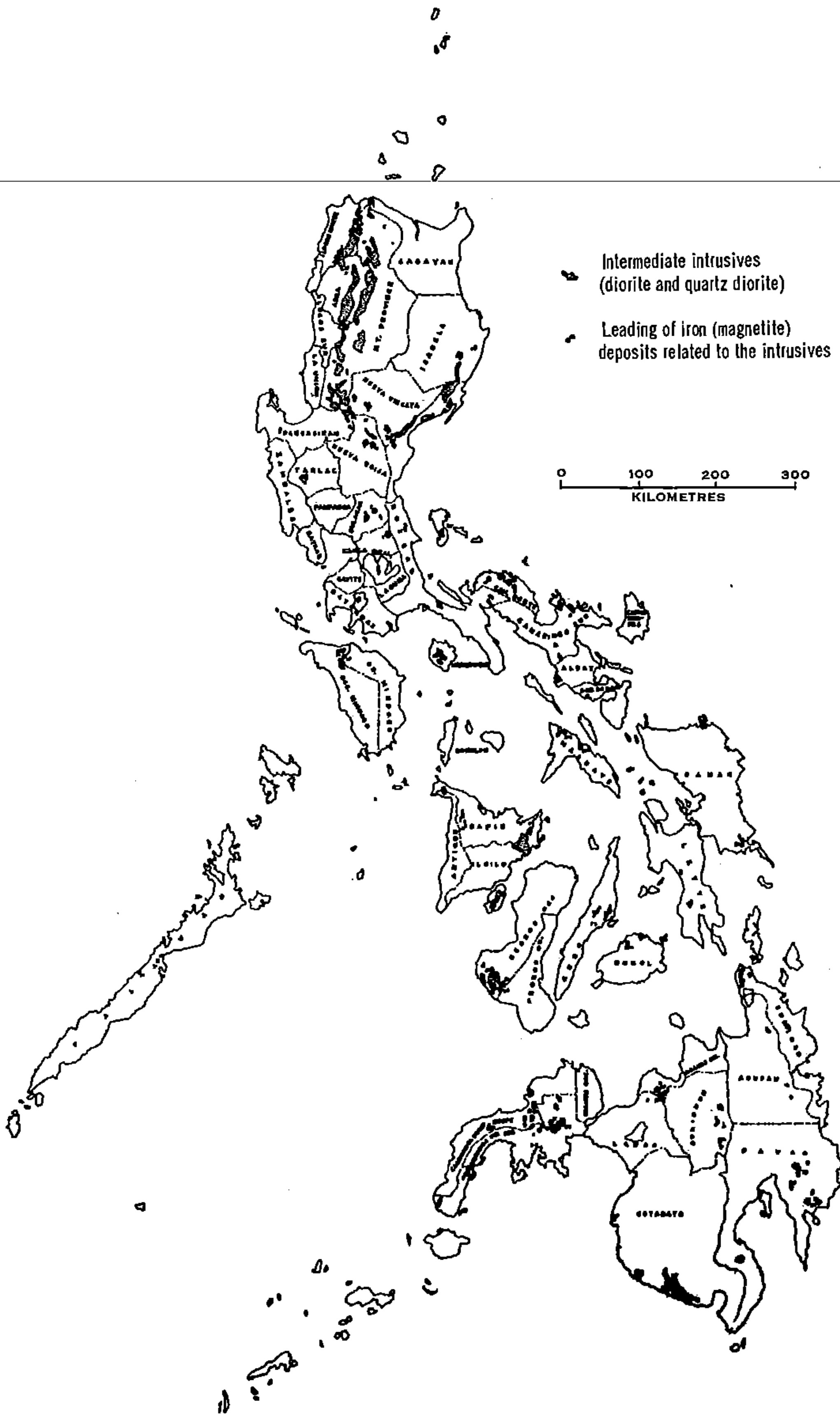


Fig. I—Philippines: Geological distribution map of diorites although the approach might be similar. Analyses were concentrated in the following areas underlain by diorite intrusives: the batholiths of the Cordillera Central and the Sierra Madre in northern Luzon, the stocks in Marinduque, the Sipalay quartz diorites in Negros Occidental and those of the Zamboanga peninsula (see figure I, p. 261). These areas were selected for four principal reasons: they are the major diorite bodies in the country large enough to warrant photogeological study; the manner of distribution of these five areas will provide a representative result vis-à-vis geology, physiography and climate; they have all been thoroughly studied in the field and laboratory by competent geologists and hence all data essential to a satisfactory result are available; all are known to be near areas of mineralization.

Reports of investigations, detailed and semi-detailed geological maps, topographic maps and other sources of pertinent facts were carefully reviewed and are liberally quoted in the present report. Interviews and conversations with informed geologists who have studied this rock and worked in these areas were also conducted. Through these data, a knowledge as close as possible to the true geological, physiographic and climatic conditions of each of the areas mentioned was obtained.

Next, an exhaustive stereoscopic study was undertaken of vertical aerial photographs of the areas: these photographs were procured from the Office of the Corps of Engineers, Armed Forces of the Philippines. Scales of the photographs were variable from one area to another, ranging from 1:32,000 ($f = 6$ inches; flying height = 16,000 ft); 1:44,000 ($f = 6$ inches; flying height = 22,000 ft) and 1:49,000 ($f = 6$ inches; flying height = 24,500 ft). Uncontrolled mosaics were likewise prepared. All stereoscopic examinations were done with a Wild mirror stereoscope in the laboratory and a simple lens stereoscope in the field and in the laboratory. Interpretation for regional correlation was performed with the former, while detailed and minute features were more suitably scrutinized with the latter. The general intention at that stage of the investigation was to correlate the field information with the photo-images. From these, the lithological contacts and other structures were traced on an overlay for each area in question, producing a preliminary photogeological map. Questionable areas, those where field data and photographic characteristics did not seem to conform, and other points of interest were noted on the same map. Finally, a route map to be used in the checking of all discrepancies in the field was prepared.

Field checking and confirmation constituted the third major step. In that phase, the aerial photographs were continuously used in the field to supplement the geological maps.

Lastly, the field data from the initial phase, the results of the field verification, and the photographic data were consolidated. A final interpretation was made in the laboratory. An attempt was made to reconcile all incongruous facts and, where reconciliation was impossible, explanations were sought. The preliminary photogeological map was finally revised to incorporate all the resulting additional details. Needless to say, such a map was more detailed, more complete, and hence more reliable.

All the areas were subjected to the above procedures, except in the Sierra Madre, Sipalay, and Zamboanga areas, where it was deemed unnecessary to execute field checking. The writer conducted the first verification in the Cordillera Central, covering Baguio, Acop, Kabayan, Bontoc and some places north of Bontoc in June–July 1965. In December of the same year, the stocks of Mahinhin and Torrijos were likewise investigated. During the latter, the writer was assisted by Guillermo R. Balce, a geologist of the Bureau of Mines.

The present report is presented in three parts. A discussion of the geological, physiographic and climatic conditions comprises the first. Most of these facts are the result of the study of highly respected and competent geologists, among them Andal, Fernandez, Gonzales, Kinkel, Oca, Pulanco and Santos-Yñogo. Reports from the Weather Bureau are also included in this part. The second part consists of the findings of subsequent photogeological studies. The results and conclusions are summarized in the third.

Geological, physiographic and climatic conditions

A general knowledge of the geology, physiography and climate of the environments where these diorites are located assumes a role of paramount importance in this study. It provides a clearer insight into the erosional development of these rocks and hence into the probable causes of formation of the landforms concerned. Since photogeology is mainly dependent on the interpretation of landforms as recorded in the aerial photographs, the data provided by this preliminary study become indispensable.

Geological setting

Lithological description

Diorite rock, including its varieties, is intrusive igneous rock of intermediate composition. Its principal minerals are oligoclase or andesine with hornblende and biotite as the chief mafic minerals. Some quartz is almost always present as interstitials and in micrographic intergrowths with the feldspars or as phenocrysts. Megascopically, the rock is mesocratic in the colour index and its mode of formation gives it a medium to coarse grained texture. This rock group occurs in various sizes, from batholiths to stocks, dikes and dikelets, or as marginal facies of larger plutonics.

Numerous studies both in the field and in the laboratory show that the diorites in the Philippines are of variable composition from place to place. The Cordillera batholiths, for example, range from those of granitic composition on the one hand to diorites on the other, with trondhjemites, granodiorites, quartz diorites and hornblende diorites as varieties. The diorites of the Baguio mineral district are light coloured, medium to coarse grained and equigranular. Those outside the Baguio area become leucocratic, with a fine-grained and relatively darker variety near contacts. The dark tone is imparted by a higher percentage of ferromagnesian minerals and lesser amounts of light grey plagioclases. In the Banaue area, Buangan in 1964 observed that the typical quartz diorites are megascopically medium to coarse grained and light coloured. Field observations showed that these rocks are massive and seemingly resistant to erosion.

In Marinduque, these rocks are typically medium to coarse grained. The Mahinhin stock is made up principally of plagioclase (An_{30} An_{48} with subordinate hornblende and quartz). The intrusive at the northern part is more of the biotite-quartz diorite variety, while that in Torrijos at the southern tip of the island is more of an andesite porphyry. Gervasio goes on to say that the andesite porphyry in the area is difficult to differentiate from the diorite. He speculates that this may be a phase of the diorite intrusive. During the field verification, it was also observed that the contact between the metavolcanics and diorites at Butansapa was more of an andesite porphyry than diorite.

The copper-bearing intrusive of the Sipalay area is quartz diorite, while that of Zamboanga del Sur is pre-Tertiary diorites with plagioclase and hornblende and some quartz as principal minerals.

Structures

It has long been evident that this particular group of igneous rocks was a body of molten material injected discordantly into older rocks such as synorogenic batholith, stocks and laccoliths, with attendant dikes, dikelets and other minor bodies. The emplacement is believed to have occurred mostly during the middle-Miocene time. Almost always, the intruded rocks are metamorphosed volcanic flows and/or metamorphosed clastics.

In the Cordillera Central area, a train of small to batholithic bodies extending north from the Baguio mineral district of Pasalang Bay at the northern tip of Luzon, are disposed in a north-south direction. These form the core of the Central Cordillera range. Here, these rocks intrude metamorphosed submarine volcanics, mostly metabasalts. Along the Sierra Madre range, the intruded rocks are metamorphosed clastics and volcanics. Likewise, in Marinduque, the diorites intrude into metamorphosed basic flows and clastics. Along the contact zones, Santos-Yñigo further observed that numerous irregular tonques of diorite cut into the metamorphic rocks. The plutonics in this island are disposed in a NW–SE direction, parallel to the island's shape and to the trend of other major structures.

The Sipalay quartz diorites also intrude into metavolcanic rocks, but both the intrusive and intruded rocks have been dynamically metamorphosed. Both are also intricately crushed. The intrusives, however, are mashed and faulted to a lesser degree than the metavolcanics, but in the same pattern.

Of a slightly different lithological and structural environment are the diorites of Zamboanga. The intruded rocks are mostly wackes, shales and other marine deposits folded by the intruding diorites.

Notwithstanding the variations in minerological composition from one place to another, the present study considers all the intermediate intrusives under one group, the diorite. Such an assumption will be shown to be justifiable in the latter part of the present report.

Climatic and physiographic conditions

In considering the landforms of any given locality, it is an elementary fact in geomorphology that physiography and climate always combine with the geological conditions to occupy the primary role in such a geomorphic development. Although the islands are strewn within the tropical zone, topographic irregularities, movements of local air currents and usual storm tracks have caused variations in climate within the archipelago. These variations, however, are mainly differences in the amount of precipitation. Two bases of classification have been found applicable: one takes the ratio of the number of dry months to that of wet months into consideration, while the other is based on the frequency of storms.

Physiography, besides implying geographic position and location of the area with respect to mountain ranges, air currents and storm paths, also includes altitude within its context. To a large extent, physiographic details are also controlling elements of climate, particularly the amount of rainfall in the area. This in turn determines run-off and density of vegetation. Altitude regulates the gradience of streams; hence their power to erode. As such, the areas selected for study are believed to comprise representative samples of these varied conditions.

Based on the amount of precipitation and seasonal changes, the country has been divided into four types of climates of longitudinal distribution (see rainfall chart and weather map below). The number of wet and dry months may vary, however, even within the same type.

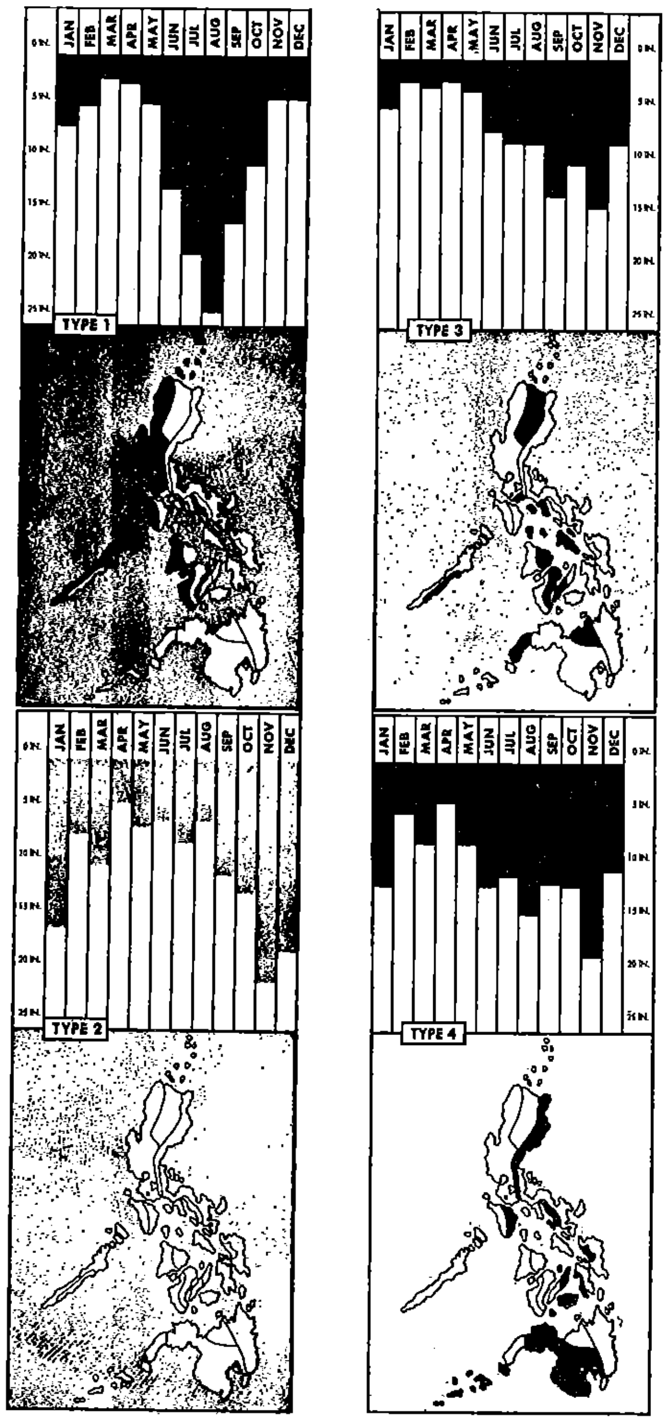


Fig. II—Philippines: Rainfall chart

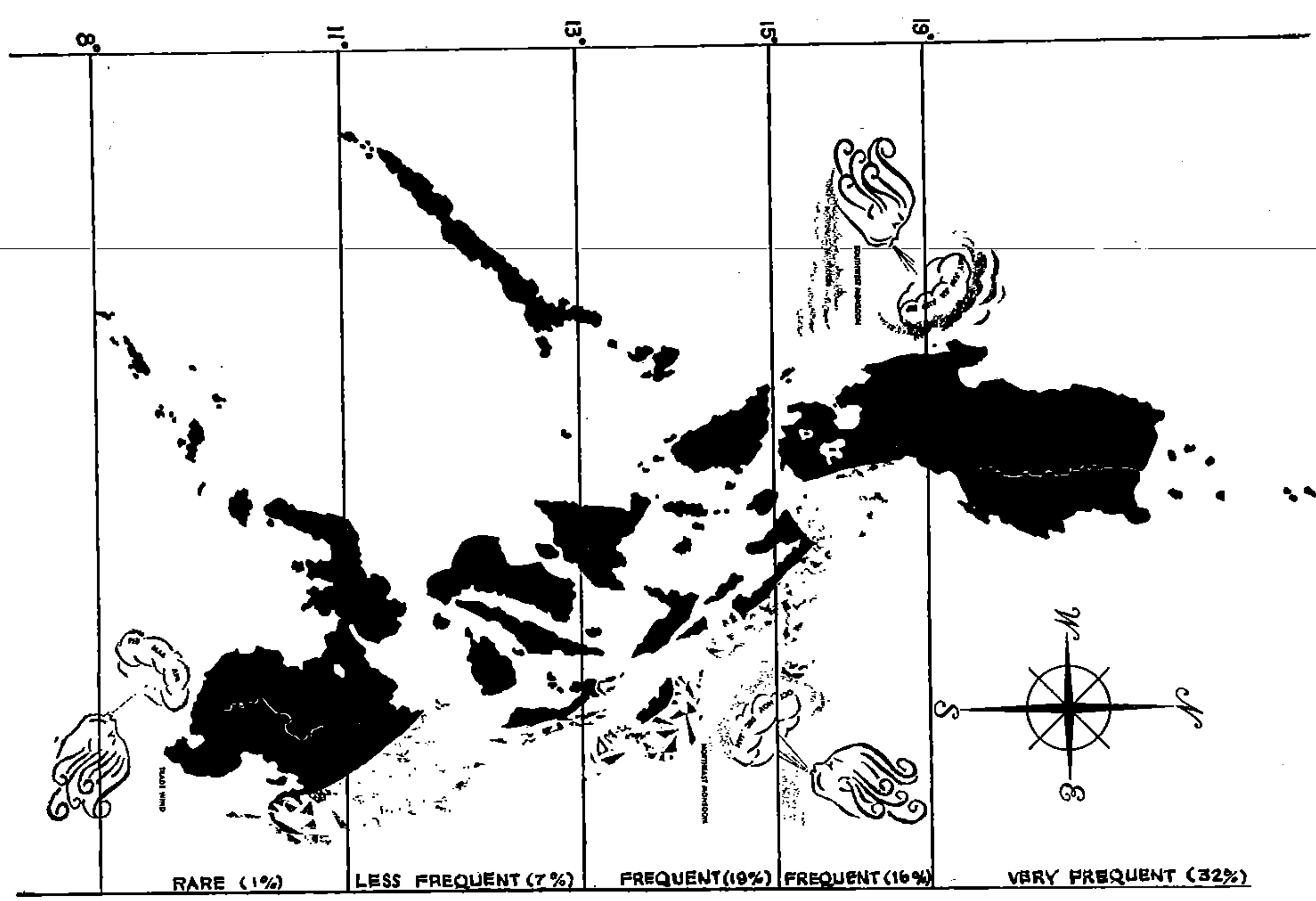


Fig. III—Philippines: Weather map, showing frequency of monsoons

Elaborating further, the first type has two pronounced seasons and the general climate within the zone is controlled principally by topography. The second has no dry season, being in the eastern coastal region where it is not shielded from northers, trade winds or storms. In the third type, the seasons are not well pronounced but relatively dry for six months and wet for the rest of the year. Lastly, the fourth type has an evenly distributed rainfall throughout the year. Classifying the areas under study into the aforementioned climatic types, we have:

First type: Cordillera Central (western part covering the provinces of Ilocos Norte, Ilocos Sur, Abra and western Mountain Province, including the Baguio district);

Second type: Camarinos Norte, Sorsogon;

Third type: Cordillera Central (north-eastern part, covering northern Mountain Province);

Fourth type: Marinduque, Sierra Madre (covering the provinces of Isabela, Nueva Vizcaya and Quezon).

From the standpoint of frequency in typhoon occurrence, however, climatic separation assumes a latitudinal character, i.e. the percentage of typhoons that hit an area relative to the total number of typhoons in the country within one year varies northward.

The Cordillera Central lies in northern Luzon and the bodies of diorites are along the eastern borders of the provinces of Ilocos Norte, Ilocos Sur, Abra and the western half of the Mountain Province. This area is bounded in the west by 120° 35′ longitude, on the north by Pasaleng Bay, eastward by the 18° 40′ north latitude, 121° 15′ longitude in the east, and at the southern end by the 16° north latitude, where the mountains meet the plains of Pangasinan. The Cordillera Central is the highest among all the areas selected, averaging around 1,500 m above sea level. Significantly, this topography is due to the structural height caused by the intrusion of the diorites. This is true for all the areas studied, relief abruptly rising as the diorite areas are approached.

Another group of elongated diorite bodies parallel the north-eastern coast of Luzon along the easternmost portion of Isabela, Nueva Vizcaya, and Quezon. This is the northern end of the Sierra Madre, assuming a height of about 1,000 m. All northern Luzon lies about 15° 30′ north latitude, the region most frequented by typhoons.

Marinduque, hemmed in by 121° 45′ longitude, 122° 10′ longitude, 13° 10′ north latitude and 13° 35′ north latitude, although it belongs to the fourth type, lies within the area where typhoons are relatively less frequent (19 per cent of the major typhoons that affect the archipelago) than in northern Luzon. The Mahinhin stock rises to only as high as 300 m. The Sipalay quartz diorite bodies are in the area between 8° north and 11° north latitude, where only 7 per cent of the typhoons occur, but belongs to the first type and attains a slightly higher elevation of 400 m. North-eastern Zamboanga del Sur is included in the fourth type but has the least frequency in typhoons (1 per cent), although higher in altitude than Sipalay, being 1,000 m above base level.

It will be noted that no representative of the second type is included in this study. No diorite rocks large enough to warrant a satisfactory photogeological study has yet been thoroughly field-surveyed in the localities of the second climatic zone. No reliable data could thus be used as a basis for preliminary investigations.

PHOTO-INTERPRETATION

Once intimate relation between the factors discussed in the preceding section and the topographic development of the areas mentioned is well appreciated, the final phase of the study may now be enunciated.

A section such as this is necessary in all photogeological work in order to attempt to correlate all the observations and interpretations made on the aerial photographs with those taken from the field. More often, such data tend to complement and supplement each other. Emphasis, however, is laid on the analysis of photo-images and their geological significance. Like all other aerial photographic interpretation work, certain elements were used, namely, structural patterns, geomorphology or landforms, drainage patterns, vegetation and tone. Each of these elements is discussed separately in the order given because an understanding of one requires a knowledge of the preceding. Furthermore, the areas under study are discussed separately with respect to these elements in a effort to discover where each of these areas is similar or different and to trace the probable explanation for such similarities and differences.

Structure

Geological structures, particularly joints, faults, shears and other major or minor ruptures, are the easiest features to interpret in aerial photographs as far as photogeology is concerned. This can be done more objectively in diorite terrains because this rock group has been established to be one of the few rocks especially characterized by such structures. Manifestations of these features are very explicit in the form of linear features, i.e. short, linear cuts or scars, straight stream courses, zoned vegetation, aligned ridges and saddles, angular stream junctions, offset ridges and topographic anomalies which are easily discerned through stereoscopic investigations. Moreover, these structures, especially the minor ones, are very well developed in areas of moderate to high relief, making their recognition easier in diorite terrain. Generally, because of the similarity in modes of formation, the diorites in the archipelago exhibit these features in more or less the same manner, the expression on the vertical aerial photograph differing very slightly. What becomes a more important factor to consider in these cases is the intensity of tectonism in the locality. This will determine the density of these ruptures in the diorite relative to that of the intruded rocks, which are similarly crushed in many areas.

Diorites in the archipelago are very rarely crossed by major faults. This is clearly shown in the aerial photographs by the lack of large linear features within the bodies. Instead, the terrain is characteristically criss-crossed by minor faults, joints and shears. Short, linear scars, thus, are dominant in the diorite and often become systematic, usually parallel to and/or oblique to the major faults and contacts. More often, the major ruptures coincide with the contacts between the intrusive and intruded rocks. On the aerial photograph these are expressed as long linear structures that may extend into two or more photographs, definitely modifying the drainage of the immediate vicinities.

But to assume that all the diorites are characterized by having more linear features than its surroundings due to these ruptures, would be carrying a generality too far. In the archipelago it must be realized that the intruded rocks around diorite areas are mostly incompetent metamorphosed volcanic flows and/or occasionally metamorphosed clastics around tectonically disturbed locales. The probability that the intruded rocks may have been sheared and ruptured to an equal if not greater degree than the intrusive itself is not remote. Some parts of the Cordillera Central provide good examples of such cases, as these areas were very much tectonically disturbed. The stresses caused by such movements produced a severely crushed region. A good number of these are attributed to the intrusion of the diorites itself. In some cases only most detailed stereoscopic scrutiny will reveal that the diorites are more mashed. This was true in the batholiths at the southern tip of the Mountain Province around the municipality of Dulupirip. It was difficult to use angular drainage patterns or zoned vegetation along shears to pinpoint the contact between the diorite and intruded metal basalts. The metamorphosed volcanics showed the same patterns to about the same degree of density as the diorite. Identification of the rock in this respect becomes difficult and unreliable because the intruded metal basalts are usually as severely crushed as the intrusives and in almost the same pattern. The use of other criteria becomes imperative.

An extreme case is that the Sipalay quartz diorite stocks were mashed and faulted to a lesser degree than the metavolcanics. Unfortunately, except for the outcrops near the coast, the region is covered almost entirely by thick forests. This field observation, therefore, cannot be translated in terms of aerial photographic characteristics because the minor structures are obscured beyond recognition. Otherwise, there is no doubt that the disparity will be clearly shown on the aerial photographs.

Even if these structures become more dense in the diorite relative to the intruded metamorphics, it is still difficult to use this fact as a means of identification. For again, we have to contend with the topography or altitude of the locality and the stage of geomorphic development. The Cordillera Central is a very high area attaining some 1,500 to 2,000 m altitude. Furthermore, the area is undergoing a stage of early to middle maturity in its present erosional development. The dominant work of the master rivers, therefore, is vertical erosion, producing steep valley sides. Tributary and tertiary streams are very much influenced by the gradient of these valley slopes. The general effect, then, is to produce young and very competent tributaries and tertiaries that follow short, straight courses. Usually the structural control afforded by the minor shears and joints are defied and slope gradience becomes an overriding control. The sub-parallelism of stream courses is clear in both diorites and metamorphics, but evidence of control by joints and shears is hardly seen. In all areas of high altitude, caution must be used in interpreting linear features in diorites as ruptures. The gradient of slopes is such that parallel to sub-parallel stream patterns are developed. Very often these drainage lines follow straight paths in the absence of structural control.

In Marinduque, on the other hand, in the Mahinhin stock, field verification showed that rupturing within the diorite was distinctly more intense than in the surrounding metal andesites. It should, therefore, be normal for the former to show more linear features than the latter, vegetation being very sparse. However, this is not the case because, unlike the Cordilleras, the Mahinhin stock, besides being at a lower elevation, shows evidences of a much later stage of erosional development. In this case, it would be impractical to interpret diorites in terms of structural features. In this particular locality, the landforms produced are virtually free from structural control; that is to say, joints, shears and other minor ruptures have been covered by thick soil cover.

Contacts between the diorites and intruded metamorphics, when traced along two or more strips, are the usual smooth curving lines unless, as mentioned earlier, major faults define such contacts. It will be shown in more detail later that these boundaries are most distinctly distinguished by marked differences in topographic configuration of the diorite and metamorphic terrain when both are bare of thick timber cover. In the presence of a forest cover, the contact is defined by the apparent line formed by the meeting of two different tree crown textures which are unique characteristics of each rock.

Detailed field studies further showed that the diorites injected numerous tonques of dikes and dikelets into the adjoining rocks, while in the intrusive itself there are occasional tubular bodies of the country rock with strips of diorite. Similarly, other features, such as primary flow structures (for instance, linear and planar parallelism of ferromagnesian minerals and marginal fissures in the solidified outer shell of the plutons), can be readily recognized in the field. Such structures, however, are too small to have any interpretative value to a photogeologist when the scales of the photographs used are those suited for regional studies. Thus these features may be classified as microfeatures in the present scales used. Moreover, in the more humid areas of the archipelago, thick tropical forest cover will totally obscure these microfeatures. Recognition and interpretation of these features will definitely require improved photography and scales at least twice larger than the present scales used. Field discoveries have shown that most of the mineralized zones are in these microfeatures, so that aside from facilitating contact delineation, proper understanding of such features and their relation to the surrounding geology may pave the way for the discovery of fresh knowledge, means and methods of locating ore deposits. Ultimately, photographic analysis of these "micro structures" may prove to to be the greatest contribution of photogeology in the study of diorites in the archipelago.

Landforms

A knowledge of the landforms observable from a stereoscopic investigation of a certain locality, their causes and processes of formation, is a *sine qua non* for a proper interpretation and recognition of diorites and all other rocks as well. The interaction between the inherent nature of the rock and the different sculpturing agents to produce the characteristic diorite landforms becomes a matter of crucial importance.

To be sure, the geomorphic development of the diorite terrain has been anything but simple. Diorite areas have been centres of tectonic activity within the archipelago; hence, intermittent uplifts have characterized the areas around this rock group. Consequently, these areas must have been involved in a multicyclic erosional development. But such intricacies are not betrayed by the landforms that are carved upon the diorites; instead, simplicity characterizes the terrain in the sense that the landforms developed are most uniform in any one locality. Obviously, homogeneity in composition and simplicity in structure throughout the mass underlies this uniformity.

The characteristic bold relief and high altitude that diorites assume are at once evident in the aerial photograph. Areas underlain by these rocks are among the highest structurally and usually topographically. This is, of course, traceable to the inherent resistance of this rock group to erosion. Almost all mountain ranges related to the diorites follow the general strike direction of the batholithic mass. In the Cordilleras, the mountains have a north-south trend parallel to that of northern Luzon; in Marinduque, the Mahinhin stock has a north-west to south-east orientation following the general direction of the island; in Sipalay and Zamboanga the phenomenon occurs, and in south-eastern Davao an elongated stock controls the trend of a mountain that reaches an altitude of over 3,500 m, probably the highest diorite body in the archipelago.

It is of note that these diorite masses lack the domal shape which is reported to be characteristic of diorite bodies in areas of higher latitudes. A plausible reason for this could be the generally fast rate of erosion, that is enhanced by the very high amount of precipitation and high altitudes. It may even be that the erosional processes were going on hand in hand with the uplift of the region which necessarily would have been very slow. This would have prevented the formation of a dome-shaped body.

The most distinguishing aerial photographic landform produced on diorites, which is common in the archipelago, is the development of a terrain densely dissected by short streams. Tributary streams are very closely spaced and parallel to each other, forming narrow ridges that are very sharp inverted V in cross-profile. The slopes of these very steep ridges are in turn minutely cut by short tertiary streams. Channels of both tributaries and tertiaries are also distinctly V-shaped and the general topography expressed on the vertical photograph is an almost badland-like terrain. To explain this feature, the massivity and relative impermeability of the diorite must be appreciated. The density of the streams running off the surface can be attributed only to the compactness of the diorite and the absence of intense crushing, at least in the main mass itself.

In a portion of northern Abra, where the altitude ranges between 600 to 1,000 m, this badland-like topography is very well exemplified. This locality falls under the first type of climatic classification, where the rainy season lasts for seven months and one-third of the major typhoons that hit the country usually occur. Vegetational cover is mainly only cogon grass. Farther to the east of the area, at the northern end of the Mountain Province, is another diorite batholith that exhibits these characteristic landforms. A comparison between the two is in order at this juncture. Unlike northern Abra, the latter is situated in a vicinity where rain is evenly distributed throughout the year, with three relatively dry months; nevertheless, typhoons occur here too. Instead of cogon grass cover, however, the area supports a thick timber growth, probably due to the more persistent rainfall. Despite this cover, the terrain is still unmistakably diorite, very well developed although subdued. It should be noted that, even if the cover is of the tropical forest type, the peculiar diorite terrain may still evolve, provided that the streams are persistent and strong enough to carve the landforms on the diorite and the relief is moderate enough to impart the necessary efficiency to the streams. It is safe to say that in general the conditions in the Cordillera Central approach the optimum and that it is in this area that diorites develop their characteristic landforms to the fullest.

Outside the Cordillera Central region, the topographies expressed are quite subdued. Either the altitude is too low, forest cover too thick or rainfall insufficient in amount and/or intensity. The Sipalay area, for example, belongs to the same climatic region as the Ilocos and western Mountain Province, but only 8 per cent of the typhoons in the archipelago hit this area. Moreover, it is at a much lower altitude, roughly 600 m. The erosive strength of the streams is undoubtedly less than that in north-western Luzon. Aside from this, the vegetational cover is much thicker than in Apayao. A much less developed diorite terrain is to be expected. Nevertheless, where the timber cover is not present, as along the shoreline of the Sipalay area, the landforms are distinctively those produced by streams sharply dissecting the slopes. However, the channels are much shallower, signifying weaker streams. Fineness of dissection is still perceptible through the thick forest cover by the erratic change in the heights of trees of the same species.

The topographic configurations described, however, are seldom interpreted as such. Photogeological interpretations must always be made in relation to the surrounding or immediate vicinity. Fortunately, diorites in the archipelago intrude and are surrounded by at most two rock types: metamorphosed volcanic flows (usually metal basalts and/or metal andesites) and/or metamorphosed volcanic. Comparison between the intrusive and the intruded rock, therefore, becomes simple because of this uniformity in the type of rock surrounding the diorites throughout the islands. In areas of moderate relief, the metamorphosed basalts such as those in the Cordillera Central also exhibit slopes finely dissected by streams in several places. The gradients of these slopes, however, are not as steep as those of the diorites and, unlike the diorites, the tributary channels form wide elongated, basin-like shapes over the metamorphosed volcanic flows. Moreover, in several places the permeability of the metal basalts is very evident, as large tracts of smooth, undissected divides can be discerned, a characteristic seldom seen in diorite areas.

This spatial relationship between the intrusive and intruded rocks, although seemingly simple, brings about some problems in interpretation. First, there are quite a number of areas where delineation between the two is hardly feasible. No clear-cut differences can be ascertained from the aerial photograph as to landforms developed or any other criteria. It is believed that in such cases there is gradation between the diorite and the metamorphics. Furthermore, metamorphism of the basalts and andesites is such that sometimes the general strength and compactness of the rock are increased and equalized throughout the mass. In that case, the strength of the diorite may be approximated or even surpassed. As was pointed out earlier, this equalization in strength, and hence in competence, leads to the development of similar structures such as joints and minor faults occurring in similar pattern and density in both rocks. All these contribute to the development of landforms which are similar and necessarily difficult to differentiate. It would take experience and acute observation to make an even approximate delineation of contacts.

The Mahinhin diorite stock of central Marinduque island presents an interesting if not enigmatic variation of the diorite topography. Considering the climate, it has almost the same amount of precipitation as the Sierra Madre range of northern Luzon and the Zamboanga areas. Distribution of rainfall is almost even throughout the year but seldom of torrential nature. Topographically, the diorite in this area stands lowest at 300 m, but the relation between the intrusive and intruded rocks is the same, the former being injected into metamorphosed clastics with intercalated dacitic and andesitic flows. The variation in the landforms developed is in the conspicuous absence of the short, closely spaced V-shaped valleyed streams. Instead, what can be seen is an almost flat, elevated platform, studded with a maze of irregularly oriented crescentic dune-like hills separated by narrow, flat-bottomed, interconnected valleys which at a glance may even resemble sinkholes in a mature karst area. Nevertheless, the sharp cutting by streams is unmistakably present. Like most of the diorite bodies in other parts of the archipelago, the terrain developed is quite distinct from the enveloping metamorphosed clastics, which exhibit bold and very coarse textured topography in this particular locality. Again, the contact zone landforms in this area grade into the intruded rocks and the gradational phase is very easily discerned in the aerial photographs as a gradation texture. Field verification has proved the observation correct and it was during this phase of the study that the gradational andesite porphyry identified as the quartz diorite approaches the Tumicob formation. Concluding from the evidence observed from the aerial photographs, i.e. an almost flat topography standing conspicuously 300 m above sea level, meandering streams, other old-stage landforms and the relation of the terrain to the surrounding area, it may be permissible to say that this is an old erosion surface that was controlled by a temporary base level. Either the Boac or Mogpog rivers could have acted as the temporary control. The abrupt deviation from the normal diorite topography of this particular locality is thus due to a difference in the stage of geomorphic development.

Another result of the photogeological study and subsequent field verification of the diorites in Marinduque should be mentioned at this point. Gervasio pointed out that, in this island, andesite porphyry whenever present was difficult to distinguish in the field. It is probably for this reason that, in the semi-detailed geological map which was prepared from a ground surface geological survey, a stock in Torrijos was mapped as quartz diorite. Preliminary photogeological studies clearly showed a disparity between that body and that found in the Mahinhin area in central Marinduque or any other diorite in the island. The former had its slopes virtually undissected and very smooth, but definitely having a distinct boundary with the surrounding metamorphosed clastics. At once this became an uncertain area, prompting a field check and a close scrutiny which tended to show that the mountain mass was capped by an andesite porphyry which obviously controlled the terrain developed. The diorite was found to be beneath this capping, which may point to another case of gradation between the diorite and the intruded rock.

At the southernmost part of the archipelago, where typhoons are very rare (1 per cent) but precipitation is, nevertheless, one of the highest, subdued landforms are exhibited. The climate is decidedly wet by normal standards. Distribution of rain is even throughout the year, with barely a month of dry period. Apparently, the volume of water that fills the channels more than compensates for the lack of the torrential type of rain. Again, the characteristic steep slopes, sharp ridges and V-shaped channels are absent, mainly because of the controlling effect of the rain forests and low altitude. Compared to the basaltic volcanic plugs that are near the area, the diorites, as in the other regions, are intensely dissected and produce a consistently more rugged terrain. The crowns of the trees are, as expected, more coarse than those of the trees growing on the basaltic plugs. Of course, even without the aforementioned criteria, the volcanic plugs by their conical landform alone cannot be mistaken for the diorites.

Drainage patterns

Streams in the ultimate analysis are the immediate determinants of the kind of landforms evolved upon the diorites; thus they must be given more than merely passing attention.

The general homogeneity of the diorite rocks focuses attention on the spatial arrangement of the streams that work on them. It is at once evident from the aerial photographs that this general nature of diorites is respected by the streams and is very well reflected by the patterns developed.

Diorites are relatively impermeable compared to other rocks, including the metamorphics. The only possible passageways of water are the joints, fractures, sheeting and/or cleavages that are almost always present in igneous rocks. Otherwise, because of the compactness of crystallization, a very negligible amount will percolate and run-off will thus be promoted. Apparently, the latter condition exists in the archipelago. The run-off observable from the aerial photographs is much more dense than in the surrounding rocks. A very fine dendritic drainage pattern with the highest degree of integration dominates the terrain and separates it very readily from the metamorphics and probably from other rock types. This pattern betrays an exiguousness in structural control. If fractures occur within the mass, these are few and far between. As such, they are prominent and detection is not too difficult, especially in areas void of forest cover.

Most noteworthy of this pattern are the unusually short tertiaries that persist when the slopes are steep. With a few variations and some exceptions, this minutely dissected terrain giving a very fine-textured topography characterizes the diorite rock group.

As stated earlier, the most notable deviation from the normal diorite pattern is that of the Mahinhin stock. Instead of being short and straight, the tributaries and tertiaries are arcuate and sickle-like in form. Von Vandat describes this as pincer-like and attributes it to the tendency of intrusives to weather to rounded, knobby, hummocky forms. Such an attribution is hardly applicable to the Mahinhin diorite. Field verification showed very few evidences of large-scale spheroidal weathering. Exfoliation, if at all present, is granular in form. Frequency of minute meanders may give an indication that these are misfit streams, which would bolster the theory that this is indeed an old erosion surface.

At the southern tip of Mountain Province, farther south of the area known as the Baguio mineral district, are areas of diorites where fracture control of the streams are more common than the normal. This is probably due to the fact that the Agno batholith is in one of the few areas where major faults cross the mass itself; hence the mashing in this locality seems to have been more intense as the drainage pattern approaches the angular type. No report to this effect, however, has been noted from field investigations. It can also be observed from the climate map that the district is in a dry region, having only three wet months compared to the northern areas where precipitation is almost year-round. It would imply that run-offs are lesser in the Agno river vicinity, and that most of the streams are concentrated along the fissures where erosion is much easier. In wetter regions, streams are decidedly stronger and denser. Hence, instead of being concentrated only in the crushed zones, which are not so numerous in the first place, streams occur everywhere and the slopes become the more dominant control. By their sheer density, the streams in such areas obscure the pattern that the fractures may otherwise manifest.

Vegetational cover

Vegetal growths supported by diorites are very variable and are not of much importance in rock identification. If these should be given concern, it is because they pose not a few problems in the photogeological study of this rock group.

All the characteristic features that have been described so far were observed from the aerial photographs of localities void of thick vegetational cover. Unfortunately, in many areas in the archipelago this is an exception rather than the rule, so that the diagnostic landforms are not fully evolved because the streams are checked by this cover. Besides, the weathered materials are held in place and sculpturing is very much retarded. The general effect is the production of a very much subdued topography and the efficacy of stereoscopic study is very much lessened. In this case, observations and interpretations must be done vicariously and almost entirely on the basis of what can be gleaned from the forest covers. The Sierra Madre, Sipalay and Zamboanga are examples of such areas that lie in wet areas and are covered with luxuriant tropical forests.

Vegetation can be more directly related to climate and topography than to bed-rock. It was thus normal to observe that abundance of plant growth, especially the thick rain forests, coincided with abundance in precipitation, altitude and slope orientation. The climate map may thus be used as a rough basis of vegetational distribution in the archipelago. In the northern Cordillera Central, for example, the lower flanks of slopes are generally covered with cogon grass, while the secondary growth forests and rain forests abound only in the areas of considerable elevation. In Banaue, Buangan observed that pine trees were abundant only above 1,000 m and disappeared beyond 1,600 m. This is true not only in diorite areas but also in others. At times the orientation of the slopes becomes the determining factor in the density or scarcity of plant growth. In the Cordillera Central, where ridges are high and slopes prominent, the northern and north-western slopes are more often covered by thicker second-growth forests as compared with the eastern and south-western slopes, which are either barren or covered with cogon grass. Absence of vegetational zoning due to bed-rock control may be the result of the advanced state of chemical weathering in these areas, obscuring almost all differences in chemical composition; hence uniform vegetation pervades all the rocks regardless of lithological variations.

Notwithstanding this obstacle, many diorite areas are still very clearly definable even if covered by these tropical forests. If such areas are located where precipitation and cyclonic storms are abundant, the streams will be strong enough to produce the fine textured topography. Very fine dendritic patterns may still be distinctly discerned. This is well illustrated in northern Mountain Province in the batholiths around the Kabugao vicinity. In addition, the high altitude (1,500 m) produces a high gradient which contributes to the eroding strength of the streams.

At lower latitudes and altitudes, the perceivable landforms become less distinct in the face of thick forest growths and weakening streams. Outlines of short, closely spaced streams may still be discernible, but sharp ridges and V-shaped channels are conspicuously absent.

A distinct difference appears, however, in the texture of tree crowns between those growing in the diorites and those in the metamorphics. The former are much coarser and seem more ruffled than the latter. Contacts in these cases are marked by the apparent line exhibited by the meeting of the two divergent tree crown textures.

Obviously, where cogon grass is the predominant cover, second-growth forests tend to converge along stream channels. Thus stream pattern analysis is greatly facilitated, especially when structural control is prominent.

Tone

Persistence of foliage, whether as dense forests or thick cogon cover, immediately discredits the justifiable use of photographic tone as a vital interpretation element. These growths have completely blanketed the soil, and still more the bed-rock. Paucity of visible outcrops from the aerial photograph thus becomes another hundrance to a more reliable interpretation. In the few areas where the soil is barren of vegetation, tonal interpretation is still doubtful. Around the Bontoc-Talubin area, for example, field confirmation of data shows that both diorite and metamorphosed volcanic flows have been highly weathered. The residual soil of the diorites weather a whitish grey, while the metal basalts weather a light reddish brown. On the aerial photograph, both would be photographed in light tones. Weathering thus tends to equalize not only the chemical composition of the soil but also the colour. The only possible instance when the true tone of the rock may be ascertained to a limited extent is where fresh landslides have exposed the bed-rock. The diorites are recorded in very light tones, while the surrounding country rock is a shade darker. It takes acute observational power to detect such changes. Even so, mass movements, particularly landsliding, are at best very erratic and scarce. Such phenomena will not provide very dependable data.

The foregoing analysis has been pieced out from the myriad details presented by the aerial photograph. Needless to say, most of these were readily discerned and, with supplementary field data, easily interpreted for their geological implications. A good number of the more important finer points, however, were extracted with some effort and only after prolonged stereoscopic examination. Even so, some valuable information was still barely perceptible or interpretable. This situation leads to an inevitable discussion of the problems encountered in the course of the study.

Problems in the photo-interpretation phase

The most acute problem encountered was the aerial photograph itself. Those available from the Office of the Corps of Engineers had been taken solely for photogrammetric and military purposes and no consideration had been given to their possible use in photo-interpretation, much less to photogeology. Numerous adjustments could have been introduced during photography to suit photogeological needs had the aerial photographs been taken for that specific purpose. For example, flight lines could have been adjusted to the direction of the major structures in and around the diorites to facilitate possible photogrammetric measurements of such structures. The diorite masses could have been photographed to lie within or at least around the centres of the format for better and undistorted stereoscopic viewing.

Apart from the above considerations, it is held certain that a scale larger than the ones used could have provided a clearer view of the detail. As it is, the scales used (1:44,000 for the Cordillera Central and Sipalay, 1:49,000 for Zamboanga and 1:32,000 for Marinduque) were excellent only for the study of large features and the regional relations between the diorite masses and the surrounding rocks. As far as that was concerned, the aerial photographs were used to the maximum. But a scale of 1:20,000, which was not available, could have been a better compromise between regional and detailed study, while a larger scale would have facilitated a more detailed study. The fact that the diorite tended to form minute landforms as a result of fine stream dissection points out the glaring need for a larger scale. In the future, when two or more scales of photography are available, ranging possibly from 1:10,000 to 1:20,000, a more definite relation between excellent interpretation for a specific photogeological purpose and scale of photography may be established. It does not need to be proved, however, that, for detailed photogeological studies such as interpretation for mineral deposit location, large scales are imperative. For the present study, ore deposit location studies could not be pursued to a satisfactory conclusion because of this problem. At best, only regional evidence could be discerned.

Lest it be misconstrued, however, it should be made clear that an enlargement of scale will be advisable only in diorite areas whose size is sufficient for the development of the characteristic topography. The recognition of geological and other phenomena on the strength of geomorphological evidence can be made only under such conditions. If the size of the diorite in question is too small, no amount of scale enlargements can bring a clear discernment of the photo evidence. It must then be established first from the small-scale photographs whether a particular intrusive is large enough to warrant the development of the characteristic terrain. Thereafter, it can be decided whether the use of larger scale photographs to study the more detailed features is advisable or not. This will be especially true when photographic ore-prospecting is considered.

Other inherent properties of the aerial photograph also proved problematical. Tilt and distortion sometimes attained such proportions as to affect interpretations, especially when the details were situated at the edges of the format. However, since no quantitative analysis was necessary, such defects did not substantially affect the data obtained and the conclusions made. Inaccuracies in exposures and other errors from the processing of the photographs greatly affected the veracity of some data, particularly those of tone and vegetation. Cloud cover did not pose too great a problem but proved most irritating when encountered, for it completely eclipsed any data from observation. When topography became very rugged, shadows had virtually the same effect as clouds.

The other problems which are not due to the photographs but are inherent in the ground surface, such as heavy soil and vegetational cover, must also be reckoned with.

However, nothing much can be done for these except to conduct further studies with a view to improving interpretation techniques. Suffice it to say that one must always be fully aware of such limitations.

Those inherent in the aerial photographs, however, leave much room for improvement. Availability of larger scale photographs alone will introduce much accuracy and reliability. Developing and other processing work, on the other hand, must always be done with utmost care. For regional study purposes, the use of super-wide-angle cameras will perhaps pave the way for minimizing many of the present problems.

Ore deposit location

It is now a common conception that the most advantageous use of the aerial photograph in geology is in its application in photographic ore prospecting. So far no ore discovery in the archipelago has been made by applying photogeological methods. This, however, should not diminish enthusiasm for the exploitation of its possibilities. That it is a potent tool in mine exploration has been proved in its use in the discovery of such deposits as the Cerro Bolivar, in Venezuela, which is at present the world's greatest high-grade iron-ore-producing deposit; the Invincible Lode, a gold-quartz deposit in the Glenorchy district of New Zealand; the gold-ore bodies in Yellowknife, Lake, Canada; and some of the uranium deposits on the Colorado plateau in the United States, to mention a few.

Like ground mineral surveys, photographic ore prospecting must also establish the general lithologic character and distribution of rocks and associated structures as a basis for carrying out a mineral survey of an area. In this respect, it has been proved in the preceding analyses that the air photograph or more generally photogeology can be used in delineating diorite areas. The facility in recognizing diorites from the present available photographs immediately points out the indispensability of small-scale aerial photography. General areas where ore deposits may exist are thus pinpointed, while extraneous localities are eliminated. Once such areas are located, a good half of the photogeological work will have been accomplished.

In the main, the ore deposits around the vicinity of diorites in the Philippines are structurally controlled. Fractures and joints are the significant ore localizers. Accordingly, since such features are quite easily identified on the aerial photographs whenever present, it is believed that the aerial photograph will become much more than a very effective aid to ground-prospecting methods; indeed, that it will be a major tool. Such a belief is supported by the fact that, based on the data of localities where ore deposits have been found by means of photogeological techniques, the aerial photograph affords other evidence which is virtually undetectable from the ground. Included among this is physiographic and botanical evidence.

At the outset, it must be emphasized that the present study is not able to set down specific and detailed criteria and evidence that could be used in photographic ore prospecting. This is so because most of the problems mentioned in the preceding section affect this particular phase of the study most.

First, the scales of the photographs used were not really effective for this purpose, which required meticulous scrutiny. As mentioned earlier, they were excellent only for regional studies. To make a detailed study was simply impossible. With this limitation, the results that will be enunciated concerning the photographic ore prospecting phase in the present study can be only regional in implication. This is not to say that regional evidence is of secondary importance. On the contrary, in any photogeological study, the evaluation must go from the general to the particular. Hence, in photographic ore-prospecting, a knowledge of regional features is essential for a better understanding of the more detailed features. These detailed features, however, must be further studied on larger scales, and this could not be done in the present case.

Secondly, in the areas mentioned, where photogeology was instrumental in the location of such deposits, the clues were anomalies that were not so sensitively recorded. Their discernment required excellently exposed photographs on scales as large as 1:10,000 to 1:20,000. Thus, in the Philippines, where conditions are not the most favourable for aerial photography, the need for better quality aerial photographs becomes all the more pressing. In the near future, with the availability of infra-red and colour photography, new photographs of these particular areas should be taken.

Nevertheless, making the most of the materials and data now available, certain observations may be made. From present field studies, it appears that diorite areas which show more faults, either major or minor, and other fissures criss-crossing them, are the ones where most of the ore discoveries are made. In other words, the localities that seem to have been more crushed during the tectonic agitations have the greater chance of possessing ore deposits. This is the apparent situation in the Cordillera Central. In the Baguio mineral district, the diorites are cut by numerous major faults and, of course, by minor faults, fissures and joints. The rest of the diorite areas are very rarely crossed by large faults. Instead, the faults are usually along the boundaries of large diorite bodies. It follows, of course, that the minor fissures and joints are more clearly discerned in the diorites of the Baguio area as compared with other areas in the region. This is probably due to the fact that the large faults which cut through rather than merely skirting around the diorites control these minor structures.

Similarly, in the Marinduque island, the mines that were or are operating are found in vicinities where linear features tend to abound. Usually, there are at or along the contacts between the diorite and the intruded rocks. Unfortunately, in other regions such as Sipalay and Zamboanga, vegetation completely obscures the minor features. There is no doubt that, with the use of larger scale photography, a more reliable interpretation can be arrived at. And even in areas with thick vegetation, some significant evidence may be discerned.

The major faults that usually define the contacts need a closer look. Since these are usually single large features spanning vast areas, the possibility of their having controlled the minor structures and the mineralization is not too remote. Most of the minor structures large enough to be recognized near these large faults have a tendency to be oriented along certain directions. No statistical analysis could be made, however, because so few such features could be discerned even on the largest scale available (1:32,000).

The best way to study the ore deposit from the aerial photograph is probably to analyse the patterns and photo-image characteristics of known producing areas in or near the diorite areas. A projection of such characteristics into the surrounding areas of the aerial photograph may then be made in an attempt to establish the presence of other areas that exhibit the same photo-images. To reiterate that large-scale aerial photographs are necessary for such a study is not to overstate the case.

SUMMARY AND CONCLUSIONS

The results of the present work are very propitious for photogeology in the Philippines and for the study of diorites, especially as regards exploitation for commercial purposes. In the light of the investigations made, it is clear that in the archipelago there is no hard and fast rule which can be used to identify diorites from aerial photographs. The conditions are so varied and complex that the structures, landforms and drainage patterns developed are likewise variable. Despite such limitations, it has nevertheless been established that diorites can definitely be recognized and interpreted from other rock types.

Before any reliable interpretation in any particular area can be undertaken, the different controlling factors must be fully understood. The geology, the climate as it varies latitudinally and longitudinally, and the physiographic conditions, including topography and location, must all be within the grasp of the interpreter. Variations in the photo-images exhibited from one area to another owing to differences in geological setting are almost entirely dependent upon the intensity of past tectonic activities in each of these areas. This fact directly affects the density of major faults that will eventually control many of the features that are evolved. As far as lithological environment is concerned, no serious problem is seen at this stage. The rocks surrounding the diorites are almost always similar throughout the archipelago—metamorphosed volcanic flows and/or occasional metamorphosed clastics. This being the case, the comparison of photo-images between the diorite and the country rock from one area to another is simplified. Lithological variations of the diorite itself from place to place proved so minor in photogeology as to be almost negligible. Such variations as were clearly delineated in field investigations were too slight to effect any drastic change in the relief forms of the diorites. Thus, even if this rock is known to have other derivatives, all these are treated under one category—the diorite group—in the present study.

Climatic variations, as far as can be seen, effect the greatest control upon the different features which are eventually imaged in the aerial photographs. Variations in the amount of precipitation enhance differences in the eroding power of streams and thickness of vegetational cover. The intensity with which precipitation is delivered, in the form of storms, also maximizes the conditions that best develop the diorite terrain. These two conditions determine to a very large degree the legibility of the characteristic photo-images of the diorite terrain. Physiography, particularly altitude, is second only to climate in order of importance. The evidence tends to point to the fact that the diorite topography is better developed in moderate to slightly high altitudes.

The most common characteristic of diorite topographies is best expressed in the landforms and drainage patterns. Although the kinds of landforms may vary throughout the archipelago, the significant fact is that in each locality there is a uniformity in the kind of landforms. In the main, the land feature is expressed as a massive topography. It has a uniform, very highly integrated, dense and pinnate-like drainage pattern. The tributary streams tend to be dendritic to sub-parallel, while the slopes of the sharp ridges produced by the deeply cut tributaries are dissected by more closely spaced tertiary streams that impart the pinnate-like pattern. Likewise, the tertiaries are deeply entrenched and V-shaped in cross profile. Such a pattern is true in maturely developed regions, such as the Cordillera Central. In the much later stages of the erosional cycle, as in the Marinduque area, the tertiary stream valleys merge with one another to form flat, interconnected stretches. However, the finely dissected peculiarity of the terrain is retained.

The term "fine dissection" as used here is, of course, relative to the bold landforms produced in the adjacent metamorphosed volcanic flows and/or metamorphosed clastics. It is believed that in the diorite topography, if compared to that of some other less permeable rocks, like some sedimentaries, fineness in features may approximate that of the latter. In some cases, where metamorphism has increased the resistance of the surrounding rock to erosion so that it resembles diorite, delineation between the two becomes difficult. But such cases are very rare. Then, too, if the intensity and pattern of crushing in both the intrusive and the intruded rocks are similar, recognition of the diorite may not be easy.

Vegetation, especially the deciduous type, will lessen the effect of the streams, and the topography becomes subdued. Recognition, however, is not greatly affected because the diorite seems to support a group of species that have coarser tree crowns than those that grow on the metamorphics. What are harder to interpret in these instances are the minor structures such as joints, minor faults and other minor linear features.

Nothing definite about the use of photogeology in mineral deposit studies can be said at this point. The materials available are not suitable for a thorough execution of this phase of the investigation. Nevertheless, there is no doubt that photogeology will be a boon to the mining industry in the Philippines as it has been in foreign countries where photo-interpretation techniques are far more advanced and developed.

A clear result of this study is the realization that photogeology is very much superior to field geology in geomorphic and structural studies. A much more objective appraisal of the geological structure of the diorite areas discussed was made from the abundant third-dimension details. This conclusion assumes an implication of importance in photogeology because many mineral ore deposits are related to these structures on or near the boundaries of diorites. Moreover, any slight inaccuracy or doubt can always be quickly verified in the field. Again, this emphasizes the interdependence of photogeology and field geology for most advantageous results.

All in all, these findings confirm the fact that the photogeologist must always treat each locality as a special case apart from other areas of the archipelago, and more so from other countries of different morphogenetic regions. Each area demands its own individual interpretation. Although some characteristics are similar, matching may be resorted to only after each area has been studied separately by the correlation and convergence of data.

Photogeology in the study and identification of diorites, thus, can and should be used in the Philippines.

CARTOGRAPHIC TECHNIQUES IN REGIONAL MINERAL EXPLORATION

Paper presented by Australia[1]

Air photography in mineral exploration

The basis of modern mineral exploration is the regional geological map, and the basis of the geological map is the planimetric map; and of course the basis of both at the present day is the aerial photograph. The importance of air photographs for geological mapping and mineral exploration cannot be over-emphasized. They have a multiplicity of uses, which can be grouped under three main headings: (*a*) for the preparation of the planimetric base; (*b*) as a basis for plotting and interpreting geological data in the field; (*c*) to present a three-dimensional picture of the geology.

Geological mapping should follow the cartography. We have made it a rule in the Bureau of Mineral Resources not to attempt to map the geology of any area until air photographs are available, and have adjusted our geological mapping programmes as far as possible to follow the preparation of topographic maps by the Division of National Mapping and the Australian Army Survey Corps, although in the earlier years of the bureau's geological mapping programme this was not always possible.

The use of air photographs in making planimetric maps is no doubt dealt with elsewhere in this conference. It is sufficient here to say that the usefulness of any topographic map to the geologist is proportional to its accuracy and accordingly to the trouble and expense that have gone into its preparation. Geology can be accurately portrayed only if the topographic features to which it is related are correctly located. The provision of contours is, of course, a tremendous advantage to the geologist, as it enables accurate sections to be drawn and three-dimensional models of the geology to be constructed.

The geologist needs the photo-scale compilation from the aerial photographs to take into the field to plot his geological data on directly from the photographs as they are recorded, and the finished planimetric map to prepare the final geological map for reproduction and publication when he returns to his headquarters.

Geologists in the field use the air photographs for navigation and finding their location and for recording the geology, either directly or on transparent overlays. For regional mapping, which is the Bureau of Mineral Resources' main geological activity, the scales that have been used are mostly between 1:45,000 and 1:50,000, but more recently most of the photography has been done at about 1:84,000, and in some areas larger scale photographs, generally at a scale of 1:30,000, have been used. The smaller scale (1:84,000) photographs have the advantage of convenience in handling and compilation because of the smaller numbers, and because they present the geology of a large area (about 60 square miles) in a single stereoscopic picture. Larger scale photographs show progressively more detail that can be used in navigation, provide more room on which to plot the geology, and enable finer subdivisions to be made of the geological formations.

As mapping becomes more detailed, photographs on an increasingly large scale are needed. For intensive mineral exploration, photographs at scales between 1:10,000 and 1:20,000 are commonly used; for example, in order to map the Constance Range iron deposits in North Queensland in satisfactory detail, the Broken Hill Pty Co. had an area of about 300 square miles photographed at a scale of 1:20,000. In the actual development of a mineral deposit for layout of workings, plant and equipment and buildings, necessitating accurate contoured plans, the scale of the air photographs used is generally between 1:5,000 and 1:10,000, although it may be as large as 1:1,000.

In this more detailed phase of mineral exploration, the use of contoured maps prepared instrumentally from air photographs has to a considerable extent displaced traditional methods of geological surveying such as plane-tabling or traversing by theodolite or by tape, compass and clinometer.

The stereoscopic pair of photographs giving a three-dimensional view of the terrain, not only cuts down enormously on the field work but also gives an appreciation of geological structure beyond that which can be obtained by direct vision. Moreover, this model is held fixed by the photographs so that it can be studied in detail and at length.

The effectiveness of air photographs for interpreting the geology depends directly on the accuracy with which the topography reflects the geological structure, not necessarily on the actual exposure of the rock formations. A common misconception exists that air photographs lose much of their geological usefulness in heavily timbered terrain, for instance in the tropics, but this is not so. Geological structures are very often reflected just as faithfully on the photographs of the heavily timbered areas of New Guinea as on those taken over the mainland of Australia. The ease of interpretation of the structure of sedimentary formations depends upon the amount of orogenic deformation that the rocks of an area have suffered since those formations were deposited. Areas which have been subject to only one minor orogeny will reflect the geological structure very faithfully, for example, the Neogene of New Guinea, the Permian and Triassic of the Sydney basin, the Proterozoic of northern Australia. On the other hand, if an area has undergone more than one major orogeny, for instance, the Cretaceous of New Guinea, the Ordoyician-Silurian of the Tasman Geosyncline, or the Archaean of Western Australia, the structure of the sediments may not be apparent, but much geological information can be interpreted from the lines on the photographs, the trace of bedding planes, joints, faults, dykes etc., or from characteristic weathering patterns. A series of standard conventions and symbols has been adopted for portraying geological features.

Outline of geological mapping procedures in the Bureau of Mineral Resources

Photogeological maps

For most areas, a photogeological map is prepared before the actual field work is commenced. This gives a picture of the geology, particularly the geological structure, points up the problem areas where the most field work will

[1] The original text of this paper, prepared by N. H. Fisher, Assistant Director (Geology), Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, Canberra, appeared as document E/CONF.52/L.33.

have to be done, enables the field geologist to plot his traverses to the best advantage, and generally serves as an advance map for field operations. Photogeological interpretation is done with a binocular traversing stereoscope, and overlays on ultraphan are made of every second photograph, with the topography and the geological details shown in distinctive colours. From the overlays a photogeological map is compiled at photo-scale on a tracing of the planimetric base which has been prepared photogrammetrically by one of the mapping authorities.

If compilation has not been done at photo-scale, enlarged or reduced transparencies are prepared. When the geology is plotted, the photogeological compilations are reduced to a scale of 1: 250,000. Generally about twelve negatives go to each 1: 250,000 sheet, and these are assembled and joined together by reference to the standard 1: 250,000 planimetric base. From this combined negative a positive is made and a composite print of both geology and planimetry is made from this positive, combined with a transparency of the planimetric base. This composite print is then edited by the photogeologist, both the photo-scale sheets and the 1:250,000 scale positives are corrected, and prints are made and hand-coloured to show up the geological formations that have been distinguished by the photogeologist.

Field mapping and geological map compilation

In addition to this base map and the aerial photographs, the geologist takes into the field the overlays prepared by the photogeologist (which, as mapping progresses, he corrects or replaces to the extent that the detail he wishes to show on the geological map differs from that selected for photo-interpretation), a transparency of the planimetric base, and one of the photogeological photo-scale compilations (without the letter symbols because formations selected by photogeologists are commonly not the same as those used for mapping on the basis of lithological identification in the field). The geologists mark up on the overlays the geology actually observed on their traverses and adjust the photogeology by extending the selected boundaries and other geological features away from the traverse routes; the field draftsman transfers the corrected geological detail to the photo-scale transparency; and as each sheet is finished the geologist edits and corrects the compilation. At the conclusion of the field work, or earlier if practicable, these corrected compilations are reduced photographically to 1:250,000, assembled as negatives, and a positive is made. From this the final tracing of the geology can be prepared, making sure that it fits exactly to the national mapping or army planimetric base.

This tracing, plus the planimetric base, is used to produce the preliminary geological maps which are printed in a limited edition—generally 200—in two colours, with the geology emphasized by the use of zip-a-tone patterns and screens as far as possible. The object of the preliminary editions is to make the results of the field work available to users as soon as possible after it is completed; they are not subject to the detailed editing nor to the time-consuming processes associated with the production of the standard full-colour geological maps which are the final product.

A print of the preliminary geological map is coloured by hand, using printer's inks, so as to conform as nearly as possible to the standard colour scheme, and a few ektachrome colour transparencies at a scale of 1:1,500,000 are made which can be lent as a guide to anyone who wishes to colour his own maps. These preliminary maps are distributed to the state geological surveys concerned, to appropriate officers within the bureau, including resident geological staff in the territories, if the area is within their domain, to companies and individuals known to be interested in the area, and the remainder are available on request. No charge is made for these maps.

The provision of these preliminary geological maps is a service that makes a useful contribution to, and is much appreciated by, the mineral exploration industry, as it makes the results of regional geological mapping available years earlier than the date of the final printed map. This is particularly important in Australia, where in most areas covered by the bureau few, if any, previous geological maps exist.

Preparation of final geological maps

The following description of the procedures used in preparing the final geological map in full colour is taken from a paper prepared, at the request of the Commonwealth Geological Liaison Officer, London, by Messrs. Townley, Morgan and Boltz with assistance from other members of the drafting section of the Geological Branch, Bureau of Mineral Resources.

Final editing and preparation for contract drafting

The preliminary edition serves as a draft copy for the drawing of the final edition. It is rechecked carefully by the author and supervising geologists, the determinations of specialists such as palaeontologists and petrologists are incorporated, and the map is carefully examined by experienced map editors.

In the drawing office, specifications for the fair drawing are prepared and the layout of the map designed. The exact positioning of all marginal data is indicated on millimetre graph paper and the contractor is required to follow this very closely.

Actually, tenders are called well before the work is prepared for the contractor, so that the copy is ready by the time the administrative procedure connected with letting the contract is finalized.

Final amendments to the copy are made and this, together with the coloured print, marginal data layout and other instructions, is dispatched to the contractor. If the project is a complex one, or the contractor is new to the work, a senior officer may personally deliver the copy and brief the contractor.

Preparation of fair drawings

A standard 1: 250,000 sheet layout has been drawn and published, and a copy of this sheet, which gives detailed information as to line weights, type styles and sizes, dimensions of conventional symbols, placement of common marginal data etc., is supplied to all drafting contractors.

Upon completion of the drawings, the contractor is obliged to supply a positive composite dye proof for checking, with line work and lettering of each plate (geological, cultural etc.) reproduced in the approximate colour of the final coloured edition. This enables a thorough check to be made of positioning, line weight and balance between individual plates.

A second proof is supplied and this, too, is carefully checked to see whether the necessary corrections have been properly made.

A strict check is carried out by senior draftsmen. Only work of high standard is acceptable, the contractor having been warned of this in his invitation to tender.

A checking form is used as an aid to thorough systematic checking and to ensure uniformity between various checkers.

When the fair drawings are finally approved, the contractor has autopositive or deep-etch copies made on dimensionally stable plastic media, suitable for lithographic reproduction. These, together with all draft copy and composite diazoprints of the plates involved, are dispatched to the Geological Branch of the Bureau of Mineral Resources.

The first standard sheet maps produced in the Geological Branch were drawn on dimensionally stable plastic and only hand-lettering used on the body of the map. Some paper "stick-up" lettering was used for marginal data.

With the improvement in photo-setting techniques and the availability of larger ranges of cartographic "photoset" type, type on stripping film has gradually replaced both hand-lettering and paper "stick-up" over the whole map.

With minor variations, plates for reproduction are produced, by both our own draftsmen and our contractors, in the manner described below.

Line-work is scribed and from the scribed sheet a positive copy is made on dimensionally stable plastic media. All the lettering and marginal data—including standard diagrams and geological symbols—are reproduced "wrong reading" on stripping film, which is given a coating of adhesive wax or "flow-on" pressure adhesive.

The stripping film is applied to the positive line copy, any necessary ink work added and the plate checked. A final copy on dimensionally stable media is then made in a form suitable for lithographic reproduction.

The number of plates prepared usually depends on the amount of detail. For remote areas, one black plate may give sufficient clarity, but most maps require two, three or even four line plates for reproduction, as follows: geology and cultural detail, black; hydrographic detail, blue; contours (where available) or dunes, brown; cultural detail of such complexity that it might confuse the geology, grey.

Colour design

Although some colour design can be planned by using compilations and the preliminary editions, the final colour design and printers' guide can be made only on the composite diazoprint which combines each fair-drawn plate.

The colour design is the work of a panel which includes, usually, the author (or his section leader), and draftsmen with a sound knowledge of colour and colour printing.

The object is to produce a design that makes for an easily read geological map which gives due emphasis to important formations and is aesthetically pleasing. Colours are generally restricted to those allocated to geological ages on the Australian standard colour chart (set up by agreement between the Bureau of Mineral Resources and the State Geological Surveys), although some latitude is possible by use of the several colours used for igneous rocks only.

Extensive use is made of a large range of dot, line and pattern screens to distinguish formations by gradations of tint or conventional lithological patterns. In addition, each formation is distinguished wherever it appears on the map by letter symbols, for instance the Telemon formation of Upper Devonian age is represented by the letters "Dut".

A recently published booklet serves as a guide and index to colours and screens used by the Geological Branch. On the first page, the complete range of colours used is identified. The succeeding pages show the screen index—the complete index on a single page but each page reproduced in each individual colour used in the scheme.

A great deal of solid colour was used on our earlier maps and this tended to give a heavy, unbalanced appearance, with background detail hard to read. Very little solid colour is now used and the use of heavier screens is restrained.

A large range of master screens is held in the Geological Branch and copies of those required are made available to printing contractors. Copies are also lent, on request, to state surveys that may wish to use them.

Colour printing

To avoid delay in publication, arrangements to call tenders and award printing contracts are made before the fair drawings are completed. Therefore careful timing is required to co-ordinate the technical and administrative processes involved, so that the copy and detailed printing instructions may be ready for delivery to the successful contractor.

Copy delivered to the printer includes a separate fair-drawn plate (or suitable copy) for each line-press plate required and a colour-printing guide is made by hand-colouring with printers' inks the composite diapositive previously mentioned.

The contractor is required to carry out all masking and making of colour and screen masters. The colour/screen masters are intended for use in making the colour-press plates, but from them a dye-proof, on white stable plastic foil, is first produced as a check.

Draftsmen check the dye-proof against the colour design and a double check is made by laying each transparent screen master over the colour design so that errors and omissions may be easily spotted.

Minor errors on the screen masters may be corrected by hand in the drawing office but the contractor is required to make the more difficult corrections or even remake the master.

Errors revealed by the dye-proof, although generally minor, are usually numerous. The appearance of a corrected dye-proof can so shock a new contractor that he is warned in advance not to be too dismayed by the number of red ink notations on the corrected proof.

The errors revealed in checking the dye-proof are usually easily corrected and prevent more expensive and time-consuming corrections at plate-making and printing stages.

At first, contractors were not required to match too closely the dyes used with the hue of the specified lithographic ink. With experience, it has been found that a close colour match greatly aids the checking of machine proof against dye proof and also provides an early indication whether changes in colours or screens would enhance the clarity and appearance of the final map.

The checked screen masters and dye-proof are returned to the printer, who then makes the press plates from which a paper machine proof is made.

Although not the complete answer to colour control, the use of the machine proof indicates whether modifications in colour are desirable; poor plate-making can be detected and condemned and a check made to see whether errors detected on the dye-proof have been corrected. After checking, the machine proof is returned and, after the necessary adjustments have been made, printing proceeds.

Conclusion

This paper has been mainly concerned with cartographic procedures in the preparation of regional geological maps, which, as mentioned earlier, are the basis of modern mineral exploration. We have no space here to consider in any detail the various techniques that are used in the more intensive phases of mineral- and oil-exploration techniques which the geologist thinks of as geologist techniques, but which may equally be claimed to be cartographic techniques. Examples of this are the preparation of depth-contour maps depicting the shape of the surface or of the bottom of a particular formation to examine structure in oil exploration; or the preparation of isopach maps showing the variation in thickness of a given formation or group of formations; or the contouring of an ore-body relative to an inclined plane generally parallel to it, to bring out the direction of the structural trends which may control the position of the ore shoots and indicate where further exploration should take place; indeed, geophysical and geochemical methods of mineral exploration rely very largely on cartographic techniques to express and interpret their results.

Most of these surveys are carried out on a grid pattern, and the distribution of results of analyses of samples showing chemical composition or of the instrumental readings indicating the magnetic, gravity, or seismic characteristics of the rocks are plotted as a series of contour maps. Geochemical methods in particular have been developed during recent years, along with rapid methods of chemical analysis, and ADP programmes have been devised so that data can be fed into the computer, processed automatically and presented, if the computer has a built-in auto-plotter, as contour maps. This procedure is particularly applicable to regional geochemical surveys, to portray the variations in chemical content element by element, or in ratios between different elements, with the geology.

In a brief paper such as this, it is obviously impossible to consider all the multitudinous cartographic techniques that geologists use in presenting the results of geological mapping and in using those results in the various aspects of mineral exploration, ranging over such diverse fields as rapid surface reconnaissance, surveys for minerals, subsurface exploration for oil and gas, detailed exploration for ore-shoots in developed mines and so on; but it is hoped that enough had been said to indicate the close relationship that exists in modern mineral search between the work of the exploration geologist and the cartographic procedures used in portraying the results.

GEOPHYSICAL SURVEY MAPPING FOR MINERAL RESOURCES IN THE BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Paper presented by Australia[1]

Introduction

Geophysical surveying forms an integral part of any comprehensive programme to develop the mineral resources of a region. The mapping of the survey results may lead to the direct location of mineral deposits, but its usual role is to assist geological mapping in the delineation of rock type and structure, either in a near-surface metalliferous environment or in the deep basement rock of a sedimentary basin.

The Bureau of Mineral Resources, Geology and Geophysics has many years of experience in geophysical surveying and mapping in all parts of the Australian continent. Although many geophysical methods are employed for specific detailed work, the main types used for covering large areas in a single survey in the search for minerals and petroleum are: reconnaissance magnetic and radiometric surveys by fixed-wing aircraft, and reconnaissance gravity surveys by helicopter.

Before any such survey is carried out, the programmed area must be known one or two years in advance because of the considerable preparation required. The survey is not contemplated unless the following material is available:

(*a*) Photogrammetric planimetric compilation showing photocentres;

(*b*) Final maps produced from (*a*);

(*c*) Aerial photographs as used in (*a*);

(*d*) Geological maps (note: it is realized that in some regions reconnaissance geophysical survey may precede geological mapping).

The aerial photographs used for plotting are those used for the compilation, even though later photographs may be available. Should the earlier photographs be lacking in detail clarity, the newer photographs may be used for navigation.

Magnetic and radiometric surveys

The work sequence is carried out in stages (see annex I).

Stage 1: Base mapping, photo shingling

The mapping and photographic material is obtained from Commonwealth and state government mapping authorities. The photo-centres and conjugate photo-centres are marked on the aerial photographs, and base maps are fair-drawn, showing the required planimetry and geology.

The proposed lines of flight are marked on the compilation sheets, transferred to a shingle mosaic embracing two complete runs of photographs, and prepared as bands using alternate photographs (20 per cent overlap). (The photographs extracted are retained for preparing further shingle mosaics in the field for marking of tie-lines to be navigated.) Each band is broken up into sections for convenient handling by the navigator in the aircraft.

[1] The original text of this paper, prepared by P. Gillespie, I. Mather and J. H. Quilty, Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, Canberra, appeared as document E/CONF.52/L.39.

The separation of lines of flight is usually one mile for reconnaissance metalliferous surveys and two to four miles for sedimentary surveys.

Stage 2: Data collection, profile mapping

During navigation along the lines indicated on the shingle mosaic, a vertical camera produces 35 mm continuous strip film, and instruments provide magnetometer, altimeter, air position indicator and scintillograph data on charts. This material is co-ordinated, bearing fiducial marks every ten seconds and showing identical consecutive numbering. When a sampling of the lines has been flown, the magnetic intensity over the area can be examined and the positions for tie-lines determined. The tie-lines, intersecting all flight-lines, are then flown.

To ensure that survey results are available at the completion of the survey, the field draftsman compiles reduced-scale magnetic intensity profile maps by identifying control from the strip film on to the photographs near the end of each line. He transfers this control to the map and reduces the magnetometer chart between this control by the use of a pantograph.

Two types of profile maps are produced, one showing alternate profiles of the lines of flight on a standard 1: 250,000 map transparency superimposed on planimetry and geology, and the other at the same scale showing all profiles but using an extended vertical scale of 1: 62,500.

In addition, a 1:250,000 or 1:500,000 map is produced in the field showing radiometric contours superimposed on planimetry and geology.

Stage 3: Flight-line plotting, reduction

On receipt of all field data at the headquarters drafting section, the mapping carried out in the field is finalized for titling and any amendment, and is produced in dye-line form as a preliminary result.

Plotting is now carried out which will result in a printed publication of magnetic intensity contours at 1: 250,000 in the case of a sedimentary survey, or four sheets at 1: 126,720 (2 miles to 1 inch) to each 1: 250,000 series area for a metalliferous survey. The inch to the mile ratio is maintained, as most mining authorities have already published related information in a similar ratio.

The 1: 250,000 series is so close in dimension to 4 miles to 1 inch mapping (1: 253,440) that very little inconvenience would be experienced in positioning or comparison.

The maps are printed with the base planimetry in black, magnetic intensity contours in light green, and radiometric information in magenta. The green and magenta have been found to create less strain on the eyes during long periods of interpretation study. The planimetry on the base map is kept to the minimum of essential features so as not to dominate the geophysical information.

Plotting is commenced by selection of control points from the centre-line of the 35 mm strip film negative (with the aid of a film reader) and identification on the (positive) aerial photograph. The error in identification must be no greater than 0.1 of a statute mile. Where the air position indicator (API) chart is available, control point separation may average 7 miles along the flight-line. Without API, an average separation of 4 miles must be adopted for the interpolation of the fiducial marks. The control points are then transferred to the photo-scale compilation sheets by a "Sketchmaster", the minimum error also being no greater than 0.1 of a statute mile. The API chart which shows the air track is now converted to ground track, the fiducial points being traced between control by the use of a ratio machine. Tie-lines are then plotted in a similar manner. The cross-over co-ordinates—that is, the positions where the tie-line crosses the line of flight—are obtained by matching the detail of the 35 mm strip film and read from the fiducial numbering; they are then listed. These lists are submitted to the Reductions Group for processing, with a trace of the flight plot.

Stage 4: (Contouring, fair-drawing)

When the Reductions Group has marked the magnetic values at a determined contour interval along the flight-lines, the Drafting Section does the preliminary contouring in pencil. The contouring is done mechanically, according to the values given. Interpretation of trend is adopted only where the lines of flight are widely separated and geological trends are known.

On completion of the contouring, the Reductions Group assess the accuracy of their original processing and carries out smoothing or, where unusual patterns or anomalies occur, a re-examination of data.

The approved contoured sheets are ink drawn and reduced photo-mechanically to final map scale. The reductions are then cut and spliced into a composite sheet, fitting exactly into the map graticule, and are dye-line printed on to scribing material. The base planimetric map, radiometric change boundaries, and anomalies are also scribed as separate sheets, thus presenting an automatic negative for the printing of each separate colour. Before going to print, proof copies are edited by the map editor and professional staff.

The contours when scribed show heavy 100 gamma contours where contour intervals are 20 gammas or heavy 50 gamma contours where the intervals are 10 gammas. They are shown considerably thicker than would appear on a normal topographic map. This technique permits an easier appreciation of the magnetic intensity pattern and allows for reduction and splicing for a composite map at smaller scale over a larger area.

Light aircraft detailed aeromagnetic surveys

Detailed aeromagnetic survey covers comparatively small areas averaging 20 square miles. For the purpose of navigation and subsequent flight-line plotting, aerial photography of good quality and latest date is of primary importance. If not available, it may be necessary to fly high-level photography for the geophysical survey. Because of the density of flight traverses, the scale of photographs and maps is arranged to be about 1: 25,000.

The base maps are fair-drawn. A topographical base map is drawn first, then a transparent copy is obtained for the purpose of superimposing the required geology on the topography. In this manner, two separate base maps are obtained, which can be used as required with total magnetic intensity contours, geophysical interpretation, or any other relevant data.

The field operation commences with the flights over the designated area, using the 1:25,000 scale photographs for visual navigation. During survey flights, in addition to the magnetometer and radio-altimeter, a 35 mm single-frame camera is operated. This has a "fish-eye" lens of 8.2 mm focal length and 186° field of vision, and the film is used for flight-path recovery.

The flight-path recovery or flight-line plotting is carried out using the 35 mm negative film. Having established the flight path on aerial photographs, the flight lines are transferred on to the base map by direct tracing. (The base maps are at photo scale.)

After evaluation of the magnetometer charts has been completed, magnetic values are transferred from the magnetometer charts on to the flight-line plot. A transparent sheet is placed over the flight-line plot which bears the magnetic values. Registration marks are made for these two sheets, and preliminary contour lines are developed on the overlay sheet.

The preliminary contouring is checked and the final fair-drawing of contours commenced. The total magnetic intensity contours are drawn on new transparent plastic material, so that the fair-drawn contours can be used with a variety of appropriate base maps, including a geophysical interpretation sheet.

The completion of fair-drawing of contours in the field coincides generally with the termination of the survey. The finalization of the material for the publication of survey results is completed at the headquarters office. This includes fair-drawing of geophysical interpretation sheet, titles, explanatory notes, reference numbers etc.

Gravity surveys by helicopter

Most of the gravity surveys made by the Bureau of Mineral Resources, Geology and Geophysics over the past ten years have been of the reconnaissance type (one station per 50 square miles) for the purpose of delineating structures in sedimentary basins. Such basins in Australia have an area of about half the continent (1.5 million square miles) and, to cover such a vast area in reasonable time, increasingly large areas are being surveyed annually (250,000 square miles in 1966 as against 48,000 square miles in 1960). These surveys are conducted using helicopters for transport. Aerial photographs are used for navigation and gravity station positioning.

Prior to the survey, a planimetric base map is drawn at 1: 250,000, each map covering an area 1° latitude × 1° 30′ longitude. The projection used is the transverse Mercator. This map shows all significant features within the area and this detail is taken from the most up-to-date topographic/planimetric mapping available from Commonwealth or state government mapping authorities.

A transparency (thermo-plastic based) is then made from the base map, and aerial-photograph principal-point positions from controlled slotted-template assemblies are added to it. Photograph and flight-line numbers are marked. This sheet becomes the "field sheet", which is used for:

"Flightplanning", that is, the laying down of a 7-mile grid (one station per 49 square miles) of proposed gravity station positions; knowing the proposed flight path of the helicopter and its relation to the air-photo coverage of the area, the appropriate photographs can be selected and annotated to show theoretical station positions (actual positions are marked on landing) and line of flight to be taken by helicopters;

Plotting of gravity station positions marked on individual air photographs during survey.

On each photograph are marked its own principal point and those of adjacent photographs. They also appear on the "field sheet". To plot the station position, the two adjacent principal points nearest to the station are selected; the ratio of the distance between these two principal points on the photograph and the field sheet is determined. The intersection of the two axes about these points gives the station position. A tolerance of 6″ of arc is allowed in the accuracy of the transferred position.

After field work is completed, the gravity station positions and numbers are transferred on to the original base map. A further transparency is then made combining the base map with a standard reference panel; on to this sheet are drawn elevations, Bouguer anomalies and gravity contours. The final map is reproduced at 1: 500,000 and lithographically printed in black. It is further reduced for incorporation in a 40 mile to 1 inch "gravity map of Australia".

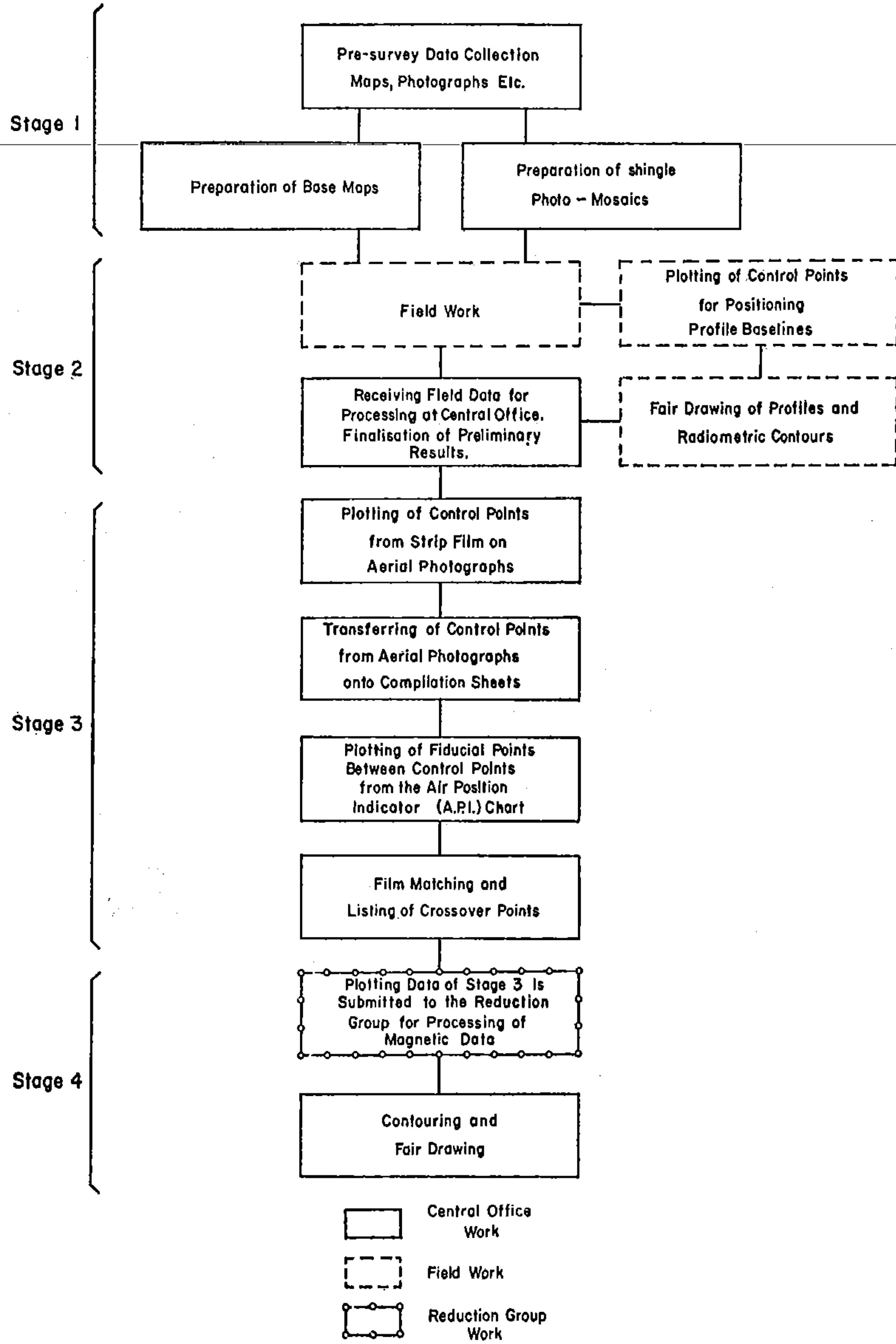
General geophysical mapping

The foregoing description of mapping procedures deals only with geophysical surveying involving airborne operations. As mentioned earlier, these surveys form part of a geophysical programme which embraces many techniques such as seismic, electrical, electromagnetic, gravimetric, magnetic and radiometric methods used in the investigation of mineral resources. The bureau, in addition, maintains a number of geophysical observatories throughout the Commonwealth. Investigation of engineering projects is also part of its programme.

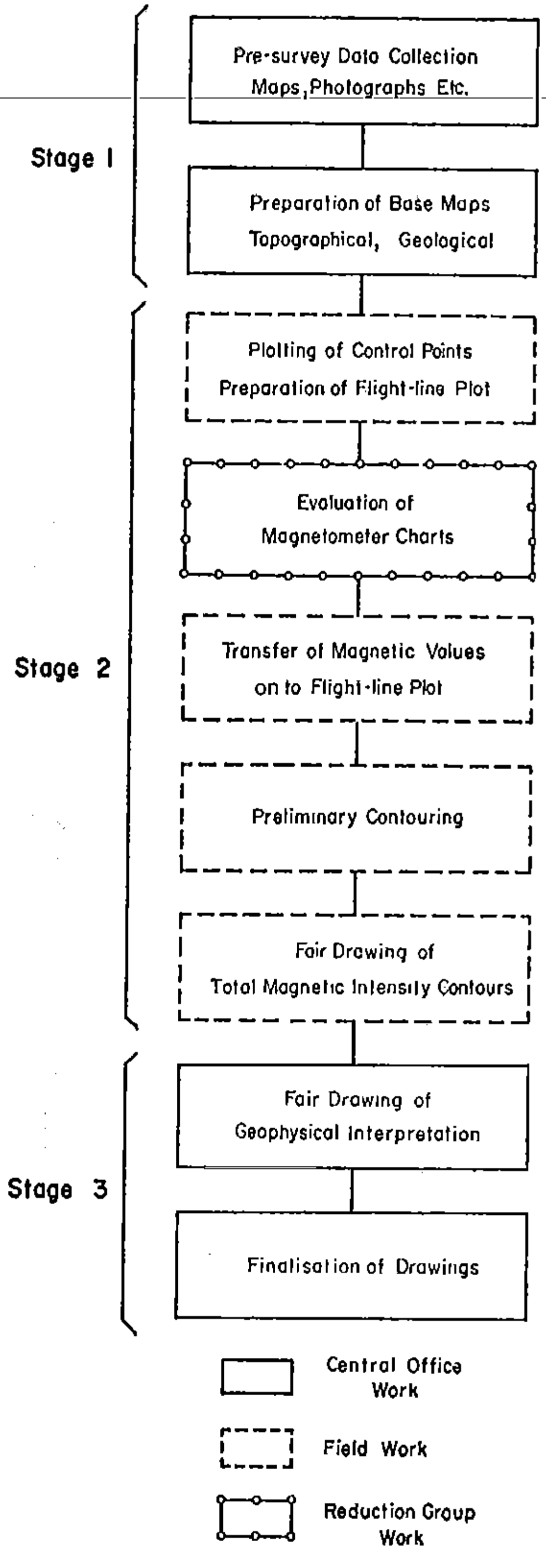
Mapping is provided for the presentation of the results of each of the above activities, which are published as a series of separate maps or for inclusion as illustrations in various publications.

Annex I

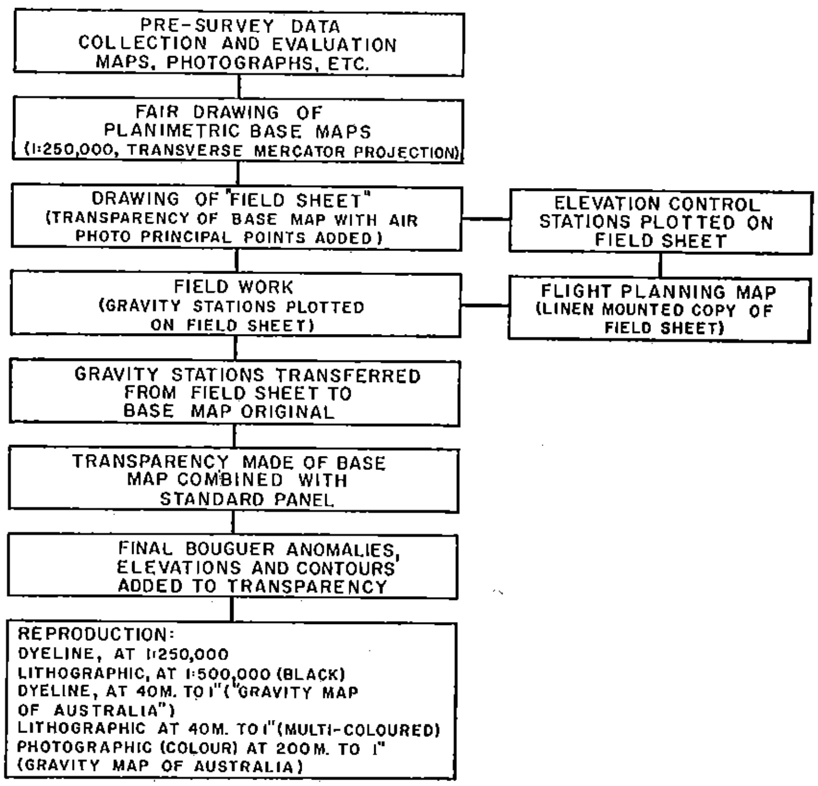
WORK SEQUENCE OF RECONNAISSANCE AEROMAGNETIC AND RADIOMETRIC DRAFTING GROUP



WORK SEQUENCE
OF DETAIL AEROMAGNETIC
DRAFTING GROUP



WORK SEQUENCE FOR MAPPING OF HELICOPTER
BORNE GRAVITY SURVEYS



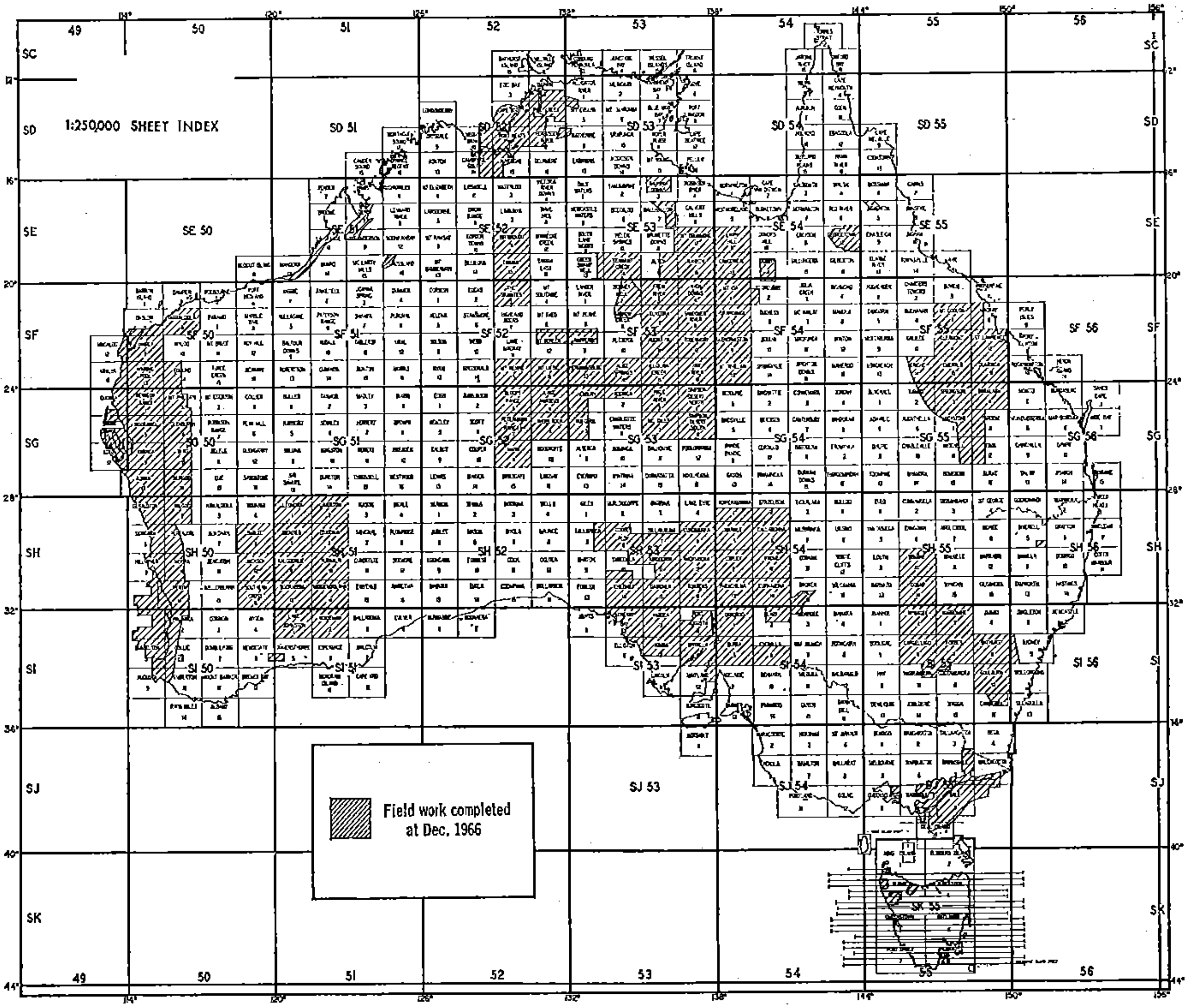


Fig. I—Australia: Aeromagnetic surveys

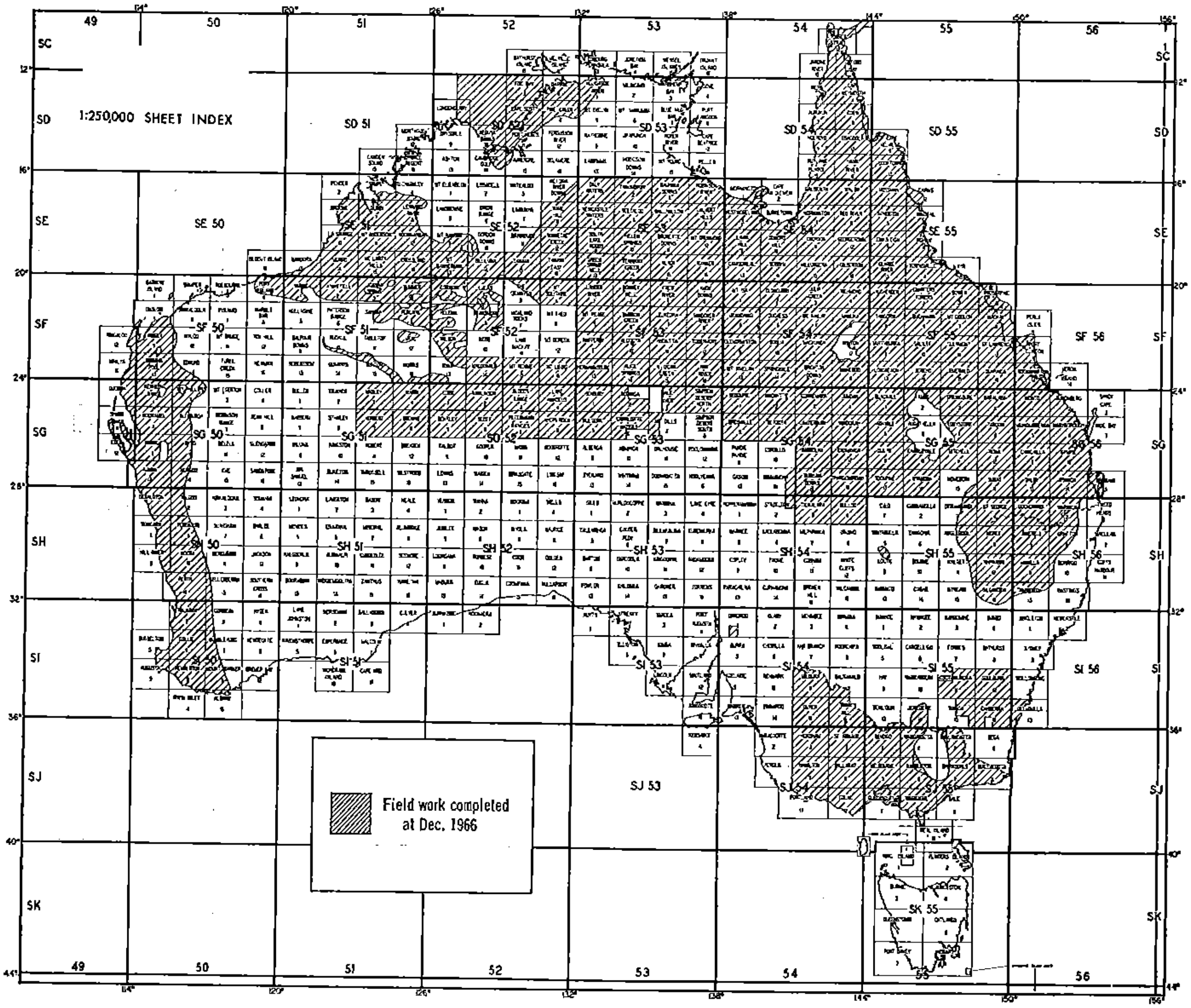


Fig. II—Australia: Gravity surveys

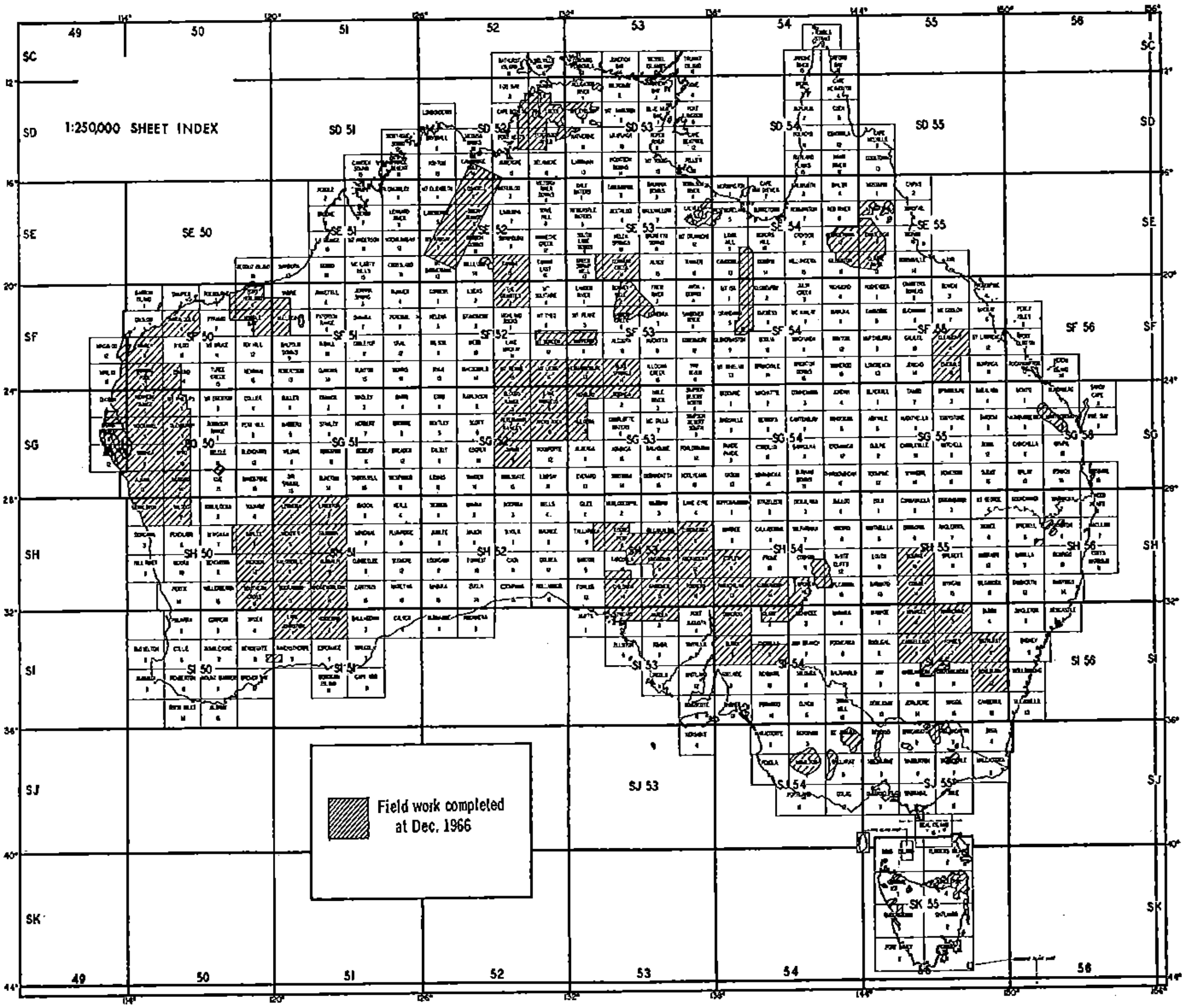


Fig. III—Australia: Radioactive mineral surveys

APPLICATION OF CARTOGRAPHIC TECHNIQUES TO THE DEVELOPMENT OF THE BROWN COAL RESOURCES OF VICTORIA

Paper presented by Australia[1]

Introduction

The surveys of the Latrobe Valley brown coal fields are a type of resource and investigation survey and are a prerequisite to the development of this mineral wealth. The survey can be considered as the action of collecting the basic topographic and geological information necessary for the development of brown coal as a source of cheap fuel for the generation of electricity, or as a fuel or raw material source for other projects.

As the survey and utilization of this vast natural wealth involve a number of persons representative of various scientific and technological disciplines, the importance of the co-ordination and integration of their work as a group cannot be overstressed. This particularly applies to the cartographic aspects of their work, where the responsibility for carrying out surveys also includes the responsibility for recording and presenting information in a readily available and acceptable form.

To meet the requirements of the primary users of the information obtained from the surveys, an integrated cartographic system was evolved to embrace the whole of the Latrobe Valley brown coal fields. The system was developed to provide an accurate and positive means of providing geographic location for the various surveys of the area and for the production of a variety of "end products", of which the large-scale map is an example.

The integrated cartographic system is considered to be logical in concept, and it is flexible in that it allows for changes in instrumentation and method. It involves the use of modern surveying equipment, photogrammetry, digital computing and data processing, which result in ultimate economy of operation. The present paper is concerned with the development of the system, its current operation and future potential in regard to the survey, evaluation and utilization of the brown coal resources of Victoria.

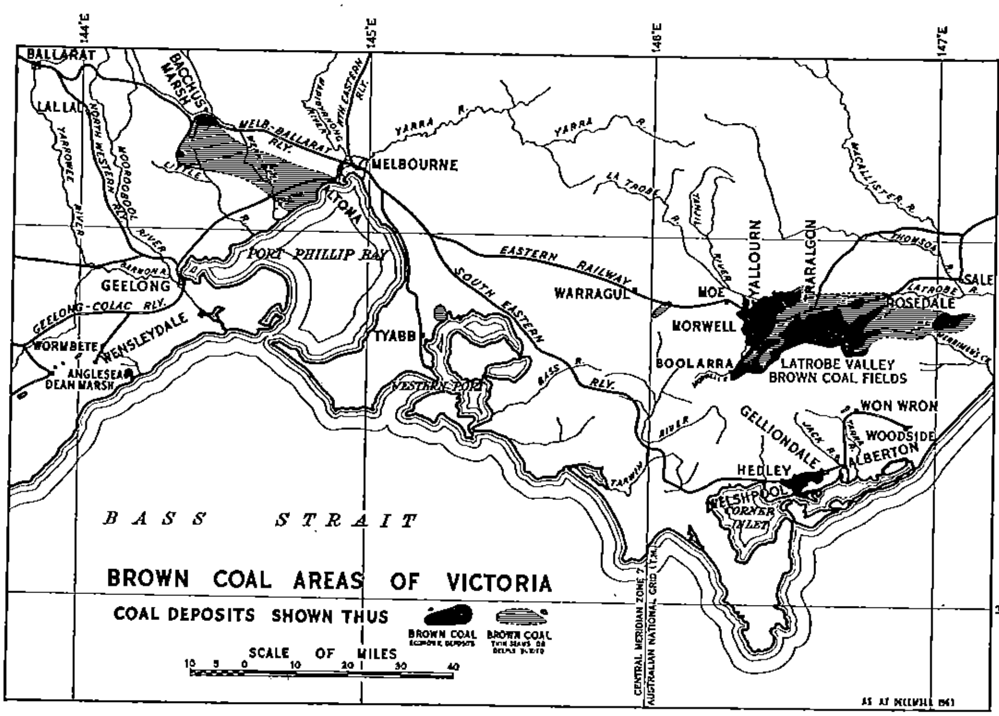


Fig. I—Australia: Geographic location of the major brown coal fields in Victoria

Brown coal resources of Victoria

The knowledge of the existence of brown coal in the State of Victoria dates back to the year 1857, when a small deposit was discovered at Lal Lal, about 70 miles north-west of Melbourne. Since that date a number of further discoveries have been made, principally in the southern section of the state (see figure I).

While a number of separate deposits occur to the west of Melbourne, the major discoveries have been made to the east, in the Gippsland basin, where the Latrobe valley deposits are among the largest in the world (see figure II).

The Latrobe Valley brown coal fields are located between 85 and 130 miles in an east-south-easterly direction from Melbourne and lie within the geographical boundaries of longitudes 146°16′ and 147°05′ east and latitudes 38°08′ and 38°23′ south. The geology of these deposits has been described by C. S. Gloe, who has estimated that, on a

[1] The original text of this paper, prepared by A. N. Mercer, State Electricity Department of Victoria, appeared as document E/CONF. 52/L.59.

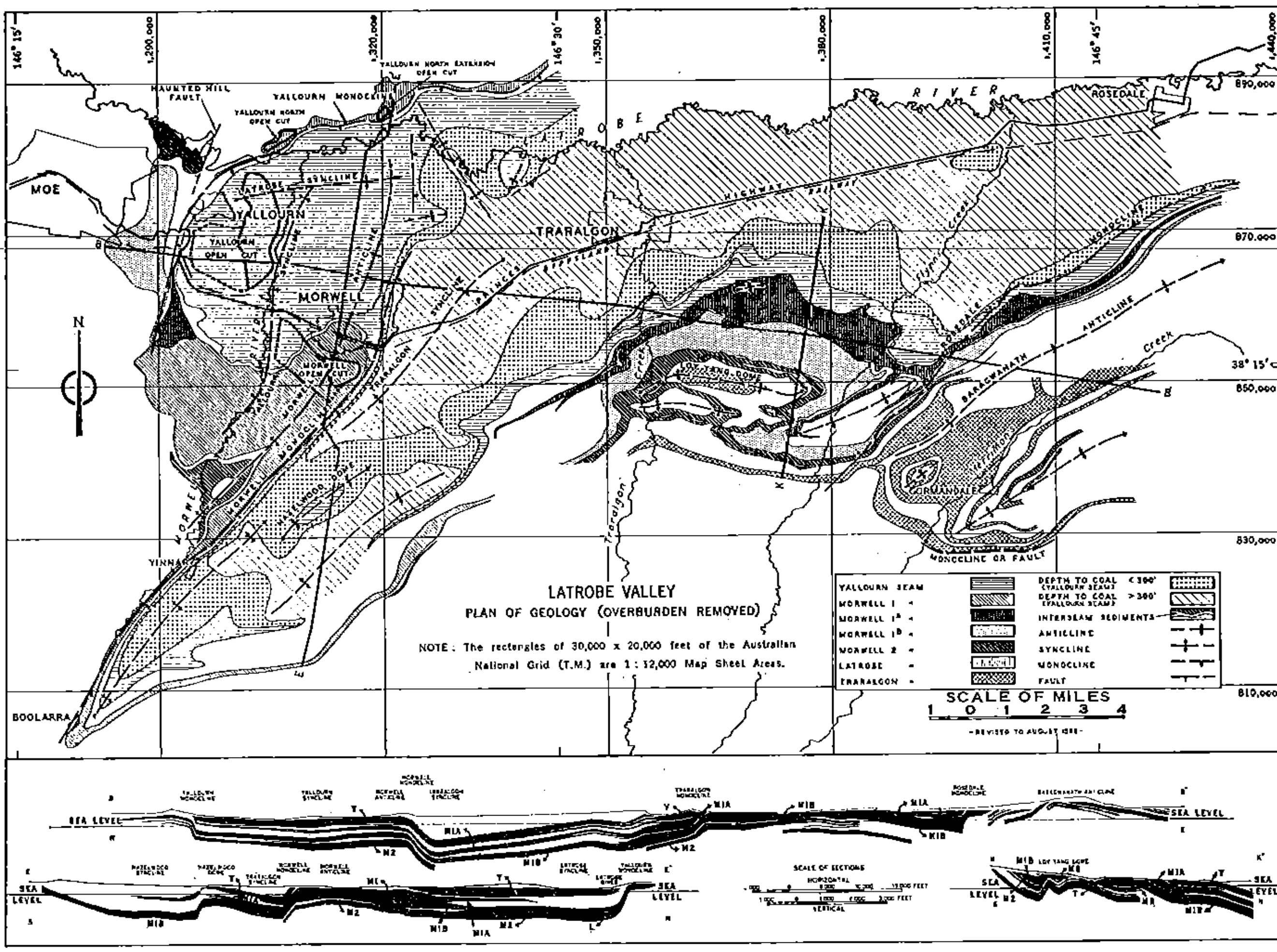


Fig. II—Australia: Location of Latrobe Valley coal deposits in the No. 7 zone, Australian national grid

geological basis, the reserves in the Latrobe valley are 47,500 million tons proved and 37,300 million tons inferred. Of the proved tonnage, some 29,000 million tons occur with less than 100 feet of overburden over the uppermost seam.

History of exploration and surveys in the Latrobe Valley

The exploration of the Latrobe Valley brown coal fields has been described as taking place in four stages.

The first stage was when the Department of Mines, Victoria, in its search for black coal prior to 1892, drilled a small number of bores and proved that big thicknesses of brown coal occurred in the Latrobe Valley depression.

The second stage commenced in 1917, when the Department of Mines began a brown coal drilling programme to prove a sufficient body of coal for the establishment of a power-generating authority (the State Electricity Commission). In the eight years of activity from 1917 to 1925, the department sank more than 700 bores, aggregating nearly 153,000 ft. Within its Yallourn territory, during the first two decades of development, the Commission sank 230 bores on a grid system to investigate future extensions of Yallourn Open Cut, and over 200 bores at close intervals in the immediate area of the open cut to ascertain the actual depth of the coal. A further 65 bores were sunk to prove the subsidiary coal field at Yallourn North. Drilling ceased in 1938.

The third stage began in 1941, when the Commission established a special section for brown coal investigation and recommenced an active drilling programme to determine sites of future projects based upon the Latrobe Valley brown coal fields. During this third stage of exploration and investigation, drilling was carried out on a grid system and the main areas where coal occurred under shallow overburden became defined.

The fourth and present stage commenced in 1951, when the necessity for the systematic geological investigation of the coal resources of the basin was realized and led to the appointment of geological staff and consultants.

In the period covering the third and fourth stages, the Commission has completed over 7,000 bores involving more than 1,850,000 ft of drilling in some twenty-six cadastral map areas.

The geodetic control surveys were carried out in two phases.

The first phase commenced in 1930, when the Royal Australian Army Survey Corps extended a second-order triangulation system from the Werribee base west of

Melbourne into the Latrobe Valley and later extended the first-order Sydney-Melbourne chain of triangles and quadrilaterals to include the Gippsland basin.

The second phase was the block adjustment of the Sydney Melbourne and Gippsland first-order triangulation by the Department of the Army. A further strengthening of the control system in the coal fields was carried out by surveyors from the Department of Crown Lands and Survey and the State Electricity Commission between 1950 and 1960.

Thus first-order geographical and rectangular co-ordinates could be used in the Latrobe Valley only in the latter part of the 1950–1960 decade and the change from second- to first-order values was made in 1960.

The lack of suitable large-scale maps and of an adequately controlled and co-ordinated survey system was a considerable handicap at the commencement of the third stage of exploration, in 1941. This situation led to inefficiency and errors in the topographic and bore location surveys. The measures taken to correct this situation led to the development of the integrated cartographic system.

The integrated cartographic system

An integrated cartographic system ensures that survey projects of any importance will be performed in a well specified manner and be tied to a common system so as to serve a variety of purposes over a long period of time. It means adoption of suitable accuracy standards, specifica-

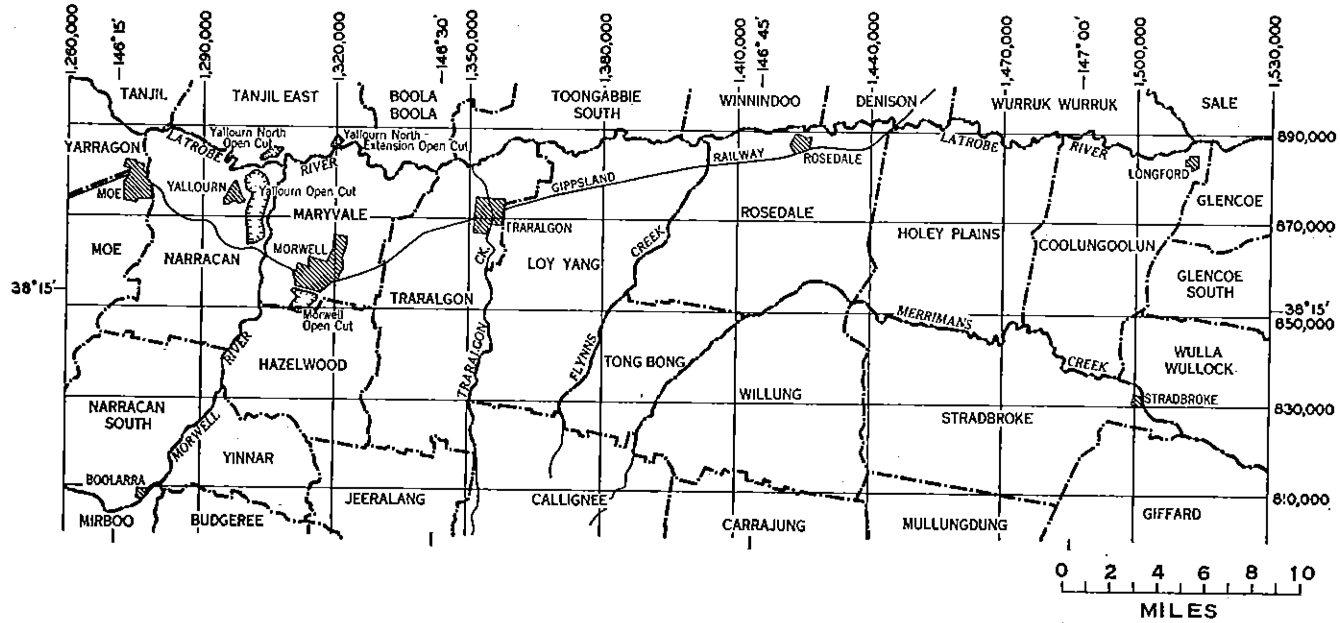


Fig. III—Australia: Cadastral map sheets in relation to the 1:12,000 topographic series

Note. Cadastral maps (parish plans) are used for the determination of ownership boundaries in relation to borehole positions.

In accordance with earlier established practice, the boreholes are numbered consecutively within the cadastral map areas in which they are located; but their geographic location is recorded by Australian National Grid (TM) rectangular co-ordinates.

The cadastral surveys of Gippsland were carried out by the State Department of Crown Lands and Survey and published in a series of county, parish, town and township maps. These maps, which were produced between 1875 and 1915, were frequently compiled on a magnetic meridian and excess length was allowed in the boundaries of allotments, so that the persons obtaining ownership from the Crown were certain of receiving the area to which they were entitled. These cadastral plans were often bounded by creeks and rivers (figure III) and, as errors and adjustments were "thrown" into river and creek boundaries and as no triangulation control was used, it was seldom possible to obtain a matching of adjoining boundaries or to retain scale.

The only topographic maps available in Gippsland prior to 1941 were the national 1 mile to 1 inch series (1 : 63,360), with 50 ft contour interval; large-scale maps of small areas of towns produced for water supply and sewerage; and detailed surveys and large-scale maps of the Yallourn works area. The surveys were all controlled with a special rectangular co-ordinate grid system with a local origin and magnetic meridian.

tions, monumentation, co-ordinate systems, map scales and map format.

The Latrobe Valley system was designed to produce a number of end products and provide a service to various primary users of the information. It was evolved over a number of years and, with the introduction of modern measuring equipment, photogrammetry, digital recording and computation and electronic data-processing techniques from 1956, the output from the system reached its present efficiency soon after 1960. The system had potential for still further automation.

The principle of cartographic integration in the Latrobe Valley was evolved as a result of several separate but interrelated requirements. The primary requirement was to provide a system of reference, the fixing of geographical location to various accuracies of particular points or features and the compilation of graphical end products. The former particularly applies to the geological survey where, owing to the occurrence of multiple coal seams and complex geological structures (see figure II), a considerable quantity of data has to be obtained and carefully evaluated for its complete interpretation. (The actual recording of strata and coal analyses involves the use of over 500,000 punched cards.)

Three principal items are needed for the fixing of geographical location.

Bore hole location. From a general viewpoint, where the coal seams are regularly bedded and where there is a clear demarcation between overburden and coal, it is considered that the location interval of ±1 ft vertically and ±5 ft horizontally would be adequate throughout the area of survey. However, where geological dips are relatively steep, location accuracies of ±1 ft, both vertically and horizontally, are desirable.

"Target" and feature location for control of aerial photography. The largest scale topographic map (at compilation scale) is the 1:1,200 map with a 1 ft contour interval. To conform with large-scale map specification, the accepted accuracy for control points is 1 in 5,000 horizontally and ±0.1 ft vertically.

Earth movement (horizontal and vertical). Rigorous control is needed for the determination of earth movements resulting from large-scale open-cut mining operations. This required the establishment of second-order triangulation adjacent to the operational area, but at sufficient distance to be unaffected by ground movements. It is estimated that the standard of accuracy is in the order of 1:100,000 from the perimeter control.

Triangulation control of the system consists of a first-order network on the perimeter of the area, second-order triangulation points located within the area at average intervals of 5 miles, with interconnecting precise traverses.

All triangulation stations are monumented with tubular steel beacons, and triangulation and precise traverse control points are also monumented with appropriate ground markings of sufficient vertical depth to be unaffected by seasonal movements.

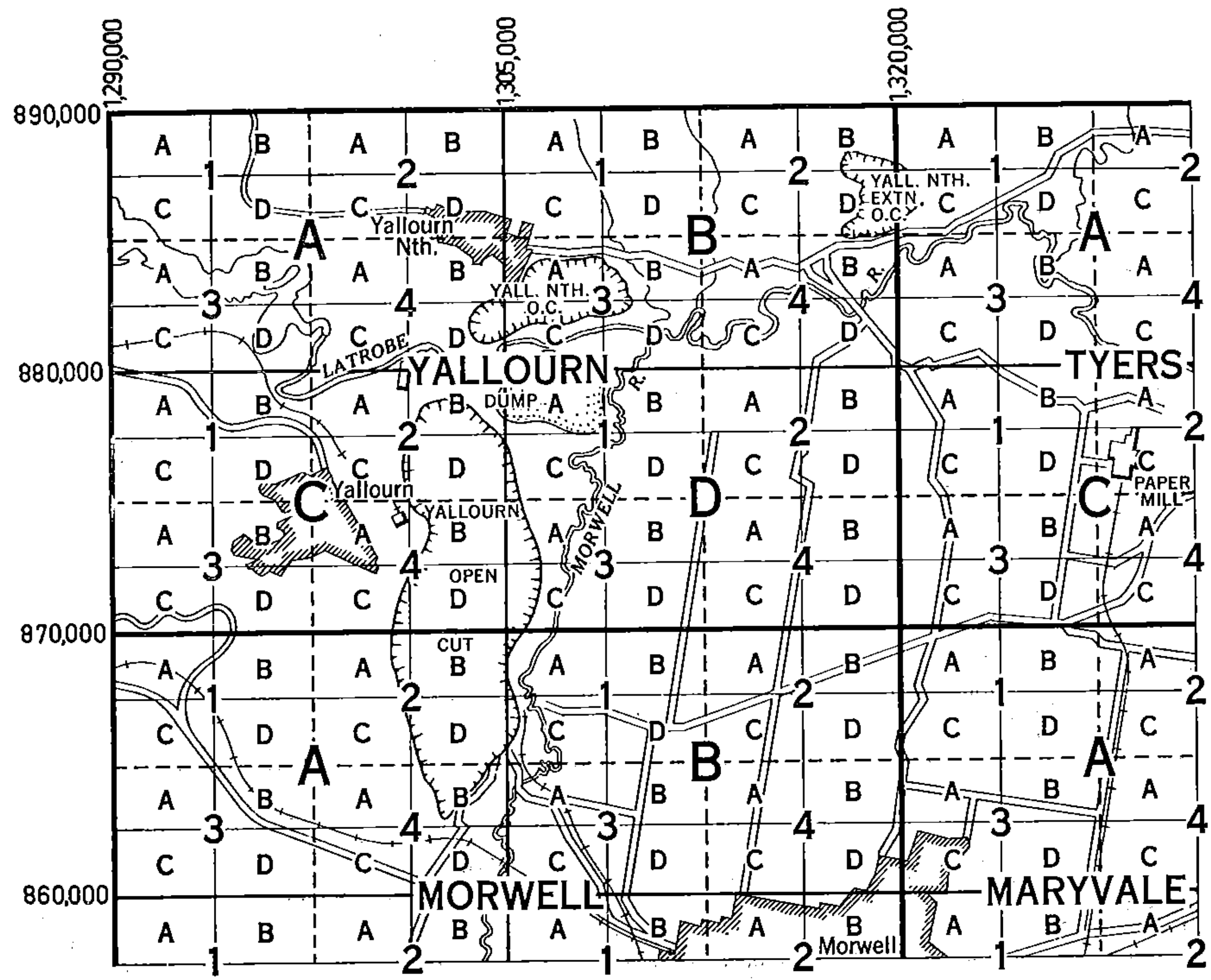


Fig. IV—Australia: Large-scale map sheet subdivision and reference system

Map name	*Scale (standard sheet)*	*Area (in feet)*
Yallourn	1:12,000	30,000 × 20,000
Yallourn A	1:4,800	15,000 × 10,000
Yallourn A1	1:2,400	7,500 × 5,000
Yallourn A1A	1:1,200	3,750 × 2,500

All survey accuracies are in conformity with state practice and legislation (State Survey Co-ordination Act) and the requirements of geographical location of the separate surveys.

The Australian national grid (TM) No. 7 zone co-ordinate system is used for all rectangular co-ordinates.

Maps and plans at various large scales are based upon subdivisions of a standard base map at 1:12,000 covering an area of 30,000 × 20,000 ft, with the rectangular co-ordinate grid lines as sheet boundaries and 1,000 × 1,000 ft grid control intervals (see figure IV).

Engineering, topographic and geological surveys are tied to each other and related to the co-ordinate system through triangulation and precise traverse controls.

A decimal-foot system of measurement is used.

Principal end-products of the system

Typical end-products of the system are listed below.

Topographical maps

Large-scale maps at 1:600, 1:1,200 and 1:2,400 each, with a 1 ft contour interval (original scale of compilation: 1:1,200), are used for the planning, design and operation of open-cut mines and for associated engineering projects.

Maps at 1:4,800 and 1:12,000 each, with a 10 ft contour interval (original scale of compilation: 1:4,800), are used for initial investigations and preliminary planning and design.

Geological maps

Geological maps include borehole location maps; "concealed outcrops" maps; structure maps for tops and bottoms of coal seams; cross-sections at various scales; "coal quality" maps at 1:4,800 and 1:12,000.

Open-cut planning and design maps

Isopachs are drawn for overburden thickness, coal thickness and variation between predicted and actual coal surfaces.

Operational maps

Progress maps at 1:2,400 are compiled at specified time intervals.

Electronic computer outputs

Graphical plottings are made from analytical information extracted from geological bore-hole records (for example, histograms of constituent values and cumulative value graphs) and from bore-hole deviation surveys. Cross-sections are made from surveys for quantity calculation. Outputs from geological records are tabulated and listed. All calculated and adjusted values from field survey observations are listed and consolidated.

The advantages are listed under four main groupings.

(*a*) The Australian national grid (TM) co-ordinate system can be used.

(i) In aerial coverage, the system includes the Latrobe Valley brown coal fields. The location of all points is defined in relation to each other. There is no discontinuity in the grid. The system is suitable for aerial computations (over the major portion of the coal deposit, the scale factor (enlargement) is less than 1 in 16,000).

(ii) It is usable on X-Y line plotters and readily usable for measurement by hand scale or by an electronic digitizer from a map.

(iii) It is readily available on national maps of the area and is known and understood in the scientific and technological professions.

(iv) It facilitates the reoccupation of a point where an observation was made.

(*b*) A uniform map sheet size and subdivision is used.

(i) This allows for an optimum usage of photo-mechanical processes and materials and for the most economic use of storage facilities (the maximum size is 40 × 30 inches for the various map scales).

(ii) Topographic map sheets may be drawn in any specified area or areas without the necessity of completing adjoining sheets and without duplication of work or overlap in map sheets (see figure IV).

(iii) Geological map sheets may be drawn to register correctly with the topographic map sheets.

(iv) The rectangular co-ordinate grid lines forming the map sheet boundaries are easy to use with automatic digitizing and plotting machines.

(*c*) The use of modern field and office equipment and procedures in the integrated system has resulted in an increase of efficiency, a higher standard of production and a reduction in cost. The specific advantages gained by the introduction and operation of the system have been attained against a rising wage, salary and cost structure (see figure V).

(i) The cost of producing a large-scale map by the newer techniques is considerably lower than that based on the use of older field methods.

(ii) The use of the electronic computer has resulted in an 80 per cent reduction in total time taken for the average triangulation or resection calculation and adjustment.

(iii) The use of the Geodimeter has resulted in field time savings of up to 70 per cent for the longer precise traverses and a considerable increase in accuracy with the longer lines measured.

(iv) The personnel engaged in precise traversing have been reduced from four persons to three persons per field party.

(*d*) The system contains potential for additional benefits, including:

Reduction in the amount of field survey carried out in operational areas by the further use of photogrammetry for both linear and quantitative measurement and the use of the orthophoto-map for progress maps;

Reduction in the amount of office work by the wider use of the electronic computer in association with electronic line digitizing equipment and automatic X-Y line plotters;

More positive means of recording land ownership and redetermination of cadastral boundaries.

Instruments and equipment

The major items of field survey instruments and equipment used in the Latrobe Valley include: a Geodimeter model 4D and a Geodimeter model 6; Wild T2 and T3 theodolites and a Tavistock theodolite; Wild N3, Kern and Cooke Troughton and Sims precise levels; Zeiss and Fennell automatic levels; electrical resistance tape comparison equipment and measuring base and a bore hole deviation survey instrument (electronic).

The electronic computer, an IBM 7040 (to be replaced in 1967 by an IBM 360, model 40) is located in the Engineering Electronic Data-Processing Division in the Commission's head office in Melbourne. The computer is used to process some twenty programmes associated with bore hole records and twenty-four programmes for survey computation, adjustment and plotting.

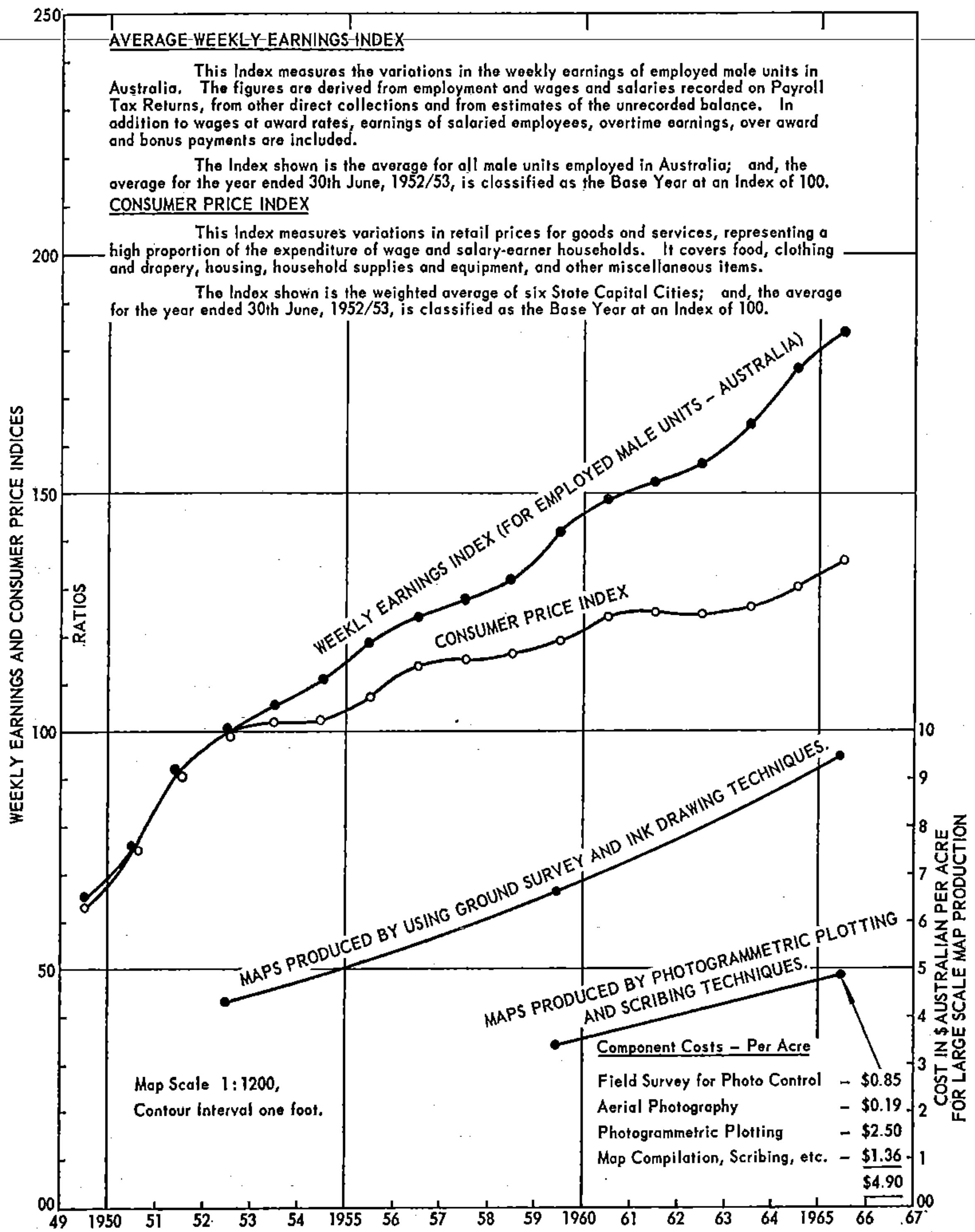


Fig. V—Australia: Large-scale map production costs and Australian economic trends

GRAVITY SURVEY FOR PETROLEUM EXPLORATION AND UNDERGROUND HEAT SURVEY

Paper presented by China[1]

A gravity reconnaissance survey was made over the plains of western Taiwan during the period of 1946–1948, and a Bouguer gravity map was made by the Chinese Petroleum Corporation (CPC). Using the Worden Gravimeter of high sensitivity, CPC resumed the gravity survey of Taiwan in 1958. The main purpose of the new survey is to check the gravity anomalies found through the earlier one and also to extend the area covered to the foothills. So far, some 35,000 gravity measurements have been made in the plain area and foothills region, where intensive exploration for petroleum are being made. The traverses are several kilometres apart and the stations are spaced at intervals of 200 to 300 m. On the average, the distribution of observation is one station per square kilometre.

The use of gravity for studying the subsurface mass distribution is effective only where there are horizontal discontinuities in mass. The Bouguer gravity map of Taiwan has served as an important guide to regional geological interpretation. In particular, residual or secondary derivation maps made in areas of interest are of direct use in planning detailed seismic surveys. The north-south isogals give a regional gravity pattern over the extensive coastal plain of western Taiwan. The Bouguer gravity anomalies found in the mobile zones can be generally classified into two kinds: gravity anomaly conforming to the subsurface structure; gravity anomaly deviating from subsurface structure.

Some seismic configurations are found to have little or no direct relationship to the gravity distribution as far as shallow horizons are concerned. Recently the Penghu islands have been covered with a gravity survey. The resulting gravity picture has provided substantial information about the westward extension of the shelf area.

As an international gravity base has been established, the existing gravity data of Taiwan can be integrated in the world-wide network to resolve major problems of geology and geophysics. In the central mountains and the sea surrounding Taiwan there are areas of thousands of square kilometres in which there is not a single gravity observation. Additional gravity measurements in these unexplored areas will greatly improve the knowledge of subsurface conditions in that part of the world.

An underground heat survey was made at Ta-tu-shan in 1965. Topographic maps at 1:10,000 covering that area of 200 km^2 were compiled with multiplex. The utilization of the underground heat will be one of the important sources of energy for industry in Taiwan.

[1] The original text of this paper, prepared by the Chinese Petroleum Corporation, appeared as document E/CONF.52/L.111.

RECENT STATUS OF PHOTOGEOLOGY IN JAPAN

Paper presented by Japan[1]

Photographs prior to 1964 covered almost the whole area of Japan at 1:20,000 scale and some portions of the area at 1:10,000. In general, flat lowlands were photographed with 150 mm focal length camera by the Geographical Survey Institute and mountainous areas with 210 mm focal length camera by the Forestry Agency. These photographs are supplied for general use through the Japanese Surveying Society and the Japanese Forest Technical Association respectively. Many photographs at various scales taken by governmental or private organizations can also be obtained, in general, through either organization. These photographs are widely used in geological investigation as well as in other sciences and technologies relating to the terrain surface.

A photographing system for emergencies has been established. Many photographs covering extensive areas for disaster investigations were taken immediately after disasters such as the Isewan typhoon in 1959, the heavy snowfall in the Hokuriku district in 1963 and the Niigata earthquake in 1964.

Infra-red and colour photographs are used on an experimental basis by some organizations for geological exploration.

It is said that there are fewer advantages in applying techniques of photo-geological interpretation in Japan because of thick solid covering, dense vegetation and cultural features as well as the complex geological structure. However, if the techniques of photogeological interpretation are applied properly, the interpretation of some valuable geological data which are hard to obtain by field survey methods alone is made possible.

Since the end of 1964, several papers on photogeology have been published. Aerial photo-interpretation for the geological survey of the alluvial plains of Japan has been developed. Most of this area is covered by large cities and industrial districts. This technique has also been applied to the redevelopment of cities and industrial plants. Similar techniques have been applied to damage investigation and analysis, and prevention of disasters caused from earthquake, flood, landslide, etc.

The Geological Survey of Japan is dealing with experimental studies on the application of terrain photogrammetry for measurements of landslide movements and the precise mapping of the surface morphological features of the landslides. The quantitative analysis of microfeatures on the terrain surface and rock outcrops is now carried out by means of close-range terrain photogrammetry.

Geothermal photography has also been introduced. Ground observations of geothermal distribution using

[1] The original text of this paper, prepared by Kyuya Matsuno, Geological Survey of Japan, appeared as document E/CONF.52/L.121. Other papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

infravision were carried out at the Hakone and Nasu volcanoes. This instrument was produced by the Nihon Electric Company. The company is now manufacturing a prototype of an airborne IR imagery instrument in co-operation with the Geological Survey.

Several governmental and private organizations as well as universities have introduced systematic training for photo-interpretation. The Geological Survey has periodically offered training to its employees in basic photogrammetry and photogeological interpretation, including field inspection. Some private organizations, such as the Japanese Petroleum Exploitation Company, participate in that training programme.

(b) Regional land-use surveys

REGIONAL LAND-USE SURVEYS

Paper presented by New Zealand[1]

Introduction

Since its foundation as a British colony and the arrival of the early settlers in the eighteen-forties, New Zealand's economy has been based on primary production. Although manufacturing industries and secondary production are becoming increasingly important in the national economy and life of the country, the land and its use remain the main factor.

Land administration in New Zealand is shared by several government departments, including:

Department of Agriculture: Activities relating to stock and farm management and production; agricultural science;

Department of Scientific and Industrial Research: Conducts geological and soils surveys and prepares related maps; other scientific studies include those related to agriculture, botany, etc.;

Forestry Department: Actively engaged in forestry, including forest development, management and conservation and timber production; conducts forest research;

Department of Lands and Deeds: Responsible for land registration;

Valuation Department: Conducts regular land valuations;

Ministry of Works: Construction works, town and country planning, including resources surveys;

Department of Industries and Commerce: Interested in production from the land and in sales promotion of related products;

Department of Statistics: Collection, collation, analysis and promulgation of statistical information;

Department of Lands and Survey: The traditional land-development, land-holding and land-disposal agency of the Government, including responsibility for reserve and national park lands; it is the Government's survey and mapping organization.

Land tenure pattern

The total area of New Zealand is approximately 66 million acres. Of this area, approximately 30 million acres comes under the jurisdiction of the Department of Lands and Survey or, in some cases, of other government departments, as shown below.

	Acreage
Crown land occupied privately (approximately 45,500 Crown leases or licences)	16,000,000
Crown land under development to provide approximately 1,500 potential farm units	1,000,000
Eroded land undergoing reconditioning	500,000
Molesworth station owned and managed by the Crown	450,000
National parks	5,000,000
Scenic reserves, etc.	1,000,000
Unoccupied Crown land, mostly unsuitable for settlement	6,000,000
Total	29,500,000
Land held by Maoris	4,000,000
Grand total	33,500,000

The remaining land, consisting of approximately 32,500,000 acres (50 per cent of the total area), is freehold.

Existing land-use surveys

Regional land-use surveys have been undertaken by the Department of Lands and Survey for several years. The work is co-ordinated by the Land Utilization Officer. To date, the areas covered by the surveys have been those of greatest need. Completed surveys have been produced for areas in north-east Taranaki, Westland and Gisborne (east coast). These surveys have taken the form of a published report covering land, climate, settlement, transport, public services, population and farming, with an appraisal and classification of the land. These reports are accompanied by maps, usually at a scale of 1 inch to 4 miles (1:253,440), showing, in full colour, tenure, land cover and land classification. The reports are further supplemented by topical maps and graphs.

Complementary to these regional land-use surveys, regional resources surveys are being prepared by the Town and Country Planning Branch of the Ministry of Works. These resources surveys are to be produced for a series of nineteen regions covering the entire country and are intended to cover a wider area and a wider field of resources than do the land-use surveys. To date, five of these regions have been completed, while work is proceeding on two more at the rate of one region every six to nine months.

Chapters in these surveys are devoted to background, climate and weather, geology, soils and water, agriculture, forestry, land use, population, employment and industry, transport, local government and prospects. They are well supported by illustrations, graphs and diagrams and

[1] The original text of this paper, prepared by D. G. Francis, Chief Cartographer, Department of Lands and Survey, appeared as document E/CONF.52/L.3.

by maps. A series of full-colour maps usually at 1:500,000 scale, depict relief, location and communications, geology, soils, potential use of soils, land use, future land use, distribution of forests and tenure.

LAND INVENTORY

There has been a long-standing need in New Zealand for a more detailed land-use survey. In 1964, an inter-departmental committee was set up, consisting of representatives from the following departments: Lands and Survey; Agriculture; New Zealand Forest Service; Industries and Commerce; Ministry of Works; Soil Bureau, Department of Scientific and Industrial Research; Valuation.

This committee has recommended the inauguration of a detailed land-use survey of New Zealand, to be known as the national land inventory. This recommendation has now been adopted and a start has been made on research and preparation.

A separate report is to be prepared for each of the 112 countries in New Zealand and seven maps in full colour at 1:63,360 scale will be prepared for each report showing land cover, geology, soils, potential pastoral use of soils, land capability, tenure and land use.

These maps are to be supported by two further maps, not for publication, showing production and carrying capacity per holding and per acre.

For detailed specifications of each map, see annex.

The production of reports and maps is to be the responsibility of the Department of Lands and Survey and information for the purpose is to be obtained by officers of the department. This is supported by additional information provided by other interested departments.

The work of research and collation has been decentralized to be undertaken in the twelve district offices of the department. An initial twelve counties have been allocated for attention, on the basis of one county per land district. These counties have been selected as areas of greatest need where suitable base maps are available together with up-to-date valuation rolls, soil survey information etc.

MAPS FOR THE LAND INVENTORY

Available map coverage on which research and mapping for the national land inventory can be based includes those listed hereunder.

Cadastral maps. Cadastral maps at a scale of 1:63,360 showing the up-to-date land subdivision pattern are available over the whole country and these form the basis for the recording of a considerable volume of statistical information for land tenure, land valuation etc.

Topographical maps. Topographical maps at a scale of 1:63,360 and on the same sheet pattern as the cadastral maps cover most of the country. They vary in standard from those showing only planimetric information to fully contoured maps.

Geological maps. Complete coverage of New Zealand is available by geological maps at 1:250,000 scale, with portions also covered at 1:63,360 scale.

Soil maps. New Zealand is covered by soil maps at a scale of 1 inch to 4 miles, with certain other maps available at larger scales.

Air photography. Coverage of almost the entire country is available with completion of the few remaining gaps planned for the near future.

The optimum sheet size of maps in the land inventory is 40 × 30 inches. This size covers smaller counties in one sheet, but most counties need two sheets, while some require as many as four or five. Natural boundaries are chosen for divisions between sheets within counties. If a suitably located natural boundary such as a mountain range or a river does not occur, then county riding boundaries are chosen as the line of demarcation between sheets.

As the main 1:63,360 topographic and cadastral series are on a regular 45,000 × 30,000 yard sheet line network covering the country in 360 sheets, the rearrangement of map layout into the irregular county sheet line pattern referred to above presents some problems. But for a land-use survey, the advantage of this rearrangement into areas with a common transport and drainage pattern and community of interest predominates.

METHOD OF MAP PREPARATION

As mentioned previously, research and supply of information for the maps is to be a joint effort by the departments concerned. However, the Department of Lands and Survey is responsible for the collection of this information and for the compilation of the maps themselves. Except in the case of geological and soil maps, where the information will be obtained from the Geological Survey. and the Soil Bureau of the Department of Scientific and Industrial Research by the Head Office of the Department of Lands and Survey, this work of collection of information and compilation has been decentralized to the twelve district offices of the Department of Lands and Survey The procedure to be adopted in the preparation of the maps is described below.

(a) *Preparation of base maps and colour guides*

(i) The county to be mapped is selected, bearing in mind the areas of greatest need, availability of base map coverage, up-to-date valuations rolls, geological and soil information, etc.

(ii) A layout map is then prepared for the county, dividing the area to be mapped into sheets of image size 20 × 30 inches or less, adopting boundaries of convenience. These are usually physical boundaries within the county such as prominent ridges or mountain ranges, rivers or county riding boundaries. This layout is then submitted to those concerned for comment and suggested improvement before finalization. The layout provides space on each map for a title panel and for the necessary reference information.

(iii) Once layout is finalized, a start is made on preparation of base maps to cover the county. These are scribed at 1:63,360 from keys prepared by assembling together transparencies from the base map drawings of NZMS 1 topographical maps at 1:63,360 scale.

These base maps, which are drawn at Cartographic Branch, Head Office, show the existing road pattern as scribed single lines. Coast lines, main rivers and streams are added, together with border line work, etc.

(iv) Concurrently with preparation of the base map, the district office of the department marks up, as scribing guides, a set of cadastral maps covering the area, to show boundaries of individual holdings. The holding pattern is marked with felt-tipped pens. On completion it is forwarded to Cartographic Branch, Head Office. Minimum holding size shown is 30 acres.

(v) Using the holding pattern guide received from the district office as a key, the holding pattern is scribed on an overlay to fit the base map prepared as described in sub-paragraph (iii).

(vi) A letter-type overlay is prepared to fit each map. To this is added names of cities and towns, rivers and streams, railways etc., together with all border and reference lettering that will be common to all maps in the series. The type is set photographically, either in a Monophoto or Photonymograph machine, on to stripping film which is waxed for application.

(vii) On completion of base map, holding pattern overlay and letter-type overlay, these are thoroughly checked both by Head Office map editing staff and by the district office concerned, and any necessary alterations or additions are made.

(viii) From the checked and amended base map and overlays, a composite reverse positive or negative transparency is prepared and from this transparency nine positive reproductions on transparent polyester grained drawing material are prepared.

(ix) The nine transparencies are then forwarded to district office, where each is completed differently and forms the base for the nine separate maps of the report. On these, the district office, from field investigations, aerial photography and local records, classifies the areas into the various categories shown in the annex.

(x) A plan print is prepared from each of the nine completed base maps referred to in sub-paragraph (ix), and these prints are then coloured in pencil as colour guides to show the various colour notations of the individual maps. Great care is taken to select coloured pencils that will closely resemble the colours selected for the published map, and also to ensure that each of these colours is noticeably different. Where any possibility of doubt or misinterpretation of these colour guides exists, the selected final colour number is added to the particular area or parcel on the colour guide.

(xi) The nine completed base maps, each with their completed colour guides, are sent to Cartographic Branch, Head Office, where colour separation overlays are prepared from each colour guide before the maps are finally printed.

(b) *Preparation of colour overlays*

The work of preparing colour-separation overlays is done for printing in three colours, mid-red, mid-blue and yellow, for all maps except geological and soil maps. The method utilized is a development of that used by the Directorate of Overseas Surveys, United Kingdom.

The colours chosen are carefully standardized to give, when combined by screening and/or overprinting, the widest possible range of tinted colours. The density of ink is chosen to produce the most suitable strength of colours for the purpose. The ink is ordered in such a way from the ink manufacturer that an even colour is maintained for all printing undertaken throughout the period of the project.

Thirty-three and 66 per cent 110-line dot screens have been prepared to cover the 28 × 38 inch image area in their correct orientation. This is 15° west of north for blue, north for yellow and 15° east of north for red.

A special colour chart has been prepared, using the inks and screens referred to above, to produce two-colour and three-colour combinations of 33 per cent, 66 per cent and full-colour densities of the chosen red, blue and yellow inks. These colour charts contain nine single colours, twenty-seven double colours and twenty-seven triple colours. Each of these colour combinations is numbered on the chart, together with an indication as to which of the three primary colours or their tints was used to produce it.

All colour tints used in preparing the base maps for the national land inventory are chosen from these sixty-three numbered colours. These tints are supplemented by a light-blue flat-tint colour for water areas.

On receipt of the nine completed base maps and colour guides, the steps described below are taken to produce the colour overlays for the land cover, potential pastoral use of soils, land capability, tenure and land-use maps.

(i) From each of the master colour guides received from the district office with the completed line drawings, three sub-colour guides are prepared, one for each of the primary colours (red, yellow and blue), for which a colour overlay is to be prepared. These show with three prominently distinct pencil colours (usually green, orange and purple) the 33 per cent, 66 per cent and full-strength components, respectively, of the particular primary colour, for instance:

First sub-colour guide: green, 33 per cent red; orange, 66 per cent red; purple, full-strength red.

Second sub-colour guide: green, 33 per cent yellow; orange, 66 per cent yellow; purple, full-strength yellow.

Third sub-colour guide: green, 33 per cent blue; orange, 66 per cent blue; purple, full-strength blue.

These sub-colour guides, when completed, are carefully checked against the master colour guide and amended where necessary. This is most important.

(ii) From the completed sub-colour guides, three separate overlays are prepared, one for each of the three colour strengths of the particular primary colour. If the amount of work in one of these overlays is average to extensive, then the work is done by cut-and-peel or etch-and-peel methods. Where etching to line work is required, this is done from a combination of the original master base map and holding pattern overlay combined (section (*a*), sub-paragraphs (iii) and (v)). Thus all lettering is eliminated from peel-coat foils. Where cut-and-peel methods are used, swivel knives are employed and the work is done over the completed final base map-transparency (section (*a*), sub-paragraph (xi)). The assessment for use of etching or cutting techniques is based on the relative extent of photomechanical and hand-cutting work involved for the particular overlay. If the amount of work in one of the overlays is below average, then it is prepared by pen-and-ink or brush-and-ink techniques, using a non-photographic blue key printed down on to the drawing foil.

(iii) Completed overlays are carefully checked against sub-colour guides before they are forwarded for printing.

The advantages of this method of preparation of colour overlays, apart from reduction of printing capacity through the use of three-colour printing for the purpose instead of multicolour printing, include the following:

The possibility of employing more than one draughtsman at a time on the work of preparing overlays for a particular map;

The elimination of the great difficulty previously experienced in checking completed colour overlays against a master colour guide.

The completion of base maps and the preparation of colour overlays and symbolization for geological and soil maps are carried out by the more conventional methods usually needed for this type of map.

Before offset printing plates are made, all colour overlays for each tint colour are combined and screened together; then the work is colour-proofed using negative-positive or positive-positive photomechanical or electrographic proofing techniques.

The completed base maps and overlays are reproduced by offset printing methods in five colours: base map, grey; water areas, light blue; colour overlays, red, yellow, blue.

Annex

CATEGORIES APPEARING ON COMPLETED MAPS FOR THE NATIONAL LAND INVENTORY

A tabulation of the categories mapped in the survey appears below, together with a brief description of the colour or colour and symbol utilized.

Symbols used appear on the final maps overprinted in the base map grey colour.

Categories for geological and soil maps have been omitted. These are conventional.

	Colour name	*Colour number*	*Symbol*
Land cover map			
Developed land			
Cropland			
Garden crops (e.g., market gardens, orchards, hops, tobacco, small fruits, vineyards, nurseries, canning crops)	Orange/red	21	
Field crops (e.g., grains, pulses, forage and root crops)	Orange/yellow	3	
Grassland			
On flat and rolling tillable land			
First-class pasture	Colours and colour numbers as yet undetermined		
Second-class pasture			
Poor pasture			
Reverting to weeds (rushes, gorse, scrub, etc.)			
Tussock land			
On hilly to steep untillable land	Colours and colour numbers as yet undetermined		
First-class pasture			
Second-class pasture			
Poor pasture			
Reverting to weeds (rushes, gorse, scrub, etc.)			
Tussock land			
Woodland			
Exotic plantations	Blue/green	18	Conifer tree pattern
Mixed exotic and native forest	Blue/green	18	
Urban land			
Residential and industrial	Red	6	
Yards, quarries, cemeteries	Magenta	33	
Undeveloped land			
Scrub			
Including manuka (m); fern (f); gorse (g); hakea (h); swamp growth (s); lupins (l); alpine herbfield (a)	Grey	38	
Forest land	Dull green	45	
Barren			
Sand and shingle			Irregular dot pattern
Rock and scree			Shingle symbol
Snowfields	Pale blue		40 per cent screen of sea-blue tint
Lakes, rivers and reservoirs	Pale blue		Solid blue

	Colour name	Colour number	Symbol
Potential pastoral use of soils map			
Soils of flat and rolling lands			
With slight soil limitations to pastoral production and use	Yellow	3	
With moderate soil limitations to pastoral production and use	Brown	62	
With severe soil limitation to pastoral production and use	Red	6	
Soils of hilly and steep lands			
With slight to moderate soil limitations to pastoral production and use	Mid-green	26	
With moderate to severe soil limitations to pastoral production and use	Blue	8	
With severe to very severe soil limitations to pastoral production and use	Purple	15	
Land capability map			
Class 1. Very good arable land	Light-green	36	
Class 2. Good arable land with slight limitations	Yellow	3	
Class 3. Arable land with moderate limitations	Crimson	31	
Class 4. Arable land with severe limitations	Blue	8	
Class 5. Very slight erosion risk but not arable due to some limitations impracticable to remove	Mid-green	26	
Class 6. Land not arable but with moderate limitations	Orange	28	
Class 7. Not arable and with severe limitations to use	Brown	62	
Class 8. Land not suitable for crop, grazing or commercial forestry	Magenta	33	
Tenure map			
Freehold	Mid-green	26	
Endowment land	Bright green	36	
Land held by local or ad hoc *bodies*	Raw umber	37	
Maori			
Not leased and occupied by others	Orange/yellow	3	
Leased to Maoris	Orange/yellow	3	32-line vertical screen pattern
Leased to Europeans	Orange/yellow	3	32-line horizontal screen pattern
Active incorporations of Maori owners	Orange/yellow	3	15-line diagonal crossed-screen pattern
Crown leasehold			
Renewable Crown leases	Orange	28	
Pastoral lease and licences	Orange	28	+ "P.1" or "P. lic"
Special leases	Orange	28	+ "Spec. L"
Crown land unalienated			
Development blocks	Pink	4	+ Name
Other, including temporary or yearly leases	Pink	4	
Held by Departments:			
Lighthouse reserves (marine)	Pink	4	+ "M"
Schools (education)	Pink	4	+ "E"
Railway	Pink	4	+ "R"
Demonstration farms (agriculture)	Pink	4	+ "Ag"
Other	Pink	4	+ Name of department
Reserves			
Public recreation (including reserves, domains, public buildings, memorials, historical purposes, etc.)	Crimson	31	
Scenic and allied reserves (including wildlife sanctuaries, flora and fauna preservation areas)	Brown	62	
National parks			
Including wilderness areas within parks			Name of park
State forest land			
Provisional State forest	Violet	13	
Permanent State forest (including forest parks)	Purple	15	

	Colour name	Colour number	Symbol
Land-use map			
Primary production			
Intensive livestock			
Poultry, pigs, horse training etc.	Crimson	31	
Cropping			
Gardens	Orange/red	21	
Fresh vegetables, small fruits, grapes, nurseries	Orange/red	21	
Vegetable crops for processing	Orange/red	21	+ "V"
Hops or tobacco	Orange/red	21	+ "h" or "t"
Orchards:			
Pip fruits	Orange/red	21	+ "1"
Stone fruits	Orange/red	21	+ "2"
Citrus fruits	Orange/red	21	+ "3"
Cash cropping (grains, pulses, roots etc.)	Orange/yellow	3	
Mixed cropping farms (60 per cent of income)			
Cropping/sheep	Orange/yellow	3	+ "Cs"
Cropping/dairy	Orange/yellow	3	+ "Cd"
Sheep/cropping	Orange/yellow	3	+ "Sc"
Dairy/cropping	Orange/yellow	3	+ "Dc"
Dairying			
Town milk supply	Bright green	36	+ "TM"
Factory supply with pigs	Bright green	36	+ "P"
Factory supply without pigs	Bright green	36	
Dairy run-off area	Bright green	36	+ "RO"
Mixed dairy and fat lamb	Magenta	33	
Fat lamb with/without cattle	Orange	28	
Store sheep with/without cattle (hill country farming)	Raw umber	37	
Sheep for fine wool (South Island high country)	Yellow	1	
Cattle farms	Brown	62	
Other farms			
Small grazing areas, minor farms Unclassified land	Blue	8	
Forestry			
Exotic	Blue/green	18	Conifer tree pattern
Mixed exotic and native	Blue/green	18	
Production per holding			
Dairy farms (*butterfat production per acre*) (in pounds)			
Under 10,000	Blue		
Between 10,000 and 15,000	Magenta		
Between 15,000 and 20,000	Red		
Between 20,000 and 30,000	Brown		
Between 30,000 and 40,000	Yellow		
Over 40,000	Bright green		
Sheep farms			
With fewer than 500 ewe equivalents	Blue		15-line diagonal hatching
With between 500 and 1,000 ewe equivalents	Magenta		15-line diagonal hatching
With between 1,000 and 1,500 ewe equivalents	Red		15-line diagonal hatching
With between 1,500 and 2,000 ewe equivalents	Brown		15-line diagonal hatching
With between 2,000 and 3,000 ewe equivalents	Yellow		15-line diagonal hatching
With over 3,000 ewe equivalents	Bright green		15-line diagonal hatching
Mixed and arable farms			15-line horizontal hatching
Exotic forests	Blue/green		
Unproductive land	Grey		

	Colour name	Colour number	Symbol
Production per acre			
Dairy farms (butterfat production per acre) (in pounds)			
Under 100	Blue		
Between 100 and 200	Red		
Between 200 and 300	Brown		
Between 300 and 400	Yellow		
Over 400	Bright green		
Sheep farms			
With less than one ewe equivalent	Blue		15-line diagonal hatching
With between 1 and 3 ewe equivalents	Red		
With between 3 and 5 ewe equivalents	Brown		
With between 5 and 7 ewe equivalents	Yellow		
Withover 7 ewe equivalents	Bright green		
Mixed and arable farms			15-line horizontal hatching
Exotic forests	Blue/green		
Unproductive land	Grey		

SOIL DESCRIPTION OF PRAN RIVER PROJECT

Paper presented by Thailand[1]

Mapping units for this survey are based on the following three main features: soils, distinguished at the level of the great soil group found in the Pran Buri irrigation project; broad groups of parent material; Landforms, as expressed by the general topography.

In each mapping unit, inclusions are found and these inclusions will be specified as far as possible in the text. General topographic terms are used in accordance with the designated ranges of slope percentages as described in the United States Department of Agriculture *Soil Survey Manual* No. 18.

Regosols

Formation and environment

Regosols (1)[2] are soils derived from recent sediments, other than young water-deposited materials in flood plains. In this area, only regosols on beach and dune sand material have been observed. These sandy regosols are found mainly along the coast, occupying strips of varying width, usually narrow lands alternating with sandy to loamy lagoons or depressions between beach ridges.

The topography of the sandy regosol areas is generally flat to undulating with a distinct micro-relief.

Morphology and diagnostic characteristics

The regosols of the surveyed area have in common their sandy texture and their lack of profile differentiation. The horizon sequence is AL-C or A1-A3-Cg.

Texture of these somewhat older beach and dune sand soils is sand or loamy sand. The regosols are yellowish brown. The drainage of the regosols is excessive. The pH values of the young regosols are around 7.

Vegetation and land use

Most of the regosols areas have an open vegetation of low shrubs, bamboo clumps and cactus, with a sparse ground cover of short grasses. Coconut trees, cassava and other dry-land crops can be grown in areas where the ground water table is not too deep.

These mapping units are found as elongated bodies along the shoreline as well as on some older beach and dune areas situated further inland. The topography is flat to undulating with a micro-relief of alternating ridges and depressions. These units are easily drained because of the predominance of sandy soils.

The regosols are generally of the Hua Hin (Hh) series. Soils of this series are sandy throughout. Hh soils are yellowish brown and the pH is around 5. Hh soils are agriculturally poor, usually too dry.

Alluvial soils

Formation and environment

Alluvial soils are composed of young, water-deposited sediments usually found on the flat to concave or gently sloping flood plains of rivers, marine plains, lakes, deltas etc. The materials from which the alluvial soils have been derived vary considerably, both in composition and in texture.

Morphology and diagnostic characteristics

The common genetic soil horizon sequence is A-C or Ag-Cg, where g denotes the gleying in the profile. The alluvial soils in the areas studied have a pH 5–6.5. The calcareous or saline members of the tidal flat area usually have a higher pH value of 6.5–8. Lower pH values of

[1] The original text of this paper, prepared by the Royal Irrigation Department, Ministry of National Development, Bangkok, appeared as document E/CONF.52/L.26.

[2] Figures in parentheses refer to the entries in the annex.

3–4.5 are common for acid sulfate soils. The base saturation ranges from 70 to 100 per cent. The cation exchange capacity of the clay fraction for 100 gm of clay is mostly above 20 m.

Drainage conditions of the alluvial soils differ greatly. Most of them are clay, poorly drained, greyish colour with distinct mottling throughout the profile. Better drained, medium textured soils are found on river levees where the soil colours are usually brownish throughout or with mottling only at medium depth.

Vegetation and land use

Most of the alluvial soils are cultivated, mainly for rice except for the too acid or too saline soils of the coastal area and the deeply flooded soils near Sam Roi Yot. Grasses, rushes, mangrove forest, or halomorphic plants are found in the non-cultivated areas.

ALLUVIAL SOILS, UNDIFFERENTIATED, ON RECENT RIVER ALLUVIUM; FLAT TOPOGRAPHY (2)

This mapping unit is indicated in a limited area near Pran Buri, where the Pran Buri river plain widens considerably. The unit includes the levee soils as well as the river alluvial plains and basins. The drainage is poor to very poor on the average, with commonly silty to clayey textures. The topography is flat to concave with slight micro-relief in the levee area. The Muang series and Rat Buri series will be found in this mapping unit.

The Tha Muang (TM) series soils are the levee soils of the Pran Buri river. They have a silty loam to clay loam texture and are yellowish brown in colour. These soils are mostly well drained, but mottling sometimes occurs in the subsoil. The pH is about 7; small mica flakes are present throughout the profile. The Rat Buri (Rb) series soils are the clayey soils of the river flood plain, found behind the river levees. They are mottled throughout. The pH is about 7.

ALLUVIAL SOILS, NON SALINE, ON RECENT MARINE ALLUVIUM; FLAT TOPOGRAPHY (4)

This mapping unit is found in depressions at some distance from the shoreline which are not, or are very seldom inundated by the sea. The unit includes most of the elongated strips of rice fields found between the sandy beaches or dunes and a larger tidal flat area in the south of the Sam Roi Yot depression. The area has a flat to slightly concave topography. Poorly drained soils with a clayey texture throughout are dominant.

The Wan Praing (Wp) series soils are soils of the tidal flats of which at least the salt in the surface soil has been leached, although the subsoil may be and often is still saline. These soils are rarely flooded by salt water and then for only short periods.

The normal soil of this series is clayey throughout, mostly a heavy clay with dark grey to grey brown surface layers, varing in humus content and neutral grey to live grey colours, slightly mottled, in the subsoil. The pH is high throughout (more than 7) and very commonly shell fragments occur at medium depth, from about 40 to 70 cm. When the Wp series borders the higher beach or terrace formations, the surface soil is often sandy to some 10 to 30 cm depth, due to the action of waves along the coast of that time.

The main body of Wp soils in the Sam Roi Yot depression are separated in Wp series, low phase. The lower soils are more hydromorphic and flood deeply; thus they cannot be used for rice growing. The higher Wp soils are mainly under paddy land.

Where in use for paddy land, the Wp soils give excellent yields averaging 40 tang/rai (2,500 kg/ha) without any fertilizer application.

ACID SULPHATE SOILS, ON RECENT AND SEMI-RECENT BRACKISH ALLUVIUM, FLAT TOPOGRAPHY (5)

This mapping unit includes the area in the northern half of the Sam Roi Yot depression, which extends as far as the Pran Buri township and the area south of this depression in the vicinity of Pran Buri. The area has a flat to concave topography. Near the edge of the semi-recent terrace, the terrace is somewhat higher and slightly undulating. Soils are clayey, poorly drained and subject to deep flooding in some rainy seasons.

The Ongkarak (Ok) series soils are found in the alluvial Sam Roi Yot depression, somewhat north of Wan Priang village. These are soils formed on brackish water sediments in a marshy environment, and hence are acid (acid-sulphate soils). The Ok soils are not or are only weakly saline.

Ok soils are heavy clay soils with a black to dark grey, humiferous surface soil, usually from 15 to 30 cm thick. Below, the grey clay is strongly mottled with red and straw yellow (cat-clay). In most profiles, the cat-clay begins at less than 40 cm depth, but in the transitional zone to the Wan Priang series soils it begins below 40 cm. Usually the acid soil conditions continue to auger depth, but in some profiles the cat-clay layer is thinner. The pH values for the dry and moist soils are well below 5, or even below 3.5 in the layers with straw yellow mottling.

In the area of Ongkarak soils, some elongated low depressions have soils which are wet throughout the year, these soils being very muddy and soft. The pH values of the wet material may be as high as 7, but upon drying the material becomes very acid. These soils have been mapped as a low phase of the Ongkarak series.

The Ok soils flood deeply for several months during each year. This, and their poor quality, excludes them at present from agricultural use. Only in the somewhat higher areas, near the semi-recent terrace, is rice grown.

The Sam Roi Yot (Sy) series soils are soils of the semi-recent terrace, which have developed in a marshy, brackish water environment and hence are acid, showing cat-clay at some depth in the profile. They are situated in a long strip, marking the transition between the higher semi-recent terrace and the lower recent coastal plains.

Profiles are clayey, with a yellowish brown to dark grey brown, more or less distinctly mottled surface soil. Below, the matrix is greyish brown with strong red mottling and with the typical straw yellow "cat-clay" spots which begin at varying depths. Surface pH values are around 5.5; the subsoil pH decreases to 4.5 or 4.

Much of the Sy area is under paddy land, giving mediocre yields. Some areas which are situated higher are not cultivated and bear a vegetation of short grasses, bamboo and shrubs.

SOLODIZED SOLONETZ SOILS (6)

Formation and environment

Solodized solonetz soils commonly occur in dry zones. The occurrence of these soils is related to the presence of salts in parent materials. They are found on the clayey part of former estuaries and shores.

Morphology and diagnostic characteristics

The solodized solonetz soils show distinct profile differentiations. The A horizon clearly shows leaching. It is structureless and usually has a loamy sand to sandy texture. The texture of the Bt horizon normally is sandy clay loam. This horizon has an extremely hard consistency when dry. Mottling is stronger in the B than in the upper horizons, whereas the C horizon is strongly gleyed. The pH is usually about 5.0 to 5.5 in the upper part of the solum. The pH values relate to the salt content which increases sharply with depth.

SOLODIZED SOLONETZ, ON MARINE TERRACE SEDIMENTS WITH FLAT TO UNDULATING TOPOGRAPHY (6)

This mapping unit occurs in the area between the terrace formations and the recent alluvium in the middle and southern parts of the country. These strips of soils occupy a relatively low position and are usually poorly drained. The soils have a loamy sand to sandy loam texture with a heavier subsoil.

The Nong Kae (Nk) series are soils of the marine terrace. They have a sandy to loamy surface over a clayey subsoil. Usually the surface layer, up to a depth of about 40 cm of less, is composed of sandy to loamy material, grey brown with indistinct mottling. Below, the material is sandy clay loam to clay, grey and mottled, very hard when dry. This rather compact clay subsoil (Bt horizon) often contains lateritic concretions, but here and there numerous fragments of coral limestone are observed. The pH is mostly around 5 in the surface soil and 7 to 8 in the subsoil. At least part of these soils have solonetz characteristics.

The vegetation is predominantly composed of grasses with thorny shrubs and scattered trees. These soils are only rarely in use for agriculture. Rice fields are found in some lower and gently sloping areas, but these have a low productivity and are often abandoned due to the lack of water and/or the high salt content of the soil when submerged.

This mapping unit is found mainly in the eastern hill range which extends from the north to the Sam Roi Yot limestone area. The topography is hilly.

NON-CALCIC BROWN (7)

Formation and environment

The formation of these soils is generally determined by the parent material and the climate. The parent material is mainly acid to intermediate, with only limited amounts of dark coloured ferromagnesium minerals. The climate is normally dry, with a rainfall lower than 1,500 mm and with a long pronounced dry season.

Morphology and diagnostic characteristics

The non-calcic brown soils have A_1 and A_2 horizons with brown and yellowish brown colours respectively. Hardening of the A horizon usually occurs in the dry season. The profiles have a medium-textured surface soil with a heavier subsoil (Bt). The colour of the Bt horizon is yellowish to reddish brown. The blocky structure of the Bt horizon is moderately well developed.

The non-calcic brown soils generally have a high base saturation, increasing with depth; concurrently the pH values are above 5 in the surface layers and increase with depth.

These soils are mostly well drained.

NON-CALCIC BROWN SOILS, ON SEMI-RECENT RIVER TERRACE SEDIMENTS; FLAT TO UNDULATING (7)

This mapping unit is found on the flat to undulating terrains south of the Pran Buri river. In places, especially close to the hills, the relief is locally accentuated due to the presence of incised drainage valleys. The soils have a silt loam to sandy loam texture and are well to moderately well drained. Close to the hills the texture may become coarser, whereas along the transitional zone to the lower recent alluvial plain finer materials are common.

The Pran Buri (Pr) series soils are the dominant soils of the semi-recent river terrace and occupy the whole western zone of the area. The "model" Pr soils are medium textured (sandy loam to silt loam) in the surface horizon and somewhat heavier at medium depth (silty clay loam to silty clay). Sandler (loamy sand) profiles have been separately mapped as "Pr-sa". Colours are dark grey brown to dark brown in the surface layers, yellowish brown to dark brown in the sub-surface layers and yellowish brown to strong brown in the subsoil. Mottling is mostly absent, but in relatively low-lying profiles or in profiles with a finely textured subsoil and an impeded drainage, some mottling may occur. Mostly, the pH is more or less acid (around 5), but the surface soils usually have a pH from 6 to 6.5. Drainage is good to slightly impeded; in the latter part of the dry season these soils dry out deeply.

The Pr soils are excellent and are extensively used for field crops (sugar cane, corn, pineapple, castor beans) and tree crops (jack fruit, custard apple, kapok, coconut). The limiting factor for the productivity of these soils is lack of moisture; under irrigation they would be among the most productive soils in the country.

GREY PODZOLIC SOILS (10)

Formation and environment

Grey podzolic soils in the study area are formed on the old terrace formations north of the Pran Buri river. This old terrace plain has an undulating topography.

Morphology and diagnostic characteristics

A typical profile shows a weak horizon differentiation. The common horizon differentiation is A_1 (Ap) A_2–Bt. The colour below the weak and thin A_1 horizon is rather uniform, commonly light grey brown, but the material may become slightly redder or more yellow with depth. The alluvial B horizon is normally weakly expressed and may reach to a depth of 100 to 200 cm. Concretionary laterite layers occur in the profile between 1 to 5 m, but little laterite was observed in the surveyed area.

The pH values are mostly 4.5 to 5.5. Base saturation varies from 10 to 65 per cent but is normally low except in sandy profiles. The cation exchange capacity is often below 10 mm for 100 gm of clay.

GREY PODZOLIC SOILS ON MARINE TERRACE SEDIMENTS WITH UNDULATING TOPOGRAPHY (10)

This mapping unit is found on terrains with an undulating topography. It occupies the inter-mountain plain north of the Pran Buri river. The unit dominantly contains leached soils with a medium texture and moderately well drained.

The Sattahip (Sh) series soils have a fine sandy loam texture in the surface soil, which is light greyish to yellowish brown. The subsoil is fine, sandy (clay) loam and has a brown to yellowish brown colour. The pH value is around 6 at the surface, decreasing with depth to 4.5 to 5.0.

The Phattaya (Py) series soils are formed on sandy material (sand, loamy sand). The profile is weakly developed, brown to yellowish brown in colour. The pH values vary from 5.0 to 6.0.

Grey podzolic soils are mostly under open shrubs, with thoxay species, bamboo and some dipterocarp species. Shifting cultivation is commonly practised on the Sattahip series soils, whereas very little cultivation is found on the sandy Phattaya series soils.

RED-YELLOW PODZOLIC SOILS

Formation and environment

The red-yellow podzolic soils are found on residium and colluvium from quartzite, as well as phyllite and gneissic rocks, on and around hills and rock outcrops.

Morphology and diagnostic characteristics

The A_1 is moderately humiferous, over a somewhat lighter coloured and leached A_2. The Bt horizon normally has a sandy clay loam texture.

The pH values are mostly 4 to 5.5 in the subsoil.

The Tha Yang (Ty) series are shallow residual soils on hill slopes with gravelly material at less than 50 cm depth.

The Lat Ya (Ly) series are deeper soils on lower parts of the hill slopes, mostly on colluvial materials derived from acid parent rocks.

Vegetation and land use

Most of the red-yellow podzolic soils are under sparse forest and low shrubs.

LITHOSOLIC RED-YELLOW PODZOLIC SOIL AND LITHOSOLS; BED-ROCK PREDOMINANTLY GNEISS; HILLY TOPOGRAPHY (13)

LITHOSOLIC RED-YELLOW PODSDIC SOILS, BED-ROCK PREDOMINANTLY QUARTZITE AND PHYLLITE, HILLY TOPOGRAPHY (14)

This mapping unit occupies the whole western hill range. The topography is hilly. The area includes deeper colluvial soils on the lower hill slopes with gravelly, medium to fine textured soils and shallow, gravelly to stony soils higher up the hills.

Annex

AREA OF EACH GREAT SOIL GROUP UNIT, PRAN BURI PROJECT

Great Soil Group	*Area (in hectares)*
1	1,000
2	5,000
4	12,900
5	58,750
6	22,500
7	129,000
10	45,000
13	300
14	1,250
TOTAL	275,700

APPLICATION OF CARTOGRAPHIC TECHNIQUES TO REGIONAL SURVEY IN AUSTRALIA

Paper presented by Australia[1]

INTRODUCTION

Adequate knowledge of present land resources is essential for the planning and undertaking of economic development. Countries with highly developed economies already have a great fund of knowledge and experience of their land resources which can be utilized in planning still further development. Sparsely settled countries or those with a traditional peasant economy, on the other hand, have much less information on the nature of their environment, at least in a form which can be used in planning and modern development. (It should not be forgotten that most peasant economies show a high degree of adaptation to, and knowledge of resources available at their level of technology.) Consequently there is a need in developing countries for regional surveys which will produce, comparatively rapidly, maps and memoirs to show the distribution and nature of the land resources of a given area, together with some assessment of likely lines of development.

In this context, "land resources" comprise soil, natural vegetation, relief, climate and, to a certain extent, hydrology. Other land resources, such as minerals, animals and human populations are considered only incidentally in these surveys.

The present paper gives an outline of regional surveys in northern and central Australia, carried out by the Land Research Division of the Commonwealth Scientific and Industrial Research Organization (CSIRO), illustrates some of the practical achievements and problems with reference to one particular survey (the Tipperary area in the Northern Territory; see figure I below) and concludes with a discussion of some of the more strictly cartographic aspects of the work.

Almost all the surveys in Australia have been carried out in the sparsely settled central and northern parts of the continent where man's impact on the landscape has been modest and where the country is still largely in its natural state. The terrain consists of plains and undulating lowlands with limited hill and mountain areas. It is mainly covered by open woodland or grassland and experiences tropical sub-humid to semi-arid climates with summer rainfall maxima. Sufficient tracks usually exist for adequate access, although 4-wheel-drive vehicles are necessary. The areas surveyed have ranged from 1,500 to 144,000 square miles with the associated field work lasting from two weeks to eight months.

The surveys are carried out by a team of three scientists (geomorphologist, pedologist and ecologist) working in close collaboration and using air photographs as their basic tool. The surveys are based on the fact that each type of country corresponds to a distinct pattern on the air photographs and the work consists essentially of identifying, describing and mapping these patterns. The results of the survey are incorporated in a map and a report which describes the various types of country, in their natural state

[1] The original text of this paper, prepared by R. W. Galloway, Division of Land Research, Commonwealth Scientific and Industrial Research Organization (CSIRO), appeared as document E/CONF. 52/L.60.

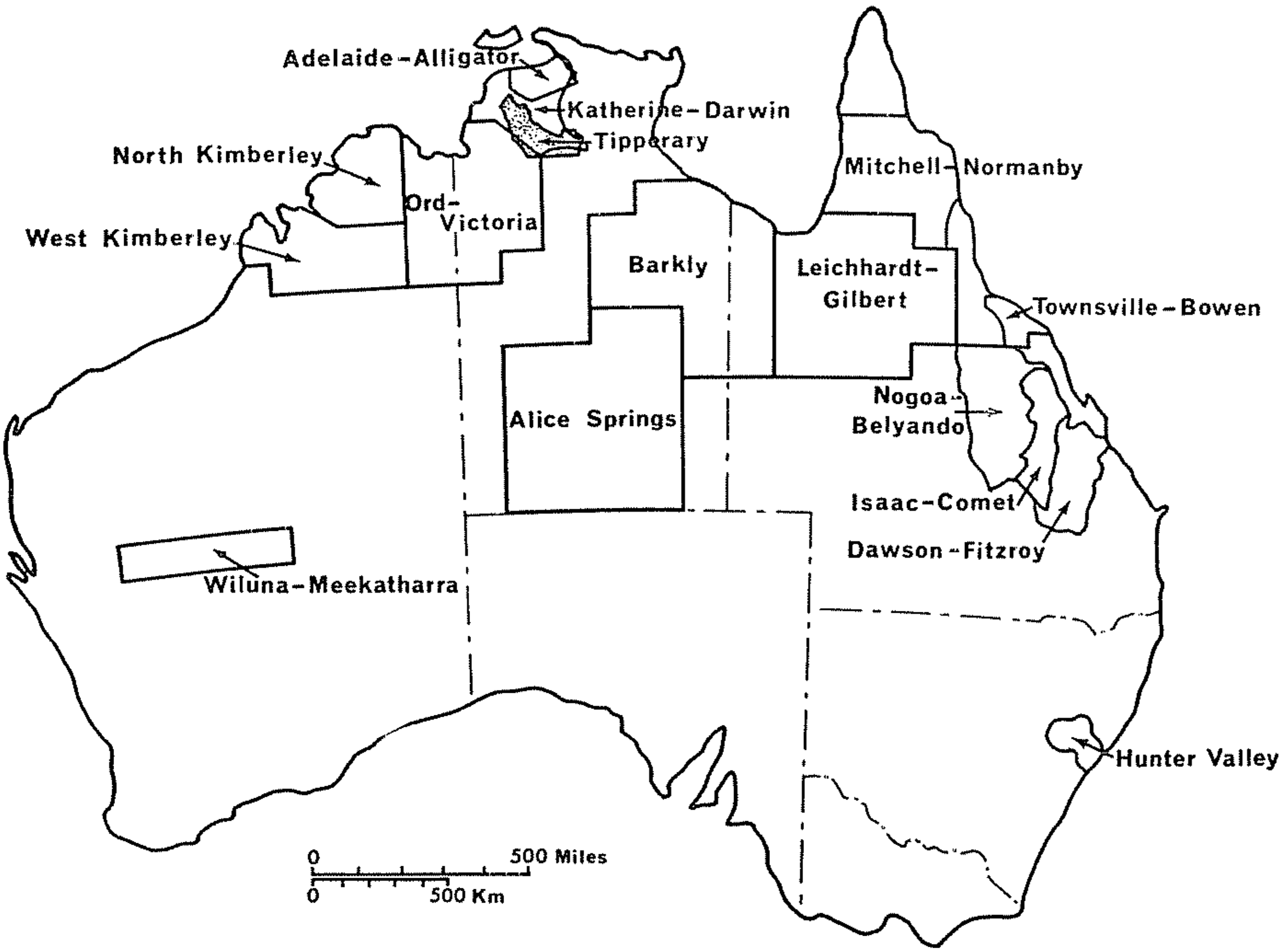


Fig. I—Australia: Areas surveyed by the Division of Land Research, CSIRO, since 1946

as far as possible, and gives further information on specific aspects of the soil, vegetation and landforms. Some account of the climate, the impact of human settlement and the pastoral and agricultural resources of the area is also given.

Survey procedure

There are five major stages in carrying out a survey. They will be considered in turn.

Choice of area and scale of operation

Requests for surveys are usually made to CSIRO from state governments seeking to know more about the less closely settled parts of their states. The extent of the area and intensity of the survey are determined in relation to available resources in men and money and the expected time of publication and degree of detail of the survey.

Preliminary assessment of available data

The most important part of this stage is the preliminary examination of the air photographs. The dominant photographic patterns are defined and assessments are made of what they mean in terms of landform, soil and vegetation. A preliminary map of these patterns may be made to show the extent and inter-relationships of the various types of country. Sites for detailed field investigations are selected within each pattern, if possible at points readily accessible from existing tracks. Traverses usually some 300 miles long, and lasting five or six days, are planned to link these sites and to give as good a general cover of the whole area as possible. If time and resources permit, a rapid preliminary field reconnaissance of the area may be made.

During this period, also, the available topographic and geological maps are studied and literature pertaining to the area is reviewed. Climatic data are assembled with a view to preparing an account of the climate, and records of the history and settlement of the area are briefly summarized. Since the underlying rocks are a major factor in determining the nature of the country, particular care is devoted to assembling all relevant geological information. In areas where no adequate geological information exists, a geologist is usually added to the field team. Elsewhere the geomorphologist is responsible for recording the geology.

Field work

In the field, the party travels in 4-wheel-drive vehicles along the previously planned traverses and thus sees and samples most of the elements comprising the main photographic patterns. The air photographs are used continuously for navigation and great care is taken to ensure that all sites observed on the ground are pin-pointed exactly on the correct pattern on the photographs. On a typical day, a dozen sites will be examined during a traverse of 50 miles. As knowledge of the area is built up, some of the original sites chosen for detailed investigation may be deleted and others substituted. At each of these sites, the scientists examine a small area, usually from one-half to two hectares, in close co-operation, and build up a comprehensive picture of the landform, soil and vegetation at that point and hence at all points where an identical photographic pattern exists. Since these three aspects of land are intimately interconnected, by working in conjunction each scientist gains much from his colleagues.

Each scientist also endeavours to understand the reasons for the distribution and the facts he observes within his own discipline so that he can interpret photographic patterns in parts of the area he has not visited with a greater confidence based on knowledge of the genesis of the landscape. For instance, the botanist may find a certain type of vegetation confined to areas subject to occasional flooding and so the distribution of flooding may be estimated, provided the relevant vegetation can be seen on the air photographs. Similarly, the pedologist can predict the soil distribution with greater accuracy if he has a knowledge of the catena relationships within the area.

In recent years, increasing use has been made of helicopters. The scientists and possibly a field assistant travel in the helicopter while a small supporting party with one or two vehicles carrying fuel, supplies and camping gear makes use of the existing tracks and sets up temporary base camps at appropriate locations. The use of a helicopter enables a survey to be carried out in a shorter time for the same expenditure. Since helicopters are an expensive method of transport with limited range, their use requires careful pre-survey planning and tight control of operations in the field. While vehicle traverses give more detailed information on the country between observation sites, helicopter traverses are not restricted to the available tracks and any photographic pattern can be investigated, provided landing sites exist. Thus helicopters are especially valuable in trackless, undeveloped country.

Preparation of map and report

On returning to base, the preliminary mapping is reviewed and corrected in the light of the information gained in the field. Descriptive tables are drawn up for each type of country that has been mapped and chapters written covering the geology, geomorphology, vegetation, soils and pastures of the area. Block diagrams are used to illustrate each type of country and to show the relationship of the component parts to each other and of the relief to the underlying geology (see figure II).

The final mapping of types of country is done stereoscopically on the air photographs. Each major photographic pattern is delineated in chinagraph and code letters summarizing the relief, soil and vegetation are appended. The mapping is done with Old Delft scanning stereoscopes, which have the great advantage of allowing two scientists from different disciplines to work together on the same photograph and so rapidly draw mutually satisfactory boundaries. A map is finally prepared from these marked photographs. A description of the climate, emphasizing agroclimatic aspects, is prepared from the available data by another section of the Division of Land Research. The data for these climatic analyses can now be rapidly prepared by using semi-standardized computer programmes.

Finally, the report and map are edited and printed. This step can take as long as or longer than the rest of the survey.

Distribution and utilization of the survey results

This fifth and final stage is a vital part of the whole procedure. A survey should not be an end in itself or a status symbol conferring some mysterious advantage on the area surveyed and the country which has carried out the survey. Unless the results are used, it is a waste of money. There have been instances of regional surveys made at great expense and then immediately locked away because they are regarded as military secrets.

There are four main avenues of utilization of surveys by the Division of Land Research. First, they supply necessary information for further research. Within the Division of Land Research, they are used in assessing the economics of agricultural development in poorly developed parts of the area and as a basis for pasture studies; other divisions within CSIRO use the information in their studies of soil, pasture, vegetation and road-making. Outside CSIRO, a wide range of research organizations such as state forestry, irrigation and agricultural services, museums and military terrain study groups use the information to further their investigations.

Secondly, survey information is used by local agricultural extension officers to further their understanding of their area. As a rule the survey reports are too broad for such local use but we can supply 1 inch to 1 mile or 1:100,000 photo-mosaics of smaller areas, with our information on soils, vegetation and landforms superimposed.

A third main avenue of utilization is in administration. The survey reports are used to assist in making decisions on the feasibility of proposed developments and the best ways of carrying them out. The survey data make a not inconsiderable contribution to the inventories of still larger areas prepared by the Resources Information Branch of the Department of National Development. These inventories are used in planning at the national level.

Fourthly, survey reports have a wide circulation (about one-third of the total) in the educational field. A considerable number go to university departments of geography in several countries and so promote knowledge of Australia. University departments of economics, agriculture and forestry also receive the reports.

In order to encourage the utilization of the reports, officers of state government departments and local development organizations are conducted round the survey area for a few days immediately after the survey in order to demonstrate the major findings. Furthermore, during the actual survey, an officer from these departments may be attached to the party and may fill one of the scientific posts.

SURVEY STAFF

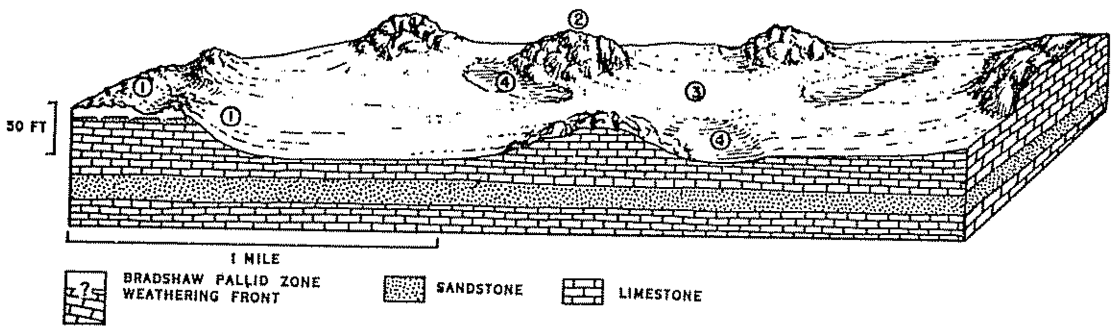
The three scientists form the essential nucleus of the survey team and one of them is appointed team leader with general responsibility for the operation of the survey. The staff are already trained in their individual disciplines before appointment and in the Australian context are usually recruited overseas. Of the dozen or so field scientists at present directly employed in regional surveys by the Division of Land Research, only two are Australian-trained. Survey methods and knowledge of the specifically Australian aspect of the various disciplines are acquired on the job, with no formal training. It is clearly necessary to have at least one scientist experienced in survey methods on the team. Successful photo-interpretation for regional surveys is largely a matter of experience and the use of two stereoscopes scanning the same photograph enables one worker

(15) Budbudjong Land System (90 sq miles)

Undulating limestone terrain with savannah woodland and grassland. Tropical tall grass country. Mainly tropical tall grass pastures on loamy red earths mixed with outcrop, only scattered areas of arable soils (estimated 15 sq miles).

Geology.—Gently dipping Cambrian limestone with some sandstone; minor silicified pallid-zone rock.

Geomorphology.—Eroded below the Tipperary surface — undulating terrain: scattered outcrop hills up to 40 ft high, with intervening lower slopes and very shallow depressions, and with gently sloping crest surfaces at the upper margin; surface drainage absent; relief up to 50 ft.



Unit	Area	Land Forms	Soils	Vegetation
1	Small	Crest surfaces: stony slopes mainly less than 2% and up to 2½ miles long; dissected margins comprise rocky slopes up to 10% with bouldery outcrops up to 20 ft high	Reddish loam over red clay (Tippera), commonly shallow; skeletal soils and outcrop on marginal slopes	Savannah woodland 25–35 ft (*E. foelscheana*, *E. confertiflora*, *Bauhinia cunninghamii*), sparse tropical tall grass (*Sehima nervosum*, *Themeda australis*, annual sorghum). Deciduous woodlands on bouldery outcrops
2	Medium	Rocky hills: bouldery outcrop slopes up to 50%, locally vertical; pitted and fluted rock surfaces	Outcrop and pockets of skeletal soils	Deciduous woodlands 15–25 ft (*Bauhinia cunninghamii*, *Gyrocarpus americanus*, *Owenia* sp., *Ficus* sp., *E. confertiflora*), with moderately dense shrub layer (*Buchanania obovata*, *Terminalia* spp., *Planchonia careya*, locally *Cycas media*) and sparse tropical tall grass (annual sorghum)
3	Very large	Lower slopes: less than 0·5% and up to ¼ mile long; firmed surfaces with scattered, low outcrop and cobble patches	Mainly reddish loam over red clay (Tippera); some Elliott and scattered outcrop	Savannah woodland 25–30 ft (*E. foelscheana*, *E. tectifica*, *E. argillacea*, *Erythrophleum chlorostachys*), with dense tropical tall grass (*Themeda australis*, *Sorghum plumosum*, *Sehima nervosum*)
4	Very small	Depressions: up to ¼ mile wide; hummocky, cracking surfaces with microrelief	Dark cracking clays (Cununurra)	Grassland, tropical tall grass 7–10 ft (*Sorghum plumosum*), with sparse trees and shrubs

Fig. II—Australia: Typical table and block diagram used to describe and illustrate a land system

to communicate to another the benefits of his experience in interpreting photographic patterns. In addition to the scientists, there is a wide range of supporting staff and services. A scientific assistant, a mechanic and a cook constitute the minimum staff requirements in the field. In the office, draftsmen, typists and photographic and editorial staff are required. In addition, a climatologist, a hydrologist and an economist may contribute to the report, while the study of field samples requires herbarium and laboratory facilities.

Survey work often reveals problems of purely scientific interest and it is usually arranged for the scientific staff to work on those problems in their own disciplines for a period after the conclusion of the survey. This not only furthers scientific knowledge but also plays a considerable part in attracting and retaining scientists of suitable calibre. Emergent countries seeking to recruit trained staff might do well to emphasize the opportunity of working in scientifically little known environments as a means of attracting suitably qualified and enthusiastic applicants.

Future developments

Regional surveys by the Division of Land Research have been carried out for twenty years in northern and central Australia. During that time, the efficiency of the team and accuracy and information content of the surveys have improved through better equipment and planning, greater attention to detail and more experienced teams. Some of the very extensive earlier surveys will require resurveying in greater detail of parts of particular significance.

While there is still room for further improvement on the traditional methods, major changes may be introduced through new means of acquiring, storing, correlating and reproducing the information. At present all surveys depend on general-purpose black-and-white air photographs, which are used by a wide variety of other agencies. In future, however, if financial limitations do not prove too severe, more specialized types of photographs may be used, such as radar photography, photography at wave-lengths chosen to emphasize diagnostic features of the landscape, and earth satellite photographs. Automatic electronic photo-interpretation does not seem likely to be a useful technique in the foreseeable future, although further investigation is required.

Storage of field data on cards or magnetic tape and computer analysis of the results is now being investigated. It requires more quantified field observations in the various disciplines, which in the past have depended partly on qualitative studies. It should enable quantitative correlations between numerous discrete field observations to be made, thus improving the accuracy of the survey, the understanding of the country and the quality of the individual scientific studies.

A typical survey: the Tipperary area, Northern Territory

The area lies 100 to 300 miles south-east of Darwin and covers 7,500 square miles. The survey re-examined part of the area covered by a much more extensive earlier investigation. It was requested by the Northern Territory administration to assess areas in which the findings of the agricultural research stations at Katherine could be applied.

It was decided that the final map should be published at a scale of 1:250,000 and the report should be ready for printing within two years of the commencement of the survey. The team comprised three scientists plus a supporting staff of four. A pedologist from the Northern Territory administration was attached for the field work and part of the subsequent mapping in the office. Six vehicles were required, one of which formed the nucleus of a fixed base camp.

Before the field period, some 700 air photographs at scales of 1:50,000 and 1:30,000 were examined and ten traverses linking about 300 areas of detailed observations were planned. Pre-field work investigation and planning occupied about three months, the field work occupied ten weeks and post-field-work mapping, description and report-writing took eighteen months up to the point when the manuscript left the division for final editing and printing in Melbourne. Twenty major types of country, each comprising four to eight sub-types, were mapped and described.

The total cost of the suvey is not easily computed since many of the personnel involved were also engaged in other projects during the same period and the share attributable to this survey cannot be accurately assessed. The analysis of costs in the table below is only a very rough approximation. By far the greatest proportion of the costs is in the form of salaries; printing, administration, transport and aerial photography costs are much lower. Of course, if special air photography had had to be flown for the survey, that item would have been much more expensive.

Approximate costs of Tipperary survey

Salaries	
Scientific staff	$A30,000
Supporting staff (field, laboratory and office)	15,000
Transport (vehicles)	
To and from survey area (6,000 miles)	4,500
During actual survey (3,000 miles)	2,000
Air fares to and from survey area	1,500
Post-survey tour for local government officers	500
Supplies and equipment	
Food	1,000
Equipment	1,000
Air photographs and maps	500
Rent, administration and miscellaneous costs	12,000
Printing and distribution of survey reports (4,000 copies)	12,000
Total	$A80,000

Some cartographic aspects

Much of the survey work is dominated by considerations of scale. Because the scale of the final map is too small to show each individual type of country, and because the scale of operation is such that detailed descriptions are not possible, a complex mapping unit is used in which smaller, simpler units of country are found in regular association with each other. This complex is termed "land system" and has been defined as an area or group of areas throughout which a recurring pattern of topography, soils and vegetation can be recognized. For instance, a piece of country may comprise rocky ridge crests, steep upper slopes with shallow soils, gentle colluvial lower slopes with deep soils, and alluvial flats in the valley bottoms; none of these small units can be mapped individually but the area throughout which they occur together in the same relationship can be mapped as a land system.

Because the map scale is usually 1:250,000 or 1:1,000,000, no tract of country less than ½ or 2 km wide respectively can be shown. This means that, on the usual air photographs at scales of 1:50,000 or 1:85,000, patterns less than 1 or 2 cm wide cannot be mapped but must be considered as elements of some larger, more complex pattern. Consequently, simple methods of transferring boundaries from air photographs to base map give fully acceptable accuracy, provided the topographic base is of good quality. Slotted template methods are not required.

The topographic base is supplied by the Department of National Development (Division of National Mapping) and shows streams, main roads and major settlements. As a first step, photo boundaries are transferred by eye to semi-controlled 1:63,360 or 1:100,000 photo-mosaics, which are then reduced photographically to the final mapping scale. The mapping boundaries on these reduced mosaics are then transferred by tracing to the base map, using topographic detail such as major streams as a guide.

Air photographs available in Australia range from 1:15,000 to 1:85,000. The most suitable scales for these surveys are 1:50,000 and 1:85,000; with larger scales, the significance of major patterns is lost, the wood can literally not be seen for the trees, and the number of photographs required for a survey reaches astronomical proportions. Obviously, more detailed surveys of smaller areas would benefit from the use of larger scale photographs.

SALIENT FEATURES OF TAIWAN'S AGRICULTURAL LAND CONSOLIDATION PROGRAMME

Paper presented by China[1]

Agriculture in Taiwan is based on small holdings. Farm plots are small and irregular; holdings are scattered over many places; easy access in the countryside is lacking and drainage and irrigation are inadequate and inconvenient. All these factors render it difficult to maximize the use of the potential resources of the agricultural lands and to improve the farm structure for the modernization of agriculture. The agricultural land consolidation programme now launched in Taiwan is intended to improve these uneconomic production conditions and the defective farm structure. The purpose of the programme is to amalgamate the tiny and irregular farm plots, to enlarge them, to pool the scattered farm holdings and consolidate them by exchange, to build farm roads for easier and better field transportation and to construct new irrigation and drainage systems for better irrigation and effective drainage. In this way the entire production environment can be improved, the farm structure modernized, agricultural resources fully utilized and the economic and social welfare of the rural community enhanced.

Taiwan is now also making efforts to develop and utilize its water resources. The Government is building reservoirs and tapping groundwater to increase the supply of irrigation water; it is also lining irrigation canals and consolidating fragmented farm holdings to economize the use of irrigation water. In this way, land consolidation helps also to promote the economic use of water resources in agriculture.

Taiwan has a total of 872,000 hectares of farm land, of which 529,000 hectares are irrigated and 343,000 are not. In the irrigated area, irrigation and drainage facilities are inadequate. Such conditions have to be improved during the consolidation by the establishment of more effective systems. In Taiwan, the fallow season on irrigated land is very short, usually only three months between the harvesting of the first crop and the planting of the second. Therefore, during the consolidation, all engineering work in connexion with the building of irrigation systems and farm roads must be completed within those three months and the engineering planning for roads, canals and the remodelling of farms must be closely co-ordinated with the harvesting and planting seasons. To meet these needs, the land consolidation programme in Taiwan must take into consideration not only the technical requirements for consolidation but also the time requirements for farming.

The programme costs for land consolidation are of two kinds: one entirely borne by the Government and the other shared by farmers and Government. The average cost of the former is about $NT400 ($US10) per hectare; that of the latter is about $NT4,000 ($US100) per hectare, which was shared by the Government and the farmers before 1963 and has been entirely borne by the farmers since then. Of this cost, 50 per cent is to be met by farmers with a loan extended by the Government at 6 per cent annual interest to be redeemed in five years. With the production on most of the consolidated farms increased after consolidation, most farmers are duly paying the loan according to schedule. The area of land consolidated therefore expands year by year, from 3,362 hectares in 1961 to 90,000 hectares in 1964. These developments demonstrate the economic benefit of the land consolidation programme in Taiwan.

In Taiwan, land consolidation projects are sponsored and implemented on a voluntary basis. To sponsor a project, agreement by 50 per cent of the local farmers is the minimum requirement. Farmers also choose their representatives to participate in the programme planning and land evaluation. All approved plans, including consolidation, exchange and redistribution of lands and programme financing are publicly announced during the course of one month. These plans can be revised when 50 per cent of the owners so request.

The exchange and consolidation of farm holdings is effected on the basis of the men who farm or operate the land rather than of those who own it. Scattered holdings are consolidated as much as possible. Since most farm holdings are small, consolidation and exchange in large areas is done in sub-sections in order to secure co-operation from farmers. In principle, each redistribution area is set at 100 hectares and, within such an area, holdings of each farm operator must be consolidated in one place by moving small plots towards larger ones and distant plots towards plots close to the farmer's home.

In view of the economic benefits flowing from the agricultural land consolidation programme and farmer co-operation in the programme, the Government plans to expand the programme by co-ordinating it with all programmes of land development, land-use improvement (such as programmes for irrigating dry land; for developing single-crop into double-crop fields and three-year one-crop fields into three-year two-crop fields, etc.) and the improvement of hilly land.

Table 3. Working schedule of the agricultural land consolidation programme in Taiwan

Fiscal year	*Acreage planned for consolidation (hectares)*
1962	4,527
1963	15,539
1964	18,982
1965	22,068
1966	25,000
1967	30,000
1968	36,000
1969	42,000
1970	50,000
1971	51,705
Total	300,000

Remarks:

The 817 hectares consolidated in 1959 and the 3,362 hectares consolidated in 1960 are not included here.

From 1959 to 1965, a total of 65,295 hectares of agricultural lands were consolidated.

The yearly goal set forth here may be revised when landowners request that their holdings be consolidated earlier than scheduled.

The original working schedule was revised after 1962. But this schedule still sets forth 300,000 hectares as the programme goal to be achieved by the end of 1971.

[1] The original text of this paper, prepared by C. L. Chen, China Research Institute of Land Economics, and submitted under agenda item 9 (*b*) and (*d*), appeared as document E/CONF.52/L.84 and Add. 1.

Table 1. Progress of land consolidation programme in Taiwan (as of May 1966)

Fiscal year	Acreage planned	Acreage consolidated	Irrigated land: Sub-total	Irrigated land: Co-ordinated with Land Bureau's rotational irrigation scheme	Irrigated land: Co-ordinated with PWCB's rotational irrigation programme	Irrigated land: Co-ordinated with flood rehabilitation programme	Irrigated land: Co-ordinated with reclamation	Dry land sub-total	Programme expenditure Unit: ($NT) hectare: Total	Programme expenditure: Engineering expenditure (on irrigated land only)	Programme expenditure: Operational expenditure
1960	817	817	817	—	—	817	—	—			
1961	3,362	3,362	3,362	—	3,056	—	306	—	18,531,802.00	17,187,002.00	1,344,800.00
1962	4,527	4,527	4,527	2,971	1,155	—	401	—	16,125,025.36	14,314,225.36	1,810,800.00
1963	15,390	15,539	5,724	3,211	1,653	—	860	9,815	25,338,805.73	20,104,705.73	5,234,100.00
1964	20,000	18,982	7,912	3,343	1,943	1,951	675	11,070	50,727,260.72	44,241,460.72	6,485,800.00
1965	22,000	22,068	11,625	4,671	4,850	—	2,104	10,443	54,000,068.53	46,217,168.53	7,782,900.00
SUB-TOTAL	66,096	65,295	33,967	14,196	12,657	2,768	4,346	31,328	164,722,962.34	142,064,562.34	22,658,400.00
1966 GOAL	22,979	In progress	14,082	9,803	3,344	—	935	8,897			7,412,200.00
TOTAL	89,075		48,049	23,999	16,001	2,768	5,281	40,225			30,070,600.00

Source: Prepared by Farmers' Service Division, JCRR.

Table 2. Agricultural land consolidation projects in Taiwan completed, by region and showing acreage (fiscal years)

Unit: hectare

County	1960 Region	1960 Acreage	1961 Region	1961 Acreage	1962 Region	1962 Acreage	1963 Region	1963 Acreage	1964 Region	1964 Acreage	1965 Region	1965 Acreage	Total Region	Total Acreage
Taipei Hsien	—	—	—	—	1	426	—	—	—	—	—	—	1	426
Yilan Hsien	—	—	1	163	—	—	—	—	1	286	2	462	4	1,091
Taoyuan Hsien	—	—	—	—	—	—	—	—	2	425	2	400	4	825
Hsinchu Hsien	—	—	1	58	—	—	—	—	1	197	1	42	3	297
Miaoli Hsien	2	198	—	—	3	515	1	425	2	233	1	541	9	1,912
Taichung Hsien	2	202	—	—	1	1,329	4	489	3	1,479	2	1,172	12	4,671
Changhua Hsien	2	194	—	—	1	300	3	924	3	2,217	2	1,989	11	5,624
Nantou Hsien	1	49	—	—	1	401	2	205	1	242	1	90	6	987
Yunlin Hsien	1	127	2	785	1	887	8	1,809	8	3,736	6	2,984	26	10,328
Chiayi Hsien	1	47	2	776	1	268	5	2,395	6	1,761	6	2,891	21	8,138
Tainan Hsien	—	—	1	320	—	—	6	2,163	6	1,649	9	3,299	22	7,431
Kaohsiung Hsien	—	—	1	685	—	—	6	1,332	5	1,489	7	2,603	19	6,110
Pingtung Hsien	—	—	—	—	—	—	10	3,154	9	3,661	7	2,163	26	8,978
Taitung Hsien	—	—	2	306	2	401	2	527	3	865	3	774	12	2,873
Hualien Hsien	—	—	1	269	—	—	3	1,555	1	742	6	2,478	11	5,044
Kaohsiung City	—	—	—	—	—	—	1	560	—	—	—	—	1	560
													23*	14,082*
													55*	25,216*
Total	9	817	11	3,362	11	4,527	51	15,539	51	18,982	55	22,068	266	104,593

* Completed in 1966.

Note: 1,596 maps were made of 266 regions, including reconnaissance maps, topographic maps, and maps of farm road and irrigation system, geographical surveys, land distribution and cadastral planning after consolidation at scales of 1:1,200 to 1:5,000.

LAND-USE SURVEYS

Paper presented by China[1]

As the Second World War had taken a heavy toll of the world's natural resources and as the rehabitation of the devastated nations and the industrialization of under-developed areas would require additional resources, an international scientific conference was convened by the United Nations in 1949 to promote the conservation and proper utilization of natural resources essential to world peace and prosperity.

The conference discussed in detail the methods and techniques of resources appraisal, and came to the conclusion that major projects had been wastefully undertaken in the absence of adequate surveys. For that reason, projects of resources improvement could hardly be successful. It was apparent that the degree of success of resources development projects was largely dependent upon the amount of basic information available during the planning stage, which must have the benefit of a full knowledge of the existence, character and extent of the resources. It was recognized by the conference accordingly that the order of procedure for the scientific conservation, utilization and development of resources was: (*a*) resources survey; (*b*) resources appraisal; (*c*) planning on the basis of such appraisal and (*d*) execution of the project.

In its resolution 614C (XXII), dealing with resources surveys, the Economic and Social Council drew attention to available information regarding techniques of resources surveys which had proved useful in practice.

The object of a resources survey may be defined as being the scientific identification, location and recording of the existence, character and extent or quantity of such resources, in order to meet planning needs for resources development. Such a survey should be concerned with: (*a*) topography, which provides a knowledge of the earth's surface and is the basis for all other resources surveys; (*b*) geology or surface geology; (*c*) soil; (*d*) hydrology; (*e*) vegetation and (*f*) animal life, including insects, fish, etc. The data concerning resources so presented may be expressed in various ways—by language, by number and by maps. Since it is important not only to record the existence, character and extent of these necessary resources facts, but also their location, maps afford the best means.

In view of the great importance placed on resources surveys for the development of resources, the China Research Institute of Land Economics, a research organization of twenty-five years' standing, has undertaken research and training in the techniques of resources survey and cartography. Graduate-level courses on resources survey and cartography have been offered since 1959. A cartography laboratory is about to be established and a draft of uniform regulations to be used as a guide for technical practice of resources surveys has also been worked out.

[1] The original text of this paper, prepared by the China Research Institute of Land Economics, appeared as document E/CONF. 52/L.112.

A demonstration project on research in techniques and methods for resources survey has been carried out since May 1966 and is summarized below.

Total area

An area of 100 km^2 to be covered by one map sheet at 1:25,000 scale.

Experimental land resources surveys

Land classification survey: geomorphological research, including drainage system, valley and gully density and gradient distribution; surface geological survey; soil survey, including physical and chemical analysis.

Land-use survey and research on land use, including paddy field, upland field, forest area, grass land, pasture land, salt-bed, fish culture area, barren land, city and town area, communication installation, land improvement and land conservation facilities, mines, power plants, weather and water observation posts, garden frames and special land features. Descriptions of landform and discussions of relations between landform, disaster, and land use are included.

Maps and explanatory text

Landform classification maps, with geomorphological profile; gradient distribution maps; drainage system and water-use maps; drainage density maps (on the same sheets as drainage system maps); surface geological maps; soil maps; detailed land-use maps margined with climate and river-water tables; explanatory text.

The maps listed above have been drawn by the scribing method and will be reproduced in multicolour next year.

Procedures and methods

Land classification survey—Provisional survey: data collection and analysis, identification by aerial photo-interpretation; field compilation: check and revision, geomorphological research; final editing: compilation, drafting.

Land-use survey—Preparatory research: data collection, including air photographs, previous maps, administrative boundaries, reference publications, data analysis, provisional classification of land-use types by photo-interpretation; field survey: supplementary collection of data, check and revision of provisional classification, detail classification of land-use types; final compilation; compilation on topographical maps.

The surveys and analyses for the planning of the agricultural, industrial and commercial developments in this area are still in progress.

A sample land-use map, with legend is appended for reference.*

* See pocket at end of volume.

PROGRESS AND UTILIZATION OF LAND-USE MAPS IN JAPAN

Paper presented by Japan[1]

PROGRESS OF LAND-USE MAPS

Twelve sheets of the land-use map series at 1:200,000 scale covering Hokkaido were prepared from fiscal year 1962 to fiscal year 1966. An explanatory note for this map series was also prepared for each district of the region. Hokkaido is the frontier region of Japan, including the least developed and most sparsely populated areas. The sheets were revised in 1966. In view of numerous cultural changes in various areas during the past few years, revisions will be made by utilizing new source data and aerial photography. In addition, the compilation of an atlas of the land-use of Hokkaido based on the 1:200,000 series is scheduled in 1967.

Ten sheets of the 1:50,000 land-use map series covering seven of the proposed areas were prepared in fiscal years 1964 and 1965. These areas are known as the "new industrial cities" or "local development cities" under the national multipurpose development plan. So far, 304 sheets of the 1:50,000 series have been completed. They cover more than one-third of Japan, excluding Hokkaido. These sheets were not published for general use and are currently for government use only.

In addition, similar land-use maps were published by various local governments. For example, the land-use map of the Hanshin metropolitan region at 1:50,000 was published by the Osaka city government in 1958. The Tokyo metropolitan land-use map at 1:30,000 was published by the Tokyo metropolitan government in 1960. The land-use map of Osaka at 1:50,000 was published by the Osaka prefectural government in 1960 and the land-use map of the capital region at 1:200,000 scale was published by the Capital Region Development Commission in 1964. In present-day Japan, land-use maps are required in cities and industrial areas in order to make new development plans in accordance with the promotion law of new industrial city construction. Therefore the Geographical Survey Institute plans to prepare land-use maps of these areas at 1:50,000 or 1:25,000 within the next several years.

In the compilation of land-use maps, it is preferable that aerial photographs should be taken at least one year prior to the execution of land-use surveys. The Geographical Survey Institute presently takes aerial photographs for urban areas every three years, and for other flat and mountain fringe areas every five years. The specifications for the land-use map series were established in 1953. They are somewhat outdated now. These specifications are being reviewed to meet current changes and to be adapted to the surveys used in conjunction with photo-interpretation.

[1] The original text of this paper, prepared by Reiko Seto and Masayoshi Takasaki, Geographical Survey Institute, appeared as document E/CONF.52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

UTILIZATION OF LAND-USE MAPS

In Japan, land-use maps are used for regional planning, city planning and land development planning rather than for other phases of land evaluation such as the classification of agricultural land-use patterns as a guide for farm management or taxation.

The main purpose of the land-use map series was to contribute to reclamation planning, forestry planning and mining planning for the underdeveloped areas prior to the actual work, which started in 1953.

Better land utilization of underdeveloped areas was the major aim in land planning at that time, for the purpose of obtaining food, timber, coal, water power and other industrial materials from the Japanese homeland. Since then, the main objective has changed to the establishment of development plans for new industrial cities and the re-development of large city areas. Currently many cities have developed master plans of their own and most large cities are revising their master plans.

In Japan, better land-use plans deal with the redevelopment of an area. Fundamentally, these plans aim at the establishment of a zoning plan, that is, of a new utilization pattern of the land. The land-use map is indispensable in this work since it depicts the present land-use pattern. The land-use character of Japan is very complex because of the complicated and subdivided geomorphology, dense population and long historical background.

Land-use maps are indispensable guides to the best routes for the cross-country expressways. To select the best routes, map series at 1:50,000 scale are prepared. Each sheet shows the land-use pattern, slope gradient, snow depth and avalanche distribution of a 2 to 3 km wide zone along the scheduled route. The scheduled route should circumvent intensively utilized land such as urban areas and productive farmlands. Avalanches are closely related to forest conditions in mountain areas.

Analytic investigation with land-use maps and landform classification maps are now being developed by geographers, city planners and regional planners for improving land utilization. The area is first divided into identical squared lots by drawing grids on the sheets of the land-use series and the landform classification series of the same scale, such as 1:50,000 for the same area. The property and intensity of the land use of each lot can then be determined by evaluating each sheet. After investigation lot by lot, the desired information can be obtained regarding the future improvement in land utilization. Moreover, the correlation of the land-use character and the land conditions, such as surface geology, soil, geomorphology, slope gradient, ground height, etc., can be determined and clarified. From this evaluation, the most appropriate land utilization form in relation to its land condition can be found. The most appropriate re-development plan can then be established.

(c) *Forest development and management*

APPLICATION OF CARTOGRAPHIC TECHNIQUES TO AUSTRALIAN FOREST DEVELOPMENT AND MANAGEMENT

Paper presented by Australia[1]

INTRODUCTION

The responsibility for forestry activity in Australia rests generally with the individual state forest services working for their respective state governments, since forestry was a responsibility which remained with the states at the time of federation. The Commonwealth Government, through its Forestry and Timber Bureau, acts in an advisory and co-ordinating capacity and is responsible for fundamental forest research and the collection and dissemination of statistics and information.

Australia does not have extensive forest resources. By FAO (Food and Agriculture Organization of the United Nations) definition, the total forest area of the continent comes to a little more than one-quarter of the land surface. However, as little as 3 per cent of the total land area carries accessible productive forest (accessible land on which timber is likely to be the main economic crop). The land categories as at June 1960 are shown below; more recent estimates are not available, as these figures do not alter rapidly.

Land categories as at 30 June 1960

(Areas in 1,000 acre units)

1. Forested land (including non-commercial forest)	512,168[a]	
(a) Accessible forests	320,373[b]	
(i) Productive forests in use	30,725	
Coniferous (softwood)		492
Non-coniferous (broadleaved)		24,352
Mixed woods		5,636
Open areas		245
(ii) Productive forests not in use		31,961[c]
(iii) Unproductive accessible forests		257,687[d]
(b) Inaccessible forests		191,795
2. Non-forested land	1,372,293	
(a) Agricultural land (including grazing)		493,826
(b) Brush land and other non-forested land		878,467
3. Total land area	1,884,461	
4. Water area (rivers and lakes)	17,031	
5. Total area	1,901,492	
6. (a) Total population as at 30 June 1961	10,508,186	
(b) Population per square mile	3.54	

[a] Includes approximately 400 million acres of land carrying only stunted tree growth.
[b] Includes approximately 260 million acres of land carrying only stunted tree growth.
[c] Includes approximately 25 million acres capable of producing fuel wood only.
[d] Carries only sparse, stunted trees.

In dealing with a natural resource which physically occupies extensive areas of land and is extremely variable in its nature, the importance of maps in their many forms as compact representations or records of location, extent, condition etc. cannot be stressed too greatly.

Maps are an integral part of any forestry activity, whether the aim is to represent the national forest resource or to identify the location of a fire look-out tower.

Australian forestry authorities have in the past relied to a great extent on professional map-makers in lands departments and the like for the preparation of topographic and planimetric base maps and have concentrated mainly on the addition of such forestry detail as is important to the many facets of forestry where maps find a use. Hence the techniques of photo-interpretation and transfer of detail have been more emphasized in training and experience than techniques of base map preparation. There have been many instances, however, where forestry activity has been concentrated in areas not previously covered by reliable base maps, due to remoteness and lack of habitation and cultural development, and forest authorities have been forced to compile base maps from first principles, supplementing control information etc.

All Australian forest services continue to work closely with their respective lands departments, which have the statutory authority for base map preparation. Only one of the forest services employs a high-order plotting machine, while most make use of such machines as the Som Stereoflex, Hilger and Watts Radial Line Plotter, Ryker PL4 Stereo Plotter, and Zeiss Stereotope, for the transfer of interpreted forest detail resulting from photo-interpretations, assessments etc.

Conventional mapping techniques are employed. On the occasions when forest organizations have had to resort to base map preparation, the slotted template method has been generally used, but it is understood that the block adjustment method has been used by private mapping companies in preparing maps for one of the major private forestry companies in Australia.

Mapping produced solely from ground survey information is insignificant in some states, while others rely on a combination of photogrammetric and ground survey techniques in the provision of basic information.

A comprehensive list of the types of map produced by the various state forest authorities is attached as annex I. The types are listed by states and approximate figures have been included to give some indication of the annual volume of production. The great variety of types is readily evident from this list, which serves as a general reference list of available material and as an indicator of the many aspects of forestry requiring a map as a permanent record of a particular situation at a given time.

TRAINING FACILITIES

Professional foresters, during their training at either of the two forestry schools in Australia, take courses covering map preparation and photo-interpretation adapted to forestry usage of these media. While the emphasis is logically on forest photo-interpretation, a basic understanding of surveying and map compilation is taught. Annex II gives a brief outline of the courses offered at each of the professional schools.

[1] The original text of this paper, prepared by M. L. Benson, Forest Research Institute, Department of National Development, Canberra, appeared as document E/CONF.52/L.61.

For personnel more likely to be directly involved in actual cartographic work, the various state forest authorities provide in-service training and sponsor or support the training of surveyors, draftsmen and so on through local technical training institutions. For example, in New South Wales, most trainees commence formal study on entrance to the department. They attend either the Surveying Certificate course or the Land and Engineering Survey Drafting Certificate course at the Sydney Technical College. This course is supplemented by on-the-job training, assisting surveyors etc. Special in-service training in photo-interpretation is provided when necessary for selected personnel. As another example, Tasmania provides training for photo-interpreters in addition to requiring the trainee to attend a basic draftsman's course at a technical college. Training extends over four years, including field instruction.

Overseas students attending the professional forestry schools under the Colombo Plan or specifically sponsored by their own Governments have received the basic instruction mentioned above, but to date no specific sponsorship of overseas students has been proposed by individual forest services for sub-professional training in forest mapping. This does not preclude the possibility of an overseas student enrolling for some of the courses and interested parties should inquire from the appropriate public authority or institution concerning the possibility of sending a student to complete a selected course.

The names and addresses of the various forest services are set out in annex III as well as, in some cases, the name of the officer most directly involved in any cartographic inquiry.

Direct aid to developing countries under the sponsorship of FAO has covered a number of forestry projects, several of which concerned resource type assessments. In these instances, techniques of a cartographic nature have been used and Australian experience has benefited the countries concerned.

Special techniques

Of considerable interest to cartographers in general, and to forest cartographers from developing countries in particular, will be mention of some of the specialized cartographic techniques that have been developed or utilized in Australian forestry practice.

Use of aircraft

In addition to the general use of specialized survey aircraft for the production of adequately controlled vertical aerial photography, there is an increasing interest in the employment of light aircraft and helicopters for work directly associated with forest mapping. Naturally, in this technological age, foresters are making considerable use of aircraft in their day-to-day functions and aircraft are providing valuable assistance to forest map-makers.

The Victorian Forests Commission employs a helicopter for vertical F24 photography to provide low-cost rapid coverage for road and track location, plantation extension mapping, direction of logging operations, location of fire boundaries and storm damage and determination of regrowth percentages. Fortunately, in this instance the cost of the flying is not borne solely by the cartographic projects, as the work is done while the aircraft is on charter for fire protection purposes.

Helicopters have been used for resource location and assessment at the photo-interpretation stage in New Guinea, while some use has been made of similar machines by the Forest Research Institute for spot-checking of interpreted forest areas. In the latter class of work, fixed-wing aircraft offer certain advantages over helicopters, particularly in tropical areas where air density limits the altitudes which can be achieved by small helicopters. The possibility of utilizing larger helicopters is seriously affected by the high cost of hiring in remote localities and the limited range of most machines.

In currently inaccessible forest areas, the concept of field checking from the air has much to recommend it. In assessing insect and fire damage for subsequent plotting, a combination of aerial reconnaissance, marking on vertical photos or exposure of oblique photographs for subsequent transfer of detail to verticals, coupled with tape-recorded commentaries, can offer considerable assistance to the map compiler.

In areas where forestry development has not previously been active and over which a broad-scale assessment of forest resources has not been accomplished, recourse to aerial reconnaissance has proved invaluable in determining the extent and location of areas to be covered by vertical aerial photography at a scale which is useful for forest photo-interpretation, namely, 1:15,840. In Victoria, for example, a preliminary photo-interpretation is prepared from small-scale photography which is available over the whole state but is quite unsuitable for detailed forest stratification; an examination is then made from the air and descriptive data recorded on tape. Selection of areas for detailed photography is a relatively simple step which can be made with considerable reliability.

Shadow point

In considering the specifications of a mission of aerial photography to be flown especially for forestry purposes, one of the most important requirements, after nominating scale and focal length of lens, is that shadow point be avoided. The phenomenon of shadow point and the harmful effects resulting from its inclusion in photographs of forests have been adequately covered in a leaflet by W. G. Sims entitled "Shadow point, Forestry and Timber" published by the Forestry and Timber Bureau in 1954, and tables have been prepared to assist in its avoidance (Forestry and Timber Bureau leaflet, 1955). This work has found wide acceptance throughout the forestry world, although in Australia it has proved difficult to convince other photograph users of the importance of shadow point to forest photo-interpretation.

Colour photography

Of major significance to forest mapping in Australia are the steps which have been taken by the Forest Research Institute and the Victorian Forests Commission in a joint study of the application of colour aerial photography to forest photo-interpretation. Investigations to date have been reported by Sims (1966) and Sims and Benson (1965 and 1966) and additional studies are in progress to evaluate further the applications of this medium. The tests so far carried out in Australia have had the support of several air-survey companies and a colour-processing laboratory which are well equipped technically and have the experience to carry out routine colour aerial missions successfully.

It has been claimed by the United States Forest Service that colour photography is not significantly more expensive than black and white when consideration is given to the magnitude of the prime cost, that is, cost of mounting the aircraft, relative to the film and processing costs, and to the additional benefits and information which can be obtained from the examination of colour photographs. Experience in Australia supports this claim, although it is probably a little early for generalized statements.

In Australian forestry, one of the major difficulties faced is that of species differentiation on photographs of the native eucalyptus forest, where a large number of species of the one genus provide insuperable problems in conventional black and white photography. Colour promises to answer a number of the species-recognition problems currently experienced.

Experiments in the application of infra-red, modified infra-red and colour infra-red films have not been encouraging and emphasis at the present time lies on the more complete appreciation of the possibilities offered by full colour films.

For a number of years, some of the Australian Forest Services have been active in the application of colour films to aerial photo-interpretation, and it is confidently predicted that their use will become routine. In this connexion, the Forests Commission of Victoria has already embarked on colour aerial photography for project work.

Inventory techniques

Highly specialized local techniques have been developed by forestry organizations in determining and representing information on forest resources. For example, the Commonwealth Government, in collaboration with the states, has developed a technique based on aerial inventory for the assessment of national forest resources. In this assessment, categories of broad forest types (eucalyptus, rain forest, cypress pine, etc.), stand size class (mature, pole, sapling, etc.), stand height and density classes are identified on photographs and the stratified results are subjected to field sampling for substantiation and collection of data not available from photographs. Checked detail is superimposed on base maps and statements on the extent and location of productive forest can be extracted.

Variations on the same theme have found acceptance in several states which have been interested in extracting a little more information in the course of the project.

At the management level, forest type maps classifying forest stands into species or species associations, and within these associations into categories of height, density, stand condition, fire history etc., are produced and used as a basis for management. Again, considerable use is made of the air photograph, both in location of boundaries in the office and as a field location aid for ground parties.

Interpreters

The type of person capable of making a reliable interpreter of forest condition or type is rather specialized. The specific attributes thought desirable and the methods of testing and developing the inherent skills which are so important are considered in a leaflet by Sims and Hall entitled "The Testing of Candidates for Training as Air-photo Interpreters", published by the Forestry and Timber Bureau, 1956.

It is relevant to note that the series of tests described in this publication have, for the past thirteen years, been given as part of the basic undergraduate training course at the Australian Forestry School referred to earlier. It is understood that this example for devising tests for interpreters was the first published work in the forestry world.

Equipment

Australian forestry authorities cannot claim to have developed specialized equipment in the cartographic field, but many ingenious applications of otherwise standard equipment have been achieved in normal forest mapping.

The Omnigraph and vertical projector have been used in the transfer of information from photograph to map, although the lack of a stereo-image principle results in errors when working from single photographs. This application is used only where the inherent errors are acceptable to the general standard of the particular project. On occasions, the speed with which a result is achieved can outweigh the loss in accuracy. For normal plotting work, stereoplotting instruments are generally employed.

To obtain maximum benefit and information from colour transparencies and prints with their characteristic high resolution, the Forest Research Institute has found it necessary to instal a zoom stereoscope capable of variation in magnification from 2.5 to 20 times. While these instruments are quite expensive, the added information available from an examination outweighs this factor and fulfils a long-felt want of the forest interpreter to obtain a closer look when doubts arise.

There is considerable scope for the application of small photocomposing and mechanical lettering machines of the Varityper type in forest-drafting organizations, based on the experience of several Australian authorities. Few of these authorities have moved into the scribing field, which has offered such considerable time-saving practices in general cartography. A great deal of use is currently found in all organizations for rapid copying on small formats and commercially available thermostatic copying machines are finding their way into many of the drawing offices of the forest authorities.

Flight planning

Consideration has been given to the provision of a concise source of information relative to number of cloudless days in meteorological regions as they may affect the over-all planning for aerial survey. While this aspect does not generally affect forest authorities directly, it is of interest to flying authorities operating a small number of aircraft.

Base map preparation

The Tasmanian Forestry Commission has reported a technique whereby the laying down of slotted templates covering small areas can be accelerated by calculation, with regard to plot scale, of the position of the template stud in the radial slot for templates which contain a fixed ground point.

Air survey aids

Aids such as those produced by the Forestry and Timber Bureau, which include dot grids, parallax wedges, forest density scales, etc. have found wide acceptance in forestry and also in the allied disciplines of geology, ecology etc.

CONCLUSION

Mapping is an indispensable function of forestry practice. Specialized techniques have been developed for forest mapping and associated assessments, with the major emphasis being placed on the collection of information through the medium of the aerial photograph. Mapping in general is performed in accordance with standard procedures, in close association with lands departments in all states.

Annex I

MAP TYPES PRODUCED BY AUSTRALIAN FOREST SERVICES

1. *New South Wales*

(*a*) Project maps for administrative planning at scale 1:126,720. Coverage: 3,600 sq. miles.

(*b*) Fire maps for fire control and local administration at scale 1:50,000 and 1:31,680. Coverage: 2,000 sq. miles.

(*c*) Forest maps for timber volume assessment, road location, management, etc. at scales 1:25,000 and 1:15,840. Coverage: 400 sq. miles.

(*d*) Photomaps as temporary coverage of forest areas. Coverage: 40 sq. miles.

(*e*) Special purpose maps for reports, tourist publicity etc. at various scales. Coverage: 2,300 sq. miles.

2. *Victoria*

(*a*) Planimetric maps for:
(i) district management records, resources surveys, logging control at scale 1:31,680; (ii) fire maps, inventory maps, reconnaissance surveys, at scale 1:63,360; (iii) aerial fire spotting, mapping fire boundaries, locality maps etc. at scale 1:126,720. Coverage: 900 sq. miles.

(*b*) Topographic maps at various scales modified from Lands Department and Survey Corps material. End use as for (*a*) above.

(*c*) Form line maps for preliminary road locations at scale 1:31,680. Coverage: 10 sq. miles.

(*d*) Soil survey, site suitability and land classification maps for determination of suitability of land for establishment of plantations, at various scales. Coverage: 550 sq. miles.

(*e*) (i) Assessment maps for the determination of areas and volumes of marketable timber at scales 1:15,840 and 1:31,680. Coverage: 150 sq. miles. (ii) Site quality maps for the determination of productivity data at scales 1:7,920 and 1:15,840. Coverage limited. (iii) Forest resource maps for the broad delineation of timber resources at scale 1:63,360. Coverage: 1,350 sq. miles.

(*f*) Special purpose maps for:
(i) publications, at various scales; coverage variable; (ii) Forest recreation at scales 1:63,360 and 1:127,620; coverage: 500 sq. miles.

(*g*) Plantation topographic maps for management, planning and control, at scales 1:7,920 and 1:15,840. Coverage: new, 60 sq. miles; revision, 100 sq. miles.

3. *Queensland*

(*a*) State maps for general administration at scales 32 and 10 miles to 1 inch. Coverage: variable.

(*b*) One-mile series for fire protection, management and administration at scale 1:63,360. Coverage: 5,300 sq. miles.

(*c*) Plantation series for plantation management at scales 1:7,920 and 1:15,840. Coverage: 8 sq. miles, not including revisions.

(*d*) Coastal hardwood series for detailed management, road location etc. at scales 1:15,840 and 1:31,680. Coverage: 75 sq. miles, including revisions.

(*e*) Western cypress and hardwood series as for (*d*) above at scales 1:31,680 and 1:63,360. Coverage included in (*b*) above.

(*f*) Logging maps for logging control of areas not covered by (*a*), (*b*) and (*c*) above, at various scales. Coverage generally limited to revisions.

(*g*) Topographic maps for definition of plantable land, road location, etc. at scales 1:7,920 and 1:15,840. Coverage: 16 sq. miles.

(*h*) National parks maps for administration and public use at various scales. Coverage: 7,000 acres.

(*i*) Photomaps for fire control in aircraft at various scales. Coverage: 4,000 sq. miles.

4. *Tasmania*

(*a*) Forest type maps for inventory and management at scales 1:15,840, 1:23,760 and 1:31,680. Coverage: 340 sq. miles.

(*b*) Topographic maps for proposed plantation establishment, road location, etc. at scales 1:15,840 and 1:7,920. Coverage: 5 sq. miles.

(*c*) Species maps for extent and location of particular species at scales 1:15,840 and 1:23,760. Coverage included in (*a*) above.

5. *South Australia*

Management maps for plantation management, control etc. at scales 1:7,920, 1:15,840, 1:31,680 and 1:63,360. Coverage not available.

6. *Western Australia*

(*a*) Forest-type maps for detailed management at scales 1:15,840 and 1:31,680. Coverage: 2,750 sq. miles.

(*b*) Topographic base maps for administration and general use at scales 1:15,840, 1:31,680 and 1:63,360. Coverage: 3,125 sq. miles.

(*c*) Small index maps for reference at various scales. Coverage not available.

7. *Northern Territory*

(*a*) Resource maps for broad-scale planning at scale 1:63,360. Coverage not available.

(*b*) Plantation maps for management control at various scales. Coverage not available.

Annex II

OUTLINES OF COURSES RELEVANT TO FOREST CARTOGRAPHY (EXCLUDING PURE SURVEYING) AT THE PROFESSIONAL FORESTRY SCHOOLS

Department of Forestry, Australian National University

Offers a six-day course aimed at introducing an awareness of the place of air photographs in forestry and testing aptitude as interpreters, and including: general introduction to principles of mapping; factors in forest photo-interpretation; forest stratification and assessment; practical sessions in which aptitude for photo-interpretation is evaluated, instruments demonstrated and techniques experienced.

School of Forestry, University of Melbourne

In addition to a short introductory course of eight lectures in the appreciation of the air photograph, a course of seventy-two hours of lectures, tutorials and practical work is available. The programme includes: an introduction to the principles of aerial photogrammetry as applied in natural resource studies; general consideration of the factors influencing aerial photography; principles, objectives and application of aerial photo-interpretation, with particular reference to forest inventory, photo-ecology and land use.

Annex III

AUSTRALIAN FOREST SERVICES

New South Wales—The Secretary, Forestry Commission of N.S.W., Box 2667, GPO, Sydney (attention: Chief, Division of Forest and Timber Resources).

Victoria—The Secretary, Forests Commission of Victoria, 453 Latrobe Street, Melbourne, C.1 (attention: Mr. V. C. Henderson, Superintending Draftsman).

Queensland—The Secretary, Department of Forestry, Box 269 Brisbane, Broadway (attention: Mr. J. Craig, Draftsman in Charge).

South Australia—The Conservator, Woods and Forests Department, Box 25, Rundle Street, PO, Adelaide.

Western Australia—The Conservator of Forests, Forests Department, Barrack Street, Perth.

Tasmania—The Chief Commissioner, Forestry Commission of Tasmania, Box 207B, GPO, Hobart.

Commonwealth—Director-General, Forestry and Timber Bureau, Canberra, ACT.

ATMOSPHERIC HAZE PENETRATION IN COLOUR AIR PHOTOGRAPHY

Paper presented by Australia[1]

Ten thousand feet appears to be the altitude which most people have been prepared to accept as the maximum flying height for the taking of vertical stereo pairs in colour aerial survey. The disturbance of colour balance by atmospheric blue haze has been felt to be the limiting factor. Until 1966 no practical trial had been attempted in Australia to permit a critical examination of this problem. The *canard* has therefore become self-perpetuating.

The Forest Research Institute, with the co-operation of Civil Aerial Surveys Pty. Ltd., Air Photographs Pty. Ltd. and the Forests Commission, Victoria, recently carried out a series of altitude trials in an effort to discover whether (*a*) the blue light scatter of atmospheric haze could be effectively filtered out or reduced to a point of acceptability, and (*b*) if filtration was not possible, at what altitude blue haze vitiated the coloured photographic image.

The introduction to Australia of a negative-positive colour system made the concept of such a trial possible, because this system does not require corrective filtration at the time of exposure. Filtration aimed at the elimination of blue haze is carried out during processing.

The location chosen for the trial included mountainous country partially covered by forests of different ages and heights. Areas of ploughed land and grazing land were also included.

Using Kodak special ektachrome MS aerographic film, type SO-151 (Aero-Neg.) in a Wild RC8 camera (No. 15UAg. 323) of 6-inch focal length, stereo triplets were exposed over the same target area at intervals of 2,500 ft, commencing at 5,000 ft and continuing to 25,000 ft above ground level. The film was processed to negative, and positive transparencies were made on Kodak Ektacolor print film expressly imported for the purpose by the processing laboratory. The correct colour-balancing filter pack for each altitude was determined by the use of a colour analyser.

[1] The original text of this paper, prepared by W. G. Sims, Technical Officer, and M. L. Benson, Forest Research Institute, Canberra, appeared as document E/CONF.52/L.62.

For comparison, additional transparencies were produced for the higher altitude exposures, using the filter pack which was determined as correct for the lowest altitude exposures only. Thus the over-all blue cast present in these transparencies must be attributed to atmospheric blue haze.

Correct exposure into the corners of the frame was achieved by the use in the camera of the recommended anti-vignetting filter, and proper shading during the printing exposure.

All colours produced on the 5,000 ft (RF 1:10,000) transparencies were bright, clear and bold, as may be expected from this altitude, and were considered by the authors and other qualified observers to be the best renditions so far achieved in Australia.

The 25,000 ft (RF 1: 50,000) transparencies which were produced using the low altitude filter pack (incorrect for 25,000 ft) exhibited considerable blue cast to the complete detriment of the image quality. On the other hand, correctly filtered transparencies at this altitude show good colour balance. There is, however, a faint opalescence which slightly softens the colours. This does not veil the colour balance to any marked degree and does not prove obtrustive; therefore it does not influence air photo-interpretation. Blue haze is very effectively reduced.

It is anticipated with confidence by those concerned in the project that the opalescence can be reduced still further and the colours enhanced.

CONCLUSION

Using the flexibility of the Kodak Aero-Neg. system and processors competent and experienced in aerial photography and colour reproduction, excellent colour aerial photography can be obtained up to altitudes of 25,000 feet with a 6-inch focal length lens. It is considered that similar results may be achieved using shorter focal length lenses. This should be tested.

FOREST DEVELOPMENT AND MANAGEMENT

Paper presented by China[1]

Cartographic techniques have been widely used in forest management and development by the Government of the Republic of China. An intensive forest land survey in the province of Taiwan began in 1925. The forest survey programme covered 1.6 million hectares, comprising approximately one-half of the total area of the province. The cartographic techniques used for forest survey include control survey by triangulation, aerial photogrammetry and detail survey.

For control survey, 2,164 triangulation stations and 84,006 reference points have been established where their geographical location was known, and marble marks have been set up in the field. These stations are used for control of forest compartment boundary surveys and detail surveys.

For forest land management, various maps have been prepared, including a property map of forest land, a national forest base map and a forest cover and operation map.

[1] The original text of this paper appeared as document E/CONF. 52/L.113.

PROPERTY MAP

This map shows every category of land by ownership. The scale used is 1:12,000. Private land is coloured red, reservation for aborigines blue, unclassified national land yellow, and national forest land is left uncoloured.

National forest base map

This map, at 1: 6,000 scale, is prepared by the different working circles which are the primary divisions of the national forest service, used as planning units for sustained yield forest management. The size of the map is 600 × 750 mm, with each sheet representing 1,620 hectares of land. The map contains information on location of triangulation stations, reference points, working circle boundaries, compartment boundaries, subcompartment boundaries, location of roads and railways and main topographic features and administrative boundaries. Being a planimetric map, it does not show topography. For each working circle, the Taiwan Forestry Bureau prepares a series of basic maps. The national forest is divided into forty-two working circles.

To prepare this map, working circle and compartment boundaries are surveyed by the method of transit and compass traversing. Aerial photographs are delineated with classification of forest cover types, forest condition, and land-use types for sub-compartment mapping purposes.

Forest cover and operation map

This map has two kinds of scale; 1:25,000 and 1:50,000. It contains the same information as the base map. Moreover, it contains information on location scheduled for initial ten-year forest operation and type of operation. Forest cover types, conifers, conifer-hardwoods mixtures, hardwoods and bamboo and land-use types are differentiated by colours. For the map at 1:50,000 scale, it also shows topography with 100m interval contour line.

In order to keep the forest information up to date, the Taiwan Forestry Bureau revises the above-mentioned maps and reinventories its forest resources every ten years. The areas and maps revised by Taiwan Forestry Bureau in the past three years are shown below.

Areas and maps revised by the Taiwan Forestry Bureau

Working circle	*Area (hectares)*	*1:6,000 revised base map (sheets)*	*1:50,000 revised forest cover map (sheets)*
Wen-shan	20,479	35	1
Nan-chuan	10,193	15	1
Tung-shi	13,509	26	1
Ta-chia-chi	74,212	70	1
Tsu-suei-chi	53,865	29	1
Pu-li	20,039	33	1
Pei-kan-chi	18,590	24	1
Chi-chi	13,056	25	1
Chu-shan	16,929	22	1
Kuan-shan	95,007	35	1
Shin-kan	31,624	41	1
Shiu-ku-luan	79,242	27	1
Ta-pa-lan	32,769	56	1
Ta-chu-suei	14,811	20	1
Lo-tung	20,142	29	1
Yi-lang	17,266	34	1
Ping-tung	33,167	24	1
TOTAL	564,900	545	17

TRAINING COURSE IN PHOTOGRAMMETRY AND PHOTO-INTERPRETATION IN FORESTRY

Paper presented by Japan[1]

GENERAL

The training course on the application of photogrammetry and photo-interpretation to forestry was arranged under the Colombo Plan prior to 1957. Since that time, between five and seven senior exports have participated in this course annually from the countries concerned. The course has been conducted by the Government Forest Experimental Station, Ministry of Agriculture and Forestry. The duration is six months.

SYLLABUSES

The course covers theories and practices of techniques concerned with the application of photogrammetry and photo-interpretation, concentrating mainly on modern techniques of forest survey in Japan. The main subjects of the course are: air photograph application in forestry; analysis of terrain condition from air photographs; analysis of forest stand from air-photographs and the use of air-photography in forest, inventory, forest roads and their construction and erosion control work.

Forest survey is a basis for forest exploitation. It includes fundamentals of forest resources survey in the form of sampling, compilation of a forest resource distribution map, forest management maps concerned with forest stratification, soil survey etc.

REFERENCE MATERIALS

The Forest Experimental Station prepared some texts for this course entitled "Photogrammetry in Forestry" in 1961, and "List of Exercises in Aerial Photogrammetry in Forestry", in 1962. In addition, some modern Japanese works and standard international works are used as references.

[1] The original text of this paper, prepared by Iwao Nakajima, Government Forest Experimental Station of Japan, appeared as document E/CONF.52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

(d) *Agricultural planning and development*

CARTOGRAPHIC TECHNIQUES AS APPLIED TO SOIL SURVEYS

Paper presented by Australia[1]

Introduction

Organized soil survey work in Australia commenced in 1927 with a small staff concerned mainly with the problems of the irrigation areas of the Murray river valley. Over the past forty years, the interests of the Division of Soils have developed from that of providing detailed soil surveys over areas with a specific problem or areas intended for future development to a more precise investigation of soils in terms of their genetic and geomorphic history. Consequently the techniques used and more particularly the information which the pedologist wishes to show have changed, resulting in the need for a new approach to mapping.

Soils and soil classification

Soil mapping has problems of presentation peculiar to itself and a brief description of what constitutes a soil, how it is classified, and how data is collected and recorded will assist in understanding them.

A soil may be described as being a widely varying mixture of mineral and organic matter. The mineral component is derived largely from the continuous breakdown of the rocks of the earth's crust and thus represents its weathered detritus. The organic matter is composed largely of vegetative material together with lesser amounts of animal and insect remains, all in various stages of decomposition.

Soils are differentiated by means of various classifications which take into account their diverse characteristics of texture, structure, colour, chemical composition, thickness and other properties of horizons that make up the soil profile. The classification may also include the geological nature of the parent material and take account of geomorphological characteristics of the landscape.

The characteristics are recognized after exposing the soil to varying depths by digging a pit or extracting a core and examining the profile.

The units of classification may be divided into a number of categories, including:

Soil phase: showing differences in depth of surface soil, stoniness and degree of slope; hence the terms, "deep" or "shallow" phase, "stony" phase and "steep "phase;

Soil type: differences in the texture of surface soil resulting in the well-known names of sand, loam, clay etc.;

Soil series: differences in parent material;

Soil families: differences in depth and development of the solum;

Great soil groups: differences in profile colour and texture and presence or absence of certain morphological features of the profile.

(Units other than those listed, such as the *principal profile form*, may be used also.)

Each of the categories may be used for specific mapping purposes, for example, soil phase and soil type for large-scale detailed mapping (1: 50,000 and larger) for irrigation areas and land settlement projects; soil series and soil families for medium-scale mapping (1:250,000) for reconnaissance surveys and pedological studies, and Great Soil Groups for small-scale mapping (1:1,000,000 and smaller) in making an assessment of large regional areas for future development, and in continental mapping. Principal profile forms are currently being used in the preparation of the Atlas of Australian Soils, which is the subject of another paper presented at this conference.[2]

Soil mapping

A soil map records the distribution of areas of different soil types or other mapping units in relation to a cadastral base.

Early soil surveys were based on regular soil examination over a rectangular grid, usually at 10 chain intervals. Soil classification was noted at each intersection and boundaries drawn around similar units, in a process comparable to the compilation of a contour map from spot heights.

Since the late 1940's, more reliance has been placed on the correlation of soils with the geomorphic and petrologic nature of the landscape. With the use of aerial photographs, the pedologist is able to delineate the various landforms and rock units of an area and soil examination and classification proceeds along irregular traverses, governed by changes in topography and petrology. Each recognized landform or change in soil pattern is examined and the information recorded in code on the aerial photograph and at length in a field note-book or *pro-forma* sheet.

Specific features such as dune formations, river terraces, erosion and others of interest to a particular survey, noted in the field, are further examined in the office with a stereoscope and recorded on the aerial photographs (see figure below).

The general procedure adopted in making a soil survey may be divided into three major sections: preliminary appraisal; execution of traverses and sampling; modification of mapping categories and map preparation.

The initial step is to obtain all available base plans and check on the aerial photo-coverage of the area to be surveyed and decide its limits. The outer boundaries are often indicated by the person or organization requesting the survey. In the absence of such limitations, the pedologist defines the extent of the survey in the light of its purpose, natural features (such as mountain ranges, rivers etc.) and state land survey divisions.

After a field reconnaissance of the area, when the complexity of the soils is noted and the size and purpose of the survey determined, a suitable scale for mapping the soils is selected.

As there is a definite relationship between soils and the topography of the landscape, it is necessary to inspect the

[1] The original text of this paper, prepared by M. C. Coulls, Division of Soils, Commonwealth Scientific and Industrial Research Organization (CSIRO), South Australia, appeared as document E/CONF. 52/L.63.

[2] See below, under agenda item 10.

soils along traverses across the main features of the area. If traverses were selected, for example, along valleys or ridges, it would be reasonable to expect a similar soil throughout the length of the traverse. Therefore, if the general pattern is in an east-west direction, north-south traverses are planned. The size of the area, accessibility and intensity of sampling govern the method of traversing to be adopted, whether on foot, by standard or by four-wheel-drive vehicles.

From the initial reconnaissance and sometimes with information from other surveys in the area, the surveyor is able to make a basic legend of the main soil mapping units. The units used are selected according to the purpose and scale of the survey, as explained earlier.

Inspection of the soil profiles along each of the predetermined traverses is now undertaken, using a hand-auger or, if possible, a power driven core-sampler. Road and railway cuttings, quarries, earthworks and other sites where the profile has been exposed also offer first-class opportunities for inspection of the soil. The soil classification and sample sites are noted on field plans and/or aerial photographs and soil boundaries delineated.

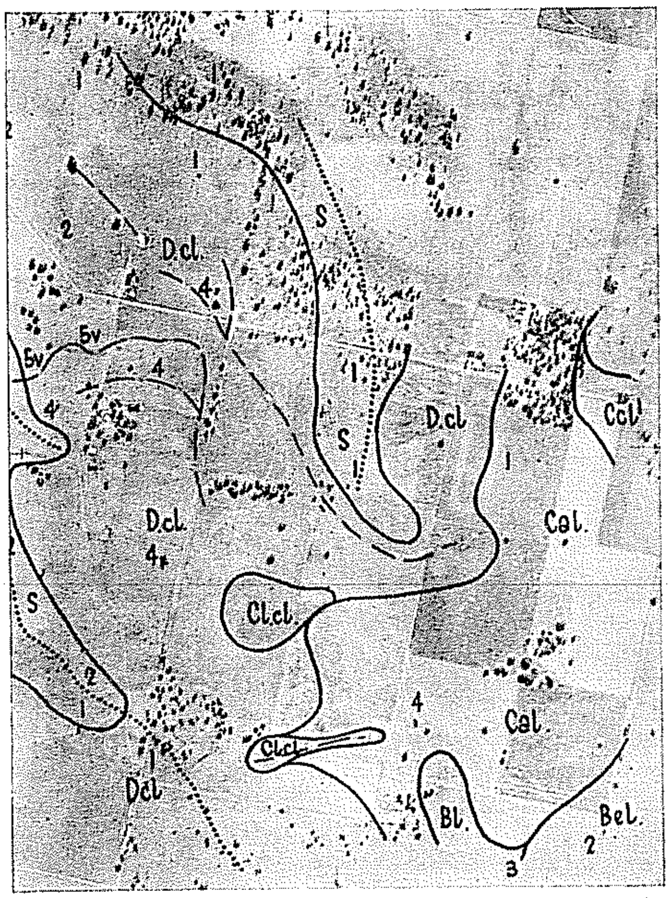


Fig. I—Australia: Aerial photograph showing soil classification and boundaries as recorded by the pedologist

At the completion of the sampling, the basic legend is modified to include variations of the original units and additional categories found on closer inspection or made necessary by an intricate soil pattern.

The soil boundaries delineated during the survey are checked for continuity and correctness and a final map manuscript prepared ready for the cartographer.

Drafting procedure

Data recording

When aerial photographs are used as the recording media, the data are transferred to a suitable base plan using a projector. The model used by CSIRO Division of Soils is the Fotokopist Omnigraph III, which has lens attachments to allow up to 10 × 10 reduction or enlargement and three-point tilt adjustment. If no base plan of the area is available, soil data and base detail are mapped using the slotted template method of base planning.

Should the area be covered by recent and accurate plans obtained from the Department of National Mapping, state land departments or the Royal Australian Survey Corps, a compilation map is prepared simply by tracing such detail as desired.

Selection of detail

Early detailed soil surveys of the division necessitated showing all land subdivision as recorded on official Land Department plans. However, recent trends in pedological investigation place more emphasis on existing roads, fences and topographic features, which are taken from aerial photographs and the surveyor's field observations. As the type and amount of cultural and topographic detail shown on soil maps varies with each survey, no standards have been established. It is therefore a matter for the pedologist and cartographer to decide. Careful selection is made of detail which will enable the map-user to locate himself easily and yet not obliterate the soil information, which is of primary importance. The selected names and other information are indicated on a compilation sheet in the approximate position in which they are to appear on the final draft and a list made, to be used in the preparation of a type order.

Preparation for scribing

The compilation manuscript shows the selected base detail, soil boundaries, sample sites, degree of slope, rock outcrops and other pedological information and nomenclature. A maximum of three blue-line guide images on scribe coat sheets which have been register-punched are prepared either photographically, if a change of scale is necessary, or with a rub-on diazo and contact printed if already at publication scale. The images are made "right reading, emulsion up", ready for positive scribing. The CSIRO publishing section prefers to bring all scribe sheets to contact positives and overlays to negatives so that processed material may be used throughout the lithographic processes. It has been found that better registration is achieved using this method of reproduction.

Scribing techniques

The draftsman receives three scribe sheets, each having a blue-line image of the compilation sheet, one for the soil boundaries (black plate) the second for cultural and topographic detail (solid grey plate) and the third for water features (blue plate). Water features are shown in blue very occasionally, being more usually combined with the second scribe sheet and printed in solid grey. The soil boundaries are scribed first, followed by the base and, when necessary, the water features. Care is taken, when scribing the hydrography, to ensure that boundaries of soil areas associated with rivers and creeks are in perfect registration.

The scribing tools in use at the moment are the New South Wales product which have plastic tool-holders and sapphire-tipped scribe tools. The draftsmen have found that the lightly constructed holders enable them to "feel" the bite of the scribe tool on the scribe sheet, offer more freedom of movement and do not obscure the work as do the heavier instruments.

Table 1. Sizes adopted for 1: 63,360 mapping

Feature	*Scribe tool size (in inches)*
Roads	.004–.014–.004
Rivers and creeks	.003
Soil boundaries	.004
Coast-line	.006
Latitude and longitude borders	.006–.024–.006
Map borders:	
Inner	.006
Outer	.006–.020
Scale	.004
Legend boxes	.004

For other mapping, scribe tool sizes are selected by the cartographer to give a comparable variation of line widths.

Preparation of overlays

The overlays used on soil maps are for: soil symbols, map title, legend and acknowledgements (black plate combined with black scribe sheet); map nomenclature (solid grey plate, combined with solid grey scribe sheet); hatching (grey plate).

Photo-lettering type faces are used exclusively and a standard specification sheet has been prepared as set out in table 2.

The cartographer, using this specification and the "name list" prepared at the time of the compilation manuscript, prepares a type order, examples of which are shown in figure II.

A copy of the type-order is forwarded to the type-setter to be reproduced on film positive or stripping film. Legends and large areas of type are prepared on film positives, "right-reading, emulsion up", and map symbols, names and acknowledgements on stripping film, "reverse-reading, emulsion up".

Map nomenclature is the first overlay prepared and is accomplished by bringing the black and solid grey scribe sheets and a pre-punched "Cronaflex" sheet in register over a light table. Names on stripping film are affixed in their correct position (by reference to the compilation manuscript) by one of two means: a pressure-pack spray adhesive known commercially as "Quik-Stick", or a water-soluble glue named "Aquadhere".

The soil symbols overlay is compiled next in a similar way. To ensure that symbols do not interfere with names already located, the name overlay and boundary scribe sheet are registered with the new "Cronaflex" overlay.

Finally the hatching overlay is prepared. On this sheet various features, such as steepness of the terrain, alluvium, rock outcrops, sand accumulation, etc., are depicted, each by standard hatchings selected from the range of stick-on hatching available commercially.

To provide a means of checking and to obtain a transparent positive from which dyelines are processed for the preparation of a colour scheme, a compositive positive of scribe sheets and overlays is prepared.

Colour schemes for soil maps pose one of our greatest problems. Because of the complex nature of soils, many thousands of types have been recognized and named, thus making it impossible to have a standard colour scheme

Table 2. Type specification for maps published by CSIRO Division of Soils

Capital cities and/or main towns	Grotesque medium caps
Other towns	Grotesque medium caps and l.c.
Legend, notes and acknowledgements	Grotesque medium caps and l.c.
Symbols	Grotesque medium caps and l.c.
Sample sites	Grotesque medium caps and l.c.
Numerals (contours, latitude and longitude)	Grotesque medium caps
County and land district names	Open stone caps
Parish and hundred names	Grotesque medium caps
Properties and other land divisions	Bembo caps
Heading:	
Type of map	Grotesque caps
Main title	Grotesque bold caps
State name and/or other locality names	Grotesque caps
Information to adjoining towns (e.g. To Adelaide)	Grotesque caps
Locality plan:	
State names	Grotesque condensed caps
Locality	Grotesque caps and l.c.
Mountains	Grotesque condensed caps
Capes, peninsulas, headlands, bluffs	Grotesque condensed caps and l.c.
Rivers	Times light italic caps and l.c.
Lakes (large)	Times light italic caps
Lakes (others)	Times light italic caps and l.c.
Oceans, gulfs, bays	Times light italic caps
Trigonometry stations	Times light caps and l.c.
Railway sidings	Grotesque medium italic caps

NOTE. When legends are large, space restricted, or soil areas small, Grotesque light condensed is substituted for Grotesque medium.

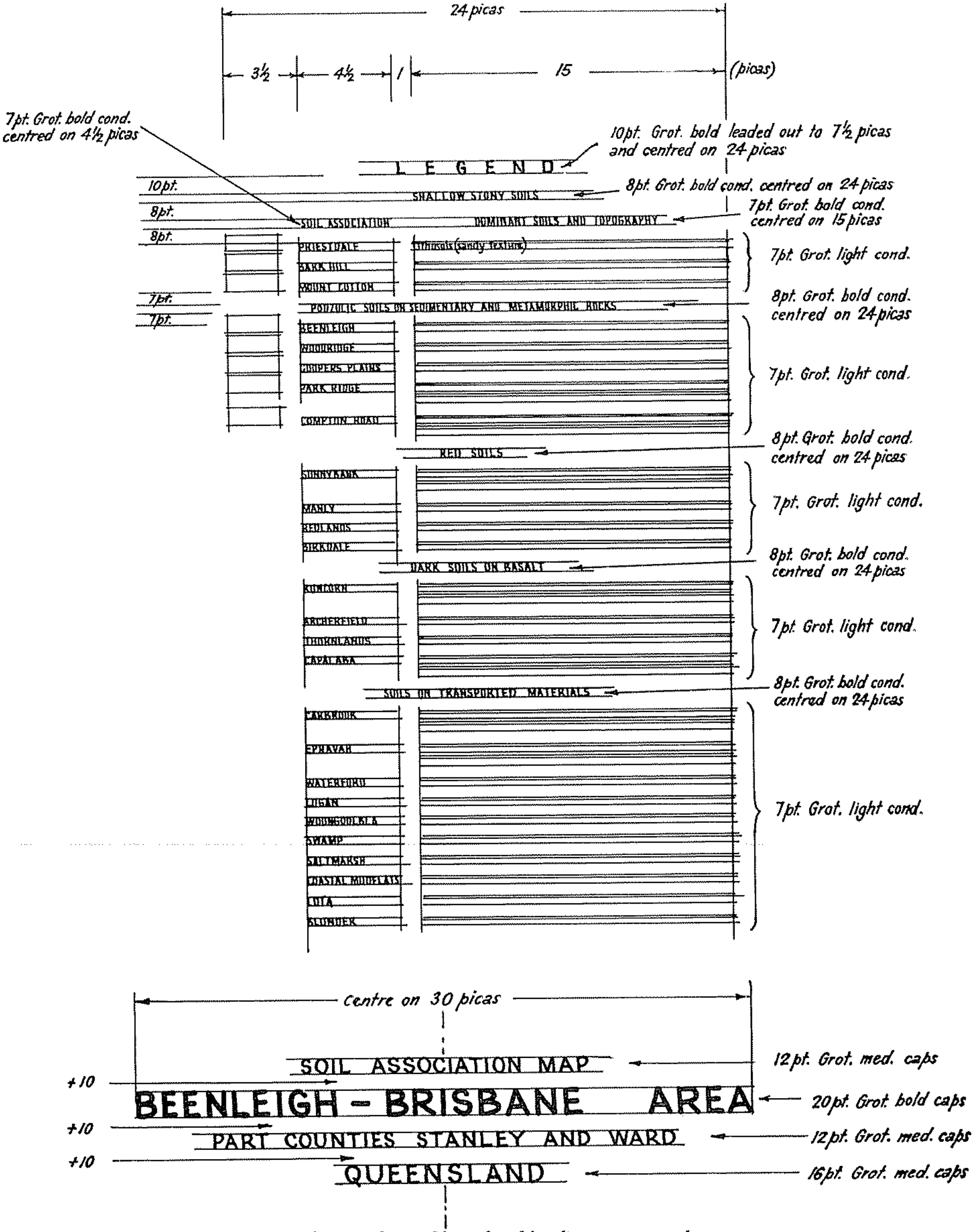


Fig.—II Australia: Mock-up of legend and heading as presented to typesetter at the detailed survey level. Consequently, there is no relationship between a particular colour on one map with the same colour on another. Some preliminary work has been carried out on the compilation of a standard set of colours and screen overlays and it is hoped that a solution to this problem will be found.

In the absence of any such standard, the main consideration of the cartographer is to present a map which not only clearly defines the soil mapping unit but also presents an harmonious colour pattern. Colours are selected from the CSIRO standardized colour chart which represents sixty colours obtained by using four basic colours: yellow, red, blue and grey and overprinting with 25 per cent and 50 per cent litho-screens. Dyelines from the composite postive are hand coloured using printer's inks diluted with mineral turpentine. The colours so produced closely resemble the final reproduction and an accurate appraisal can be made of the colour scheme. Completeness of boundaries and correctness of symboling is very readily checked whilst colouring.

Colour separation and proofing

When the final decision on the colours to be used has been made, colour separation negatives for each of the selected basic colours and screens are prepared. The masks are prepared by contact-printing in a vacuum frame, a positive of the soil boundary scribe sheet on to a polyester base "peel-coat" material. The product used is manufactured by the Direct Reproduction Corporation of the United States and called "Strip-rite". The material is coated with a light sensitive emulsion which is hardened on exposure. The areas protected by the line-work of the boundary sheet remain soluble and can be washed away with an etching solution and water. Stripping for each colour mask is now accomplished by inserting the point of a scalpel or print trimmer under the edge of an area and peeling it off, giving a negative mask ready for proofing.

Before preparing the printing plates it is necessary to make a final check of the map. This is facilitated by making a photo-colour proof on white opaque plastic. The plastic sheet is coated in a whirler with bichromated albumen to which a colour pigment is added. After each coating the appropriate negative is exposed and developed by flushing with a dilute solution of ammonia and water, until each scribe sheet, overlay and colour mask has been reproduced.

A very close examination is made and any corrections are noted on the proof and subsequently made to the original. Corrections to line work are made directly on the scribe sheets. Type corrections, if few, are made by stripping in on the negative; if numerous, they are added to the type overlay and a new negative obtained. Colour mask corrections are accomplished by stripping out areas omitted or opaquing areas stripped in error.

The map components are now ready to go to the platemaker and lithographer for final reproduction. This final stage is performed by the CSIRO publishing section located in Melbourne, and all final corrections are made there by the cartographer from Adelaide.

In conclusion, the drafting work for the Division of Soils is carried out at the headquarters situated in Adelaide. Map manuscripts, aerial photographs and surveyors' instructions are forwarded from the regional centres at Brisbane, Canberra, Hobart and Perth. Constant liaison is maintained with the pedologist during the drafting and progress copies of the map are forwarded to him for checking and comment. A staff of four senior draftsmen handles the mapping work of twenty pedologists and illustrations for scientific publications for some seventy research scientists.

PRACTICAL APPLICATION OF CARTOGRAPHIC TECHNIQUES FOR AGRICULTURAL PLANNING AND DEVELOPMENT

Paper presented by Japan[1]

At present, agricultural planning and development are effectively attainable through the practical application of existing maps. To resolve the problems concerned with Japanese agriculture, many kinds of maps are used to analyse the status of agriculture. Maps, used together with agricultural statistics, are among the most indispensable tools for helping us to understand the real status of agriculture.

The status of agriculture, that is, the physical condition of cultivated land, crops and livestock distribution, must first be examined. Then planning and development can be determined by using maps and adding on them basic information and data already available. The Ministry of Agriculture and Forestry conducts an agricultural census every five years and takes part in the world agricultural census, which takes place every ten years. The data derived from such censuses are valuable in the operation of agricultural maps. In the mapping of the whole country for several of the major regions, agricultural maps are compiled at a chorographical scale, that is 1:1,000,000 or smaller. The maps are divided into administrative units.

Topographic maps at scales of 1:25,000 or 1:50,000 are used when available in the research concerning the physical condition of cultivated land, including soil classification, slope declivity, suitable land for specific crops, irrigation systems by type, land improvement, land requiring improvement by type, field productivity, factors hindering modernization of farming, etc. The results derived from the research are drawn on the maps, and new maps are produced at smaller scales to determine detailed land development, production, etc. Large-scale maps are required.

[1] The original text of this paper, prepared by Fukuo Ueno, Komazawa University, appeared as document E/CONF.52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

(e) *Assessment and use of water resources*

A MAP OF UNDERGROUND WATER IN AUSTRALIA

Paper presented by Australia[1]

INTRODUCTION

The map "Australia: Underground Water" was prepared to accompany the *Review of Australia's Water Resources, 1963*, published in 1965 by the Department of National Development on behalf of the Australian Water Resources Council. A folded copy of the map-sheet is included in an end-pocket with each copy of the review. In addition to the main map of Australia at 1:5,000,000, the sheet also carries two small maps, one showing the principal sedimentary basins and the other showing precipitation and the main divisions of the surface drainage.

As the preface to the review states: "The six state governments of Australia are responsible for the control and conservation of water within their own areas. The area under state control amounts to 2,446,500 square miles out of a total area of the mainland and Tasmania of 2,971,100 square miles. The Commonwealth Government is responsible for the Northern Territory and the Australian Capital Territory. It also has interests in water measurement and conservation through its responsibilities for providing meteorological, flood warning and research services, the development of special areas (Snowy Mountains Hydro-electric Authority) and the accumulation of knowledge on basic national resources."

The Australian Water Resources Council comprises Commonwealth and state ministers with interests in water resources. It is serviced by a standing committee of officers aided by technical committees and working groups drawn mainly from the state and Commonwealth authorities whose functions include the measurement and assessment of water resources. These authorities are referred to collectively in this paper as the "water authorities".

The *Review of Australia's Water Resources, 1963*, was planned to fulfil the first stage of the council's principal objective of providing a comprehensive assessment of Australia's water resources so that future planning could be carried out on a sound scientific basis.

The section of the review dealing with surface water resources was based mainly on stream gauging data supplemented, in ungauged areas, by estimates based on precipitation data and on analogy with gauged areas. Nearly 200 river basins formed the unit areas and these were grouped into twelve drainage divisions. The tables, text and maps summarized a large quantity of organized data.

Underground water proved to be a much more difficult subject to review on an Australia-wide basis. Not only was the subject generally much more complex, but it was also mostly less well documented and its data less well organized. From particular knowledge of certain areas that had been studied in detail and from general knowledge of many other areas, a broadly descriptive account of resources could be made, but this would not have given a concise and readily understood assessment of resources or have indicated clearly the main areas requiring further investigation.

A clue to a partial solution to this problem came in a report prepared by New South Wales. The report contained several maps dealing with the underground water resources of that state. One dealt with the water resources of hard rocks (igneous, metamorphic, hard sediments, etc.); the second, with those of softer rocks (sandstones, limestones, etc.) including sedimentary basins; and the third, with those of unconsolidated materials (alluvium and aeolianite). In each case the map showed the extent of the rock group and, by broad classes, the quality of the water in parts per million of total solids. Some additional information, not important for present purposes, was also given.

An important feature of these maps was that they made use of the relatively abundant geological information to extend the limited data available on water quality and yield. The validity of extrapolation on this basis depends on the degree to which any particular rock formation used as a unit in mapping may be regarded as having uniform water characteristics.

Using the information presented on these three maps, geographers of the Department of National Development in Canberra made a composite map of a selected, complex area and then of New South Wales as a whole. This involved designing distinctive but compatible means of representation for the rock groupings. It was important that each grouping should still be readily seen even if overprinted by one of the others, as required for showing overlying rock groups.

The results of these early tests proved to be so encouraging that it was decided to show the draft to the state and Commonwealth water authorities and to seek their assistance in compiling similar information for the whole of Australia. There followed a series of requests for specific data, discussions with individual authorities and joint meetings to resolve the problems. This action was carried out through the auspices of the Technical Committee on Underground Water. Some modifications were necessary to the original specifications as the information was assembled, but basically the concepts were unchanged.

MAP PRODUCTION AND CONTENT

The material from each state and from the Northern Territory was supplied separately as specially prepared maps at scales ranging from 1:1,000,000 to 1:2,500,000. In Canberra, this information, much of it previously unpublished, was progressively incorporated in a single compilation at 1:4,500,000. In carrying out the reductions to this scale, frequent reference was made to source data such as large-scale geological maps to ensure that the interpretation given was as consistent as was possible with the data available. A number of problems were referred back to the water authorities for further consideration.

The map was produced by the Department of National Development. The department's geographic staff designed it and supervised its production; the Bureau of Mineral

[1] The original text of this paper, prepared by T. W. Plumb, Water Power and Geographic Branch, Department of National Development, Canberra, appeared as document E/CONF.52/L.34.

Resources, Geology and Geophysics assisted in the assembly and interpretation of the data; and the Division of National Mapping carried out the drawing. The sheet was printed by the Commonwealth Government Printer.

On the map as printed, the rock groups were defined as follows:

Unconsolidated sediments: alluvial, aeolian, coastal and lacustrine unconsolidated sediments;

Porous rocks: sedimentary rocks with intergranular porosity and permeability; solution cavities may be present in limestones;

Fractured rocks: igneous, metamorphic and deformed sedimentary rocks; with porosity and permeability in fractures, joints, solution cavities and weathered zones.

Water quality (total dissolved salts in parts per million) was shown in five classes representing ranges of numerical values (less than 1,000, 1,000 to 3,000, 3,000 to 7,000, 7,000 to 14,000 and more than 14,000 ppm). A class was added for areas for which the data available on water quality were insufficient to justify its inclusion in any of the other classes. A boundary in black was used to indicate each change of rock group or quality class.

Unconsolidated sediments were represented by dots, fractured rocks by parallel lines and porous rocks by flat colour. A separate colour was used for each quality class; thus blue was used for less than 1,000 ppm and green for 1,000 to 3,000 ppm. Areas of flat colour representing porous rocks were shown in a percentage tint of the full colour used for the dots and lines of the unconsolidated sediments and fractured rocks. Thus it was possible to show overlying rock groups by placing dots or lines over areas of percentage tint in the same or another colour, or, in the case of unconsolidated sediments overlying factured rocks, by combining dots with lines. Some examples are shown in the map legend and many more can be found on the map itself.

In some areas, the range of water qualities in a single rock group extended beyond the limits of one quality class. Where this was considered particularly significant, it was shown by alternate rows of dots, lines or areas in different colours to represent the range of qualities.

In the special case of the Great Artesian Basin, where over large areas there are at least two main groups of aquifers in the one rock group, narrow bands of colour were used for the upper aquifers and wider bands for the lower.

No information on water yield was shown on the map itself, but a table was included in the map legend. This indicated the general range of values for each of the three rock groups and gave some specific examples of achieved yields. For instance, yields of 5,000 to 30,000 gallons per hour have been achieved from the coastal sand near Newcastle, New South Wales; 100 to 2,000 from the fractured rocks of the southern tablelands of New South Wales, and artesian flows of 1,000 to 50,000 from the Great Artesian Basin in Queensland.

The map gives only a partial assessment of underground water resources. It deals mainly with one aspect: water quality. In so doing, it suggests which areas may warrant fuller investigation because they have generally good quality water. Another important feature of the map is that it shows the extent of the areas of inadequate water data. In may be found that there is little underground water in some of these areas, but some investigation of most of them would be warranted. Currently water authorities throughout Australia are engaged in a major programme of investigations, a significant part of which is being financed by the Commonwealth Government.

The full possibilities of classification and the methods of representation used in the map sheet are by no means exhausted. In studying smaller areas in greater detail, a further subdivision of the classification may be warranted. For example, granite rocks, basalts and deformed sediments may have very different water characteristics and therefore justify subdivision of the fractured rocks group. Similar differences may be found in particular formations in a sedimentary basin or in unconsolidated sediments of different lithology or age. A map which attempts some of these subdivisions in the Fitzroy region of Queensland is currently being prepared by the Goegraphic Section of the Department of National Development. Work on somewhat similar lines is being undertaken by the Geological Survey of Queensland.

MAPPING OF SURFACE WATER RESOURCES

Paper presented by Australia[1]

INTRODUCTION

The amount of data concerning hydrological phenomena is so great that some form of summarized cartographic representation is usually necessary for ready comprehension. This was recognized during the first session of the Co-ordinating Council of the International Hydrological Decade. The council recommended the establishment of a working group to make proposals regarding objectives of hydrological maps, types of maps to be prepared and priorities, standards, scales and symbols to be adopted. It also recommended preparation of hydrogeological maps, particularly of arid zones.

The present paper is based partly on experience gained in map production and the analysis of hydrological data. It also reflects ideas being developed for map series that are being planned and incorporates observations based on a study of water resources maps produced in other countries.

The content and design of maps of surface water resources varies with the purpose for which maps are required, the scale and the nature and density of data.

In general, small-scale maps (about 1:5,000,000), even though they may not permit detailed study of developmental possibilities, may provide the broad picture of the distribution of water resources. They can be of considerable importance, especially if published as part of a series of resources maps; for example, if the same projection and scale are used, maps of geology, soils, vegetation etc. can be more readily compared. In many areas such maps call for international co-operation.

At medium and large scales, water resources maps may be a national or local task. They can provide a basis for

[1] The original text of this paper, prepared by V. J. Ceplecha, Water Power and Geographic Branch, Department of National Development, Canberra, appeared as document E/CONF.52/L.45.

preliminary assessment of water resources of a particular area or serve as a visual inventory of material for preliminary technical, developmental and economic studies. It is customary to attach hydrological maps to reports dealing with specific projects. In such cases, they can provide a guide for further engineering investigations.

Considerable basic data are necessary to produce maps of surface water resources. Apart from the topographic information necessary to produce a suitable base map, the information required includes long-term records of rainfall, run-off and other phenomena necessary for the calculation and characterization of water resources. The paucity of data in the whole or part of the area to be mapped could impose limitations on the scale of presentation or decrease the reliability of the information presented.

The content of surface water resources maps at various scales, the methods of presentation of the subject matter, their merits and deficiencies and the influence of data on the methods of presentation are discussed below in some detail and demonstrated by examples. Frequent reference is made to the map-sheet "Surface Water" (1965) of the *Fitzroy Region, Queensland, Resources Series* (published by the Resources Information and Development Branch, Department of National Development, Canberra, 1965), in which some of the methods described have been used.

Representation of stream pattern and drainage

Streams are the frame to which much of the hydrological information relevant for the evaluation of water resources is fitted either directly or indirectly; this applies to gauging stations, stream discharge and its characteristics and the chemical properties of waters. It is also generally recognized that drainage patterns reflect the influence of such factors as slopes, differences in lithology, structural contrasts and recent uplifts. With a careful selection of streams and stream symbols, much of such basic information can be built into the map and conveyed to the reader.

Despite the availability of data, little attention has been paid in the past to objective selection of stream patterns for maps of various scales. Such selection involves both the representative selection of drainage patterns and the proportional representation of drainage densities. These objectives can be achieved for large- and medium-scale maps (up to about 1:1,000,000 scale) by using Horton's system of stream orders as a criterion for stream selection. A paper describing methods based on this system is in preparation. They have been used for improved selection of streams for the map-sheet "Surface Water" of the Fitzroy series and some others.

Stream networks can also be very effectively used—mainly on small-scale maps representing continents or similar areas—to present certain properties of stream flow which supplement the main topic and would be otherwise difficult to depict. Thus, by suitable combination of stream symbols and colours, stream-flow properties such as magnitude of average discharge, permanence of flow, seasonal distribution of stream flow, dominant source of water, duration of ice cover in cold climates and salinity can be shown in broad classes without using more map space than ordinarily required for the stream pattern.

Some of the above properties are well defined from the available data but for others it may be necessary in certain areas to define arbitrary limits which should be observed when analysing the data (and should be defined quantitatively in the legend). Thus the classification of streams into permanent and intermittent can lead to ambiguities and inconsistencies if these terms are not defined in terms of frequency (and duration) of periods of no flow. Such definitions, of course, are possible only if sufficient information is available.

On medium- and large-scale maps this classification of streams is usually impracticable because of the lack of information about many minor ungauged streams. It would also lose its purpose, since the objective of classification is to show regional contrasts, rather than local anomalies.

Sources of hydrological data

In a broader sense, hydrological data include results of measurements of all components of the hydrological cycle. From the point of view of mapping surface water resources, the most important are stream flow and rainfall data.

The manner of classification of the sources of hydrological information, that is, the stream-gauging stations and rainfall stations, will vary with the scale and other contents of the map. The main advantages of including this information are the following:

The availability of hydrological information in the area is indicated;

The relative reliability of the information is shown;

The need may be indicated for further stations owing to deficiencies of data in some areas.

To serve the above mapping purposes, sources of hydrological data should be classified and broadly characterized. In addition to the location and identification (name and operating authority) of the station, the length of record and the quality and homogeneity of data should be indicated. The quality of the data may include such factors as type of attendance (professional or otherwise); homogeneity may be indicated by the degree and quality of rating at high, medium or low stages of the stream.

It is not usually possible or necessary to show all this information on maps except, perhaps, on those dealing specifically with hydrographic installations. At small scales, the main purpose of showing the sources is to indicate the reliability of other information presented, and this may be achieved satisfactorily by showing the locations (and consequently the density) and, in broad classes, the period of record. The purpose of this type of information on medium-scale regional maps is, apart from the indication of reliability, to convey further information on the availability of data. The scale of these maps (about 1:1,000,000) usually does not impose any cartographic restrictions on representation. The limitations —if any—are usually in the availability of data (such as incomplete information on quality and homogeneity). Some examples of the classification and ways of representing data related to measuring stations on medium-scale maps are shown on the Fitzroy region maps of climate and surface water.

Methods of representation of surface water resources

The rainfall (or, more generally, precipitation) and run-off are both important for assessment of surface water resources. Both these phenomena and their characteristics are therefore needed for water resources mapping, and, having similar statistical properties, can be represented similarly. Hydrological data are usually not normally distributed, so one of the basic problems of the presentation is whether to represent the resources by mean or median values. The median is less affected by extreme occurrences, but its relationship to the mean, representing the total resource, varies considerably from area to area. The variation in the relationship between the mean and the median is demonstrated in figure I for two selected streams; one in central Queensland (Fitzroy river at Riverslea) and the other in northern Victoria (Murray river at Jingellic).

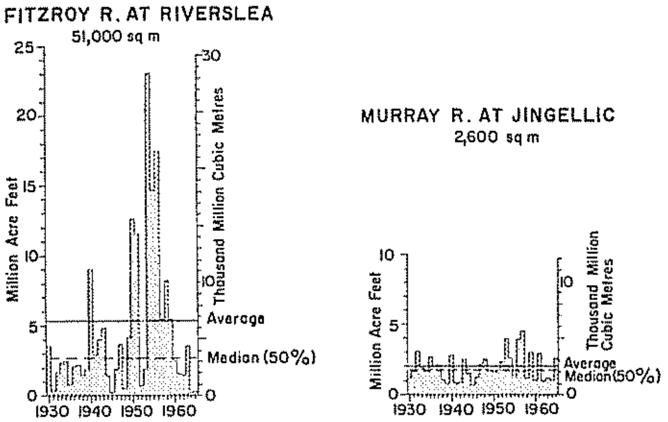


Fig. I—Australia: Histograms of annual run-off

Since the aim of mapping resources is usually to present the total available resource, the median seems to be less suitable for this purpose. However, in such cases as the Fitzroy river shown in the example, the median is likely to be a closer approximation to the amount of water which can be economically utilized. In data analysis, the median values are difficult to handle statistically if extrapolation of data in time or space is necessary (for example, correlations of median values within the basin or from different basins may not be possible because of variations in the distortion of data).

The main difficulty in presenting mean values is often their relatively high variability with time, particularly in arid areas. It follows that the period on which the mean values selected for presentation are based should be as long as practicable.

The magnitude of the error of the mean, however, which a map can absorb without any major misrepresentations varies with the scale of the map and also with the rainfall or run-off gradients presented. In areas of higher gradients, a large percentage deviation from the mean will have comparatively small meaning cartographically, since it may not be plottable.

For medium- and large-scale maps, however, it is advisable to adjust records to a common period and to select a relatively long period (at least thirty to forty years) as a basis for presentation. If records of two or more phenomena are used in analysis (for example, rainfall and run-off), these should be adjusted to a common period.

Similar criteria apply to variability of run-off, although perhaps for different reasons: the period selected for analysis should be as long as possible to minimize sampling errors and data should be adjusted to a common period to ensure comparability. However, methods used for adjusting data to a common period (such as frequency analysis) are different from those used for adjusting mean values.

Representation of run-off

The selection of the method of representing run-off depends to a large extent on the nature of the data available, the scale of presentation and the purpose for which the map is to be used.

The simplest method is probably to show the stream thickness proportional to the average discharge it carries. Suitable only for small-scale maps, its value for presentation of water resources is rather limited; it provides, however, a basis for comparison (it has therefore been used for presentation of peak discharges). Discharge data may be divided into several classes, each class being represented by a stream-line of specified thickness or the stream-lines may be directly proportional to discharge.

Another simple method is the use of histograms of annual run-off. These show the volume of run-off at gauged points and at the same time indicate the variability. This method of representation is applicable to any scale but selection may be necessary if used for small-scale maps.

Run-off can also be represented by choropleths, using as unit areas catchments for which average run-off has been calculated. However, since run-off is a continuous variable, large differences exist within unit areas. This method can be recommended only in areas for which abundant run-off records are available (so that unit area may be small) or for which it is not possible to develop relationships between rainfall and run-off because rainfall data are inadequate or unsuitable for analysis.

A very useful method for representing run-off is by isopleths (isarithmic method), in much the same way as isohyets are used for representation of rainfall. Isopleths of run-off are usually derived from isohyets with the aid of suitable relationships between run-off and rainfall and possibly other climatic elements such as evaporation, temperatures etc. The process is time-consuming, but often relationships derived for one catchment can be applied in other catchments having similar climatic and geomorphic characteristics.

With suitable adjustment of intervals between the isopleths, the method can be used at any scale, its application to large-scale mapping being mainly limited by the availability of data.

It is also possible to show by isopleths the integrated total run-off carried at points along the stream; in this case, however, the isopleths are discontinuous at catchment boundaries and the method is rarely used.

Two of the above methods are illustrated in the figure below, in which the run-off of Tasmania is represented by both choropleths and isopleths.

Representation of variability

General trends expressed in terms of mean annual values give only a very incomplete picture of the distribution of water resources in time. They do not indicate the seasonal distribution of run-off and its variation in time, nor the variation of annual run-off. These factors influence the effectiveness with which water can be used directly in run-of-river projects or stored in reservoirs and therefore they have a direct bearing on the size of reservoirs needed for water conservation.

Variability can be expressed by methods of representation similar to those used for average run-off; the simplest indication of variability can be built into the classification

..s (for example, permanent, seasonal and ephem- . This may be supplemented—for selected basins—by annual discharge graphs (histograms) showing also the differences between the median and average values, regarded as the index of distortion. This method is also suitable for rainfall.

It is relatively simple to represent variability of run-off of the whole catchment gauged at the outlet or of rainfall at a selected point. Both the seasonal and annual variability and the variability in time can be shown by a single graph (see figure II below). Although the arithmetic

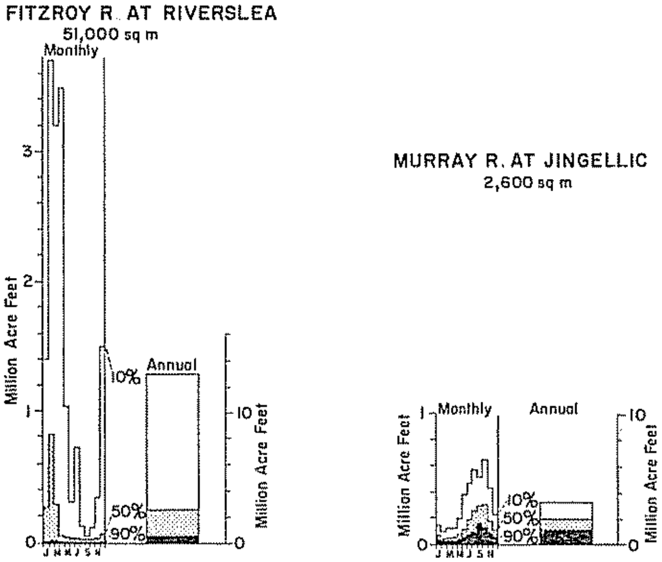


Fig. II—Australia: Variability of monthly and annual run-off (indicated by percentage probability of occurrence)

scale is preferred because of easier comparability between graphs, a semi-logarithmic scale may also be used. The advantage of semi-logarithmic graphs is that, because of their relatively wider range, they are capable of handling data with greater vertical spread.

For both arithmetic and semi-logarithmic scales, it is quite possible to represent three levels of probability of occurrence on a single graph: for example, the median and the upper and lower deciles or the median and the upper and lower quartiles.

The representation of variability by isopleths for elements measured at a point, for example, rainfall, does not present, any particular problems. The isopleths in such a case connects points with equal coefficients of variation or equal average deviations from the mean.

However, representation of variability by isopleths is usually possible only for a single time unit—a year, season or month—and more than one map would be necessary to show all information that can be represented by graphs. The advantage of isopleths is that they show spatial variability by continuous lines and not merely values for selected locations.

To represent the variability of elements measured on an aerial basis (for example, run-off) by isopleths is more complex, mainly owing to the introduction of a new parameter—the area of the catchment. While empirical and exact methods to overcome this difficulty exist, their application can be quite time-consuming without the use of a computer. Even if the difficulty of analysing data can be overcome, the limitations of the isopleth method mentioned above still remain.

In some maps the variability is presented by isopleths in terms of maximum and minimum annual or seasonal run-off. Maximum or minimum run-off should be defined in terms of the period during which it was recorded or the frequency of occurrence. The main disadvantage, common to all representations of variability by isopleths, is that the values shown cannot be summed up, since the recorded maxima or minima would not occur simultaneously over a large basin.

Representation of chemical properties

Chemical properties of surface water and their variations often impose many restrictions on the use of water for domestic, industrial or rural purposes. The specific properties selected for mapping would mainly depend on the purpose of the map and the range of data available. The information which may be required for reconnaissance investigations is the total content of dissolved solids, the relative concentration of sodium, boron content, hardness, any unusual pollution from industrial or municipal wastes and the quantity of transported sediment.

The properties which may most commonly be useful are salinity and hardness. Both may be expressed in parts per million. It is common to select class intervals in such a way that they correspond generally to the suitability of water for specific uses.

Salinity and hardness tend to vary inversely with the discharge of the stream, highest and most critical concentrations being recorded when the discharge is low (usually in the dry season). This should be taken into account when the data are analysed. Similar variations with volume of water stored can be observed in some lakes.

Considerable difficulty could be experienced in generalization from individual samples, mainly because at low discharges the chemical properties can be influenced locally by ground-water intrusions; generalization upstream or downstream is therefore usually possible only where large numbers of samples have been collected. For this reason the simplest method of representation may be to show results of observations at individual locations without trying any further generalization.

In coastal areas, the information on water quality may be supplemented by showing tidal limits; these, while indicating the limits of sea-water influence inland, do not always represent the downstream limits of water use.

However, more elaborate methods of representation of chemical properties of waters have been devised and used in some European countries; one of them (used in the physical and geographical atlas of the world, Moscow, 1964) is the six-pointed star method by which the chemical composition of water is given in terms of the content of six ions, three anions ($HCO'_3SO''_4$ and Cl') and three cations ($Ca^{\cdot\cdot}$, $Mg^{\cdot\cdot}$ and $Na^{\cdot}+K^{\cdot}$). Each ray of the star is then proportional to the milligtam or percentage equivalent of each ion.

Another property of interest for evaluation of the "life time" of storage reservoirs or for determining the erosion hazard is the sediment yield, a property associated with discharge. Maps dealing with this aspect are rare, probably because of the lack of data.

Some specific topics associated with the hydrology of an area, though not directly necessary for the assessment of

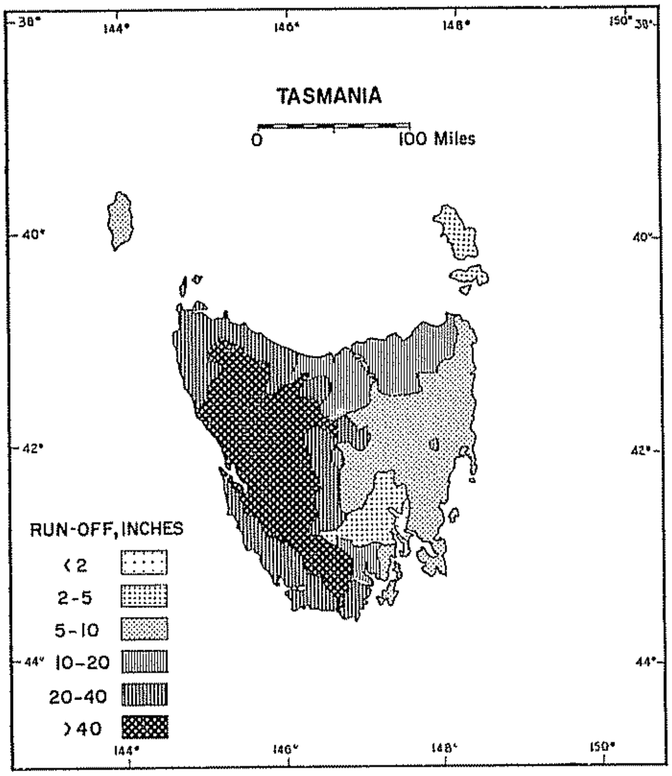


Fig. III—Australia: Average annual run-off by choropleths in Tasmania

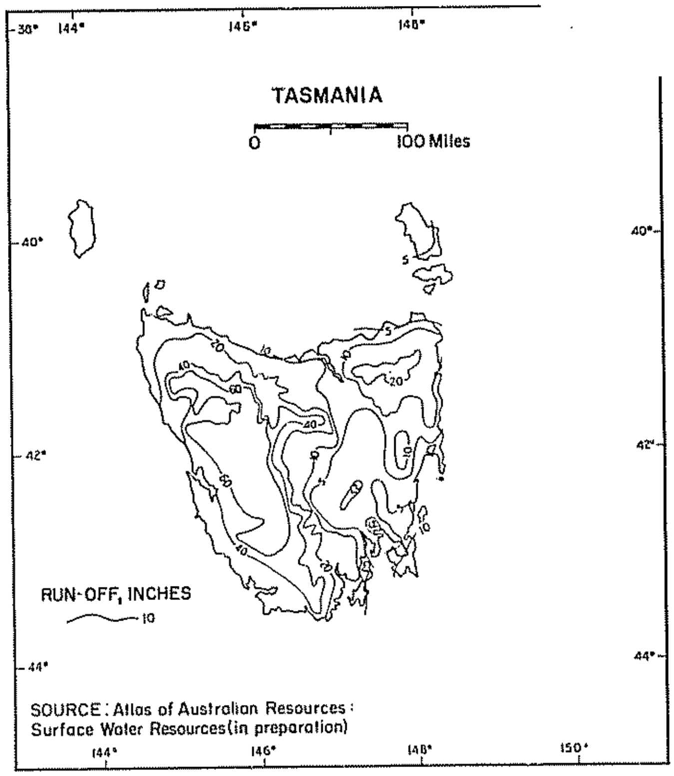


Fig. IV—Australia: Average annual run-off by isopleths in Tasmania

water resources, may be useful for other purposes. For example, the extent of flooding and its frequency may be of interest for planning irrigation areas, for assessment of possible flood damage or—in a more specific case—for planning the gauging station network. Such information is rarely readily available and usually has to be reconstructed with the aid of aerial photographs and scattered information about flood heights. The extent of flooding is suitable for presentation on medium-scale maps if it is intended as supplementary information by which regional comparisons can be made. For evaluation of flood damage, however, detailed maps may be necessary.

COLOUR PHOTOGRAPHY FOR WATER RESOURCES STUDIES

Paper presented by the United States of America[1]

Aerial photography is now widely used by the Water Resources Division, United States Geological Survey, in its studies of the water resources of the nation. Prior to 1961, when the Phoenix Research Unit of the Water Resources Division began developing a capability for obtaining aerial photography, project chiefs on water resources studies occasionally used existing black-and-white aerial photographs to obtain simple estimates of land-use and other parameters related to water resources. Since 1961, the Phoenix Research Unit has provided photography planned especially to meet limited project needs of the division.

Aerial photography is obtained by the Phoenix Research Unit using either of two planes: a twin-engine Beechcraft BE-18 or a single-engine Beechcraft T-34. Both have been adapted for aerial photography. The BE-18 is equipped to take simultaneous pictures from two cameras. To date, all work has been done using modified K-17 cameras. Developing is done in the Phoenix laboratory, using the Morse rewind system.

In 1962, the total amount of photography obtained by the Phoenix Research Unit was fewer than 500 frames of panchromatic film. In fiscal year 1966, however, the unit flew more than 9,100 frames of photography for water resources studies. Of these, 36 per cent were regular colour film, and 30 per cent were infra-red colour. An additional 4,057 frames of panchromatic film were taken of the San Andreas fault area in southern California for geological studies.

The intensive use of colour film for water resources studies—about two-thirds of the photography in 1966—indicates its value for these studies. Early experiences, particularly in the Florida Everglades, indicated clearly the superiority of colour film to panchromatic film. This does not mean that panchromatic or regular infra-red film is without uses. Quite the contrary: for specific purposes, such as shoreline delineation, they may be unexcelled. However, for over-all interpretation potential, colour film provides the best capabilities.

[1] The original text of this paper, prepared by W. J. Schneider, Water Resources Division, United States Geological Survey, appeared as document E/CONF.52/L.50.

...ctors in particular make colour film ideal for use ... ater resources studies. These are depth penetration through water, and excellent discrimination of water indicators, such as vegetation. Depth penetration is particularly important in studies of lakes or open-water areas such as the Florida Everglades, where knowledge of bottom conditions such as types and orientation of vegetation or sediments are important factors in understanding the hydrological regimen. Discrimination of vegetation, both aquatic and terrestrial, often provides the photo-interpretation key by which limited observations of hydrological data can be extended to regional characteristics for large areas.

Experiences within the Water Resources Division have shown that meaningful interpretation of the photographs depends upon adequate ground-control data. Usually such data must be obtained in the field at the time of the photography. In the Water Resources Division, these field data are obtained by the project personnel who are thoroughly familiar with the water problems of the area. These personnel are mainly hydrologists with professional training as engineers, geologists or water chemists. The photographs are later interpreted by the same project personnel, occasionally with some assistance from the Phoenix unit or the staff hydrologists of the division. In the interpretation of the photographs, all available field data are used and interpreted in terms of the personal knowledge and observations of the project personnel. In many cases, the available hydrological data collected over periods of years—even over decades—can be meaningfully interpreted and extended on the basis of current ground-control data and photographs.

Most of the colour photographs obtained to date for water resources studies have been at medium altitudes—generally between 4,000 and 6,000 ft. The resultant scale of the photographs of 1:8,000 to 1:12,000 is generally sufficiently large to permit detailed interpretations of water-related features, but for extremely detailed study of small areas photographs have been obtained from as low as 1,000 ft. To date, limited studies of high-altitude photography from aircraft and spacecraft indicate that only gross inferences are possible. For the type of information necessary for quantitative water resources studies, photography below 8,000 ft is usually required.

Aerial photography has been used successfully in more than 100 water resources projects to date. In 1966, photography was obtained for forty-two projects; colour photography was obtained for twenty-eight of these. As previously stated, 66 per cent of the photography during 1966—5,976 frames—was either colour or infra-red colour. Some of the better-known areas in which colour photographs are being used in water resources studies are the Florida Everglades, Great Salt Lake, prairie pothole areas of North Dakota, Lake Erie and the Potomac river. They are being used in such diversified studies as offshore springs, coastal estuaries, pollution, urbanization effects, water availability and flow regimens.

The Water Resources Division first used colour photography on a large scale in its studies of the water resources of the Florida Everglades. More than 3,200 frames of photography were obtained over the Everglades National Park area in southern Florida during April 1964. Since then, more than 700 additional frames of both colour and infra-red colour have been obtained. The photographs are currently being used to assess the flow regimen of the Everglades and to evaluate possible changes in the ecology as related to changes in the water regimen.

A further significant item now being studied is the

Fig. I—United States of America: Reproduction from regular colour transparency, scale 1:6,000, of area in Florida Everglades

Fig. II—United States of America: Reproduction from infra-red colour transparency, also at 1:6,000 scale of same area as figure on left (I) presence of rock reefs across the Everglades which serve as natural barriers to the flow of fresh water. The rock reefs are easily identified by the oriented hammock and sawgrass which form on the slightly higher elevations of the reefs. Excellent examples are shown in the following two figures. Figure I shows a typical Everglades environment in regular colour. The three main ecological communities are the hammocks containing trees (darker green, coarsely mottled areas), sawgrass (lighter grey-green, more evenly textured areas), and open water (light orange-brown areas). Direction of flow is from top to bottom. A line of small hammocks and dense sawgrass on the rock reef that forms a barrier to flow can be readily seen across the centre of the photograph. Figure II shows the same area in infra-red colour. It may be noted particularly that the small hammocks along the reef are more easily identified than in regular colour because the red colour of the trees is in sharp contrast to the blues and greens of the rest of the photograph.

Infra-red colour photographs are also excellent for delineating the mangrove shoreline and brackish water marshes of southern Florida. Figure III below shows an areas along the Florida Bay coastline at 1:10,000 scale. The dense, coastal mangrove jungle is clearly shown by the deep red areas. Inland from the coastal jungle, the circular red areas are hammocks of trees, generally mangrove in the periphery and fresh-water types in the interior. The light grey areas adjacent to the coast are marshes of halophytic grasses and scattered dwarf red mangroves up to 5 ft tall. The individual mangroves are clearly visible in the photograph. Inland from the marsh area, and just visible in the photograph, is the typical sawgrass of the fresh-water Everglades, shown by the dark grey area in the extreme upper right of the figure.

The hydrological environment of the area can be from the vegetative cover. The areas of dense mang and the estuarine channels are systematically inundated by tidal action. The brackish-water marsh is an intermediate zone where salinity varies seasonally with the fresh-water outflow from the Everglades. The water in this zone varies from almost fresh during high run-off in autumn to salty during low run-off in spring. The water in the sawgrass area is perennially fresh, and varies seasonally in depth.

Colour photographs are also being used in Florida to identify areas of fresh-water discharge along the coastline. Figure IV below shows an area just east of Cutler, Florida. Areas of ground-water discharge into Biscayne Bay can be identified by the presence of *diplanthera*, a grass that tolerates only moderate salinity, and therefore can grow only in those coastal areas where dilution of sea water by fresh-water discharge reduces salinity. In the photograph, the grass can be seen extending seaward from the shoreline for about 300 ft as a solid mass. Beyond this, scattered patches of *thalassia* occur. Because *thalassia* will tolerate only very high salinity, the area of fresh-water discharge can be identified as occurring only in the near vicinity of the shoreline.

Vegetation as an indicator of salinity of water is also being studied in the prairie pothole areas of North Dakota The potholes are depressions of various sizes and depths that were formed when retreating glaciers left huge blocks of ice in their wake. Today, these depressions contain water that ranges in salinity from near zero to three times that of sea water. Some preliminary observations from aerial photographs indicate that salinity of the ponds can be determined from the photographs. Figure V shows a typical group of pothole lakes at 1:12,000 scale. Water in the individual lakes ranges from fresh to very saline.

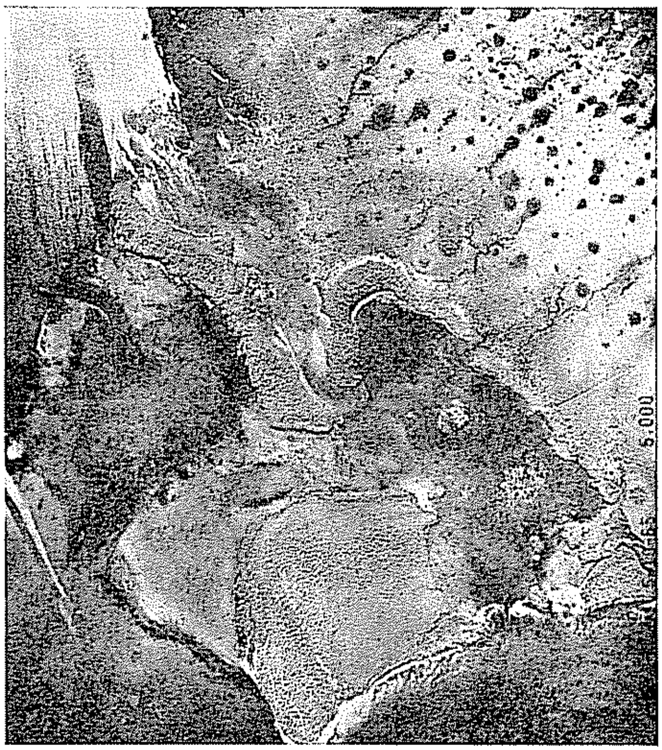


Fig. III—United States of America: Reproduction from infra-red colour transparency, at 1:10,000 scale, of coastal area along Florida Bay

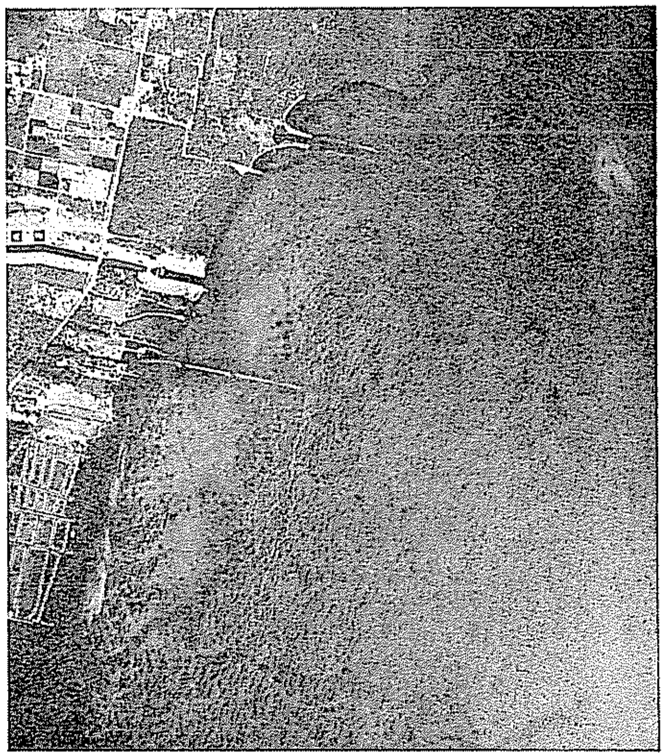


Fig. IV—United States of America: Reproduction from regular colour transparency, at 1:12,000 scale, of shoreline area east of Cutler, Florida

Fig. V—United States of America: Reproduction from regular colour transparency, at 1:12,000 scale, of part of Prairie Pothole area in North Dakota

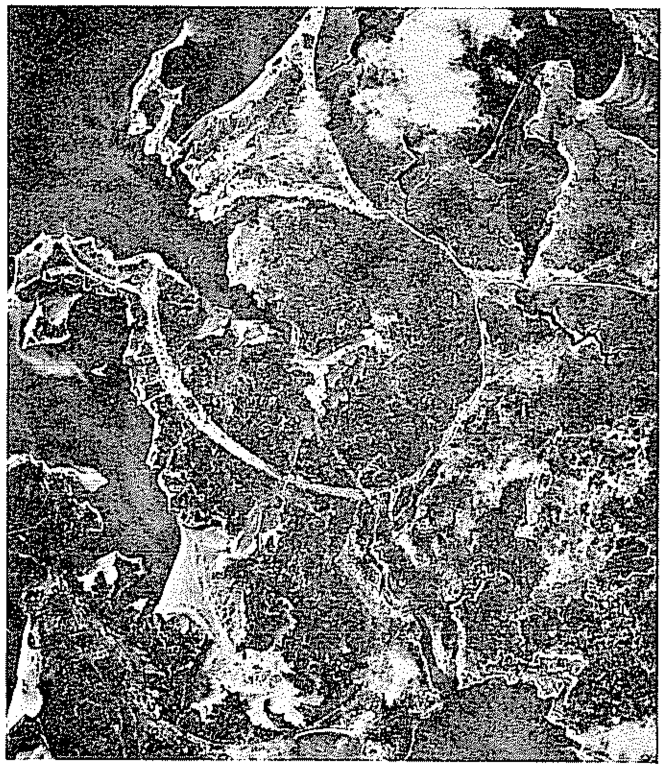


Fig. VI—United States of America: Reproduction from infra-red colour transparency, at 1:20,000 scale, of area near Salisbury, Md.

Although this photograph was obtained in October after a killing frost, vegetation still can be used to infer both salinity of the water and the ground-water conditions that govern the extent of salinity. The lake in the lower left of the photograph is highly saline. Note the complete lack of aquatic vegetation and also the presence of white salt deposits along the shoreline. Although the water in the lake to the right of the photograph is saline, the area along the right shoreline is only slightly brackish as a result of fresh-water inflow from a spring originating in the small clump of trees to the right of the lake. Evidence of ground-water inflow can also be seen in the small lake in the extreme upper left of the photograph. Dense vegetation—trees along the shoreline and aquatic vegetation in the lake—mark an area of fresh-water discharge to the lake. In the upper right is a shallow dry pothole covered with fresh-water vegetation.

In eastern Maryland, aerial photographs are being used to identify and locate topographic features similar to the famous Carolina bays along the coastal regions of North Carolina. As seen in figure VI, the bays in the Maryland area consist of sand ridges surrounding poorly drained depressions. Shown here in infra-red colour at 1:20,000 scale is a bay located along Chesapeake Bay west of Salisbury, Maryland. It should be noted especially that cultural development is entirely along the sand ridge. Farther inland, although still as pronounced, the bays consist of similar sand ridges with less permeable clay soils in the depressions. Because the depressions collect and store run-off from rainfall, they are significant factors in controlling the hydrological regimen of the area, and in regulating storm run-off.

In studies of the Great Salt Lake, aerial photographs are used to identify circulation patterns as well as movement and deposition of sediments in the lake. As in other studies, areas of ground-water inflow to the lake can be identified by denser vegetation growing in the vicinity of the discharge area. Of particular interest are bioherms growing on the lake bottom. Bioherms—coral-like reefs several feet high formed by minute living organisms such as corals and algae—occur in formations similar in shape and size to desiccation cracks formed in soils. This suggests that at one time these areas of lake bottom were exposed, dried out and cracked and that, following subsequent inundation, the organisms occupied the cracks in the bottom and began growing and forming the bioherms. Figure VII shows the pattern of bioherm formations at a scale of 1:12,000.

In preliminary reconnaissance studies of Lake Erie, colour photographs have been used to identify flow patterns, especially as related to the discharge of polluted wastes to the lake. It has been especially useful in the appraisal of water-quality data obtained at specific locations in the lake. The photography has been invaluable in assessing the circulation patterns in the vicinity of the mouths of rivers, so that continuous water-quality monitors may be located in representative lake environments. A common flow pattern is shown in figure VIII. Shown here at 1:8,000 scale is the Cuyahoga river as it enters Lake Erie at Cleveland, Ohio. The industrially polluted river water diffuses as it is carried eastward on the lake surface by the prevailing wind. Evidence of the warmer river water overriding the cooler lake water is seen in the boat wakes in which the upper layer water has been mixed sufficiently with the underlying lake water so that the wake appears quite similar to lake water.

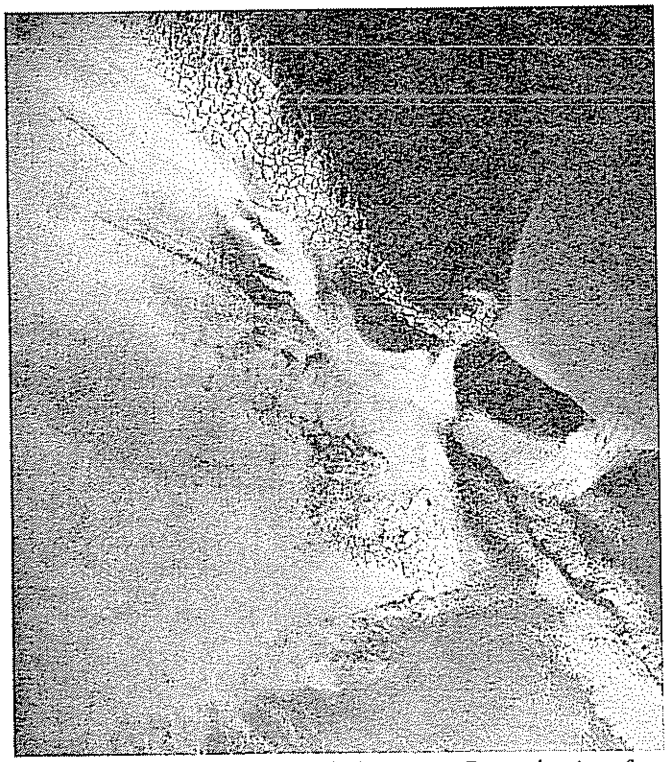


Fig. VII—United States of America: Reproduction from regular colour transparency, at 1:12,000 scale, of part of Great Salt Lake, Utah, showing configuration of bottom surface

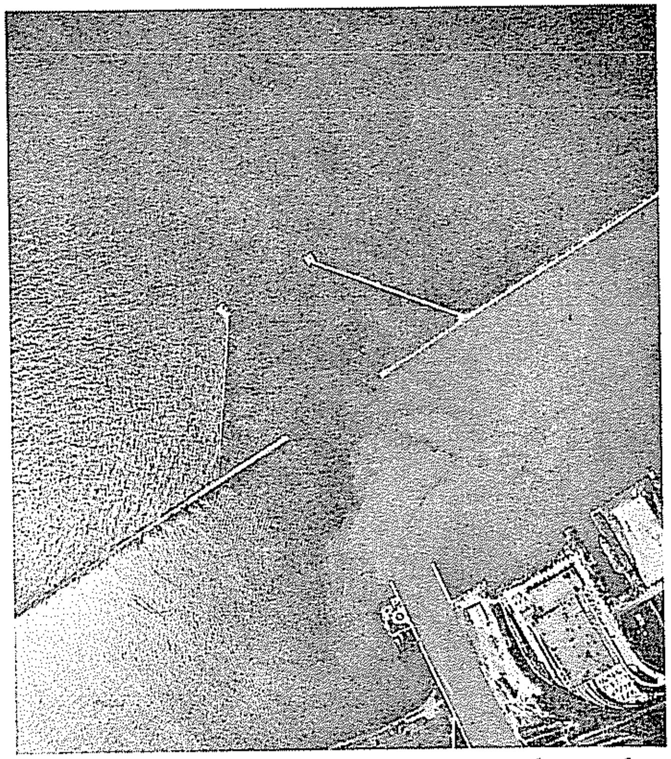


Fig. VIII—United States of America: Reproduction from regular colour transparency, at 1:8,000 scale, of Lake Erie at Cleveland, Ohio

Colour photography has been used successfully by the Water Resources Division for water resources studies since 1962. In each case, however, photography has been introduced to the project after the initial planning phase and while the study was in progress. In several projects—notably those in the Florida Everglades and in the prairie pothole area—the use of photography has made possible broad regional approaches to water problems that would not be possible by on-the-ground coverage. It is quite likely that future water resources studies of large areas will include provisions for aerial photography in the initial planning of projects. It is also expected that colour aerial photography will play an increasingly important role in future water resources investigations.

MAPPING FOR WATER CONSERVANCY AREA

Paper presented by China[1]

Maps of different water catchment area have been prepared for the planning of reservoirs and dam sites in Taiwan during the last three years. Four different steps have been undertaken in mapping: triangulation, levelling, traverse and topography. One cadastral control station was used as the initial point. The levelling was connected to the first-order levelling bench-mark if possible. The closure error was not greater than 7 mm$\sqrt{K}$. The mapping work during the period under review (1964–1966) is shown below.

Table 1. Triangulation

Area	*Description*	*No. of stations*	*Standard*	*Remarks*
Kao-Ping-Chi valley	Joint triangulation	47	Third order	Field observations have been completed. Co-ordinates and indirect elevations have not been computed.
Kao-Ping-Chi valley	Topographic control survey	41		

[1] The original text of this paper appeared as document E/CONF.52/L.114.

Table 2. Levelling

Area	Description	Length (km)	Standard	Remarks
Kao-Ping-Chi valley	Levelling network	128	Third order	Closure errors not greater than 7 mm$\sqrt{K}$. (K = number of km_2)
Cho-Shui valley	Joint levelling between Ching-yun and Wu-Chieh	100	Third order	

Table 3. Topography

Area	Description	No. of map sheets	Scale	Remarks
Cho-Shui valley	Shih-Tzu-Tou reservoir diversion surveying project	2	1:2,500	Base map
Cho-Shui valley	Waterways (south of Chi-Chi) surveying project	12	1:5,000	Manuscripts
Cho-Shui valley	Inundated areas (caused by Chi-Chi regulating pondage) surveying project	7	1:5,000	Manuscripts
Cho-Shui valley	Ku-Ku Shan quarry site surveying project	5	1:2,500	Manuscripts
Cho-Wu-Chi valley	Chung-Liao photogrammetric mapping project	34	1:10,000	Manuscripts
Kao-Ping-Chi valley	Chi-Shan Chi photogrammetric mapping project	44	1:10,000	Manuscripts
Kao-Ping-Chi valley	Min-Tsu dam site topographic project	37	1:1,000	Manuscripts

(f) *Civil engineering projects*

EFFICIENCY AND ECONOMY OF PHOTOGRAMMETRIC SURVEYS FOR ENGINEERING (PRINCIPALLY ROAD CONSTRUCTION) PURPOSES IN TROPICAL REGIONS

Paper presented by Australia[1]

INTRODUCTION—THE PROBLEMS

For cartographic purposes, it is generally assumed to be at least desirable to relate map sheets to an adopted national geodetic co-ordinate system and an established level datum. It is not proposed, in this paper, to challenge that assumption. For engineering purposes, the products of the cartographer have been found to be of great value. The engineer generally asks the cartographer to provide his type of product at larger scales, covering smaller areas, than the general map sheet coverage of the country, but does not know enough of the basic technology of cartography to question the efficiency and economy of the procedures employed. For his part, the cartographer takes justifiable pride in his traditions of associating absolute precision with a given format or contour interval and rarely asks the engineer whether something less than this would be acceptable. When it is established that a relaxation of tolerances would be accepted by the engineer, the tendency is to regard engineering mapping as somewhat inferior to "cartographic" mapping.

In this context, fundamental changes in thinking are required on both sides. First, the engineer, who is not unaccustomed to the adoption of arbitrary co-ordinate origins or an arbitrary level datum when it is not convenient to connect to a "known" system, must learn to think in terms of the types of measurements which he "derives" from maps, rather than the types of measurements which are generally "portrayed" on maps. Secondly, the cartographer (or the photogrammetrist) must appreciate that the engineer can derive measurements from maps which do not purport to portray topographic information exactly in the form to which cartographers are accustomed.

It may be reasonable, at this stage, to relate these thoughts to the fundamentals of photogrammetry. It may be accepted that the survey photograph is capable of geometric restitution in the form of a "bundle of rays" analogous to the bundle passing through the perspective centre of the camera at the instant of exposure. The analogy is not exact, but it is close enough for the present purpose. Each bundle of rays so restituted has six degrees of freedom: three of position (of the perspective centre) and three of rotation (about the perspective centre). Any two bundles of (partially) conjugate rays thus have a total of twelve degrees of freedom between them. The two photogrammetric procedures of relative orientation and absolute orientation generally aim at determining all twelve of these degrees of freedom. It may be accepted that the relative orientation, being a spatial resection with five degrees of freedom, leaves seven degrees of freedom to be determined in absolute orientation.

[1] The original text of this paper, prepared by W. B. R. Smith, Supervising Engineer, Rural Investigations Section, Department of Main Roads, New South Wales, and G. J. Cocks, Technical Director, Map-Makers, Sydney, New South Wales, appeared as document E/CONF.52/L.38.

Once the relative orientation has been achieved, we have an exact reconstruction of the spatial geometry of the conjugate parts of the two bundles of rays: at an unknown scale, at unknown inclination of the model to the terrain reference surface, with unknown position and unknown azimuth. A practicable sequence of operations in absolute orientation is to achieve first a known scale, for which it is necessary to have knowledge of one spatial distance in the model. It is then possible to "level" the model from a knowledge of the height differences between any three non-colinear points, preferably located at or near three corners of the model. At that stage it is possible to derive any relative quantities which are capable of derivation from the model. The usual remaining steps in the absolute orientation establish the spatial co-ordinates (X, Y and Z) of one point and the azimuth of a line. These quantities are of an absolute nature and have no influence whatever on relative measurements which may be derived from the model. For engineering purposes, the governing criteria must thus be scale and gradient—the relative parameters—with the addition of the absolute parameters being justified only if it is convenient to obtain them or if there is some compelling reason (such as a necessity for setting-out for construction) for the determination of these parameters. Even then, the necessity for information in such absolute terms should not be accepted without question.

Photogrammetric methods of processing terrain data are known to be much stronger in relative than in absolute precision, for reasons associated with these considerations concerning the fundamentals of photogrammetry. The major problem which must be overcome by those who would aim at enhancing the efficiency and economy of photogrammetric surveys for engineering purposes is to induce both engineers and photogrammetrists to think in such fundamental terms and to relate this thinking to their professional practice. The engineer is concerned with the relative positions of points in the terrain and with height differences between such points. It may be accepted that, in any photogrammetric model whose relative orientation has been achieved (that is, in which all conjugate rays intersect in space within a tolerance which will depend on the instrumentation and purpose), there is a faithful reconstruction of the geometry of the objects within the field of view of both photographs at their respective instants of exposure. Spatial distances and angles may be observed between any series of points within this common field of view—or be derived from observations which are possible in the model at that stage.

Observations in photogrammetric models may generally be recorded either in graphical or in digital form, it being necessary to make a choice regarding the form of presentation depending on the nature of the requirement. The problems of the engineer are in fitting some type of structure into the terrain, with complex spatial geometry generally being a feature both of his structures and of the terrain. The road engineer, for instance, has the basic problem of providing road pavements over which it will be reasonable to expect a number of vehicles to travel at a particular speed, between various points of origin and destination. He must endeavour to ensure that these pavements are structurally sound, that they remain generally unobstructed by such undesirable things as water or debris, and that the geometrical arrangement (and continuity) is such as to allow the designated traffic flow.

A problem which is most acute for the engineer in tropical countries is that of keeping water and some types of debris away from the road pavement, or conveying from the pavement such quantities as he cannot keep away. For this he must plan adequate drainage facilities and sometimes support his pavements on bridge structures. In order to keep some other types of debris from his pavements, he must provide batters in cuttings at angles which will be dependent on the nature of the terrain. To avoid other types of debris, he must remove some vegetation from the vicinity of his road. He must allow for the merging and diverging of traffic streams by intersections or interchanges, or for unimpeded flow by overpasses or underpasses, and for other requirements determined by considerations of safety or convenience.

For the planning of drainage facilities, the engineer often needs some information concerning the volumes of water which his drainage structures must be able to pass in a given time. For this purpose, studies of some aspects of terrain form may be called for. The catchment area of the subject stream is one of the pertinent parameters, while its length (from source to site) and its mean gradient will be others. Much of the information required for these purposes can be obtained photogrammetrically, but there is no need for anything but relative measurements. Geographic position will be of interest only to the extent that it bears on rainfall intensities. For other details of road planning there is likely to be even less interest in geographic (or geodetic) position, although it may be convenient to use geodetic information if such is readily available. Longitudinal sections or cross-sections of the terrain, related either to an adopted centre line or to some axis of reference, presented either in digital or in graphical form, give the engineer the details of terrain form in which he is interested. For these, scale and a level reference surface are the prime requirements, while position and datum are generally of little consequence.

Similar statements could be made regarding other engineering survey requirements. The requisite precision of measurement, or of portrayal, of terrain form will vary with the purpose to be served by the survey. In this context, if efficiency and economy of survey are to be criteria, the engineer and the photogrammetrist must continually, and in liaison, be seeking answers to the basic question: "How much is enough?" when approaching decisions on the detail of the control and photography which should be used for the various stages of project planning. The answers will depend on other questions: "What instrumentation is available?" "What are the problems in obtaining planned photography?" "What is the nature of the information required for this stage of investigation?" "What information is readily available?" "How reliable is that information?" "If we spend a little more at this stage, will there be benefits at later stages or for other purposes which would justify this expenditure?" "Is expedition more, or less, important than cost?" "What are we trying to achieve?"

Scale and Gradient in Strip Triangulation

Assessments of the patterns and magnitudes of errors propagated through photogrammetric strips in scale are of interest as far as the derivation of distances between points is concerned, but the gross propagation of position errors should give rise to no more than academic interest. Similarly, it is the inclination of the strip reference surface resulting from error propagation in spatial triangulation which will affect derived height differences, while gross values of propagated height discrepancies are comparatively unimportant. Where the engineer uses a graphical product, such as a contoured map sheet (or a series of such sheets), it is generally unnecessary to adopt (or to portray) any planimetric co-ordinate system. Connexions between successive photogrammetric models may be made graphically, generally with a precision quite consistent with graphical portrayal of terrain data.

For planimetric precision in engineering mapping for road purposes, graphical accuracies will generally suffice even for setting-out, but there may be requirements for different scales of graphical portrayal for different types of road facilities. There must be continuity in the road structure, of course, but the construction engineer can generally be relied upon to achieve this, even if the survey information is significantly outside generally specified tolerances. Even when substantial monuments are established in the field for survey purposes and established as to position in a national geodetic co-ordinate system, the engineer is interested only in re-establishment of position "relative to" the positions of these monuments "in the terrain". That a point through which a road centre-line must pass, 2 miles from another point on the same centre-line, might be "out of position" by, say, 100 ft, by the criterion of application of the design alignment to the national geodetic co-ordinate system, will not worry the engineer, as long as his road fits the terrain in between.

A similar argument can be developed regarding gradients and heights. As long as the succession of gradients and vertical curves of the road pavement satisfy the design criteria (they need not conform exactly to the detail of the designer's suggested realization of these criteria to do that) and provided that the construction operations have been economic, the engineer has generally done his job well. The accuracy of a survey connexion related to the national datum need have no influence on the comfort and safety with which the occupants of vehicles may travel along the constructed road, provided that the precision of relative or derived quantities is adequate for the engineering purpose in between. The propagation of datum in aerial triangulation is thus of interest to the surveyor and the cartographer, but inconsequential to the construction engineer. It is vital, however, to distinguish between the propagation of datum and the propagation of gradients in the reference surface.

Thoughts concerning the practical application of these concepts have been developing for some time. Some relevant experimental work was carried out during 1963, in the context of a project undertaken at the time for the Queensland Main Roads Department, but the results were not considered of sufficient consequence to warrant publication at that time. A specification was written for strip adjustment based on this concept during 1965, subsequently published as the first appendix to a paper presented to the third biennial conference of the Australian Road Research Board in Sydney in September 1966. Various projects have recently been planned in such a manner as to render the results capable of analysis against the criteria enunciated in that specification. That analysis has been published in the form of a paper presented to the Congress of the Institution of Surveyors, Australia, in February 1967.[2]

The investigation and planning of developmental projects in the part of the world covered by the terms of reference of this conference present challenges to mankind. There is urgency associated with the needs for accelerated engineering studies aimed at regional self-sufficiency in agriculture, water, minerals, basic industries such as steel and aluminium, and secondary and tertiary industries. A pertinent viewpoint is given expression in a paper presented to the inaugural meeting of the New South Wales branch of the Australian Photogrammetric Society[3] as follows:

> "The future of photogrammetry, generally, presents many challenges. While the highly developed industrial complexes of Europe and North America must be expected to continue to dominate the development of photogrammetric instruments and fundamental techniques, the application of these techniques to survey problems is a field in which engineers, surveyors, cartographers and photogrammetrists in other places must pursue research and development. Indeed, many of the problems with which we are faced in Australia (and in Australian Territories) are almost unknown in Europe and North America where, furthermore, the resources available to be devoted to the solution of those problems which do arise are more formidable than ours can be in the predictable future. We have the paradox, in Australia, of a highly developed society and one of the most under-developed countries in the world, in relation to the geographic extent of the continent we occupy.
>
> "There are reasons—historical and climatic—for this state of affairs, which it is not a purpose of a paper such as this to examine. This paradox, however, while a weakness from some viewpoints, indicates a direction in which the inherent strengths of our highly developed society may find outlets both satisfying and profitable. The problems of the remainder of the "under-developed" world are with us constantly and lend themselves to close scrutiny from positions of reasonable comfort. While it may be desirable to have experienced a measure of discomfort in order to appreciate the full import of relevant problems, there must be at least moderate comfort—sufficient to allow some detachment of thought—provided for those from whom some originality of thought is expected.
>
> "It is abundantly clear that there is scope for originality of thought in the field of procedural development in engineering photogrammetry. . . ."

The challenge which must be faced is to make the most efficient use possible of the technical manpower and the technological resources available for deployment on the tasks of investigation. While it may give the surveyor a great deal of satisfaction to say that a particular control survey was performed rigorously and would satisfy the most exacting specification, or for the photogrammetrist or the cartographer to make a similar observation, the criterion should rather be in the form of the question: "If we were not quite so rigorous, would we be able to produce adequate information for more investigations in a given period of time?" This viewpoint is developed further in the paper from which the extract quoted above was taken. Following the introduction of some thoughts on the uses of automated instruments, it is stated:

> "However, it is likely that conventional restitution instruments will retain an important place in photogrammetric practice at least for the next decade. Regardless of the means employed for the production of the

[2] Smith, W. B. R., Prins, P. J., and Cocks, G. J., "The Application of the Criteria of Scale and Gradient to the Adjustment of Photogrammetric Strip Triangulation". Institution of Surveyors, Australia, Tenth Survey Congress, Sydney, February 1967.

[3] Lenehan, A. T., and Smith, W. B. R., "The Growth and Development of Photogrammetry for Main Roads Purposes in New South Wales". Australian Photogrammetric Society, inaugural meeting, Sydney, 16 August 1966.

contour map—automated or conventional—the efficiency and economy of the control surveys will remain of great importance. Enough should be spent on the control for any project to ensure that the product is adequate, technically, for the purpose intended, but no more.

"For main roads purposes there will be a proportion of photogrammetric projects in connexion with which the requirements for precision will fully tax the available facilities for control surveys. In those cases the planning and execution of the work must be meticulous, demanding constant vigilance. The greater challenge lies in determining the criteria of adequacy in control, particularly (but not only) when high absolute precision is not required. How much is enough? This is the basic question which must be asked constantly. It may be varied to suit the context in which it arises. How far is it permissible to extrapolate? Over what length of gap is it warranted to interpolate? Are these the right questions?"

It may be warranted to emphasize that these questions are particularly pertinent to our region. Where there are highly developed geodetic control systems, it will often be more economical to aim at rigorous control than to improvise. In many parts of Australia—and of Australian Territories—it is necessary to approach control surveys on the assumption that nothing of value will be found to exist. It seems very likely that such paucity of information will be experienced in many other parts of the region represented at this conference.

If, as seems to be likely, it is warranted to plan control control surveys for engineering investigations on the basis of a series of groups of control points, within each of which there would be full interconnexion, but between which there need be no connexion whatever, then the impact on the economy and expedition of engineering investigations could be considerable. While it is believed that the results already achieved in the development of this concept have been significant, the time has come for others to join in the exploration of these realms of thought and apply them to their practical problems.

Aerial photography in tropical (and sub-tropical) regions

With the recent developments in photogrammetric instrumentation, it has become possible to produce photogrammetric maps at the large scales generally demanded for engineering purposes, using smaller scale photography than would have been contemplated even a few years ago. The impact which these developments have had on the economy and efficiency of photogrammetric surveys has been significant. In this instrumentation, aerial cameras have an important place. It is the aerial photograph on which the photogrammetrist records his "raw" data. Here again, if thinking is oriented towards the requirements for relative rather than absolute precision in engineering mapping, these data can be used to produce yet larger scales of of maps from smaller scales of photographs than is the practice even now.

The correlation between scale of photograph and flying height is determined by the principal distance (focal length) of the camera. The smaller the principal distance, the smaller the photo-scale for a given flying height. It is only very recently that restitution instruments have been produced which combine the possibilities of large enlargements between photograph and plotting table with the ability to restitute photography with super-wide-angle (and hence short principal distance) characteristics. The opinion is expressed that experience in the use of this combination of instrumentation will lead to further developments in these fields. It is of great importance to Asia and the Far East that this development be accelerated. Efficiencies of data collation and processing which are acceptable in Europe and North America cannot be tolerated here.

A point to be borne in mind in this context is that, even though the costs of obtaining aerial photography are significant, it is usually the case that the component of cost attributable to photography is only a small percentage of the cost of any photogrammetric survey. Thus, on the criterion of expenditure, it may be warranted to incur significant increases in costs at the photographic stage, if savings can be made at other stages of the work. Such aspects as the targeting of control points and multiple flying of preplanned photographic runs should be considered. On projects on which targeting is carried out for each planned model of a strip, it has been established to be sound practice to fly each strip at least twice with 80 per cent longitudinal overlap, in order to have reasonable certainty of being able to select one set of 60 per cent overlap which fits the planning. The greatest part of the cost of aerial photography is in positioning the aircraft over the project area under conditions suitable for photography. The increase in cost involved in exposing a few more frames at that time is negligible, as is the cost involved in flying each strip more than once, for engineering project photography.

Another point to be considered may be put in the form of the question; "What are the optimum (or acceptable) meteorological conditions under which this photography should be taken?" It is likely that part of the answer to this question will be influenced by the nature of the terrain and of its vegetation. On these and related points, some pertinent comments have been made by W. B. R. Smith in a paper entitled "The need for research in photogrammetric technology for road purposes in Australia" (Australian Road Research Board Paper No. 250, September 1966):

> "The cartographer, from his interest in the over-all mapping of large areas, tends to accept the fact that parts of the terrain may be obscured in photography by hill shadows, by vegetation or by the shadows cast by vegetation, under the conditions which he considers to be optimum for aerial photography. In Australia, we do not have the seasonal variation in foliage which is characteristic of most of the trees indigenous to Europe and North America. Vegetation is generally more vigorous in gullies and creeks than it is on ridges, with the consequence that heighting observations from photogrammetric models must inevitably be less reliable in such places than on ridges. The road engineer, however, has a particular interest in gullies, creeks, rivers, swamps and other low-lying places, for reasons on which no elaboration need be given here. Thus, at least when using panchromatic photography, it is reasonable to question whether the conditions which the cartographic photogrammetrist considers to be optimum for his purposes are really the most suitable for road purposes in Australia.
>
> "The air crews engaged on photographic work for survey purposes, and the laboratory technicians who process the exposed films, have come to accept the conditions normally specified for cartographic photography as being the only ones under which such photography

should ever be exposed. A new series of skills must be learned by these people if they are to obtain the best quality of photography attainable under conditions which they consider to be adverse. Despite these problems, some success has been achieved locally in taking project photography under completely overcast conditions, the principal criterion being that there should be no cloud between the aircraft and the terrain, with the result that vegetation and hill shadows have been eliminated entirely. While this success may be cited as an example (Howlett, 1959) of 'adjustments... in limited and pragmatic ways . . . to meet immediate and urgent needs of application', the adjustment has been made in the face of scepticism (stronger words could be used) expressed by the personnel responsible for production. Furthermore, it is now known whether different criteria would be application, for instance, to colour photography."

While there are wide ranges both of prevailing meteorological conditions and of topographic types in tropical (and sub-tropical) regions, these ranges differ from those encountered in temperate regions. There are also seasonal variations in meteorological conditions, and hence in vegetation coverage of the terrain, in tropical and subtropical regions, but again the nature of these variations differs from that encountered in temperate latitudes. We have wet areas and dry areas, with the meaning of those comparative adjectives varying from place to place. We have wet seasons and dry seasons, often influenced by the direction of the prevailing wind and by topographic form. In Papua, for instance, Port Moresby is in a comparatively dry area, with annual rainfall generally about 40 inches (1 m) and falling principally between December and March, while the annual rainfall in the Papuan Gulf is up to ten times that amount, falling principally between April and December. However, Kikori (in the gulf) often has more rain in its "dry" season than Port Moresby has in its "wet".

One of the characteristics of tropical meteorological conditions with which the aerial photographer must live is turbulence. This is a problem even in temperate latitudes, of course, but the occurrence and the severity of the phenomenon are more pronounced in tropical regions. Even when there is a total absence of cloud, turbulence can preclude photography during "normal" hours, particularly at the low altitudes often required for engineering purposes. It was found, for instance, in Darwin in the middle of a dry season (July 1962) that photography from an altitude of 3,000 ft was practicable only up to about 9 a.m. each day, due to the diurnal build-up of turbulence beyond critical levels by about that time. Shadows of vegetation and buildings obscured more of the terrain at those times than would have been the case closer to noon, but this circumstance had to be accepted.

The correlation between cloud cover and turbulence deserves special consideration in tropical areas. The question needs to be asked whether even intermittent cloud cover must necessarily preclude photography. A case can be quoted of a dam site on the Bowen river in tropical Queensland photographed in 1961 from an effective altitude of about 4,000 ft, which was just below the cloud-base of intermittent cumulus then building up—at about 10 a.m. The decision to take this photography has been prompted by rather tentative inquiry from the Queensland Water Conservation and Irrigation Commission, which required information for preliminary investigation purposes. A proposal based on the use of that photography was accepted by the client and a ground control survey planned and performed. Apart from intermittent and pronounced cloud shadows, which taxed the dodging facilities available, in processing laboratories, it was found that the photograph common to the two models to be plotted had an omega inclination beyond the limits which could be accepted by the restitution instrument. In this case, use was made of a "rectified" diapositive, which gave an acceptable relative and absolute orientation in each model. Part of the problem might have been avoided had the run been flown with an 80 per cent overlap, or flown twice, but the cost of repositioning an aircraft in the project area would have exceeded the total fee for the survey quite significantly.

Photographic costs in tropical regions are often proportionally greater than those incurred in temperate zones. For instance, in temperate Australia, it is unusual for the cost of aerial photography to exceed about 15 per cent of the total for any large project. In New Guinea, however, a figure of 50 per cent would be more common. Even with this higher proportion, it is often necessary to accept photography very different from that planned. Disjointed runs and wildly varying flying heights are not uncommon. However, it is doubted whether those who have carried out ground investigation for road or dam locations in difficult areas would have been too critical of variations in photography had such been available to assist them.

Other technical aspects

There are many technical developments of which we hear from time to time, which may warrant consideration for engineering mapping purposes but concerning which the authors of this paper must admit either to limited practical knowledge or to profound ignorance. Amongst these it would appear to be not unlikely that some use could be made of the horizon camera or the statoscope for strengthening strip triangulation. Any item which gives promise of reducing dependence on ground survey should be given more than passing consideration, particularly in tropical areas where movement of survey parties is not easy. Party mobility can be enhanced, of course, by the provision of helicopter support, which often proves to be economic desite the apparent cost. Similarly, an investigation of the value of such aids as the laser profile recorder may establish an economic justification for its use, despite its high capital cost.

Costs of (and payment for) photogrammetric services

The administrative arrangements which are made to obtain aerial photography and photogrammetric services will at least influence the efficiency and economy of the work performed. Although some photogrammetric survey work is generated by requirements of private enterprise, the greater part of this work is, and is likely to remain, generated by governmental organizations. With the inevitable growth of demand for photogrammetric services, some form of organization must be set up to ensure that demands are satisfied. Whether such organizations should undertake either the whole or a part of production will depend on many factors. For cartographic purposes, it appears to be common practice for at least the greater part of productivity to be undertaken directly by governmental establishments, thus creating capacities which can be diverted to satisfy at least some of the requirements for engineering photogrammetry.

The diversity of requirements for engineering survey is often such that the resultant productivity does not fit readily into a cartographic organization. There is thus a tendency for engineering photogrammetric work to be undertaken predominantly by private practitioners, who must aim at satisfying the requirements of diverse clients. Furthermore, the private practitioners must generally aim at multiple-shift instrument operation, coupled with high rates of productivity, if they are to achieve a turnover adequate to service capital invested and return profits, while offering their clients an economical service. It is sometimes contended by those in control of governmental organizations that they have no similar compulsion. Such attitudes must be examined critically, for investment by governmental organizations commits national resources just as much as does investment by private enterprise. Efficiencies of utilization of national resources are of similar consequence, whether located in the public or the private sectors of industry.

Costs of photogrammetric surveys should be approached realistically and assessed so that comparisons between work performed governmentally and work performed by private practitioners will be meaningful. One aspect demanding consideration, particularly for engineering purposes, is the identity of specifications for work performed "outside", compared with that performed "inside" the initiating authority.

It is expected that the statement will be challenged, but the opinion is expressed that the real costs to the nation of productive photogrammetric work are unlikely to be lower if undertaken within the governmental organization than they would be if undertaken by private practitioners. Any analysis which purports to establish a case to the contrary should be viewed with some scepticism. However, this does not specifically imply that photogrammetric productivity must be the exclusive preserve of private practitioners. Governmental organizations could be engaged mainly in procedural development and research—in order to specify the procedures to be followed in production—and must have the capacity to check work carried out elsewhere and to undertake a proportion of the productive work generated.

An important component of cost of photogrammetric work to any nation must be the education and training of technological personnel. This component will be greatest in countries where no facilities are established for such education and training. In those cases the necessary technical know-how must be imported, and paid for generally at "expatriate" rates. Productive work may be obtained, of course, by contractual arrangements with foreign organizations, but few nations would be able to afford such an arrangement for very long. Particularly for engineering purposes, the question of timing and liaison between client and contractor must tend to militate against efficiencies in terrain data-processing, when the client and the terrain are in one country and the contractor in another.

Positive encouragement should thus be given by Governments to the establishment of viable photogrammetric private enterprises with predominantly resident management. Such encouragement must include facilities created by Governments for eduction and training of local technological personnel available for employment in these enterprises. In this context it must be appreciated that the cost to the nation of dependence facilities, either for production or for technological education and training, cannot be measured only in terms of short-term and tangible considerations. The import is likely to have been designed for alien conditions and to require adaptation to local conditions, be that import either of ideas or of products. While it may be necessary, in the short run, to import ideas, methods and personnel, in order to achieve local self-sufficiency in a tolerable period of time, this must not be accepted as being necessarily the optimum for local adaptation.

Conclusion

The region covered by the terms of reference of this conference contains a very significant proportion of world population and land area. Influencing the nature, development, standard of living, distribution and growth of this population within the region are factors of climate, topography and history, amongst others. Solutions to the problems facing those who have responsibilities for planning the economic and social development of this region are vital matters for mankind. It is hoped that this paper may provide some food for thought in approaching some of these problems. The question should be not only: "How do we do these things?", but also: "What should we do?" It is believed that there should be an element of urgency associated with our search for the answers to these questions.

MAPPING FOR TIDAL-POWER INVESTIGATION IN THE KIMBERLEYS

Paper presented by Australia[1]

The present paper summarizes the mapping operation of a site selected for close investigation by the Government of Western Australia in association with the French consulting firm, SOGREAH.

Time, so often the necessity which mothers invention in mapping, produced two "firsts" in Western Australian procedures, namely, the use of air-to-ground radio during the photographic operation; and the use of infra-red film as a practical tool in the delineation of water boundaries at high and low tides.

The area mapped is indicated in figure I and comprises:

General mapping: 1:15,000 with 50 ft contours produced in twelve sheets and embracing an area of 600 square miles;

Selective mapping: 1:7,500 with 10 ft contours of three areas for investigation as potential storage basins;

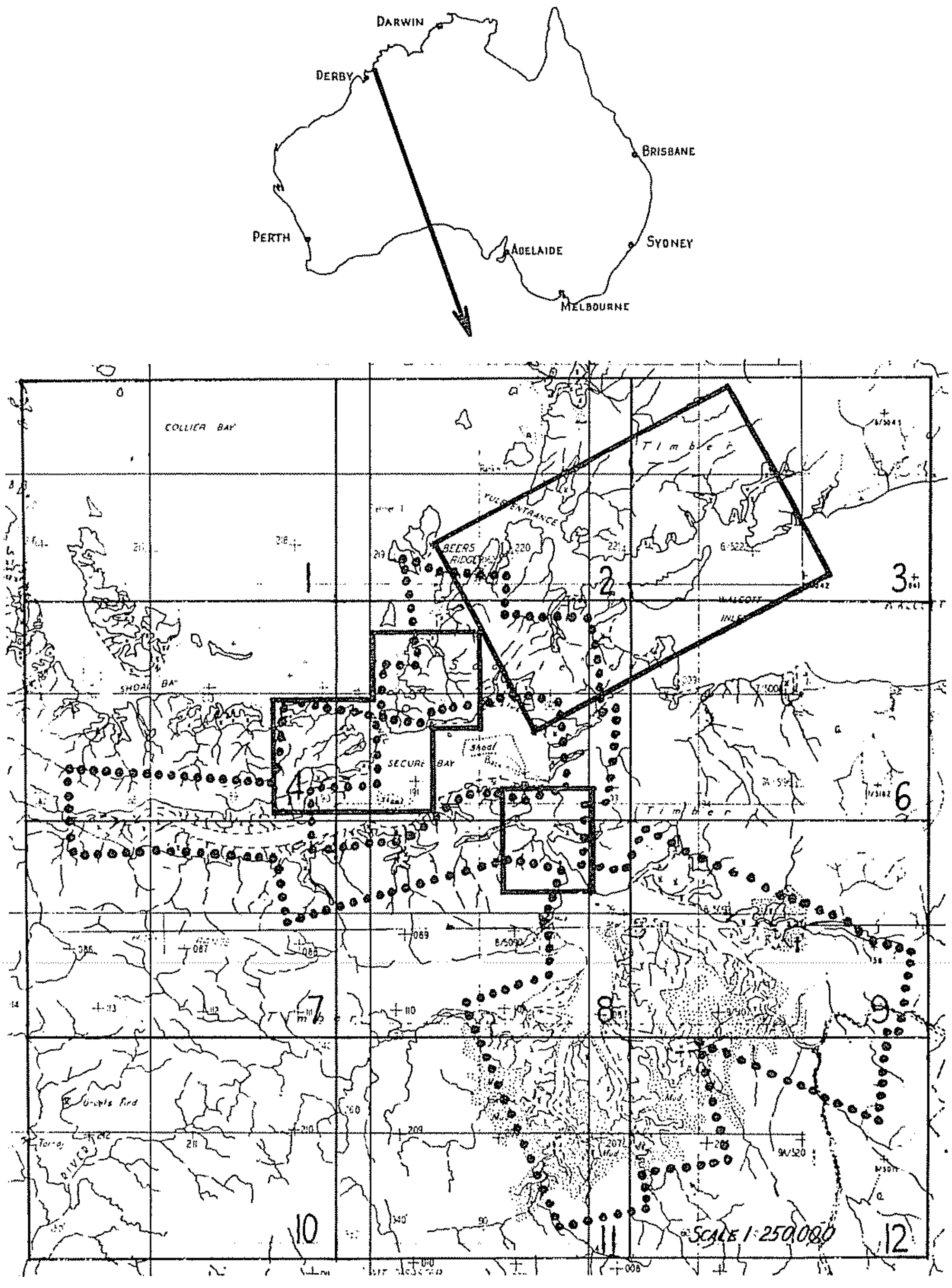
Selective mapping: 1:7,500 as a planimetric edition only, to delineate the area of water at high and low tides with Secure Bay;

Hydrographic survey of the approaches to and within the basin of Secure Bay;

The establishment of sufficient ground survey data to ensure 1–4 above and further engineering control surveys in respect to damming of the area.

The plotting instruments available at the time included a Wild A7 (without automatic recording); a Wild A8 and a Williamson 7-projector Multiplex.

[1] The original text of this paper, prepared by officers of the Department of Lands and Surveys, Western Australia, appeared as document E/CONF.52/L.64.



Sheets 1-12: General mapping 50' contours

Selective mapping 10' contours

Selective mapping Tidal

Fig. I—Australia: Area mapped for tidal-power investigation

Planning of the mapping centred about the utilization of each plotter to its maximum capacity and in flow form is summarized hereunder.

General mapping	*Selective mapping*
	Photography
1:40,000 panchromatic	1:20,000 (*a*) Panchromatic (*b*) Infra-red
	Control
Air triangulation Wild A.7	Values transferred to 1:20,000 panchromatic and infra-red
	Plotting
Multiple 1:15,000 50 ft contours	Wild A.8 1:7,500 10 ft contours 1:7,500 planimetric
	Fair drawing
12 sheets 1:15,000 1 sheet 1:30,000	3 sheets of areas for potential storage basins, plus sheets showing high, mean and low water

Photographic details

Aircraft: DC3
Camera: Zeiss RMK 15/23 Pleogon with infra-red attachment
Navigational aids: Doppler, standard drift sight (Williamson)
Film: Kodak super XX, Kodak infra-red
Base for operations: Derby

The photographic planning as previously outlined in the report was completed on a semi-controlled mosaic of the area. Premarking was finalized in the manner later to be described and on 21 June 1963 photography began.

SUMMARY

21 June

Left Derby and upon arrival at Secure Bay established radio contact with the Survey Ship *Gunga-Din*; climbed to 20,000 ft and completed the high-altitude cover. Used super XX, X2 filter, 1/500 sec., F.8.

Descending to 10,000 ft, completed a "dummy run" of photography to be flown at low tide the following morning. This required maximum crew co-ordination with individual firing of the camera at each exposure station. Visual navigation and timing were an essential part of the exercise, due to the limited time available, during the slack water period.

22 June

Unavoidable delays at Derby negated the low-altitude photography planned, and the day was spent taking photographs at height of 25,000 ft over Walcott Inlet, to the east of Secure Bay, followed by further test runs to co-ordinate air-ground radio control of tidal readings with photography.

23 June

Left Derby at 05.30 hours and arrived at Secure Bay to complete low-water coverage, commencing at 06.30 hours with panchromatic film. Returned to Derby and at 12.00 hours the same day completed ten similar runs of the area at high tide.

Exposures varied from 1/200 at F5. 6 to 1/500 at F8 during the day, with good film quality (D. 19 developer).

24 June

Completed infra-red photography of the same areas in similar manner. Low-tide photography commencing at 07.21 hours and high tide at 13.29 hours.

The times of photography depended upon prior field investigation by hydrographers and engineers to study the tidal phenomena in this relatively unknown area, and to establish the times and cycle of high and low water. Infra-red film, while still somewhat experimental, was chosen in an endeavour to obtain the maximum in definition of the water area, so inconveniently flanked by mangroves. In the event of failure, the same areas were reflown with panchromatic film, as indicated.

Samples of the photography are indicated below.

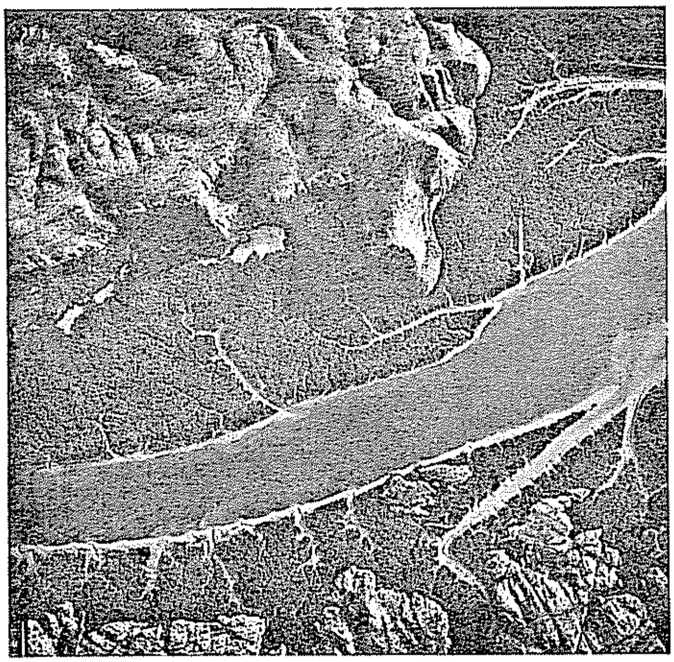


Fig. II—Australia: Low tide (panchromatic photography)

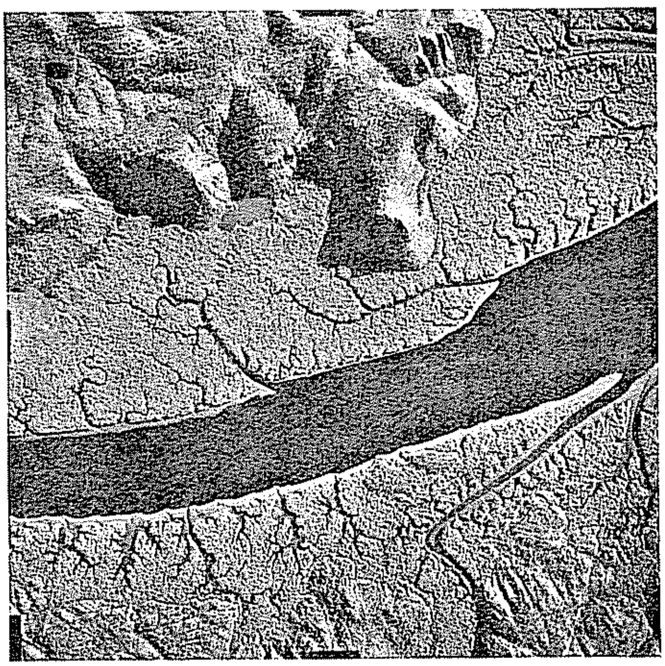


Fig. III—Australia: Low tide (infra-red photography)

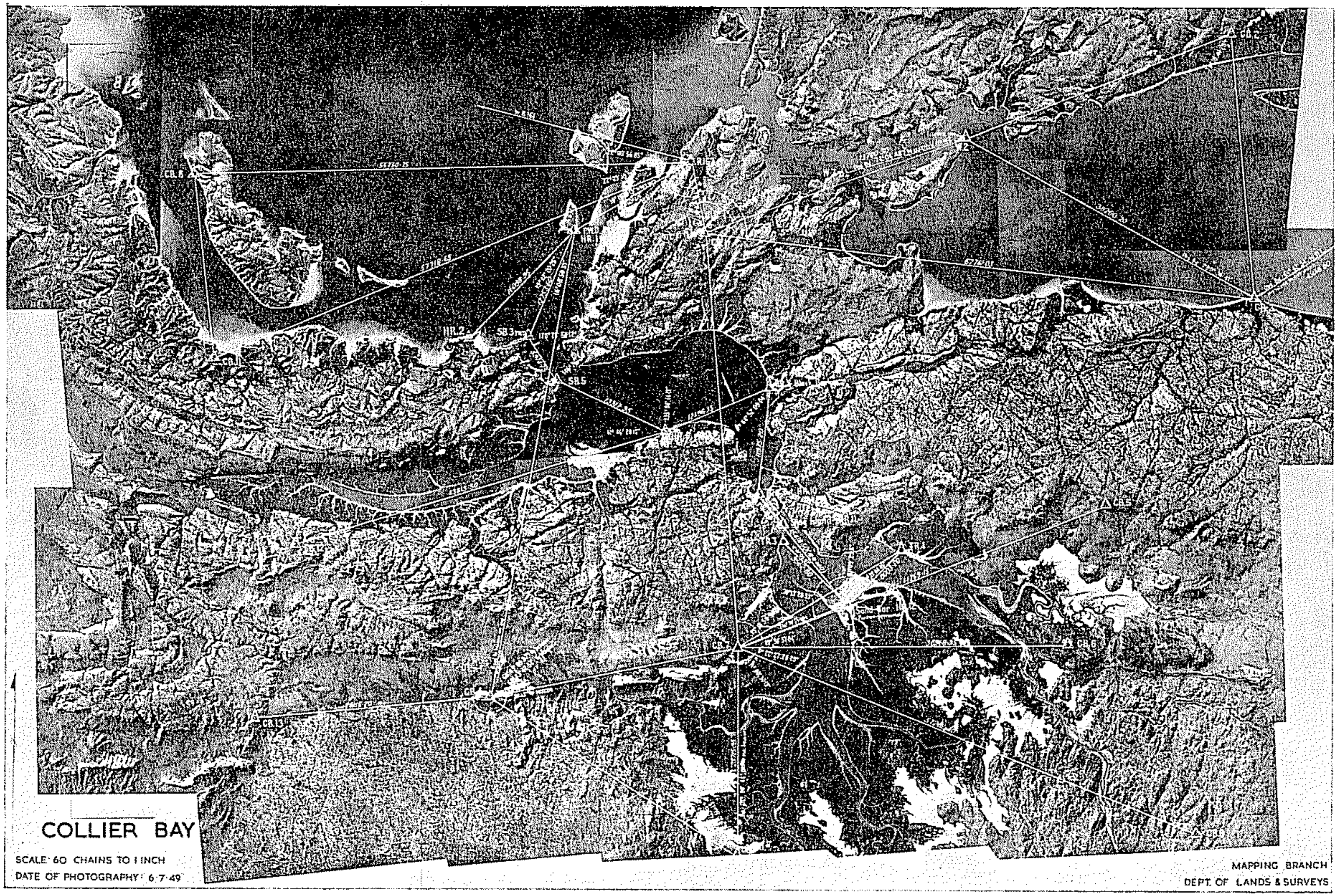


Fig. IV.—Australia: Control surveys for tidal investigation at Secure Bay

The Zeiss infra-red attachment and filter was used and exposures varied from 1/100 sec., F5.6 to 1/300 sec., F5.6. Processing for the 180 ft of film was completed in the Zeiss automatic rewind equipment.

The developer used was the DK. 50, at a constant temperature of 68°; developing time: 13 minutes.

It was noticeable that, as the light improved, so did the negative quality.

Field work

For a variety of reasons it was not possible to take a normal sized tellurometer party on this trip. We were to use helicopter transport for the photographic control of the more remote country and water transport from the Survey Ship *Gunga-Din* for the hydrographic control surveys. Additional personnel could be borrowed from the ship if needed.

During May, preliminary reconnaissance and minor exploratory excursions were carried out and a land-based camp set up on a tiny shingle beach outside the bay. Survey work commenced with the arrival of the helicopter on 1 June.

On control work of this nature using tellurometer, it is usually advantageous to locate a central station from which lines can be radiated to the required control points. In and around Secure Bay there is country as rough and unfriendly as can be found anywhere. The hills are mostly in the vicinity of 500 to 700 ft, fairly heavily timbered, rough and broken under foot, with cane-grass and spinifex disguising the hazards set for the carelessly placed foot. Their relative similarity in height prevented any centrally placed station from having an all-round view, although we were forunate in having to occupy only three main radiating hills.

Reoccupation of two existing army standard traverse stations, R162 and R161, provided a start for our own work. A distance and direction was read from R162 to a higher hill nearby (designated Collier Bay 1.). These two stations made up two of the three major points. From CB1, three lines were radiated, one of which, CB7, become the third main radiating station.

A connexion by direction and distance from R162 to Shale island was read at the same time in anticipation of the need for an easily accessible site from which later hydrographic lines could be expanded. CB7 was then occupied as the central instrument station, and a further five points located from it by direction and tellurometer distance. Further extension to fix the remaining points was managed by single line measurement and direction from suitable outlying stations.

As each station was finished, two lengths of white plastic sheet, each 21 ft long and 3 ft wide, were used to identify the site. The sheets were arranged either at right angles with the station at the apex, or as a V-shape with varying acute angles. It was expected that some of the plastic lengths would be left for about a fortnight before the photography, so care was needed to see that they were not blown away, both by the prevailing wind and, if the point was near the landing area, by the violent down-draught caused by the helicopter on take-off. Rocks were placed at varying intervals in straight lines across the sheet to avoid breaking the outline.

Very stringent limitations were fixed by the single fact of time; we had ten days use of the helicopter, with no hope of extension. The uncomfortable thought was constant that, once the helicopter left, access to most of the control points was out of the question, so priority was given to remote stations and compromise became part of our planning.

With a few exceptions to suit circumstances, the central station was occupied by observer and recorder with tellurometer and theodolite (Tavistock $3\frac{1}{2}$ inch), plus ancillary equipment, This required two flights, the helicopter capacity being only pilot plus 500 lbs. Similarly, the first remote station was occupied by two trips and it was usually mid-morning by the time the parties were established.

Two measurements were taken for each line, the first over a range of twenty frequency changes. It was usual then to carry out the reciprocal vertical angle reading, then shift the remote tellurometer forward or back a few feet for an eccentric second measurement, this one over a range of ten frequency changes.

All equipment and one man then shifted to the next station, leaving the second man to mark the station before being taken to the next point, in turn.

In the first few days of observing, attempts were made to read the horizontal angles from strategically placed, standard steel beacons as back marks, forward to a helio at the remote station. The idea was abandoned when it was found that there was a very busy observer at one end of the line and unavoidable waiting at the other. The problem was solved by leaving the parties on the hills overnight; during the late afternoon, the helicopter would set Tilley lamps at the radial stations. Complete rounds of angles could then be read to a number of points. Twelve arcs were read for each angle.

Compromise was in reference to the planning of a day and night programme. To keep up the necessary average of stations per day, for instance, it was not always possible to occupy as many points as we wished during the daylight and flying time and, if we had a well conditioned triangle, a base line measured and the light at the third corner of the triangle visible from both ends of the base, intersection angles were read to it by the two observers. CB2 and 4 were fixed in this manner. It was a relatively simple matter to occupy them later for reading reciprocal verticals and for marking. By the lucky siting of stations, both photographic and later hydrographic, we were able to obtain an angular enclosure of a large section of the work. This fact, combined with carefully placed sun azimuth observations, helped minimize the chances of undetected gross errors.

The photographic control was completed during the afternoon of the tenth day and the traverse work for the hydrographic control commenced soon after.

The same system of two measurements per line continued, but no night observing was necessary with the less exacting time conditions. Angles on the very short lines (2 or 3 miles) were read to beacons, or helios, which were required to show only a reflection of the clear sky to be easily visible. This section of the work was performed as a normal traverse exercise, except that we were occupying stations which had already been marked by the Public Works Department, and we were instructed to carry precise vertical heights by reciprocal angles from Shale island through to the end of the traverse.

Vertical angles on the photographic control had been normal procedure for reduction of slope distance and calculation to mean sea level, with one additional requisite, that the eventual 50 ft contour information should be controlled by these vertical heights. When plotting of previous projects depended on the Multiplex or A8, horizontal and vertical surveys had been completely separate entities, each having independent control points to satisfy template assembly and plotting needs. By judicious placing of the control points for the A7's needs, each station became the component for the two dimensions.

The precise vertical angles within the hydrographic traverse were to combat the obvious difficulties facing spirit-levelling connexion between the gauges, T1 at Shale island and T3 and T4 inside the bay. Verification of height differences was arranged by either two independent readings of single lines or reciprocal readings across the third side of a triangle to prove the two traverse sides; for example, lines HR1 to SB3, SB3 to SB5, were traversed and height differences observed. The check was obtained direct from HR1 to SB5.

When our ground surveys were completed, the photography was carried out as normal survey flight for the 20,000 ft exercise. At 10,000 ft, infra-red film was used to give clear definition of water's edge at high tide and again when photographed at low tide. Ground-to-air radio communication was maintained during this critical photography, to keep two tide-observing parties and the air crew informed for timing the runs. The critical nature of the time limits may be seen from the fact that, once the tide has turned, it is only a short while—say fifteen to twenty minutes—before there is a sea-level change of 0.7 ft every five minutes.

Once this operation was over, our field responsibility in the investigation was ended and one of the many stages of the over-all undertaking was completed; field work was continued on engineering and echo-sounding surveys, together with the constant gathering of tidal data.

Compilation

The configuration of the area with its extensive sections of coastline, islands and inland water areas were both an asset and a handicap. Although photography was planned to reduce as far as possible the number of models containing extensive water areas, these still occurred on the northern photographic strips and presented difficulties to the planned A7 aerotriangulation. However, the coastline provided a considerable amount of supporting information for level control and it was resolved to break down the major network of field survey control by a stereotemplate assumbly, Aerotriangulate the southernmost runs for height only, and utilize available field level control and coastline values for the remainder.

The preparation work before the instruments could start work was quite extensive. The general cover was to be used to control all the mapping by selecting and transferring points for all the compilations, so that their values could be obtained either from the template assembly or from the aerotriangulated strips. The tidal boundaries were interpreted on the plotting instruments and the infra-red photography showed the water's edge cleanly. In areas such as the mangroves or extreme high tide, the boundaries were followed by the marking left on the ground, but the models were levelled and the floating mark kept on the correct tidal value as a check on the interpretation.

Speed was important and the complete photogrammetric operation took six weeks. This was for a total amount of approximately 900 square miles of map cover. Interpretation from the provided map sheets in association with tidal readings is indicated in the figure V.

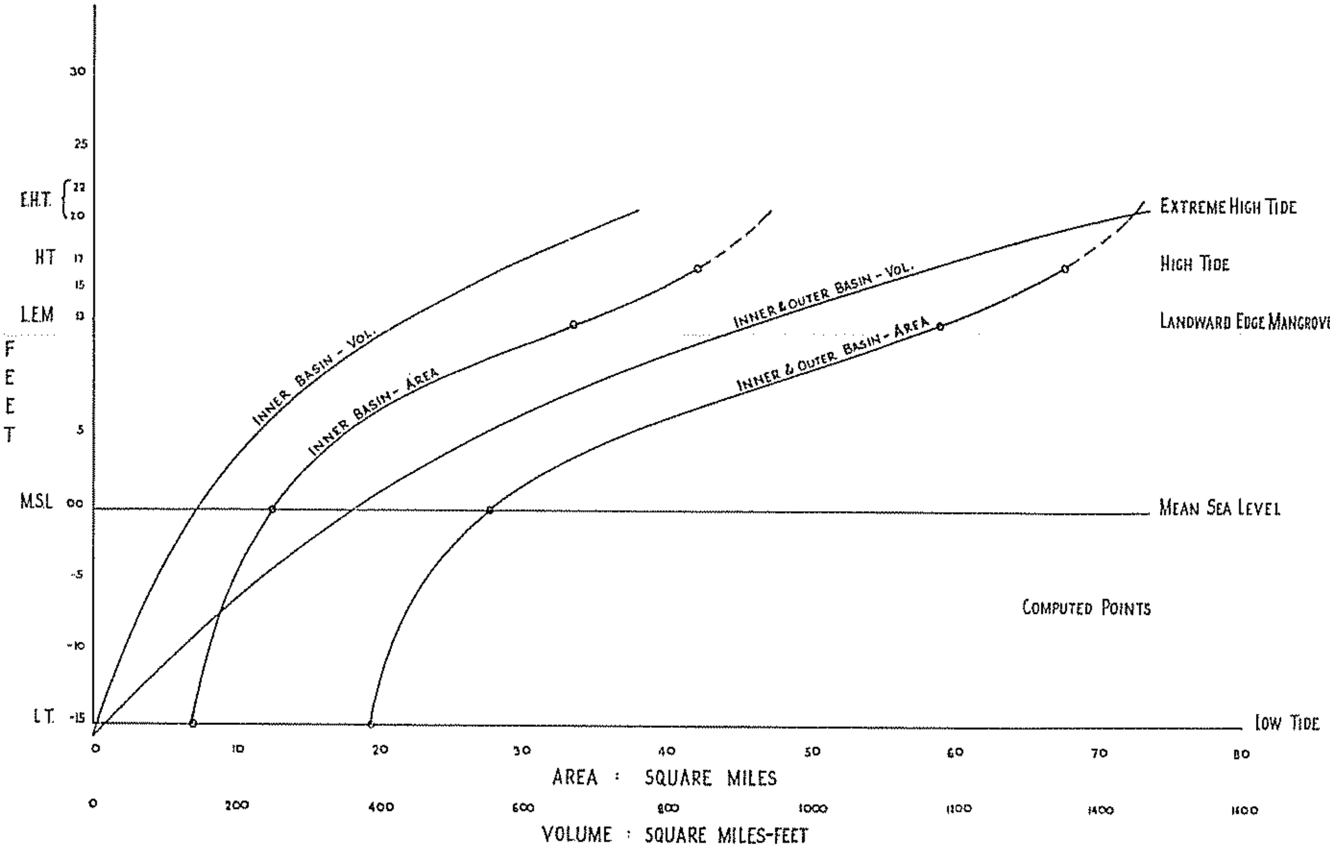


Fig. V—Australia: Tidal-power investigations, Secure Bay scheme; area and volume of basin

Conclusion

Secure Bay may never be developed for tidal power; the extensive coastline from Darwin to Derby contains many similar sites requiring further investigation. Only the future will tell of their economic potential in Australian industry. Photogrammetric mapping has proved a most useful and economical tool by which to furnish data. This exercise, completed in 1963, has shown the following:

Infra-red film is a useful adjunct in mapping of this nature;

Premarking for infra-red is best satisfied using metal impregnated cloth or foil; standard marking is unsatisfactory;

Where mangroves abound in the area, the mapping of HWM, using either infra-red or panchromatic film, is nullified, becoming more a matter of interpretation and common sense on the part of the instrument operator; thus low-water photography correlated with tidal readings is all that is necessary;

The photographic scale of the water areas to be mapped could have been extended to 1:30,000, ensuring a satisfactory accuracy, plus the important advantage of a lesser photographic time during tidal change.

LARGE-SCALE MAPPING FOR ENGINEERING REQUIREMENTS, SEWERAGE, HIGHWAYS AND OPEN CUTS

Paper presented by Australia[1]

Aerial surveys have now been accepted by engineers as the best means of obtaining much of the topographic data required to meet the complexity and magnitude of the problems facing them. The object of the photogrammetrist is to provide the necessary information to the desired scale and accuracy as economically as possible, and to have it available when needed. With modern equipment and good organization it is possible to achieve this objective. Present-day methods of preparing large-scale maps in the state of Victoria, and the uses to which they are put, will be described.

Basic survey and map information

It is universally accepted that a basic geodetic survey and a small or medium-scale map coverage should precede large-scale mapping, but in newly developing countries it is likely that all three operations will occur simultaneously. In these circumstances, it may be necessary to prepare maps at small scales immediately prior to the preparation of the final large-scale map required for engineering design and construction.

In Victoria, base maps for developing areas are published at a scale of 1: 4,800, and it may be of interest to outline briefly the method of production. Areas of about twenty map sheets are covered by a block of aerial photographs flown at a scale of 1:12,000 and consisting of ten to twelve runs of twenty to twenty-five photographs each. Nine symmetrically placed horizontal control points are obtained for the block, and vertical control is supplied on every fourth or fifth photograph. Stereotriangulation is carried out with Wild A7 and A8 autographs using the "independent pairs" method. Machine co-ordinates and heights are recorded on punched cards and processed by an electronic computer for adjustment and transformation to the state grid system. Detail and contours are plotted, and the map printed in three colours: black, blue and brown. A possible alternative to this type of mapping may be the orthophoto map which can be produced quickly and contains a wealth of information not possible to show on a conventional line map.

[1] The original text of this paper, prepared by C. E. Middleton, Chief Photogrammetrist, Victorian Department of Crown Lands and Survey, appeared as document E/CONF.52/L.65.

Considerations in large-scale mapping

Before large-scale mapping is undertaken, consideration must be given to the use for which the map is required. In the interests of speed and economy, the optimum in area, detail content, contour interval and accuracy must be determined. Unlike small-scale maps, large-scale information is usually prepared for one specific purpose only. This is fairly obvious in the case of maps prepared for highway construction, reservoir sites and open-cut mines. It is therefore relatively simple to determine the specification required from both a quantitive and qualitive point of view. This matter, although appearing rather elementary, is often neglected, and more often than not greater detail and accuracy are provided than is really necessary. To overcome this problem, the map-maker and the map-user should discuss the project and obtain a clear understinding of each other's work and requirements.

The use of the aerial photograph itself should never be overlooked. In flat areas, photographs taken with a long focal length lens, and enlarged to a scale of 1:480, have proved successful for sewerage and drainage projects.

Maps for sewerage design and construction

The determination of sewer shed areas, and the design of large mains and treatment works can be effected using 1:4,800 base maps showing 5 ft contours, but for detail design, recording of constructed sewers and letting contracts, it is considered that a map at a scale of 1:480 is necessary. The final map should show the ground plan of each building, title boundaries and easements, street curbing and crossings, fence lines, drainage and any other plottable detail. Heights are to be shown for the floor level and corners of each dwelling and at the corners of property boundaries. The accuracy required is ±0.2 ft for spot heights and ±0.5 ft for position.

Procedure for mapping at 1: 480 scale

A photomap of the area to be mapped is prepared at a convenient scale, and flight lines plotted for the aerial photography to ensure that the best possible photo coverage is obtained. A Wild RC7 plate camera with a 4 inch focal length lens is flown at an altitude of approximately 1,600 ft above ground, giving a photo-scale of 1:4,800. (It has been the usual practice to use a Wild RC7 plate camera for this work, as Wild A5 autographs taking a maximum plate size of 7 inches × 7 inches are used for plotting. A similar accuracy could probably be obtained using a modern film camera and a Wild A8 or Zeiss stereometrograph plotter.)

The aerial photographs are taken at an appropriate time to avoid "hot spot" and to obtain maximum definition. After the prints have been prepared, photographic reference points are chosen in the office and neat sketches made of points visible on the photograph which will be suitable for measuring to in the stereoplotter. These sketches are made on a *pro forma* (see figure I below), which is forwarded to the field with the photograph for the determination and entry of co-ordinate and height values. The survey connecting the reference points to the basic geodetic marks is carried out to an accuracy of 1:5,000 for position, and ±0.1 ft for height.

When the plate camera is used there is no requirement for diapositives as the negatives are placed directly into the picture carriers. This is a slight advantage as it is rarely possible to reproduce a diapositive as good as the original negative. All detail on the photographs is plotted in the normal way on pre-gridded Cronaflex sheets. Spot heights are read and written on the sheet opposite their plotted position by a table assistant. It has been found necessary automatically to record the spot height readings and check the written values to avoid errors.

The photogrammetric plot (figure II) is forwarded to survey draftsmen, who add title boundary information using the occupation plotted from the photographs for control. The map is inked up at this stage, and copies mounted on plane tables and taken into the field where the eaves of buildings are cut back to show the true ground plan, floor levels are obtained and obscured detail plotted. The information returned from the field is added to the map (figure III), which is then complete and made available to the engineers for detailed design and construction. The final map shows the position and detail of constructed sewers, and is reproduced for use as the record and working map.

Maps for highway design and construction

Large-scale maps are required by highway engineers for design and construction including the determination of alignments, profile gradients, the calculation of volumes for excavation and embankments, location of structures and to show the relationship of the work to property boundaries. Information is also required outside the construction zone by surveyors for setting-out purposes. The most suitable map for this work is plotted at a scale of 1:600, with 2 ft contours. The accuracy required is ±0.5 ft for both position and height.

Procedure for mapping at 1: 600 scale

A photomap is prepared of the proposed route at a convenient scale for the planning of aerial photography and ground control. The required position for each individual photograph is plotted on the photomap. This information is supplied to the aerial photographer together with other relevant specifications, including the time of day (to avoid hot-spot) and the season (to avoid long grass), for taking the photographs. A Wild RC8 film camera with a 6 inch focal length lens is flown at an altitude of approximately 2,400 ft above ground to give a photo-scale of 1:4,800.

Individual exposures are taken for large-scale mapping in rural areas because suitable photographic reference points are seldom available. Targets are necessary, and their required positions are indicated on a separate copy of the photomap which is used by the field surveyors. Co-ordinates and heights obtained in the field should be to such an accuracy that any errors in the work will not be measurable at the model scale.

The types of target vary, but white or yellow disks 1 ft in diameter are satisfactory, provided indicator marks or trenches are used to identify them. The photographs must be taken as soon as possible after the targets have been placed on the ground, otherwise maintenance problems occur.

If the photography is satisfactory, glass diapositives are prepared, but before they are placed in the plotting machine, well defined points suitable for use in setting out the final construction are indicated, and a sketch of each point prepared. This enables the operator to identify the required points quickly, thereby saving expensive machine time. Detail and contours are plotted on pre-gridded Cronaflex sheets, and the co-ordinates and heights of the points previously indicated on the diapositives are read and recorded automatically on punched cards. The numerical values are transformed to the state grid system and level datum, are listed and supplied for use with the map. Although property boundaries are accurately plotted on large-scale maps, it is the general practice in Victoria to carry out separate surveys and prepare special plans for land acquisition purposes.

A digital terrain model can be supplied direct from the plotter in addition to contours, in order to facilitate the use of electronic computers for highway design. In the introductory stage of this technique, it is usual for the engineer to study the contour map and interpolate values himself to obtain the digital data required.

Maps for open-cut brown-coal mines

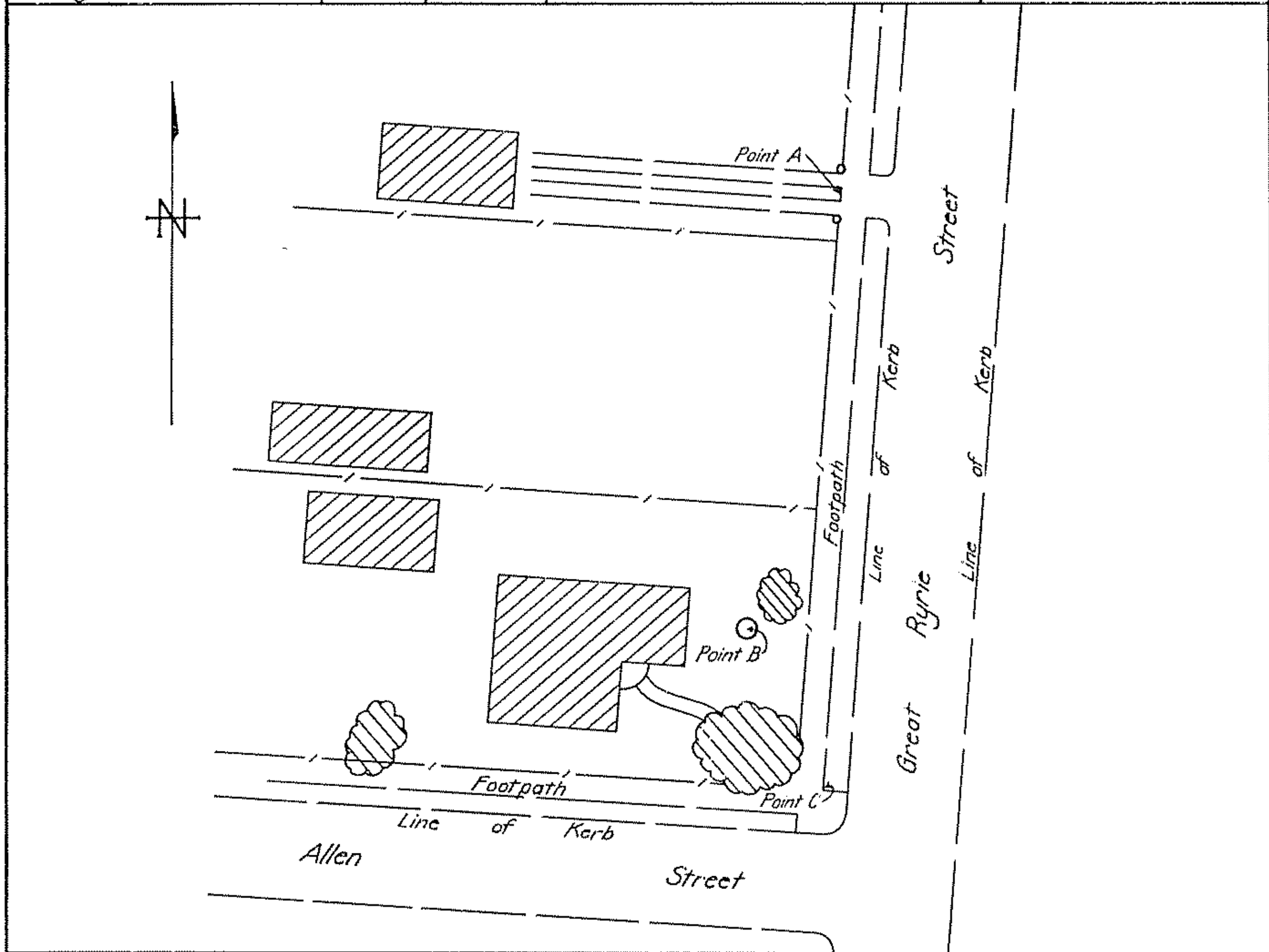
The maps prepared by aerial survey for the brown-coal-fields of the Latrobe Valley in Victoria are at scales of 1:4,800, 1:2,400 and 1:1,200. The 1:2,400 map is used to show progress of operations in the open cuts, and the 1:1,200 maps showing 1 ft contours are used for planning, design and operation, and for estimation of overburden quantities.

Procedure for mapping at 1: 1,200 scale

The 1:1,200 maps are prepared over gently undulating terrain with grass cover which is short enough in the late autumn and winter months not seriously to interfere with the plotting of 1 ft contours from aerial photographs. The map accuracy required is that no errors should be greater than ±0.5 ft for both position and height.

The procedure for mapping is similar to that described for highway work, except that the mapping is done in rectangular blocks rather than in strips. Targets are placed out in rows by ground survey to an accuracy of 1:5,000 in position and ±0.1 ft in height. Photographs are taken as individual exposures to ensure that the targets appear in the required positions on each model. Detail plotting and contouring is carried out with a Wild A8 autograph, and in areas of dense detail it is necessary to check the identification of certain features in the field. The final sheets are scribed by direct tracing from the original pencil plots. Although a Wild RC7 plate camera has been used

PROJECT	RUN	PHOTO	FIELD BOOK	PAGE
Ringwood East	2	15	F.B. 25 L.B. 197	33, 34 47



POINT	DESCRIPTION	CO-ORDINATES IN FEET		HEIGHT IN FEET
		E	N	
2/15/A	In centre of gateway	———	———	194·3
2/15/B	In centre of small circular garden bed	187 305·6	243 976·1	202·1
2/15/C	Corner of nature strip	187 332·5	243 945·6	203·6

R Brown — SURVEYOR | 11 6·65 — DATE

Fig. I—Australia: Pro forma *showing sketch of photographic reference points with co-ordinate and height values obtained in the field*

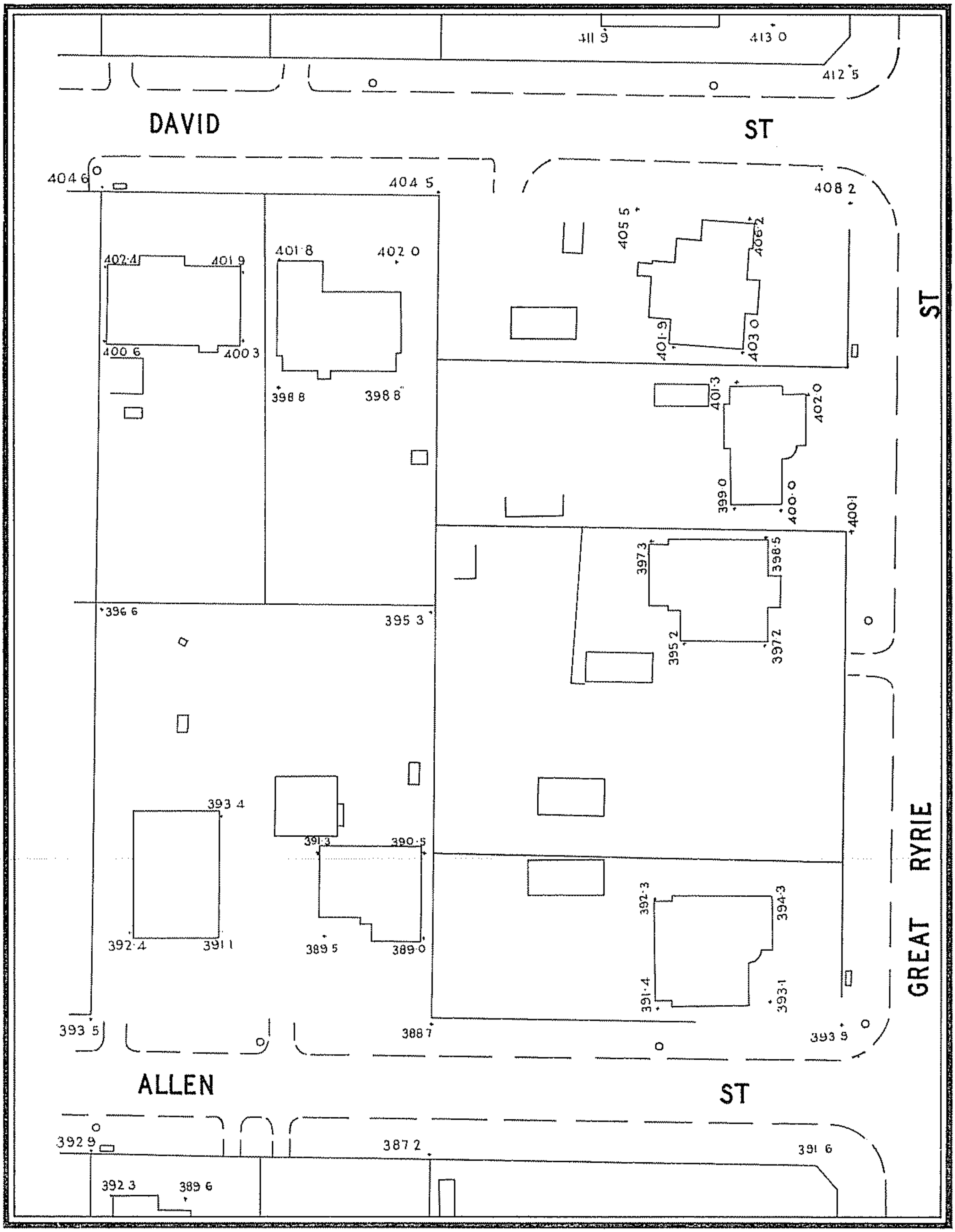


Fig. II—Australia: Extract from 1: 480 photogrammetric plot

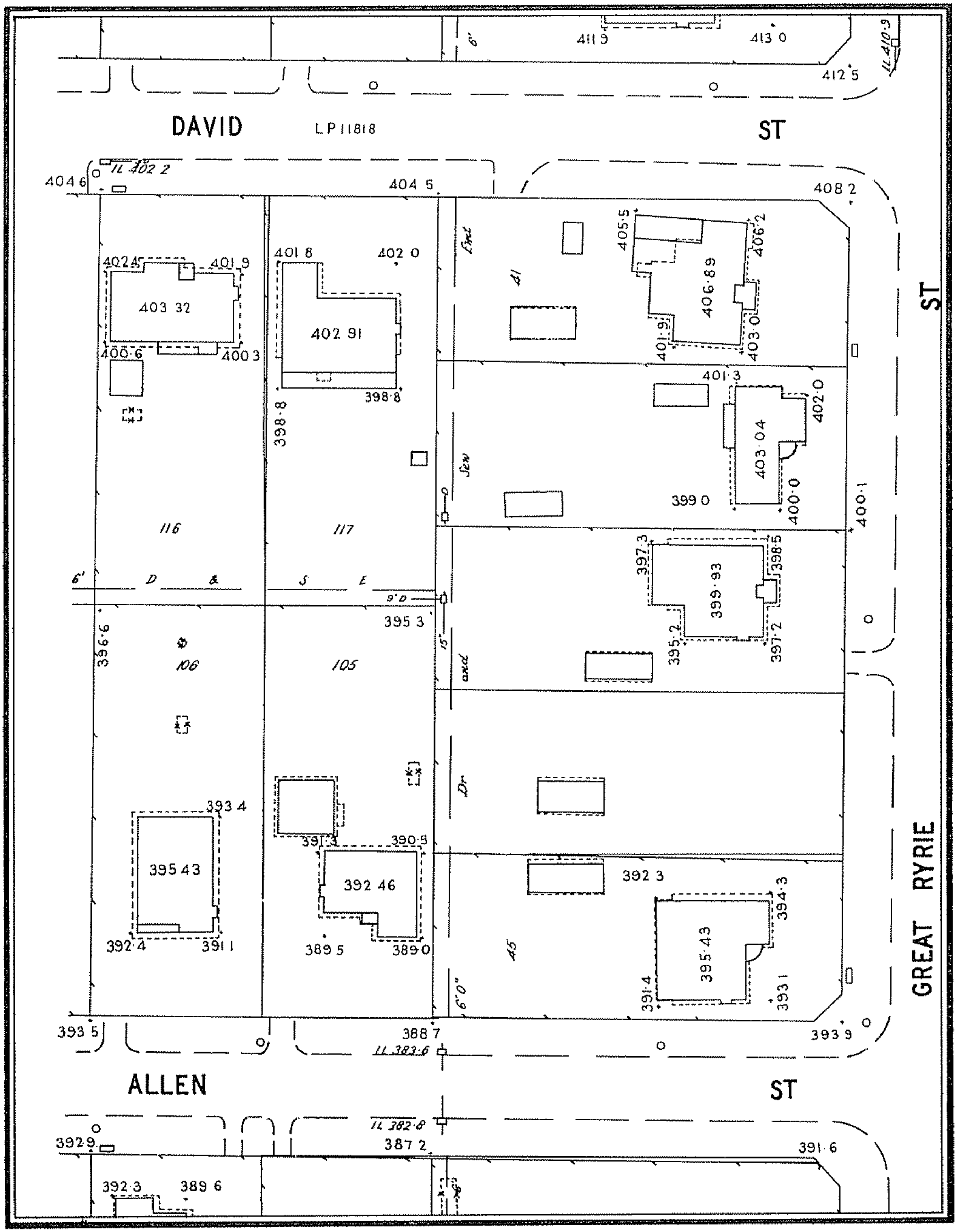


Fig. III—Australia: 1: 480 plot after field completion extensively for this work, it is now possible to obtain the required accuracy more economically with a Wild RC8 film camera flown at 2,400 ft above ground.

Volume determination

Quantities of overburden and coal removed from the open cuts have also been determined by aerial survey. Cross-sections of the working faces are measured from aerial photographs at three-monthly intervals. Values along profiles are recorded on punched cards for processing by an electronic computer. If this procedure is properly organized, it is more efficient than normal ground survey methods.

Tests for map accuracy

It is neither practical nor economical to have all maps tested in the field to determine whether they conform to the standard of accuracy required. It is possible, however, with little difficulty, to determine probable relative accuracies during the plotting process by checking on control points not used for the initial absolute orientation. After scaling the model on two control points, the error on a third point can be measured, and its effect on the accuracy of the plot after averaging out on other points can be determined. Similarly, for heights, a check on a fourth control point will determine the probable accuracy of contours.

Organization

The Victorian Department of Crown Lands and Survey is a centralized survey and mapping authority responsible for both small- and large-scale topographic mapping, cadastral survey and survey co-ordination.

The department uses an Aero Commander and a Cessna 180 aircraft which are chartered to carry out photography required by the state. A full range of Wild and Williamson cameras is available. Large-scale mapping requires photography especially planned and flown for each project, and a close liaison between air, ground and office personnel. Complete facilities are provided in a central photographic laboratory for processing film, and for preparing diapositives, prints and enlargements.

A geodetic survey section provides precise co-ordinates and heights for specially established permanent marks for each project. Engineering surveyors from client departments carry out traversing and levelling between these marks for supplementary control.

A full range of equipment is available including Wild A5, A6, A7 and A8 plotters, Kern PG2 plotters, Multiplex, a Zeiss stereocomparator and Wild PUG point transfer devices. Several sets of automatic recording equipment including typewriters and card punches are available for connexion to the A7 and A8 and the comparator.

When title boundaries are to be shown on large-scale maps, it is necessary to employ experienced survey draftsmen to search for and add information obtained from plans of subdivision and other cadastral survey data.

A cartographic section is employed to prepare final drawings for reproduction. Most of the drawing is done for medium- and small-scale maps which are printed in colour. Engineers are usually satisfied with copies of original photogrammetric plots, unless the maps are to be used for other purposes.

The photographic laboratory is equipped with a process camera and facilities for preparing positive transparencies, blue line prints, dyelines, etc. All printing is undertaken by the Government Printing Office.

Staff training

It is of considerable advantage if photogrammetric technicians have a good background knowledge of the work for which they are preparing maps. As far as possible they should be given the opportunity to visit and become familiar with areas they are required to plot. Good stereoscopic vision is essential, and unless this faculty is inherent from the beginning further training is of no value. Topographic expression is developed, but no special training is given in photo-interpretation. Interpretation in forestry, geology and other disciplines is left to experts qualified in these fields.

Plotting output

Total map production usually depends on the number of plotting machines available. Output can be conveniently measured by the time taken to plot each model. This varies considerably owing to many factors including scale, contour interval, density of detail, terrain and the purpose for which the mapping is required. The table below gives an indication of plotting rates obtainable for large-scale mapping at scales from 1:480 to 1:4,800.

Plotting rates for large-scale mapping

Map scale	*Contour interval (feet)*	*Land use*	*Terrain*	*Camera*	*Photoscale*	*Plotter*	*Area per model (acres)*	*Plotting time per model (hours)*	*Purpose of map*
1:4,800	5	Urban	Flat to undulating	RC8 6″	1:12,000	A6	625	20–30	General base map
1:4,800	10	Rural	Undulating	RC8 6″	1:12,000	A6	625	7–15	General base map
1:1,200	1	Open-cut and works area	—	RC8 6″	1:4,800	A8	90	40–50	Open-cut planning design and operation
1:1,200	1	Rural	Undulating	RC8 6″	1:4,800	A8	90	20–30	Estimation of overburden
1:600	2	Urban	Flat to undulating	RC8 6″	1:4,800	A8	90	20–40	Highway design and construction
1:600	2	Rural	Undulating	RC8 6″	1:4,800	A8	90	15–25	Highway design and construction
1:480	Precise spot heights	Urban	Undulating	RC7 4″	1:4,800	A5	30	15–20	Sewerage design and construction

Conclusion

The purpose of this paper has been to outline the current practices used in Victoria to provide topographic data in a form acceptable to engineers for design and construction work. Not all conditions and circumstances are suitable for making full use of aerial photography; vegetation may obscure the ground, weather conditions may limit the taking of photographs and requirements may differ, but despite these limitations, photogrammetry can still play an important role in providing complete topographic information.

Methods must be continually reviewed to take full advantage of new equipment, materials and the experience and ability of personnel engaged in the work. The stage has almost been reached in Victoria for the application of stereotriangulation to large-scale mapping, thus increasing efficiency and providing greater economy in the over-all survey programme. Although the large-scale map may be the end product, it should always be kept in mind that useful supplementary information can be obtained from the aerial photograph itself. Colour film and improved photographic techniques are adding a new dimension to aerial survey.

APPLICATION OF CARTOGRAPHIC TECHNIQUES TO THE SNOWY MOUNTAINS HYDRO-ELECTRIC SCHEME

Paper presented by Australia[1]

Introduction

The Snowy Mountains scheme is a large-scale engineering project in the south-eastern corner of the state of New South Wales which develops the water resources of the Snowy Mountains area for power generation and irrigation. In an area of over 3,000 square miles, the Snowy river and its principal tributary, the Eucumbene river, are diverted inland by trans-mountain tunnels to the Murray and Murrumbidgee rivers, and the steep gradients of the mountain streams are utilized for the generation of hydro-electric power by a series of dams and power stations.

The scheme is being constructed by the Snowy Mountains Hydro-electric Authority, a statutory body of the Commonwealth of Australia. Work commenced in 1949 and, on present planning, will be completed in 1974.

The authority is responsible for the planning, investigation, design and construction of the many different engineering projects and structures which together make up the scheme. These activities require maps and charts of the area in which engineering structures are to be located, showing topographical features in graphical form or other physical features related to engineering construction work. Ranging from small-scale topographical maps to charts drawn at enlarged scales, a great variety of maps and charts have been produced by the authority for its engineering requirements. It is the purpose of this paper to describe the cartographic techniques by which these maps and charts have been prepared.

[1] The original text of this paper, prepared by W. Wassermann, Head of Survey Branch, Snowy Mountains Hydro-electric Authority, appeared as document E/CONF.52/L.66.

Maps and charts required by the Snowy Mountains Hydro-electric Authority

The requirements of maps and charts for various phases of the work may be summarized as follows:

Planning phase—Small-scale maps embracing the whole scheme for general planning; medium-scale maps for planning the interconnexion of projects, networks of roads, transmission lines and communication links.

Investigation phase—Medium-scale maps for engineering feasibility studies and geological, materials and hydrographic investigations of project areas; route plans, profiles and sections for the investigation of linear construction projects such as roads, aqueducts and transmission lines.

Table 1. Summary of topographic mapping

Scale	*Area covered (sq. miles)*	*Contour interval (feet)*	*Method of production*
1 inch = 4 miles (1:253,440)	9,600	200	Compiled
1 inch = 1 mile (1:63,360)	4,320	200	Compiled
4 inches = 1 mile (1:15,840)	5,136	50	Aerial photogrammetry
6 inches = 1 mile (1:10,560)	39	25	Aerial photogrammetry
8 inches = 1 mile (1:7,920)	130	20	Aerial photogrammetry
16 inches = 1 mile (1:3,960)	94	20	Aerial photogrammetry
1 inch = 400 ft (1:4,800)	41	20	Aerial photogrammetry
1 inch = 200 ft (1:2,400)	175	10 or 20	Aerial photogrammetry and terrestrial photogrammetry
1 inch = 100 ft (1:1,200)	5	5	Tacheometry or terrestrial or aerial photogrammetry
1 inch = 50 ft (1:600)	51	2 or 5	Tacheometry or terrestrial or aerial photogrammetry
1 inch = 20 ft (1:240)	3	2 or 5	Tacheometry or terrestrial or aerial photogrammetry

Note. The extent of the area covered by 4 inch = 1 mile and 1 inch = 1 mile maps is shown on the 4 mile = 1 inch map appended to the present paper.

Design phase—Large-scale maps of works areas for detailed geological mapping, materials investigation and for the design of structures; route plans and maps at large scales for the designing of linear structures; charts displaying the results of special measurements such as settlement and deflection of completed structures, cross-sectional areas of tunnels, etc.

Construction phase—Setting out plans for the location of structures and construction details on the ground; contour plans and sections for volume computations; work-as-executed maps and charts.

When work commenced on the Snowy Mountains scheme in 1949, the only maps available were Army maps at 4 miles to 1 inch with 300 ft contours and Snow Lease maps at an approximate scale of 1.2 miles to 1 inch without topographical detail. They were of little value save for very preliminary investigations.

The authority therefore had to produce all maps and charts needed for its work. Listed in table 1 is a summary of the topographic mapping carried out.

Reference grid system and control surveys

In view of the extensive areas which had to be mapped and the interconnexion of the various projects of the scheme, it was necessary to introduce a common reference grid of plane co-ordinates for all mapping. As the Snowy Mountains area is located nearly centrally to the 148° 30′ east meridian of longitude, the intersection of this meridian with the parallel of latitude 34° south was chosen as the origin of the Snowy Mountains grid, a plane rectantular system of co-ordinates. False co-ordinates of 300 miles east and 300 miles north were assigned to the origin to avoid any negative co-ordinate values for points in or near the Snowy Mountains area. The transformation of geographical co-ordinates to grid values was based on a transverse Mercator projection of Clark's 1858 reference spheroid.

The extent of the authority's mapping work also made it necessary to establish a large number of reference points for the horizontal and vertical control of detail surveys in project areas. The only accurate horizontal control existing in the area before the authority commenced work were six points of a first-order chain of triangulation by the New South Wales Department of Lands, which crossed the southern part of the Snowy Mountains. Based on these points, first-order triangulation was extended over the whole area and divided up by triangulations of second, third and fourth orders and by precise traversing. The position of about 1,300 new reference points was established in this manner.

As no reliable reference point for elevation had been established in or near the Snowy Mountains area, the authority established its own assumed level datum in the vicinity of Jindabyne, about 40 miles west of Cooma. The approximate height above sea level of this datum point was determined by a level connexion to the Cooma railway station, where the Department of Railways had established the height of a bench-mark by third-order levelling.

Based on the Snowy Mountains datum, level control was extended to all major works centres by a network of precise levelling, totalling about 800 miles and establishing the elevation of about 1,200 bench-marks relative to a common datum.

Recently observed connexions between the precise level network of the authority and that of the New South Wales Department of Lands suggest that levels taken on the Snowy Mountains datum read about 3 ft greater than levels taken on the New South Wales datum.

The 4 inch to 1 mile maps

When the authority commenced the development of the Snowy Mountains scheme, it soon became apparent that accurate contour maps of medium scale would be required for the planning of engineering projects in the area. It was therefore decided to produce maps at a scale of 4 inches = 1 mile (1:15,840), with 50 ft contours, for the entire area which could possibly be of interest in the development of the scheme. As the authority, at that time, had no facilities for the photogrammetric mapping of large areas, a contract was awarded in 1952 to a private mapping organization for the supply of aerial photographs and the plotting of contour maps by multiplex equipment.

Aerial photographs, covering 5,376 square miles of mountainous country, were taken with an Eagle IX camera and 6-inch wide-angle lens from an average flying height of 25,000 ft above sea level. Selected areas were also photographed from 15,000 ft above sea level. A total of 940 photographs were exposed on fifteen films; 831 of them were taken for plotting while 109 were in tie-runs across flight strips.

These aerial photographs were used for the plotting of 166 sheets of contour maps at a 4 inch to 1 mile scale covering a total area of 5,136 square miles. The authority carried out the necessary air-photo control surveys to provide check points for aerial triangulation by bridging on the 7 projector multiplex equipment used by the contractor. Horizontal control averaged less than 2 points per map sheet (8 miles × 4 miles) and was extended by triangulating, resecting and traversing; vertical control averaged 7 points per sheet and was established by barometric levelling. Map sheets were fair-drawn on Ethulon, a transparent plastic drawing material, and reproduced by diapositive process.

Maps for project investigations

Maps at a larger scale than 4 inches to 1 mile and with more accurate representation of topographic and planimetric features were required for the detailed planning and investigation of individual engineering projects. Such maps show generally 10 or 20 ft contours and sufficient detail to allow the study of alternative possibilities of locating structures, supply lines, camp sites, etc., and to record the results of geological and materials investigations.

The maps mainly used by the authority for the above work were drawn to a scale of 200 ft to 1 inch, with 10 or 20 ft contours, depending on the steepness of the terrain. In special cases, such as large reservoir areas or long tunnel lines, smaller scales such as 400 ft to 1 inch, 16 inches to 1 mile and 8 inches to 1 mile were used. These maps were invariably produced by photogrammetric techniques using aerial photographs and a Wild A7 precision plotting instrument. Air-photo control surveys of sufficient density to ensure the accuracy of subsequent aerial triangulations and plotting of contour maps to usual standards were carried out by triangulation, tellurometer traversing and trigonometric heighting methods. Control surveys were always connected to established horizontal and vertical datum points in the area.

Many sheets were pencil-drawn on Permatrace, a transparent plastic material of good dimensional stability, and progressively fair-drawn by a tracer working on the plotting table of the Wild A7 autograph. Some details of typical mapping at 200 ft = 1 inch scale completed in recent times are given in table 2.

Mapping for design and construction

In the design and construction phases of engineering projects, maps, plans and charts of large scales and great detail are required to decide on the exact dimensions and location of structures. Contour maps are prepared at scales ranging from 10 ft = 1 inch to 100 ft = 1 inch, with contour spacings from 1 to 5 feet. Examples of mapping requirements at this stage of engineering development are plans of profiles and sections at similar scales and charts of various forms and scales which show the results of measured physical features.

In the early stages of the authority's work, large-scale contour maps and route plans were mainly produced by tacheometric surveys, using ordinary vernier and optical reading theodolites for the reading of stadia intercepts. After readings had been reduced either with slide rule or with stadia tables and mechanical computing machines, surveyed points were plotted with scales and protractors and, in the case of topographical maps, contour lines interpolated. Progress of mapping by this method was slow and a large number of survey parties and draftsmen had to be employed on this work to supply the necessary map coverage for numerous projects.

A substantial increase in the speed of tacheometric field surveys and their reductions was achieved by the introduction of auto-reduction tacheometers of the Wild RDS, Hammer-Fennel and Kern types. The best results were obtained with the Wild tacheometers and they are now almost exclusively used where dense timber and bush cover prevent the use of photogrammetric techniques, or if the area is so small that photogrammetric methods would be uneconomical.

It is estimated that the introduction of auto-reduction tacheometers increased output from field survey parties by at least 100 per cent while the time required for the reduction of readings was reduced by about 75 per cent as compared with ordinary stadia surveys.

Production figures for tacheometric surveys vary widely depending on the difficulties of the terrain, density of vegetation, length of connexions to existing control and the skill of the surveyor. Details of two tacheometric surveys carried out in the Snowy Mountains area are given in table 3 as examples of this type of mapping.

Notwithstanding the greater speed of field surveys following the introduction of auto-reduction tacheometers, large-scale mapping by tacheometric methods remained slow and expensive. Faster and more economical methods of mapping at large scales had therefore to be used if the needs of this type of map for the authority's work were to be met in time.

A Wild photo-theodolite was therefore purchased in 1951 and was used for the mapping of project areas in steep and difficult country by terrestrial photogrammetric methods. These applications proved so successful that a second instrument of this type was purchased in 1955.

Terrestrial photogrammetric mapping has been used mainly for the production of large-scale maps of high accuracy and close contour intervals as required for the design of dams, power stations, diversion structures and road locations in precipitous country. A special application has been the mapping of areas of open-cut excavations for the computing of volumes.

Up to the present time, a total of 3,000 glass plates have been exposed with the authority's two photo-theodolites on seventy-seven separate assignments. Contour maps of an area totalling more than 6,400 acres were plotted at scales ranging from 1 inch = 5 ft to 1 inch = 200 ft, while profiles and sections were plotted in numerous other applications.

Initially photo-theodolite surveys were plotted on a Wild A5 autograph owned by the Department of Lands of Victoria, but the authority purchased its own Wild A7 autograph in 1955. The accuracy of contours and profiles plotted from terrestrial photogrammetric surveys has repeatedly been tested as being better than 3 inches, while

Table 2. Aerial mapping at 200 ft = 1 inch scale

	Photography		*Plotting*				
Purpose	*Lens (mm)*	*Scale*	*Models*	*Days*	*Contour (feet)*	*Map sheets*	*Area (acres)*
Project investigation	210	1:10,000	23	41	20	16	5,100
Storage capacity	115	1:11,000	9	13	5	3	410
Township area	115	1:13,500	41	58	5	15	12,800
Transmission line investigation	210	1:9,500	9	13	10	2	1,100
Project investigation	115	1:14,500	8	24	10	5	4,180
Road location	210	1:9,500	11	10	10	4	6 miles × 1,200 ft

Table 3. Tacheometric field surveys for 1 inch = 50 ft mapping with 5 ft contours

Locality	*Vegetation*	*Area (acres)*	*Points*	*Party/days*
Stadia readings:				
Undulating, medium slopes, regular features	50 per cent open grass land, 50 per cent very dense bush with timber re-growth	118	2,400	59
Auto-reduction readings:				
River valley, steep slopes, broken features	Large trees and medium-dense bush	83	12,750	54

the time required for producing contour maps of a specified area is usually only about one-quarter of that estimated for tacheometric survey methods.

While terrestrial photogrammetry is a very useful method for mapping at large scales, it can be applied to best advantage when the area to be covered is overlooked from a nearby vantage point. In our practice it has therefore been mostly used for project mapping in narrow river valleys with steep side slopes where vegetation has been sparse or where timber and bush had previously been cleared for construction work.

Aerial photogrammetry does not suffer from these limitations because the camera station is airborne. The pictures are taken looking down vertically and therefore even medium timber and light scrub of the variety occurring in the Snowy Mountains area do not interfere seriously with the plotting of contour lines from aerial photographs. Since the authority purchased its own Wild RC8 aerial camera (1959) and installed it in its De Havilland Beaver aircraft, aerial photogrammetric methods have increasingly been used for large-scale mapping. As the authority also has its own precision plotting equipment, practically all topographical mapping at scales of 50 ft = 1 inch and smaller is now carried out by aerial photogrammetric methods. Many route investigations and design surveys for roads and transmission lines are also carried out by aerial photogrammetric methods. Some production figures for 1 inch = 50 ft contour mapping are given in table 4.

While no difficulties were experienced in this type of mapping to meet normal accuracy standards, some doubt existed as to whether maps produced by photogrammetric methods would be of sufficient accuracy to be used for volume computations as the basis for payments to contractors. In this type of mapping, a high degree of accuracy is necessary and for any number of random test points the standard deviation in position and in height should not exceed ± 3 inches and no errors must exceed 6 inches.

A practical test with a large number of accurately located target points was carried out and revealed that contour maps of the required accuracy could be plotted from aerial photographs by the precision equipment if very low flying heights and individual model control were employed.

These tests were carried out early in 1962 and, since then, aerial photogrammetric methods have been used almost exclusively to produce contour maps at very large scales (1 inch = 20, 25 or 40 ft) for volume computations.

Small-scale maps and drafting techniques

A picture of the authority's cartographic activities would be incomplete without mentioning the small-scale, multicoloured maps compiled for general planning purposes. In this category of maps fall the general map of the area at a scale of 4 miles = 1 inch, the twelve sheets of the 1 mile = 1 inch coloured map series and the maps of Lake Eucumbene and Lake Jindabyne at scales of 2 miles = 1 inch. These maps were produced from other maps at larger scales by compilation and were commercially printed from colour-separated fair drawings prepared by the authority.

This work, as well as all other cartographic drafting, is carried out by the drafting section of the authority's survey branch. While originally only ordinary drafting techniques and materials were used, modern methods of scribing and photo-mechanical reproduction are now employed. A whirler for the coating of plastic sheets with sensitized dyes, a Varitype headliner for photo-mechanical type setting, a vacuum frame with arc lamp for contact printing and developing facilities for Astrafoil, Stabiline, Cronaflex, Watercote and 3M printing plates are the main items of equipment used in the preparation of maps.

Conclusions

In common with other mapping agencies, the authority, in its mapping techniques, has shown a definite trend over the years away from topographical field survey and towards the ever increasing use of photogrammetric methods. Of particular interest is the application of photogrammetry to very large scale mapping of high accuracy.

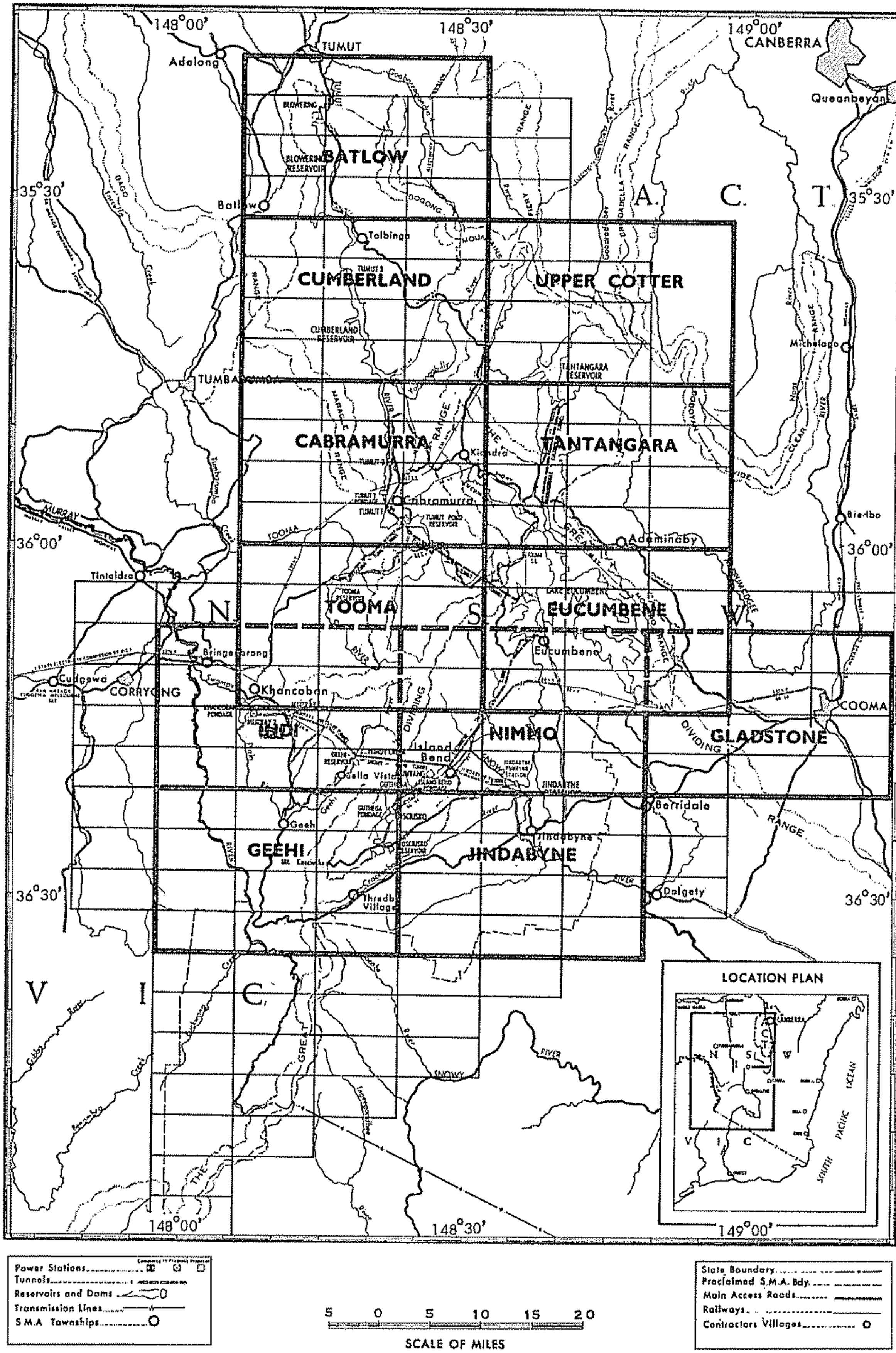
Several factors favour the use of these photogrammetric techniques. Being engaged on engineering projects, the authority has a great demand for maps of construction sites which are or can be cleared from tree and bush cover which might interfere with the plotting of very accurate contour maps. Mapping of timbered areas to normal standards of accuracy at large scales is assisted by the character of the native eucalyptus trees, whose foliage and crown shape allow light to penetrate to the ground.

The very extensive application of photogrammetric mapping techniques by the authority has been possible only because all the essential photogrammetric equipment and the skilled personnel to handle it are available within the organization. Because it has its own aircraft, precision aerial camera, phototheodolite, developing and printing facilities, survey parties for ground control surveys and precise photogrammetric plotting equipment, the authority is able to use photogrammetric techniques whenever required and economically justified.

It should not be overlooked that the aerial photographs taken by the authority are also used for many allied activities. Examples are the recording of flooding on major rivers, progress on construction sites, catchment activities and geological investigations. Of the 19,340 aerial photographs taken to date by the authority, it is estimated that only about 70 per cent were used for mapping purposes, while the remaining 30 per cent were taken for other representational purposes.

Table 4. Aerial mapping at 50 ft = 1 inch scale

	Photography		*Plotting*				
Purpose	*Lens (mm)*	*Scale*	*Models*	*Days*	*Contour (feet)*	*Map sheets*	*Area (acres)*
Township layout . . .	115	1:7,500	6	18	2	6	482
Dam site area	115	1:10,600	1	5	5	2	98
Sand deposit	115	1:6,000	2	12	5	3	220
Storage capacity . . .	115	1:11,500	4	5	5	4	50
Road design	115	1:7,700	24	20	2	20	8.5 miles × 400 ft



Australia: Map index showing 1-inch and 4-inch map coverage

CABLE LOCATION BY PHOTOGRAMMETRIC METHODS, CAIRNS AND HINTERLAND TELEVISION STATION

Paper presented by Australia[1]

Background

As channels available for allocation in the television frequency spectrum are limited, the Broadcasting Control Board has adopted a policy of maximum area coverage for each channel. In the Cairns region the area to be served extends from Mosman to Tully along the coast and westerly to Mareeba, Atherton and Ravenshoe on the Atherton Tableland. The service can be provided in two ways. The preferred one is to establish a major station near the summit of the highest suitable mountain and use only one national and one commercial frequency. The alternative is to establish one main station with medium to high powered translators all on substantial hills or mountains. These require site preparation, access, buildings, equipment and maintenance staff, and all use two very scarce frequencies each. Apart from considerations of cost, it will readily be appreciated that the board could run out of frequencies before completing the project.

This paper has been prepared to record particulars of photogrammetric and field survey investigations in respect of the designing of an acccess road and cableway to Queensland's two highest peaks to serve a television transmitting facility to be erected on one. A road to the summit of Mount Bartle Frere was the first considered, but, as will be seen from this paper, it will probably be abandoned in favour of a cableway to Mount Bellenden Ker.

Mounts Bartle Frere and Bellenden Ker are the two highest peaks in the Australian tropics and in Queensland, and are both well over 5,000 ft high. They both rise out of the coastal plain and are almost surrounded by the Mulgrave and Russell rivers whose headwaters are separated by a narrow ridge to the west about 1,800 ft high. This same ridge connects Bartle Frere with the Atherton tableland and was surveyed for road access purposes when Bartle Frere was under consideration as the site. This type of topography with mountains rising to 5,000 ft in about 3 miles is unusual in Australia.

Both mountains are covered by primary rain forests and are believed to be the wettest places in Australia. Reliable estimates of rainfall over a long period have not been kept for obvious reasons, but in the "dry" season in the course of the surveys daily falls of up to 10 inches were common and occasionally 20 inches or more were recorded.

Naturalists have found these mountains to be of tremendous interest and have travelled from many parts of the world to visit the area. Over fifty extremely rare species of plant life have been recorded and many of these are to be found only on Bellenden Ker. In particular, Bartle Frere is noted for its leptospernum wooroonooran, a unique type of ti tree, and Bellenden Ker for its dracophyllum sayeri and rhododendron lochae. The rhododendron is Australia's sole indigenous member of the species and is found only in this region. The lower slopes in particular of both hills are generously endowed with gympie gympie (stinging tree) and a tremendous variety of thorns and hooks to plague the unwary.

Very appropriately, Bellenden Ker was named on 22 June 1819 by King after an English botanist, John Bellenden Ker (1764–1842), a friend of the explorer, Alan Cunningham. Its height is 5,212 ft by our measurement to ground level.

Mount Bartle Frere was named in 1873 by George E. Dalrymple after Sir Henry Bartle Edward Frere, a Governor of Bombay and President of the Royal Geographical Society. Its height is 5,287 ft.

Photogrammetric planning

In 1962, the Commonwealth Department of Works was requested to provide preliminary estimates of cost of ten cable-car and road-access routes to possible television transmitter tower sites near the summits of these mountains. Available survey information was hopelessly inadequate and, since that department was under pressure to deliver a quick result, the Department of the Interior was requested to provide contour surveys of all routes within three weeks.

Photogrammetry offered the obvious solution. There was no time to provide control for the existing RC8 photography and it would have been necessary to bridge over eighteen models from the railway on the east to a road to the west of the mountain. At that time, it was ascertained that National Mapping had just obtained RC9 photography of the area taken from 25,000 ft and that the area of interest could be bridged with three models. The Queensland Government kindly allowed a departmental contractor (Queensland Aerial Survey Co.) to plot and contour the area on its recently installed B8 plotter.

The end result was that photogrammetric plans at approximately 1,200 ft to 1 inch, with contours varying from 40 to 200 ft intervals, were delivered to the Department of Works only one day late.

Access road survey

As a result of this work, it was possible for Department of Works engineers to eliminate most of the proposals and instructions were received to effect a more detailed ground survey of a 1-in-8 road route to the summit of Mount Bartle Frere from the west, crossing the narrow ridge between the Mulgrave and Russell rivers. Even though Mount Bellenden Ker was considered a far more suitable site technically for a transmitter, it was felt that access by either cable car or road would be far more expensive than the route to be surveyed and accordingly at that point of time Mount Bartle Frere was selected as the site.

The survey was undertaken in the winter months of 1964 by a party of ten, including the leader, N. G. Divett, and the surveyor, B. J. Moloney. The total length of road surveyed was over 66,000 ft and the total climb on the main mountain was just over 3,000 ft.

The survey itself was a feat of physical endurance and the sickness and casualties suffered by the party are a story in themselves. Pack horses were used to provision the lower camp and supplies were dropped by Bush Pilots Pty. Ltd. to the top camp when weather permitted. All supplies to intermediate camps and many to the top camp were carried in.

[1] The original text of this paper, prepared by the Department of the Interior, Canberra, appeared as document E/CONF.52/L.67.

The project disclosed the existence of a hitherto unsuspected problem which subsequently has thrown doubts on the prospects of the road ever being constructed. The 1-in-8 route was found to cross in steep sideling twenty-five boulder-filled gorges which averaged from 200 to 400 ft in width. These gorges were of unknown depth but were thought to be 100 ft and more deep. The boulders varied in diameter up to 100 ft, presenting an engineering problem of considerable magnitude.

Change of site

The cost of construction and probable maintenance of the road as estimated by the Department of Works was so large that Mount Bellenden Ker was returned to the fore as possibly the most suitable and economic site for a television station. Accordingly, the Department of Works was commissioned to provide an estimate of cost of establishing a cableway to the tower position near the summit of Queensland's second highest mountain. The rise from the base to the tower position is about 5,000 ft.

A conference was held in July 1965 with officers from the Postmaster-General's Department, representing the Broadcasting Control Board, with officers from the Departments of Works and Interior in attendance. As the route lies mainly in a wilderness national park, concern was felt that the state government might not agree to the Commonwealth acquiring the necessary land and the meeting requested that the matter be resolved before moneys were spent on surveys and investigations.

The meeting was then informed of the Postmaster-General's Department minimum requirements for the cableway as follows:

Number of tracks: 1.

Maximum weight: 1 ton (including weight of car).

Size of largest piece: 12 × 6 × 8 ft, but to handle pieces up to 30 ft if possible.

Number of cars for freight: 1 for the Postmaster-General, but two desirable during construction operations.

Number of passenger cabins: 1 (number of passengers being limited so that weight of cabin and passengers is not greater than 1 ton).

Speed: 10 mph for freight and passengers.

Control: Push button.

Drive: To be at bottom of mountain.

With the point in mind that the project might develop tourist potential, the Department of Works was asked for an additional price to cover provision to operate three passenger cabins of, say, six persons each.

As expected, the Conservator of Forests, who is responsible for national parks in Queensland, was quite disturbed at the prospect of damage and permanent scarring to the face of the mountain, which is visible to tourists for many miles along the Bruce highway. He regarded the area, as indeed it is, to be a feature of particular interest and one of high aesthetic value, and only reluctantly agreed in principle, subject to there being an absolute minimum of clearing on the park.

Cableway feasibility

The Department of Works employed W. Carter, a consulting engineer with overseas cableway experience, to provide a feasibility report and preliminary design. Mr. Carter's initial work was based on the RC9 photogrammetry of the area produced at 1,200 ft to 1 inch in 1962, and from this he selected a number of routes which in his view merited a more detailed examination. The area of interest embracing all the routes was shaped like a large fan of some 4 miles radius. It included an area around the summit and mast position, embraced the eastern slopes of the mountain and extended to include the Bruce highway, which runs generally north-south in this area.

A further conference was held in September 1965 to discuss progress and further action. Mr. Carter and the Conservator of Forests were present, in addition to those who attended the July meeting. Mr. Carter answered a large variety of questions on every aspect of cable-way construction. Mr. Trist, the Conservator of Forests, felt that it would be possible to fly the cable in by helicopter but Mr. Carter informed the meeting that it would be absolutely necessary to clear a line 20 ft wide to the horizon for the full length and that the clearing would need to be larger where the cables came close to the ground. He pointed out that the bigger the sag the less strong would the cable need to be and the less strain there would be on towers, with consequent savings in cost. The point to be noted here was that it would be very important to have completely reliable level information, not only at the tower sites but also for the full length of the route. Mr. Carter also informed the meeting that approximately nine tower sites would be needed, that a power line could not be attached to the main towers for safety reasons and would need to form a separate project. Clearing of trees would be necessary to a sufficient extent to prevent a falling tree from damaging any of the installations.

The meeting was informed that the Department of the Interior intended to refly the area at a suitable altitude and to premark the area with large yellow plastic crosses at spots which would require complete clearing. In all ten marks were to be placed. Plans were to be prepared at 400 ft to 1 inch with the best possible contours. Forestry approved of entry into the national park and gave permission to clear out the required squares. The meeting requested Interior to proceed so that firm estimates might be prepared for submission to the Parliamentary Public Accounts Committee.

Helicopters could not be used by the clearing parties owing to the dense canopy of tropical growth, so the clearing parties enlarged the areas to 100 ft square and ensured that there was adequate horizontal clearance on the down-hill side for helicopter approach purposes.

With a loaded pack, the mountain is a hard two day's climb and, with the excessive rain, it can be imagined how difficult it is to provision and equip a large party of men near the summit. It was therefore arranged for a helicopter supplied by Helicopter Utilities to assist during the measuring programme. The clearing parties, led by Senior Surveyor, N. G. Divett, cleared out the mountain sites in twelve days of extremely strenuous effort. One site would take a party of three or four equipped with chain-saws four or five days to clear.

Photographic control

While awaiting the arrival of the helicopter (a Bell 47G2), the party commenced the provision of horizontal and vertical control to the points among the sugar cane. Horizontal control was effected by tellurometer and the vertical by simultaneous reciprocal angles supported by spirit levelling.

The helicopter at that time could be used only to get men and equipment to the 3,000 ft level and could not reach the summit because of cloud and rain. It was again necessary for the parties to carry heavy equipment and packs. Luckily at the end of the measuring programme it was possible to lift the whole party and equipment out from the summit region.

The entire measuring programme on the mountain had to be effected as the weather allowed. The cloud tended to lift at night and accordingly more observations were taken then. A framework of control was established on the flat land and then each point on the hill, except the tower position, was connected to from three stations for both level and position. All horizontal angles were read and simultaneous reciprocals were observed on each line measured. Because of the nature of the land near the television tower position, it was necessary to carry horizontal position and level to that point by theodolite, chain and tellurometer traverse from the summit control point, a distance of about 2,000 ft.

In this exercise, it was important to eliminate gross mistakes rather than minor errors and accordingly no attempt was made to adjust the observations. Nevertheless, it is interesting to note the comparisons in position and level of each point as determined from each direction. It will be appreciated from the results which follow that, for the purpose of providing the required photograph control, there was no hesitation in adopting a simple arithmetic mean.

Root level	*N.*	*E.*	*From*
	Bob's Knoll		
688.03	211227.09	190889.03	Level crossing
688.14	211226.90	190888.99	South Knoll
687.84	211227.32	190888.99	Bellenden Ker
	Tick camp		
3239.11	207206.87	182337.39	Level crossing
3238.89	207207.48	182337.93	Bellenden Ker
3239.58	207206.63	182338.08	Junction Creek
	Summit		
5212.45	210448.94	177993.71	South Knoll
5212.25	210449.93	177993.87	Level crossing
5211.70	210449.82	177994.01	North slope

This, then, completed the first stage of the project, which allowed photogrammetric plotting to proceed. Prints of the machine plot were subsequently made available to the Department of Works and Mr. Carter, the cableway expert.

From this information, the most suitable profile was selected and a tree-top profile of the route was provided by Interior. Spot heights at changes of grade along the route were also determined by photogrammetry.

Tree-top profiles were provided also of three possible routes for a 22 kv power line.

Further field survey

The determination of the positions on the ground of trestle sites which had been selected on the photogrammetric contour plan by Mr. Carter provided an interesting problem, since it is impossible to see out of the jungle without spending a number of days clearing. Considerable thought was given to using gas-filled balloons let through holes in the tree canopy, but this idea was abandoned for a number of reasons. Eventually a Verey pistol was fired through a hole cut in the canpoy. Two parties, one on Bob's Knoll and the other set up on the centre line at the foot of the mountain, triangulated the flare by theodolite, determined the mountain party's position and advised them by radio which way to go. It is extremely difficult in this type of country to know whether one is on the right spur and also to carry forward bearing and distance reliably. Nevertheless, the method worked very well and after a few trials the parties were able to establish the centre line within a few feet, certainly enough to clear out a trestle position and helicopter pad. A number of the positions were too rough to use as helicopter pads and alternate areas were used.

The final line was measured by a tellurometer traverse from trestle site to trestle site along the centre line carrying level through by reobserving simultaneous reciprocals.

Station 10, being the position of the photo-control cross at the television tower position, was adopted as the cableway terminal point by Mr. Carter.

The centre length as measured compared with the length as deduced from the previous co-ordinates is as follows:

As measured: 19386.34; root level, 5061.2;

As deduced: 19386.42; root level, 5062.8.

A preliminary report has now been prepared by the consultant and is to be submitted to the Parliamentary Accounts Committee in 1967. Most of the technical details have been extracted from the report but details of cost cannot be disclosed at this time. However, it seems quite likely that detailed design will proceed and that further field surveys and photogrammetric investigation will be required.

Conclusion

Many lessons have been learned from this very arduous but interesting survey and possibly the capacity of human beings to undergo physical hardship is not the least important.

One other important fact has also emerged and relates to contouring by aerial survey of large areas which are completely covered by primary tropical growth. It was noted that timber near the summit of the mountain was stunted but of reasonably uniform height and that, as the slopes descended, tree heights gradually increased. By judicious sampling of tree-top heights in such country, it is possible to produce a reasonably accurate ground contour survey.

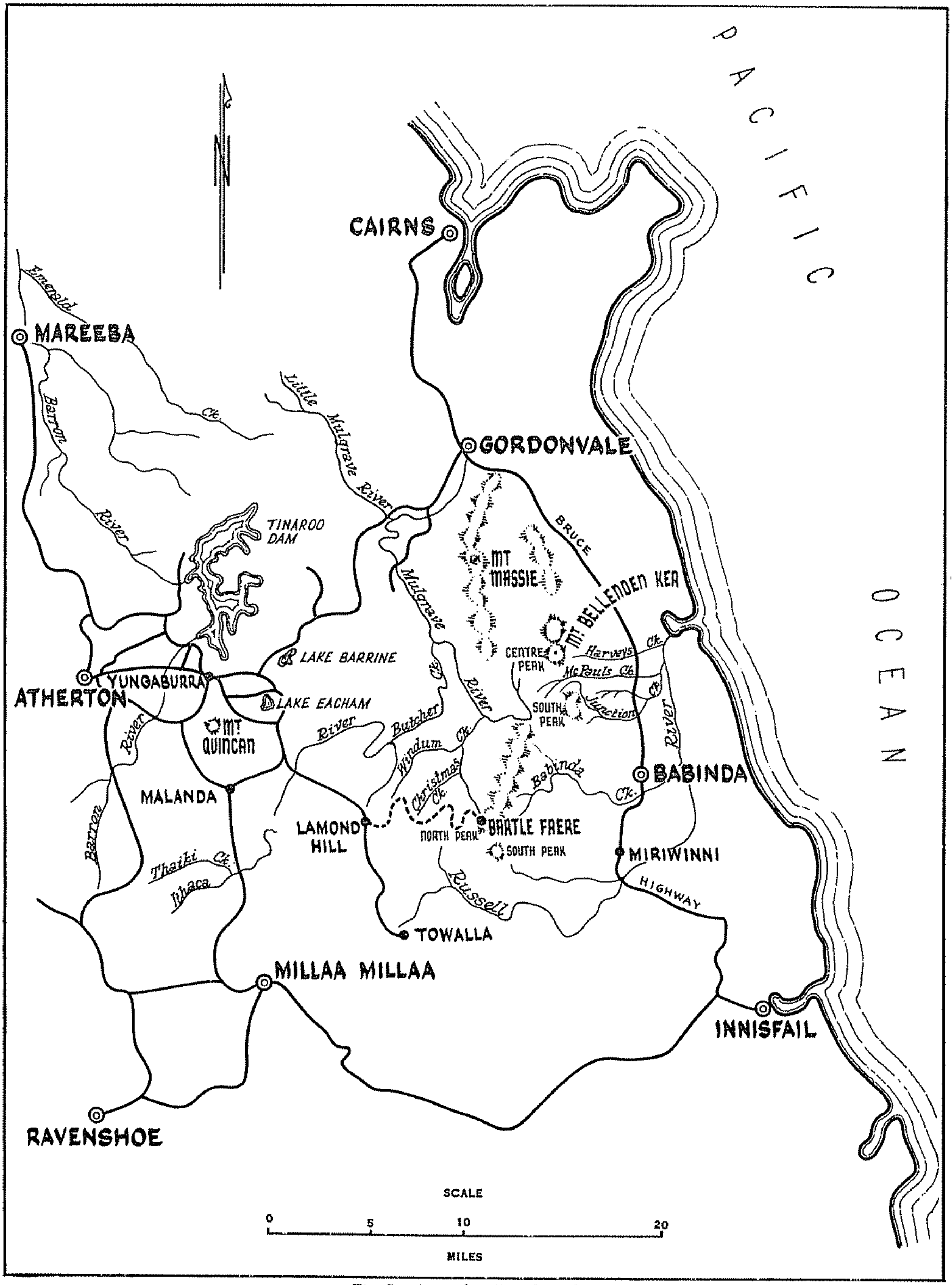


Fig. I—Australia: Locality plan

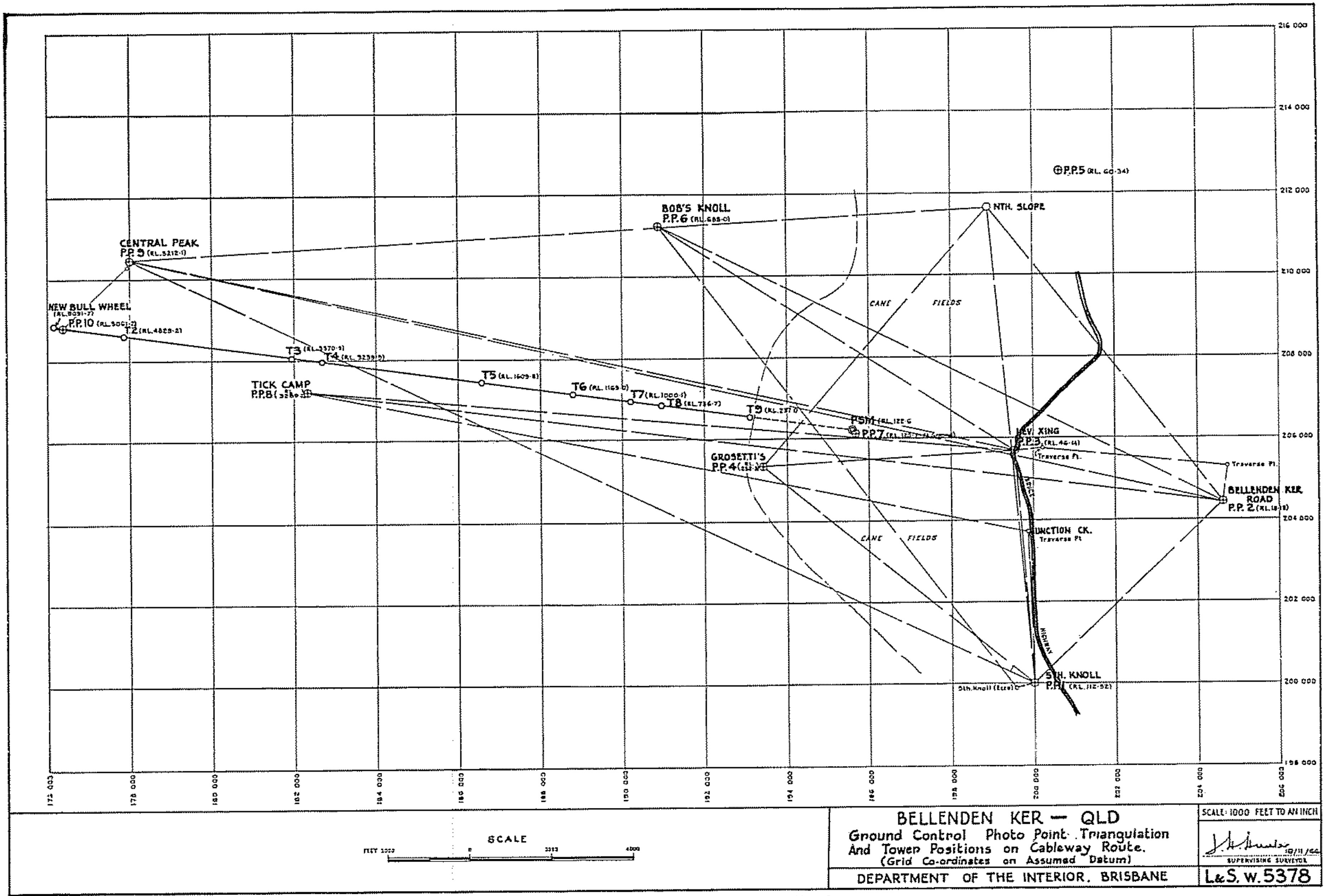


Fig. II—Australia: Cableway route, Bellenden Ker

(g) Land settlement and land tenure

CARTOGRAPHY AND LAND SETTLEMENT

Paper presented by Australia[1]

INTRODUCTION

Western Australia is generally referred to as the western third of Australia and as such comprises some 975,920 square miles.

The area is approximately limited in the south by latitude 35° south and in the north by latitude 14° south. This extensive area contains soil and vegetation types which vary from those associated with the semi-tropical north to the rain forests in the extreme south-west.

Settlement has been adapted over the years to the methods of agricultural usage which have been found to be readily applicable to the various areas. At the present stage, the south-western portion of the state, where the rainfall exceeds 10 inches annually, is mainly devoted to the more intensive forms of agriculture, including wheat and sheep production. About 60 per cent of the remainder of the state is utilized for pastoral pursuits, large cattle or sheep stations. The remaining area has either been retained as reserve land or consists of semi-arid country not suitable for agricultural or pastoral use with present-day methods and resources.

There are some small areas of intensive agriculture in such places as the Ord river irrigation area in the far north and in the Fitzroy river area, near Derby in the West Kimberley area.

That portion of the state between the 10 inch Isohyet and the coast is referred to as the agricultural region of Western Australia and is indicated on map.*

The heavier forest country is mostly confined to the extreme south-west, in a belt where the rainfall is between 25 and 50 inches annually.

This heavy forest country is generally adjoined by a belt of more openly timbered country confined more or less to the 20 to 25 inch annual rainfall belt. Although there are areas of forest outside these general limits, they are less extensive and more of a savannah type.

The areas within the 10 to 20 inch rainfall belt of the south west of Western Australia contain the largest percentage of unimproved land in the agricultural region. It is this portion of the state where intense investigation into agricultural potential is at present being carried out. The vegetation in this region varies greatly both in size and in density, ranging from savannah type country containing timber such as salmon gum, white gum, York gum, gimlet and morrel through mallet and wodjil country to open heath type scrub plain.

AGRICULTURAL DEVELOPMENT

Since the turn of the century, the introduction of artificial fertilizers together with the development of subterranean clovers and more drought resistant wheat varieties has led to a spectacular increase in development and a consequent expansion of the agricultural region. The expansion has included areas previously considered to be of little or no agricultural potential, such as land of inherent low fertility in the better rainfall areas, sand plain country, also generally of low natural fertility, in the coastal areas and land of good quality in the parts of the agricultural region where rainfall is less assured. This latter area is still largely undeveloped.

Development has reached the stage where there is not a great deal of available Crown land remaining in the more attractive rainfall areas, that is, where the annual rainfall is in excess of 13 inches with a growing season rainfall of 7 inches or more spread over a four to five month period. Consequently, the continual demand for farming land has resulted in a constant endeavour to investigate and extend development into the lower rainfall portions of the agricultural region.

LAND SETTLEMENT GENERALLY

Land settlement in Western Australia has taken place in a series of bursts or surges and could perhaps be visualized in graph form with a number of peaks and hollows. The hollows would represent the periods of the two world wars and the world economic slump of the 1930s. The peaks would represent the war service schemes of the 1920s, which were put into effect following the First World War, and the civilian land settlement scheme, known locally as the "3,500 farm scheme".

The magnitude of the land settlement schemes implemented in the period between the two world wars was impressive. The schemes embraced the provision of roads, railways, water supplies and all the services required in a community where a distance 15 miles from the nearest railway siding was considered to be a serious drawback.

The Surveyor General, who is responsible for the investigation and planning of areas of Crown land for possible future settlement, was required to evolve methods which could quickly and effectively deal with the mapping and planning of the large areas of land involved. In this respect, even though the basic principles of land investigation remain constant today, the use of aerial photographs and other cartographic techniques now play a major part in reducing the time factor and facilitating the plotting of natural features.

These schemes were curtailed in the early 1930s, but they made possible the development of portions of the agricultural region which are today among the prime producing areas of the state.

Settlement after the Second World War was of a much more sophisticated nature due to advances in agricultural science, the advent of modern road transport and the development of heavy earth-moving machinery, particularly the bulldozer tractor.

BASIC CLASSIFICATION METHODS

The basis of all soil investigation surveys, or classification surveys as they are more generally known, is mapping related to a ground control which has been established to an

[1] The original text of this paper, prepared by F. H. Bray, W. G. Henderson and J. R. McFadden, Division of Surveyors, Department of Lands and Surveys, Western Australia, appeared as document E/CONF.52/L.40.

* See pocket at end of volume for map entitled: "Land Use in South West of Western Australia".

accuracy sufficient to allow the production of a map to show the demarcation between the various soil types at a scale suited to the particular purpose of the proposed development. This plan then forms the basis for road and farm design.

The scale of plans for development of wheat and sheep farms which vary in size from 2,000 to 5,000 acres could be from 1 inch to 20 chains (approx. 1:16,000) to 1 inch to 1 mile (approx. 1:64,000). On the other hand, for development for pastoral or sheep and cattle station farms, that is, carrying capacity appraisals rather than soil surveys, a scale of 1:250,000 could suffice.

The ground control involves the survey and marking of base lines by theodolite and chain, generally in the form of a grid system over the area under investigation. The spacing of the base lines is governed by the terrain and the distance which can reasonably be traversed by a classifying party in a day. In open country the base lines may be as much as seven miles apart, whereas in forest country they could be between 2½ and 3 miles apart.

The actual classification is carried out along grid lines between the base lines by compass and chain traverse. Test holes are sunk with an auger or spade at regular intervals along all base lines and all grid lines and the soil descriptions appropriately recorded. The interval between the grid traverses and the frequency of test holes is governed by the type of country being dealt with.

Assessment of classification gradings

In Western Australia, the term "soil classification" is used to describe the broad agricultural soil investigations where soil types are categorized into grades which cover a wide range and the very comprehensive soil surveys where the soil associations are more finely defined in relation to agricultural potential. A description of this more comprehensive soil survey as applied to the area north of Perth, known as the "Midlands light land area", is attached as an annex to this paper.

Soil investigation in this state is carried out in close co-operation with the soil scientists of the Western Australian Agricultural Department. Assessments are made with due regard to the saline and acidic qualities of soil and productivity experiments carried out by the Agricultural Department on comparable soils. These experiments are conducted either on government research stations or on various private properties throughout the state.

In the days before the Second World War, soils were usually appraised in three classes which were readily identified by vegetation cover. The poorer country, designated third class, was at that time regarded as being practically useless. Agricultural and scientific techniques and advances have, in the intervening years, developed to such an extent that much of the former third-class land can now be brought into production on an economic basis.

Use of aerial photographs and plans

The advances in the techniques of aerial photography as a cartographic aid following the Second World War have found their application in land investigation and classification.

Photogrammetry has provided a means of obtaining accurate topographical maps prior to classification and these maps, in the form of line compilations of the separate sheets, are ideal for use as base plans for the survey, regardless of whether the actual soil types can be identified on the individual photographs.

Experience has shown that in certain areas vegetation is usually related to the soil type. The vegetation appears on the photographs as a consistent pattern and it is therefore possible to define the limits of the soil type on the photo. This information can then be transferred to the base plan.

In areas such as that discussed in the annex, where soil relation to vegetation cannot be readily interpreted on the photographs, photography still plays a major part in fixing internal topographical detail and to a lesser degree in interpolating the soil pattern.

Stock carrying or pastoral appraisement is more concerned with the type and density of vegetation, since the accent is on natural grazing with no tillage of soil. In the pastoral areas, topographical features such as hills, mountains, rivers and water points are of great importance and in this respect the air photographs provide a really excellent source of information.

Procedure for dealing with a typical area

Collecting data, records and preliminary considerations

All available information, maps, photographs and descriptions of the area under consideration are assembled and scrutinized thoroughly. Any existing classification sheets which were prepared prior to the Second World War are especially useful. These have been found to be very reliable as regards the internal soil descriptions and definitions of the vegetation types. They are accurate as regards the heavy soil types, but limited in distinctions of the variations in the lighter soil types. Part of a typical sheet classification is shown as appendix D.*

The availability of line compilations is of equal, if not greater, value than old classification detail. These plans make possible a reasonable selection of suitable road routes and base lines prior to commencement of field work.

Frequently the ground conditions are difficult to relate to the photographs because of changes due to bush fires and regrowth and it may be desirable to have the area under consideration re-flown. Should this not be practicable, the line compilations still provide excellent base plans for the investigation.

The only additional work required on the photographs is to plot thereon cadastral information, proposed base lines, road routes etc. and to assess areas which would probably require closer field investigation.

Preselection of road routes as base lines for field investigation

This aspect is also a preliminary and is done on existing information with particular use of aerial photographs and line compilations; the techniques of using these media as an aid to road location have been the subject of many papers and will not be commented on at length here.

The major routes and, to a lesser degree, the internal service road system are usually determined in close co-operation with the state road authority, in this case, the Main Roads Department of Western Australia and the local governing authority or shire council.

The routes are selected with due consideration of access to centres and towns, the limitations of topography and the proximity to other major roads.

* See pocket at end of volume.

Field work

The field work commences with the location of the road routes and base lines. This is effected by theodolite and chain traverse, usually employing a bulldozer for clearing these lines, providing access tracks for the field parties.

The traverse detail is transferred on to the photographs. Ideally the area should be re-flown so that the actual bulldozed lines are evident on the photographs.

The project is now at a stage where the field classification can be carried out. This work includes identification on the photographs of the location of any obvious source of road material, attractive timbered areas, and areas containing a cross section of the native fauna and flora, natural features, areas liable to be adversely affected by topography or soil type. These areas are then reserved for suitable purposes. A minimum of 20 per cent of all new land designed for rural subdivision is reserved in Western Australia.

Final office work

The final work of marking up the photographs and transferring the information on to cronaflex transparencies is done in the office. Finished plans are prepared and suitably coloured to indicate the various soil types, and these plans are then used to prepare a subdivisional design.

In the case of areas which cannot satisfactorily be dealt with on the broad principles of aerial photo-interpretation, it is necessary to carry out more detailed and closer investigation on the ground by conventional methods.

Costs

Costs are difficult to assess in this type of work where so much use is made of existing plans and records. For this reason the costs which are given and which are only estimates do not include the costs of the existing information but refer only to actual field costs.

If it is necessary to have an area especially mapped to the stage at which line compilations are available, the cost of such work must be added.

The costs vary between 3 and 12 cents per acre. The higher figure is incurred in areas where comprehensive soil survey is required because of photo-identification difficulties and the lower figure in areas where the assessment is made by the maximum use of aerial photographs.

Summary

There are broadly three different techniques applied to land classification in Western Australia none of which is entirely dependent of the other. They are:

The conventional method of base line with compass grid traverse used where aerial photo-coverage is not procurable for economic or other reasons;

Combined use of the conventional methods and field interpretation of aerial photographs, used in areas where vegetation to soil relationship is consistent;

A combination of conventional methods and the use of aerial photographs to verify the position of topographical features.

The prime advantage derived from the use of air photographic techniques in land classification is the rapidity with which a given area can be mapped at an equitable cost, but it must be stressed that photographic techniques are regarded only as an aid to conventional methods which must still be employed to provide the necessary field checks.

Annex

THE MIDLANDS LIGHT LAND AREA

The demand for Crown land for agricultural purposes in the years following the Second World War caused attention to be focused on an extensive area west of the Perth-Geraldton railway, referred to as the Midlands area, which had hitherto been regarded as unsuitable for development.

This area, comprising some 1,100,000 acres, consists mainly of undulating sand plain with a heath-like coverage of scrub and is situated in an assured rainfall belt of 18 to 25 inches. Following problems associated with the early development of portions of this area, it was realized that the conventional methods of classification that relied on vegetation coverage and surface soil indications were inadequate when applied to assessing the agricultural potential of this area, and it was accepted that a system of more detailed field investigations, involving the application of soil survey techniques, was necessary.

The critical factor in the soil associations of this plain country is the distribution of the better quality yellow sands, the occurrence of gravel, and the subsoil depth at which these occur. As it was known that the vegetation pattern did not change appreciably from one soil association to another, it was not found possible to determine the soil types purely by the vegetation coverage.

The solution to the problem of classifying the area as rapidly as possible and obtaining the information required was found to be by a combination of air photograph interpretation and conventional ground methods.

The area under investigation was covered by aerial photography and, following selection of a particular section, survey information of any cadastral surveys in or on the perimeter of the section was prepared, the latter being required to assist in controlling the base lines with which the section was subsequently gridded.

The minimum personnel requirements were found to be: surveyor; draftsman; 1 survey hand driver; 2 survey hands; with the following vehicular equipment: 1 30 cwt. truck; 1 long-wheel-base Land Rover.

The urgency of the work demanded the employment of up to three field parties in one particular area, all parties being based on the above requirement, any expansion of the party strength being in units of two employees.

The area was first gridded with parallel base lines at about 5 mile intervals, ranged and chained to cadastral standards and connected to existing cadastral surveys on the perimeter of the area. These base lines were positioned so as to, where possible, cut across any general change in topography, and were marked at 10 chain intervals with painted stakes with a metal identifying tag attached.

Following the establishment of the base lines, the soil survey proceeded on the basis of compass and chain traverses, on a 20 chain grid, between the base lines. At each 10 chain interval along the base lines and the intervening compass traverses auger holes were sunk to a subsoil depth of 3 ft and the soil profile recorded.

This procedure was carried forward progressively until the whole area was covered.

The presence of the draftsman in the field was essential to the rapid and progressive compilation of the base sheet transparencies. As the field work progressed so the information was transmitted to the draftsman and recorded on the base sheets, extensive use being made of the aerial photographs not only in correlating the information regarding disposition of the soil types but in the fixing of the prominent physical features, such as "breakaways", which are a peculiarity of this country.

The base sheets were laid down from uncontrolled photo-mosaics and while this procedure could be open to question, no serious problem or patent inaccuracies were detected.

The base sheets compiled by the draftsman in the field were on Cronaflex on a scale of 20 chains to 1 inch. These transparencies were then reduced to 40 chains and from these the final soil survey sheets were printed.

The final sheets, in addition to their value in providing the essential information on the distribution of soil types, were also of inestimable value in designing a suitable road system, as any physical features which could cause an obstruction to road alignment had been accurately located by the correlation of the information obtained in the field and the details provided by the air photographs.

The soil surveys of the area by this procedure of a combination of conventional ground methods and air photograph interpretation made it possible to cover this extensive area in the least possible time and at a very equitable cost.

LAND TENURE AND CADASTRAL SURVEY SYSTEM IN WESTERN AUSTRALIA

Paper presented by Australia[1]

INTRODUCTION

When the colony of Western Australia was founded in 1829 it was settled by English people and naturally they brought with them the laws of their mother country, as far as they were applicable. These laws were of course applicable to land use and for many years the English conveyancing system prevailed.

The land was annexed on behalf of the Crown and grants were made to those who became eligible, either in consideration for money payment or for services rendered.

The Crown grant was in the English form, usually reserving to His Majesty the right to precious metals and also the right to resume 20 per cent for certain purposes, and requiring an annual payment of one peppercorn, thereby acknowledging that the Crown actually was still the absolute owner. Sales of land were by conveyance and the original grant remained the fountainhead of legal ownership.

In 1874, the Torrens system was introduced and the Land Titles Office was founded. From that time onward Crown grants were passed to the Titles Office and were registered in accordance with the Transfer of Land Act under which the registered proprietor obtained a certificate of title. The whole concept of land holding and transfer was simplified. It became possible to transfer land by a simple form of transfer and the Crown virtually guaranteed the title.

This system still prevails in Western Australia and is governed by the Transfer of Land Act, 1893–1959. Various improvements have been made to the original Act but the system remains virtually the same.

In Western Australia, the Surveyor General is responsible for all land and geodetic surveys and for topographical mapping. This paper, however, deals only with the subdivisional surveys.

LAND TENURE UNDER THE LAND ACT

The utilization of Crown land is dealt with under the Land Act, 1933–1965, which is a re-enactment, with suitable amendments, of the Land Act, 1898. As mentioned previously, all unalienated land is held by the Crown and instruments of alienation and lease are dealt with on behalf of Her Majesty by the Governor in Executive Council, being Her Majesty's representative in Western Australia.

For the sake of convenience, the Land Act divides the state into five divisions: the South West Division, the Kimberley Division, the North West Division, the Eucla Division and the Eastern Division. These divisions have been made having in mind climatic and geographical features. For example, the South West Division comprises land having a temperate climate in the south-west part of the state with a reasonable rainfall in the growing period and generally suitable for agricultural settlement. This is the main agricultural portion of the state. The Kimberley Division is tropical, receiving its rainfall during the summer months following a long period of dry in the winter. The North West Division includes coastal country extending inland to a certain extent but the rainfall is much less than in the Kimberley Division and there is not the rapid tropical growth. The Eucla Division is in the south-eastern portion of the state, receiving winter rains and contains a considerable portion of the Nullarbor plain. The Eastern Division includes the central part of the state to the border of the Northern Territory and South Australia, and includes probably the poorest portion of the state and receives the lowest rainfall.

These divisions in turn are divided into land districts and in these are numerous townsites. Townsite land is subdivided into lots and agricultural land into locations.

The usual method of disposing of town lots is by auction. The sales are notified in the *Gazette* and special conditions are generally imposed, the main one being (for residential land) that a house or building be erected within a certain time, usually two years. Ten per cent of the purchase money is payable at the sale and the balance within twelve months.

In the south west land division locations are, as a rule, made available under conditional purchase conditions. The land is advertised as open for selection and applications are invited. For many years now the number of applicants has exceeded the number of blocks and in all cases the applications are dealt with by a land board which interviews applicants and decides on the allocation. The price of the land is fixed by the Governor after assessment by the Surveyor General, the minimum being 20 cents per acre and varying according to soil, rainfall, vegetation and distance from railway, wheat bin etc.

Land is granted for a term of twenty-five years, after which, on fulfilment of the conditions and payment of the full amount, a Crown grant is issued. Earlier fulfilment of the conditions and payment of the purchase price entitles a Crown grant before the expiration of twenty-five years.

The lessee must within two years from the date of approval of the application take possession of the land and reside on it for at least six months of each year. He is also required to effect improvements by way of clearing and cultivation of at least 10 per cent of the total area within two years and at least 5 per cent in each of the next following eight years and progressively sow to pasture or crop or to both, to ensure that at least 20 per cent of the total area of the land is or has been so sown by the end of the fifth year and 50 per cent by the end of the eleventh year and shall fence in at least the cleared and cultivated land within the first five years and the whole of the land within ten years.

Leases are subject to inspection by land inspectors to ensure that the conditions are being carried out.

[1] The original text of this paper, prepared by Harold Camm, Surveyor General of Western Australia, appeared as document E/CONF.52/L.41 and Add. 1.

Most of the land now being made available is in the lower rainfall areas and a large holding is needed to make an economic unit. Blocks vary from about 1,800 to 5,000 acres. The normal maximum area is 5,000 acres, but the Governor may approve an area exceeding that acreage, but not exceeding 10,000 acres, in any case where the Minister is satisfied that a holding requires an area greater than 5,000 acres to be a standard economic farm unit.

For agricultural purposes the above-mentioned conditional purchase system is usual. However, the land is frequently required for many other purposes and the Land Act provides for leasing up to a term of twenty-one years for certain specified purposes. These specified purposes are defined in the Act and the Governor has power also to lease for any other purpose after notice in the *Gazette*. If the term of the lease is greater than ten years, notice must be published and applications invited. The minimum rental is $4.00 but there is no maximum.

Town or suburban lands may be leased on such terms as the Governor thinks fit.

A large proportion of the state is not at this stage suitable for agricultural development on account of the nature of the soil and the rainfall, or both. Much of this land, however, contains natural pastures and is utilized in large holdings for grazing purposes. The maximum permissible area is 1,000,000 acres. Pastoral leases are granted for a term expiring on 30 June 2015, at rentals which are fixed by the Pastoral Appraisement Board. This board comprises the Surveyor General (chairman), the Director of Agriculture and two other persons appointed by the Governor who hold office for a period of five years. One of these persons is a representative of the Pastoralists' and Graziers' Association. The annual rent is fixed by the Minister for Lands on the advice of the Pastoral Appraisement Board and is based on the pastoral capabilities of the land, its distance from a port or railway, or other circumstances affecting its value for pastoral purposes.

A pastoral lease gives no right to the soil or timber, but in some areas a limited amount of chaining is permitted to improve the growth of grasses.

The carrying capacity of most of this land would be 1 sheep to 30 or 40 acres, and over-all would vary from about 1 sheep to 15 acres to 1 to 100 acres.

The pastoral leases are granted under stringent development and stocking conditions. Within twelve months after the commencement of his lease, the lessee must submit a plan showing the improvements he contemplates, such improvements to provide for the reasonable development of all portions of the land capable of utilization for pastoral purposes. After the plan has been approved by the Minister for Lands, the improvements must be effected according to the plan and the minimum amount to be spent annually on such improvements is two and one-half times the rent payable for the year.

The land must be stocked and kept stocked with such numbers of sheep or cattle, or both, as the Pastoral Appraisement Board considers to be a sufficient number. The board has power to prohibit the lessee from increasing the number of stock, to require him to reduce the number of stock and to require him to provide and maintain suitable fencing for the control of any area of the lease which has been adversely affected by excessive numbers of stock depastured thereon. A pastoral lease is liable to forfeiture if the lessee permits all or part of the land to deteriorate to the point of necessitating lengthy protection from grazing.

Land Titles Office

As mentioned earlier, the Torrens system of land registration operates in Western Australia. Every conditional purchase lease and grant of land from the Crown is registered in the Land Titles Office and comes under the operation of the Transfer of Land Act which provides for transfers, mortgages, leases, caveats etc. and actually guarantees title to the registered proprietor subject to certain principles. Once the conditional purchase lease or Crown grant has been registered in the Titles Office, all subsequent dealings are made through that office and the Department of Lands and Surveys has no further jurisdiction apart from surveys and, in the case of conditional purchase leases, field inspection. A transfer of a conditional purchase lease must, however, be approved by the Minister for Lands before it can be registered. There is provision for land which becomes registered by transfer or otherwise in the name of Her Majesty to be revested in Her Majesty as of her former estate. The land then again becomes vacant Crown land and is no longer under the operation of the Transfer of Land Act.

Surveys

Every boundary survey in Western Australia must be carried out by a licensed surveyor, that is, one who has been registered under the Licensed Surveyors' Act. This act provides for a Land Surveyors' Licensing Board consisting of the Surveyor General who is the chairman, three members appointed by the Governor on the nomination of the Surveyor General and two appointed by the Governor on the nomination of the Institution of Surveyors. The act gives the board power to grant licences to practise to surveyors who have duly qualified and have had the prescribed practical experience. Licensed surveyors are the only persons authorized to carry out boundary surveys.

There is a reciprocal agreement between the surveyors' boards of all Australian states and New Zealand, and a surveyor registered by any one of these boards is entitled, on production of a letter of recommendation, to be registered with any other board. There is also reciprocity to a lesser degree with the Royal Institute of Chartered Surveyors.

The Licensed Surveyors' Act also provides that no boundary survey shall be accepted or adopted by any government department or sub-department unless a plan of such survey has been lodged with and approved by the Surveyor General or other person appointed by the Governor to approve plans of authorized surveys.

Surveys are carried out by theodolite and chain, using normal traversing methods. In large blocks now being alienated, this entails the running of long straight lines by the production method. Steel bands 5 chains by $\frac{1}{8}$ inch are normally used and corrections made for standard, temperature, slope, sag etc. The limit of closure in rural lands is 2 links to 1 mile or 1 in 4,000. Angular close is a limit of 15″ per angle, with a maximum of 3′. In town surveys, the chainage error is limited to 1 in 8,000 and the angular to 10″ per angle with a maximum of 1′.

A recent amendment to the regulations controlling surveys has legalized the use of photogrammetric methods in certain cases. The new regulation reads:

> "In special cases, such as where the value of the land does not warrant a normal ground survey, or where the rugged nature of the ground prevents an accurate survey by normal methods, or where a natural boundary such as a river or the seashore can be located with sufficient accuracy by photogrammetric methods, the Surveyor

General may authorize a survey to be carried out by photogrammetric methods using aerial photographs and ground control by a licensed surveyor. In such instances special conditions may be laid down by the Surveyor General for marking boundaries."

In rural lands, each location corner is marked by a wooden post 4 × 4 inches, pointed on the top, 30 inches long and 18 inches in the ground. It is painted white. As an alternative, a flat-topped concrete block may be used, 18 × 2½ × 2½ inches, sunk 15 inches in the ground. On lines exceeding 12 chains in length, iron spikes, 10 × ½ inches are placed at intervals of 10 chains. Posts and spikes have trenches indicating the direction of the lines. In early surveys, a tree near each corner was blazed and marked and connected to the corner. Ever since the turn of the century, however, there has been a system of reference marking at location corners. These reference marks are two iron spikes, usually 5 links from the corner, and sunk under the surface on production of the lines, or in any other position which might appear to be more permanent. Farmers are encouraged to protect survey marks and to erect fences in such a way as not to interfere with posts or spikes.

Surveys of Crown land are made under instruction from the Surveyor General and are effected either by departmental staff surveyors or by contract surveyors paid by results. Subdivisions of freehold land are carried out by private surveyors at the request of the owner.

In all cases of boundary survey, the actual field notes taken in the field are deposited with the Surveyor General.

In the case of Crown land, all subdivisional designs are prepared departmentally and are subject to the approval of the Surveyor General under whose direction the surveys are carried out. Subdivisions of freehold land, however, are designed by the private surveyor or town planner and are subject to the approval of the Town Planning Board.

Examination of surveys

Prior to 1893, little, if any, examination was given departmentally to surveys and it was recognized that the surveyor signing the plan accepted full responsibility. From 1893 until 1948 there was an Inspector of Plans and Surveys in the Land Titles Office who controlled a staff dealing with examination of surveys in that office; the Department of Lands and Surveys also had officers carrying out those duties in connexion with surveys of Crown lands. The Inspector of Plans and Surveys in the Titles Office had authority to approve plans of surveys of freehold land on behalf of the Surveyor General and in the Lands Department surveys were approved usually by the Surveyor General but also at times by district surveyors who were granted authority in that respect.

Regulations for the guidance of surveyors have for many years been in four parts, comprising the General Regulations which apply to all boundary surveys, the Lands Department Regulations which contain special provisions for the survey of Crown land, the Titles Office Regulations which are applicable to survey of freehold lands and the Mines Department Regulations which are operative in connexion with surveys of mines.

The standards and methods for all types of boundary survey are covered by the General Regulations and in order to ensure uniformity of standards it was decided in 1948 to amalgamate the examination staffs of the Lands Department and Titles Office under one Inspector of Plans and Surveys.

To facilitate this, Titles Office field books have since that date been lodged with the Surveyor General in the Lands Department, but Titles Office plans and diagrams are still deposited with the Registrar of Titles and are legal documents under the Transfer of Land Act. Immediately on registration, however, they are passed to the Inspector of Plans and Surveys in the Lands Department for examination and approval and are dealt with by his staff. This system has many desirable features. One is that a single staff carries out the examination of surveys under a single administrative head, with a resulting uniformity in standards and methods. Another important feature is that staff are available to cope with unexpected rushes in any section and in urgent cases results can be produced much more quickly than would otherwise be the case.

The Mines Department still retains an examination staff but survey matters are referred to the Inspector of Plans and Surveys as the officer who gives final approval to the plan on behalf of the Surveyor General.

All surveys are connected to an existing survey and in most cases they abut. One important aspect of examination, therefore, is an investigation to ensure that the surveyor has adopted the correct alignments, especially in the case of older surveys. The previous field books are of course extremely useful for this purpose. All aspects of the survey are investigated, including angular and linear closures, observations, etc. Observations for true meridian are taken at intervals not exceeding five miles. Another important part of examination is the legal side. The status of the land, easements, encumbrances, closed roads, etc., all have to be verified.

In round figures, the number of surveys deposited are as follows: Lands Department, 1,100 per annum; Titles Office, 1,600 per annum. These figures are not, of course, a true indication of the volume of work, because in some cases the survey is a simple one which can be examined in an hour or two, whereas another might be a large subdivision of a number of blocks.

Plans

On completion of every cadastral survey, a plan is drawn at any convenient scale to show in detail all boundaries, survey marks, distances, angles, bearings, lot or location numbers and areas. Any topographical detail shown in the field book is also shown. This plan is numbered and recorded, and becomes the official record of the survey. It is available for inspection by surveyors as information for future surveys.

After approval by the Surveyor General, the survey is plotted on to the over-all comprehensive cadastral map which is available to the public.

Cadastral maps in Western Australia, by virtue of their original reproduction method, are termed "lithographs". Although the stone media has long since been replaced by zinc and latterly aluminium plates, the name has been perpetuated and the map distribution centre of the department has by common usage been known as the "litho room".

Approximately 1,500 cadastral maps (lithographs) of various scales are held and include:

4 Chain maps	(1:3,168)	of the larger towns and cities published in "series" editions;
6 Chain maps	(1:4,752)	of townsites;

20 Chain maps	(1:15,840)	which form the basic cadastral coverage in a standard rectangular sheet system.
40 Chain maps	(1:31,680)	
80 Chain maps	(1:63,360)	
240 Chain maps	(1:190,080)	
300 Chain maps	(1:237,600)	
800 Chain maps	(1:633,600)	

The original concept of the cadastral mapping series was to provide a pictorial record of the alienation of Crown land only. Whilst the system has been functional, the development of the state and the subsequent necessity for including land subdivisions under the Transfer of Land Act, to give the plans more meaning, have introduced problems.

Undoubtedly the most pressing of these problems are the updating of existing plans; storage and the planning of a new series edition of cadastral plans to the same scale and format as the Commonwealth topographic series.

The plans at present held are designed about a rectangular sheet system on a modified polyconic projection, and to a standard sheet size contained within "double elephant" drawing paper. The framework of the series is the 80 chain maps, and the 40 and 20 chain plans are a simple breakdown of the series. On the other hand, the 240 and 800 maps are a generalized reduction of the 80s to provide basic index material. The 300 chain series were developed to meet the needs of pastoral administration and a general mapping cover of the state.

In their original compilation, the plans were plotted and hand-lettered on mounted drawing paper and the information transferred to stone for lithographic reproduction. Updating was carried out directly on the stone and only in cases where revision was extensive were the original drawings handled and new stones reproduced.

Precision process cameras, stable plastics and modern drawing and printing methods did much to improve the speed of updating; nevertheless, no plan could ever be considered up-to-date when printed. Several hundred copies of each printing were often stored for years before demands were made. To meet a sudden requirement for a particular map, hand revision of a published plan has been necessary.

Eighteen months ago, the department completed an investigation into ways and means of overcoming these problems and finding a basis on which planned future mapping of a new cadastral series could be adequately controlled with maximum public satisfaction. The outcome of these investigations are contained below.

All original maps (mounted drawing paper) were photographically transferred to transparent polyester plastics.

Revision was carried out on each map and a second transparency made onto a stable diazo type plastic.

One hundred plans were printed by offset methods from the original transparency and stored for sale.

The diazo copy was held in the drawing office and subjected to daily revision. Ammonia-type paper prints are made when a fully up-dated sheet is required. (Up-dating of the diazo copy is completed on a weighted basis and, according to the importance and quantity of up-dating, a scaled diagram on the edge of the copy indicates the need for revision of the printing transparency and further offset copies.)

Uncertainty as to the number of copies to be printed remained, and it therefore seemed logical to carry the investigation towards ways and means of dispensing entirely with the lithographic printing and provide a service whereby an up-to-date map could be supplied upon demand from a stored transparency.

The mechanics of such a system, requiring some form of speedy printing, are simple in their installation and control. The system has the double advantage of providing an immense saving in storage with minimum wastage, plus a greater utilization of the maps themselves. For example, local authority boundaries (shires), which are becoming increasingly important in government legislation within Western Australia, can be included and subjected to revision in the same way as the cadastral detail. This information, which generally requires certification by the department, can then be made available at minimum delay and expense for legal and general administrative action. Again, as a result of suitable co-ordination, the needs of various departments which are at present forced to maintain and up-date their own series of the same maps, can be included to ensure maximum economy with the minimum manpower.

The real disadvantage in the system stems from the fact that the only speedy printing machinery available for handling the size of material required is of the diazo type. Undoubtedly, the development of electro-static printing will ultimately ensure printing to "double elephant" size and the disadvantages of limited permanency associated with the diazo images will be nullified.

Investigations prove that, within Western Australia, the actual cost of diazo printing is 60 per cent of that of offset printing based upon a run of 100 copies. Furthermore, the sales of dyeline copies during the past twelve months have given strength to the argument that a cadastral map is respected more for being up-to-date than for its archival quality.

Action is proceeding to replace the present "litho room" by a Central Plan Agency, which will handle the sales of all Commonwealth and state mapping and provide an information centre for geodetic, topographic and aerial survey data.

Future cadastral mapping planned to the formats and scales of the national series will seek to maintain the necessary relativity between common points in the two series. From experience gained to date, a diazo print of the cadastral series supplemented by a printed topographic map of the same area will provide maximum user satisfaction.

SURVEY OF THE SOUTH AUSTRALIAN–NORTHERN TERRITORY BORDER

Paper presented by Australia[1]

INTRODUCTION

The present paper constitutes a brief combined report extracted from the notes of the Department of Lands, South Australia, and from those of the Lands and Survey Branch, Northern Territory, on the technical methods adopted in the survey of the border between the two areas.

The border runs along the 26° latitude south from the 129° longitude east to the 138° longitude east (Poeppel Corner). From 129° E to 136° E it passes through semi-desert country which is hilly in the western portion and gradually flattens out to a desert area (Simpson Desert) between 136° and 138°.

The Northern Territory is administered by the Commonwealth Government and the state of South Australia by its own government.

By the end of 1962, it was evident that adjusted values on a new spheroid and new origin (common to the whole of Australia) would soon be available for the geodetic network crossing the Northern Territory–South Australia border in the vicinity of the Alice Springs–Port Augusta railway.

Instead of continuing the survey of the 26th parallel westerly from Poeppel Corner across the uninhabited Simpson Desert, it was decided to establish a starting point based on the latest geodetic value of Mt Hearne just south of the border as supplied by the Director of National Mapping.

COMMONWEALTH (NORTHERN TERRITORY)—SOUTH AUSTRALIAN AGREEMENT

The following are extracts from a draft agreement reached during a conference of the Surveyors General of the Northern Territory and South Australia held in Adelaide in December 1962:

> "It is proposed that a licensed surveyor of the staff of the Surveyor General of South Australia shall co-operate with a licensed surveyor of the staff of the Surveyor General of the Northern Territory in the establishment of an obelisk on the 26th parallel of south latitude in the vicinity of Mt Hearne by adopting the computed distance from Mt Hearne trigonometric station, using the geodetic co-ordinates of that station as supplied by the Division of National Mapping of the Department of National Development.
>
> "Through this obelisk, the boundary shall be marked easterly to the boundary between Queensland and the Northern Territory or its prolongation south, and westerly to the eastern boundary of Western Australia by mile posts and half-mile posts on the arc of the 26th parallel as determined by offsets computed from a traverse which shall be connected to all suitable trigonometric stations adjacent thereto, and by the adoption of the geodetic co-ordinates of such stations; the field work to be carried out on behalf of the two Governments by the staff of the Surveyor General for the Northern Territory assisted by computations carried out by the staff of the Surveyor General of South Australia, field assistance and equipment to be made available by South Australia only when deemed necessary by the two Surveyors General.
>
> "Notwithstanding what any future surveys may show to be the exact position of the 26th parallel of south latitude, the mile posts and half-mile posts referred to above shall, for the purpose of determining the boundary aforesaid, be deemed to be on the 26th parallel of south latitude."

NORTHERN TERRITORY RESPONSIBILITY

The Lands and Survey Branch is responsible for: the fixing of the main stations along the parallel from the adjacent geodetic network; the traverse in the vicinity of the 26th parallel between the main stations; the offsetting from the traverse of the mile, half-mile and miscellaneous stations on to the 26th parallel at the correct mileage; the emplacement of marks.

The work has been simplified to a considerable extent by the fact that the geodetic survey followed the border very closely for the whole length of the survey (apart from a section east of Mt Hearne) with stations approximately 25 miles apart and no station more than 5 miles from the border.

A survey instruction was issued by the Surveyor General, Northern Territory, to cover this survey by the Alice Springs branch. The main provisions of this instruction are set out hereunder.

The survey is to commence in the vicinity of Mt Hearne and extend easterly to the 136th meridian and westerly to within ½ mile of 129th meridian, a total distance of approximately 440 miles.

The point of origin near Mt Hearne is to consist of a substantial concrete pillar which will be the zero point for the east and west mileages.

The parallel is to be marked by offsets from a traverse chord at intervals of half a mile and at all other points to ensure intervisibility between marks. The distance in miles and feet, east or west of the origin, reduced to sea level, is to be shown on all marks. Reference marks are to be placed, where possible, at every mile post. These reference marks shall be an 18 inch concrete block sunk 6 inches below ground level 50 ft north of the mile post and two steel reference spikes placed 10 ft east and west of the mile post.

Every endeavour is to be made to run the chords so that their end points are intervisible and where possible these chords should not exceed 5 miles.

First-order tellurometer and angle connexions are to be made to the traverse in the vicinity of each National Mapping trigonometrical station adjacent to the border.

Second-order horizontal and vertical angles are to be read over as long a length of each chord as possible to provide control between the first-order stations. The number of second-order stations should not exceed fifteen between each first-order point.

Datum for the survey shall be geodetic co-ordinates as supplied by the Director of National Mapping on 17 May 1963. These are from the central origin computed on the 165 spheroid.

The 136th meridian is the eastern limit of pastoral occupation by either South Australia or the Northern Territory. As the accurate trigonometrical surveys did not

[1] The original text of this paper, prepared by V. T. O'Brien, Surveyor General, Northern Territory, appeared as document E/CONF.52/L.68.

extend easterly past the 135th meridian, it was necessary to provide tellurometer control over about 60 miles east from Mt Hearne. A closed loop to first-order standards was completed over this section in 1963 by the Geodetic Section from Darwin.

South Australian responsibility

The Department of Lands is responsible for the computation and adjustment of the main and traverse stations, the computation of the offsets from the traverse to the parallel at the correct mileages and the supply of equipment as required.

The values used for the geodetic stations are those for the 165 spheroid ($a = 6{,}378{,}165$ m, $1/f = 298.3$) and all computations on the spheroid have been carried out by the Clarke traverse programme on the ICT Sirius computer.

The computations have been carried out in geographicals on the spheroid to simplify the computations of the offsets to the parallel.

Fixing the starting point

At the end of June 1963, the surveyors from the Northern Territory and South Australia established the obelisk near Mt Hearne and commenced marking the border.

First-order measurements were taken from the geodetic survey to establish the horizontal position of the obelisk marking the origin of the border survey.

Spirit levelling to the starting obelisk was carried out from a bench-mark provided by the Department of Interior. The level derived from Mt Hearne using the trigonometrical height was only 4 ft different from that of the spirit level value, which was remarkable since the trigonometrical heights had been carried over a distance of approximately 2,000 miles.

Method of survey

The survey work along the border was carried out as a three-phased operation.

The preliminary traverse was ranged and marked from the vicinity of trigonometrical station to trigonometrical station.

The traverse angles were observed and tellurometer connexions made to the trigonometrical stations as provided in the instructions.

After computations and adjustments of the control traverse and field work by the Department of Lands, South Australia, the actual border was marked by offsets from the preliminary traverse.

A chain and theodolite traverse was run between the main stations, setting out chords of approximately 4 miles in length with pegs every half-mile and at other points that required marking. The traverse was ranged with a T2 theodolite and chained carefully with invar chains which had been standardized by the New South Wales Lands Department. Both ranging and chaining were done with greater care than would normally be taken on rural cadastral work. An accuracy of about 1 in 25,000 was aimed at for comparison between the first-order points.

The results obtained over the first three sections are set out hereunder:

Section	Length (miles)	Misclosure Latitude	Misclosure Longitude	Misclosure Azimuth
Mt Hearne to Mt Grundy . . .	22	0".004	0".007	3".639
Mt Grundy to Mt Mead . . .	23½	0".014	0".056	2".551
Mt Mead to Mt Darling . . .	24½	0".028	0".018	2".795

Azimuth of the preliminary traverse was maintained by frequent observations on sigma octantis, a faint circumpolar star in the southern sky. Astronomical azimuths were not required for the final marking as the geodetic azimuth of the adjacent trigonometrical chain was adopted for the survey. However, it was essential that the preliminary clearing of the traverse should be as close as possible to the final boundary to eliminate unnecessary extra work.

The first section over bare "gibber" plains was only controlled with sun observations. These were not accurate enough as the terminal point near Mt Grundy had "drifted" about 12 ft north of the 26th parallel. In the next two sections no offset was more than 2 ft from the 26th parallel. The offsets were generally much larger in longitude than in latitude as no great effort was made to locate the preliminary pegs closer than a few feet to the correct longitude.

The standard of observation for the second phase was that recommended by the National Mapping Council. The angular closures indicate that this standard was easily obtained. The average misclosure was 3 inches for an average of eight stations per section. The angles were usually observed during the late afternoon and evening to minimize atmospheric shimmer.

The geographical co-ordinates of the stations were calculated by the Clarke formula programme on the ICT Sirius electronic computer, from one of the main stations. The printed results of the misclosure between the two main stations were then adjusted linearly and, from a tabulated list of the correct longitude for each half-mile post, the difference was reduced to an angle and distance to be offset from the traverse point.

Marking

As the marking of the actual border was the end result of all the work, great care was taken that this should be of a high standard. Difficulty was experienced in marking some of the more rocky country.

It was found necessary to place small marks set in concrete under those concrete posts which could not be set deeply in the ground and referenced as instructed.

Standard concrete Northern Territory survey posts with a special border tablet set in the top are placed every mile. These are 5 inches square at the top, 8 inches at the bottom and 30 inches long, projecting 12 inches above ground level.

At the half-mile interval between standard posts, concrete blocks are emplaced 4 × 4 inches square and 30 inches long.

Reference marks are placed at each mile post, 50 ft north of the mark. These are 8 inches diameter at bottom, 7 inches at the top and 18 inches long, set with the top 6 inches below ground level.

At all points of public interest, a 12 inch diameter monocrete pipe 6 ft long and 4 ft above ground level is placed. In difficult hilly country where it is difficult to mark at the exact half-mile interval, the marks are placed at reasonable points nearby.

Progress of survey

The work was commenced in June 1963 and has proceeded at the rate of approximately 100 miles per season.

During 1963, 69½ miles were traversed and computed, connexions being made to Mt Grundy, Mt Mead and Mt Darling, the first section 00–22 miles being permanently marked.

Following representations by property owners, a start was made at the 155 mile post using a connexion from Sentinel Hill. During the 1964 season, the border traverse was extended 74 miles from the 155 mile peg to the 229 mile peg with connexions to Mt Cuthbert, Mt Ayliffe and finally Mt Woodward. Final marking was also carried out along the section of 22 to 69 miles traversed during the 1963 season.

During 1965, 115 miles were ranged and observed in two sections: 69 to 155 miles and 229 to 258 miles, with a final connexion to Mt Whinham from the 287 mile post. Final marking was also effected on the 74 miles traversed during the 1964 season. The 86 mile gap between Mt Darling and Sentinel Hill was completed in the section 69 to 155 miles mentioned above.

Trigonometrical stations were originally erected on these hills by South Australian surveyors for a triangulation carried out in 1884. Most of these were constructed of local stone, being erected as a cairn approxmately 8 ft high. In practically every instance they have been found to be in good condition.

The triangulation was recently resurveyed by a National Mapping party which ran a control tellurometer traverse along the trigonometrical stations in the vicinity of the border.

The fourth year of survey (1966) progressed favourably as follows: permanently marked, 115 miles 69 to 155 miles west and 229 to 258 miles west; computations available for marking 117 to 155½ miles west and 234 to 258 miles west; preliminary traverse from 258 to 291½ miles west re-observed for angle misclosure and 00 to 69 miles east traversed.

It is anticipated that the balance of the traversing (81 miles) to the 129th meridian or thereabouts will be completed in 1967 and most of the permanent marking (involving 182 miles).

A summary of survey results is set out in the table below.

The cost is shared equally by the South Australian Department of Lands and the Northern Territory administration. The cost is determined from salaries for field, computing and drafting operations, holiday pay, travelling expenses, payroll tax, operation and maintenance of vehicles supply of photographs, maps, pegs, survey marks and plaques. Overhead expenses are not included.

Survey costs average $A130 per mile.

The present position, as at December 1966, is as follows: total length of border to be traversed and permanently marked, 440 miles; total length of border permanently surveyed to date, 258 miles; balance to be permanently surveyed, of which 102 miles have been traversed, 182 miles.

The programme to 1 November 1967 will therefore involve 80 miles of traverse and 182 miles of final marking to complete the section from the Western Australian border at 129° to 136° east longitude in the Simpson Desert 2° west of the Queensland border at 138° east longitude.

Some of the final marking in the 1967 season will unavoidably be held over to the 1968 season because of the time lag in the computations.

Survey conditions

When tellurometer crews were sent from Darwin to carry out the various connexions, they were exposed to a rather severe climatic change during the central Australian winter. The meteorological readings necessary for tellurometer observations show maximum "dry bulb" readings at times as low as 40 degrees F at noon. When this is observed on top of a 4,000 ft peak in a 20 mph wind, even persons acclimatized in the centre long for warmer climates. Observations from similar peaks later in the season were made in a more congenial temperature of 85° with a 27° depression of the wet bulb.

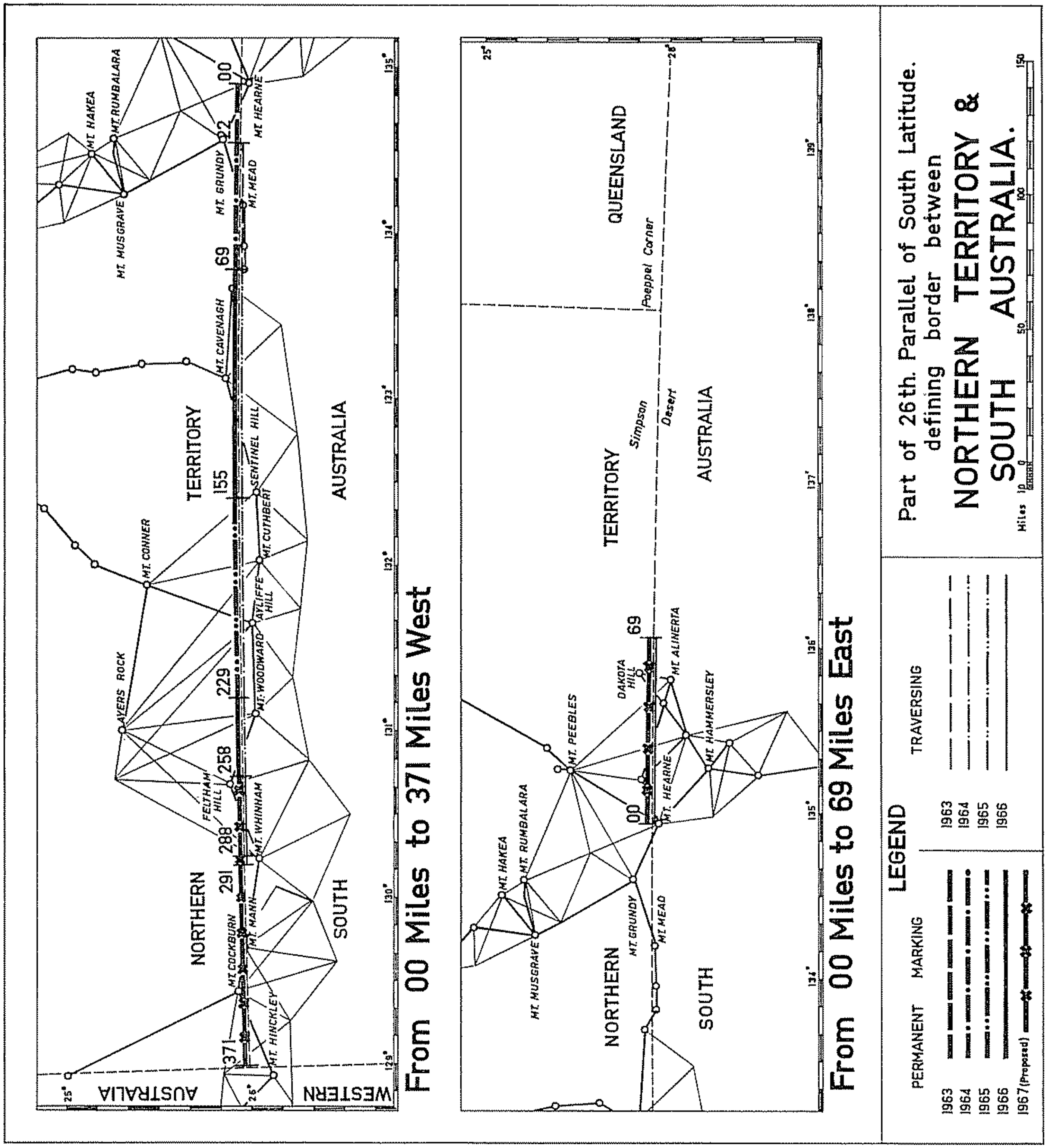
The prolonged drought in the area traversed by the survey has been a mixed blessing to the survey crews The absence of burrs and long grass and the diminishing of the fly population can be counted on the credit side, while the frequent duststorms and generally rather depressing look of the country are not good for morale.

The use of a power-chain-saw has greatly facilitated the clearing of a "skyline" necessary for observing over long sections of the traverse. This was particularly noticeable in the section west from Feltham Hill where there are large numbers of desert oaks. These trees grow up to 2 ft in diameter and have large spreading crowns. Axemen would take up to an hour to cut one of these hardwood trees which can be felled with the power-saw in 10 minutes.

Summary of survey results up to 1966

(The values below are based on the survey field season, which ends with the withdrawal of field parties about 1 November each year.)

	Permanent markings			*Traversed*			*Costs of field work*		
Survey season	*Section*	*Miles (A)*	*Scheduled*	*Section*	*Miles (B)*	*Total miles (A) + (B)*	*Salaries, allowances etc. (in $A)*	*Vehicle costs (in $A)*	*Total (in $A)*
To Nov. 1963	00–22	22	45	22–69 west	47	69	6,760		6,760
To Nov. 1964	22–69	47	(100) 145	155–229 west	74	121	9,998	2,464	12,462
To Nov. 1965	155–229	74	(100) 245	69–155 229–258 258–288 re-observed	115	189	12,340	2,428	14,768
To Nov. 1966	69–155 229–258	115	(100) 345	258–288 288–291 west	102	217	10,680	2,036	12,716



Australia: Part of 26th parallel south defining border between Northern Territory and South Australia

Final comments

It is intended that the marked position of the border will remain the boundary regardless of any future geodetic survey or adjustment.

A proposal that one chain (66 ft wide) reserves be proclaimed on each side of the border to protect marks was abandoned when it was realized that the reserved area with its cleared lines and working tracks could lead to its further use as a track to the detriment of survey marks and the danger of sumps of vehicles being damaged by striking survey marks hidden by regrowth. It is now proposed that fencing on the Border be offset slightly around survey marks.

It is proposed that the mile posts or at least some of them will be marked with aerial markers and the length of the survey photographed from the air to provide control for mapping operations.

TIDAL LAND RECLAMATION IN TAIWAN

Paper presented by China[1]

Rivers in western Taiwan with head water from the central mountains are short and turbulent, and their geological condition is very poor. During the flood season these streams churn towards the sea with huge quantities of mud and sand. The deposits rise gradually year after year and new so-called tidal land is formed.

In order to increase the acreage of cultivated land, tidal lands along the western coast have been diked and reclaimed into farms and fish-ponds. Before the beginning of reclamation work, it is very important to understand the changing condition and variation of shorelines and sea-bottom. In recent years, aerial survey methods have been adopted for tidal land reclamation and aerial photographs at 1:10,000 and sea charts at 1:5,000 have been obtained. The depths were determined by echo-sounding and were found to be between 2.0 and 20.0 m.

Such observations assist in the planning and design of tidal land reclamation work.

A total of sixty-one topographic map sheets at 1:2,500 near Chiang-Hua Hsien and fifteen sheets at 1:5,000 near Tainan Hsien have been prepared in the past two years.

In addition, many of the cross-sections and bench-marks along the coastline of the Taichung and Chiang-Hua district were set up in the beginning of 1966.

[1] The original text of this paper appeared as document E/CONF.52/L.115.

(h) City Development

APPLICATION OF CARTOGRAPHIC TECHNIQUES TO THE PLANNING AND DEVELOPMENT OF THE CITY OF CANBERRA

Paper presented by Australia[1]

Introduction

Map-making is an indispensable part of town planning. The first maps for the planning of the city of Canberra were prepared in 1911 from detailed surveys of the area by Surveyor Charles Robert Scrivener after the Seat of Government Act had been passed and the proclamation made vesting the Australian Capital Territory in the Commonwealth. These maps provided the basic information for those who participated in the international competition for the design of the city of Canberra. Walter Burley Griffin's design was awarded first premium and in 1923 the Griffin plan was gazetted and thus became the first statutory plan of Canberra. This plan remained virtually unchanged until 1958, when the National Capital Development Commission was appointed to undertake and carry out the planning, development and construction of the city of Canberra as the national capital of the Commonwealth of Australia.

Then two factors made it necessary to review the adequacy of the statutory plan and to decide whether it could provide a satisfactory basis for the future development of the national capital. These were changes in technical development which greatly influenced the theory and practice of the town planning and the growth which had occurred since 1923.

In 1959, the commission published the *Planning Survey Report of Canberra City District* which contained some twenty maps based on the statutory plan and showing information on topography, geology, soils, residential density, manufacturing industry, open space uses etc.

Until recently, the growth of the city was contained within the area of that statutory plan which was intended to provide for a population of approximately 75,000 people. New districts, beyond the original boundaries of the city had to be planned. This required more mapping information to enable the commission to prepare an outline development plan which would indicate the form and extent of the city considered most appropriate for accommodating 250,000 people and provide for continued, orderly growth beyond that level.

Base maps

Base maps for planning purposes are essentially topographical maps showing the configuration of land and existing physical features. Apart from being informative, however, these maps are normally used as the medium on which planning proposals are superimposed and special consideration must therefore be given to the amount of detail to be included, the manner in which it is shown and the suitability of the maps for reduction or enlargement.

The Survey Branch of the Department of the Interior is the survey authority for Canberra and provides all large-scale maps required by the commission. Close co-operation between both organizations ensures continuity of map supply (see figure I).

[1] The original text of this paper, prepared by H. R. Voss, National Capital Development Commission, Canberra, appeared as document E/CONF.52/L.69.

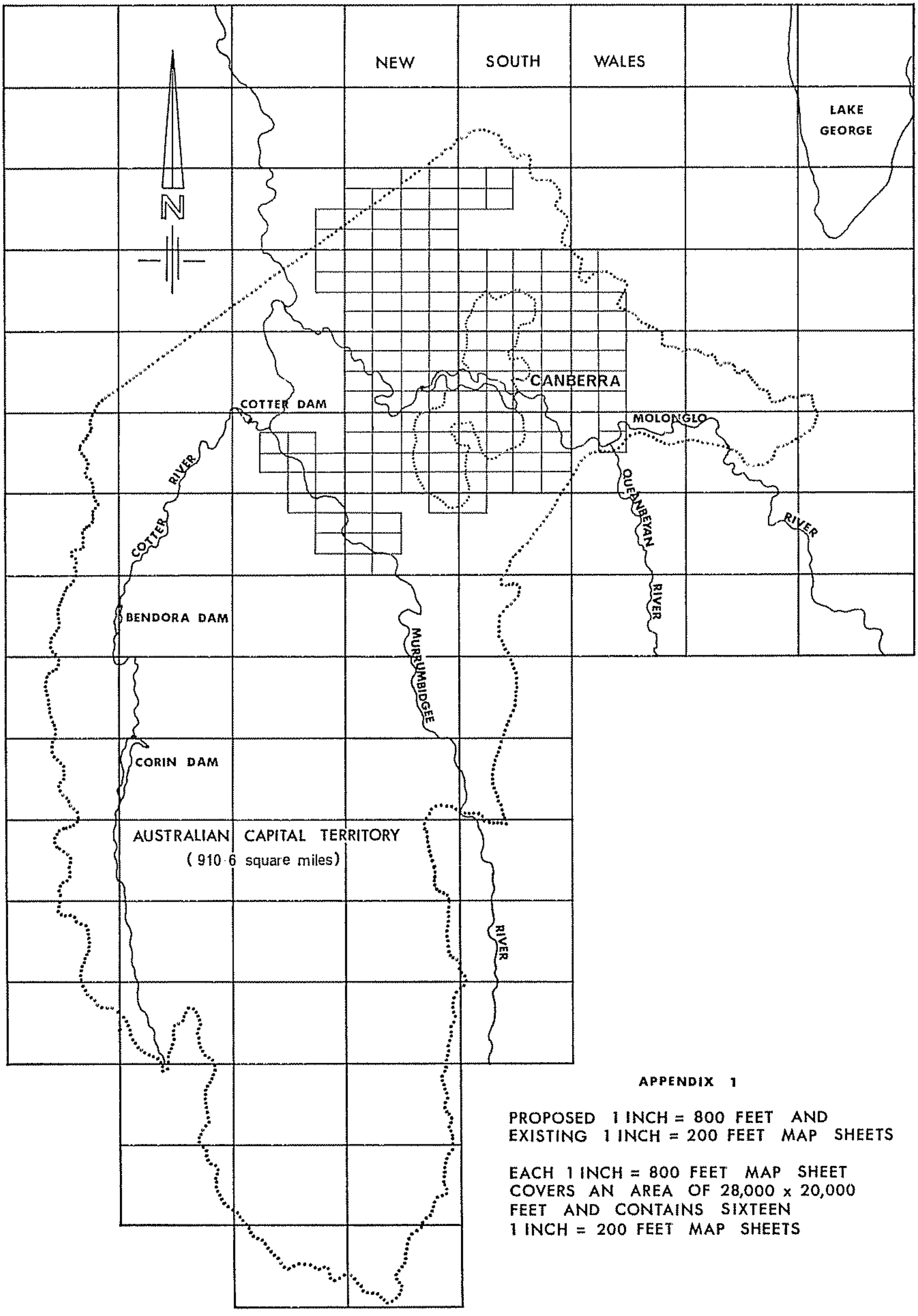


Fig. I—Australia: Map sheets (proposed 1 inch = 800 feet and existing 1 inch = 200 feet)

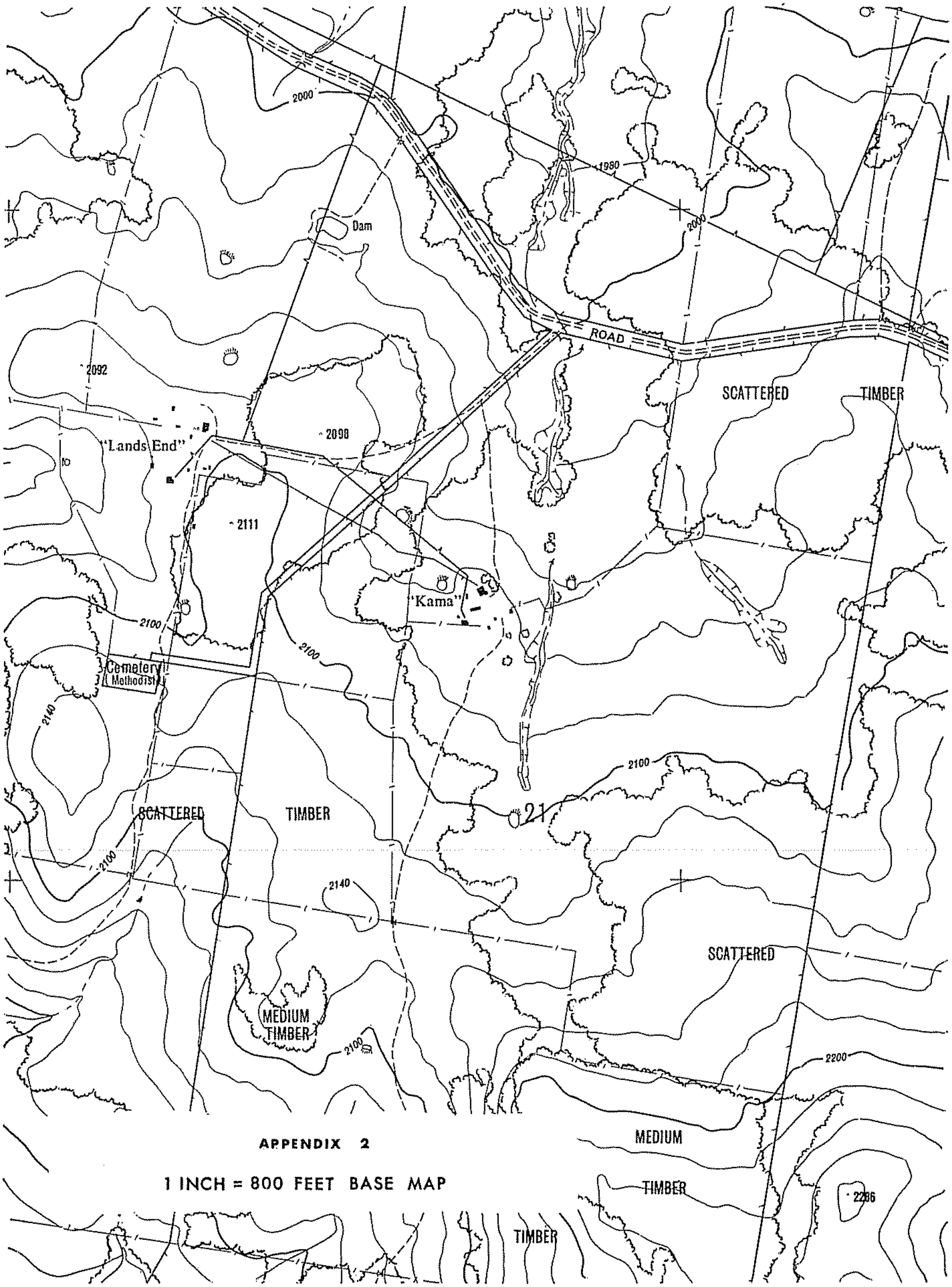


Fig. II—Australia: Base map (1 inch = 800 feet)

The 1 inch = 800 ft and 1 inch = 200 ft maps as prepared by the Survey Branch, Department of the Interior, are considered ideal for planning purposes. Two colours are used: salmon brown for contours and black for all other physical detail and nomenclature. Type faces are of clean, open style, well suited for enlargement or reduction (figure II).

Under a co-ordinated mapping programme for the Commonwealth as a whole, mapping in Australia at scales 1:250,000 and 1:50,000 is carried out by the Division of National Mapping of the Department of National Development, the Royal Australian Survey Corps and the lands department in each state. This mapping programme provides almost complete coverage of the Australian capital territory at a scale of 1:50,000 and regional coverage at 1:250,000.

The following table illustrates what is considered an ideal set of base maps for the design of a new city. Scales shown in brackets in this table and in the following paragraphs indicate the nearest equivalent metric scale.

Ideal base maps for design of new city

Scale	*Contour interval (in feet)*	*Usage*
1:250,000	250	Regional planning, road and other communication systems, connexion with interstate highways, railways etc.
1:50,000	50	Outline planning, determination of boundaries for new districts, main transportation routes and major service facilities
1 inch = 800 ft (1:10,000)[a]	20	District planning, road system, determination of neighbourhood boundaries, broad land uses and trunk services
1 inch = 200 ft (1:2,500)[a]	5	Neighbourhood planning, detailed land uses, road layout, general location of services
1 inch = 40 ft (1:500)[a]	1	Detailed design of block sub-division, roads, services and special projects, such as schools, playing fields, shopping centres etc.

[a] Nearest equivalent metric scale

Because of the rapid development of Canberra, this ideal set of maps has not always been available. However, the Survey Branch of the Department of the Interior now has one of the best equipped photogrammetric sections in this country, manned with experienced staff, and for the planning of future new districts and neighbourhoods planners will be provided with base maps to the standard required.

The shape and size of districts or neighbourhoods do not always conform with any one sheet of these base maps. A composite of two or more sheets or parts thereof can be easily prepared by joining copies and obtaining prints or transparencies by either dyeline or photographic reproduction methods. Similarly, if the dimensions of the area require a scale reproduction, reduced photographic negatives can be joined and a composite transparent copy obtained. These reproductions are usually kept as master copies from which any number of transparent prints may be made on which the planner can superimpose his proposals.

Planning maps

Planning maps may be defined as visual aids which show facts (survey and research data) and ideas (planning proposals). With these maps, planners want to demonstrate facts which lead to their proposals and show that the best possible solution has been achieved. As these maps are used in discussion and may be required to be displayed before committees, councils and the public, they should be attractively presented. Lettering should be simple and neat, colours should harmonize and line work should be clean. In fact, cartographic skill coupled with a touch of artistry shouldbe applied to capture and sustain the viewer's interest.

The amount of information which can be presented on one sheet of paper is of course limited. Two alternative techniques may be employed to overcome this problem: to produce a number of maps, or to produce one map with a series of transparent overlays.

Preference is given to the first rechnique. A number of maps are prepared and the content of any one of these is restricted to particular facts or ideas, for example, the overall planning scheme (outline development plan) may be presented on one map; employment distribution, traffic flow, school catchments etc. on others. This may need a certain amount of cross-reference, as none of these maps gives a comprehensive picture; however, neither can this be satisfactorily achieved with a series of overlays. Where more than one overlay is used, clarity is lost not only of the base but also of subsequent sheets. The lack of totality in the first method is amply compensated for by the clear statement which can be obtained from any one map.

From time to time planning projects, especially those of Canberra's magnitude, require the publication of explanatory reports. It must therefore be kept in mind that planning maps may have to be reduced to book or report format and lettering sizes, thickness of lines and line intervals must be determined accordingly. The scale of these maps and their dimensions are largely dependent upon the area which is to be covered as well as size limitations for offset or dyeline reproduction. These considerations resulted in the adoption of a scale of 1 inch to ½ mile (1:25,000) for the commission's outline development plan for a population of 250,000. The trimmed sheet size of 30¼ × 39½ inches readily enabled reduction to the final report size of 8½ × 11 inches. The commission subsequently published *The Future Canberra* (Angus and Robertson Ltd., 1965)—a plan for the development of Canberra up to a population of 250,000.

The compilation of a base for these planning maps was carried out by the commission's cartographic staff and a contract was let for the production of a hill-shading sheet and scribed separations fo 25 and 50 ft contours, drainage system, roads and property boundaries. From these separations, full size (1 inch = ½ mile) offset prints were obtained with the following colours: roads and boundaries, black; 25-foot contours, sepia; drainage systems, blue; hill-shading, olive green.

These offset prints served as a base upon which facts and ideas were superimposed to become planning maps. From rough crayon-coloured sheets final maps of display standard were prepared by hand-colouring with printer's inks. These inks may be mixed to obtain any desired shade. They are transparent and, when diluted with mineral turpentine to become a creamy, smooth flowing mixture, can be applied with a sable hair brush. Application is made quite liberally and surplus ink is blotted off with paper tissues. The ink will not "creep" and large or delicately shaped small areas can be equally well coloured. Join marks on large areas will not be visible. The final effect is very pleasing and almost identical to an offset print. Water-colour rendering, which needs a certain skill, may be faster but is less attractive. Another advantage is that, should offset prints be required, printers find it quite easy to match colours and prefer a fully coloured map to small pieces of colour samples. After a drying period of one day, nomenclature can be added. Transfer type is an ideal medium. A reasonable choice of type faces is available and application is easy and fast. Sheets of various types can be easily stored so that no time delay through ordering of stripping film or bromides occurs. Selected type is checked for reducibility with the aid of an optical pantograph and is then directly applied to the coloured planning maps. A protective coating with fixative may be sprayed over these maps.

Hand-colouring of planning maps seems to be quite economical if two or three sets only have to be prepared. For short runs of, say, twelve to twenty-five copies, silk screen printing would be the most expeditious means of reproduction.

The hand-coloured maps also served as master plans for the production of colour separations for the reduced size maps which were selected for inclusion in the commission's publication, *The Future Canberra*. Separations of line drawings were already available so that only the masks for area colours had to be prepared. Both ink masks on plastic material and peel-coat sheets were used. Nomenclature was added to the black line drawings (figure III).

In addition to the presentation of facts and ideas for the over-all scheme, such maps or diagrams as "Proposals for a district", "Proposals for a neighbourhood", "Future growth pattern", "Proposed city development" etc. were included. Generally, compilation and final production proceeded exactly as explained before. However, a different technique of presentation was applied in the preparation of the map showing "Proposals for Woden district". This is a two-colour map showing roads, proposed buildings and nomenclature in black and open space in green. A very fine stipple was used on green belts, parklands and playing fields within the district and, in order to give an indication of the changing slope of the ground outside this area, the density of the stipple was increased and the diameter of the dots was made larger with the rising ground.

This technique can be quite easily executed with the aid of mapping nibs and drafting fountain pens of varying thicknesses. It gives an appreciation of the terrain and also conveys the open space concept.

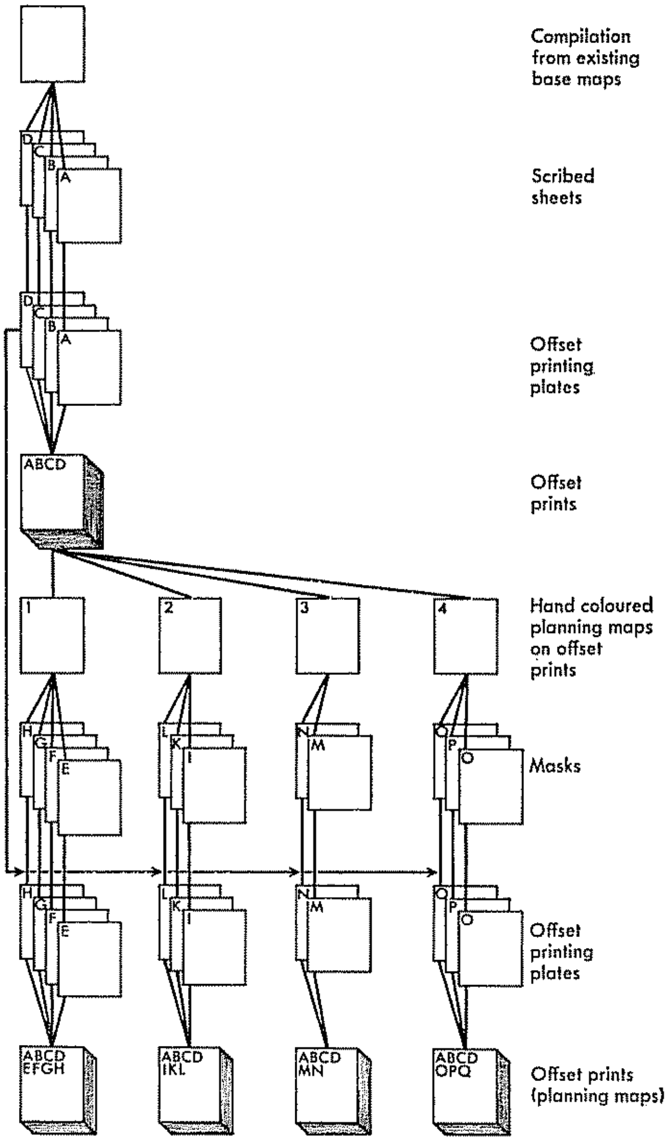


Fig. III—Australia: Production schedule for planning maps

Aerial photography

For Canberra, aerial photography is carried out for the production of base maps at scales of 1 inch = 800 ft (1:10,000) and 1 inch = 200 ft (1:2,500). Again, close co-operation between the Survey Branch of the Department of the Interior and the commission ensures adequate photographic coverage and the programmed completion of base maps and a supply of aerial photographs to meet town planning needs.

Flying and photography is carried out by contractors along specified flight lines which run east-west following the centre lines of the 1 inch = 800 ft or 1 inch = 200 ft map sheets. Other requirements are:

For 1 inch = 800 ft (1:10,000) maps: camera, Wild RC8; lens, 6 inches; flying height, 21,000 feet above sea level; overlap along flight line: 60 per cent.

For 1 inch = 200 ft (1:2,500) maps: camera, Wild RC8; lens, 6 inches; flying height, 6,500 feet above sea level; overlap along flight line: 60 per cent. Or: camera, Wild RC8; lens: 115.44 mm; flying height: 6,500 ft above sea level; overlap along flight line: 60 per cent.

Apart from its importance for map-making, aerial photography is to the planners as valuable as the maps which are compiled from aerial photographs. Photographs show considerable detail of land-use and surface features which would unnecessarily clutter up a map if they were all included. Geological faults and fractures are often detect-able, the extent of cultivation shows up clearly, forests and trees are readily identifiable and a true record of urban or city development can be obtained. Aerial photographs and maps provide the planner with a most comprehensive picture of that part of the earth's surface which he wants to develop.

The commission maintains a library of all aerial photographs which is constantly referred to by planners, engineers and geologists. From time to time mosaics of important areas, such as the "parliamentary triangle" or the "city centre" are required to give an up-to-date impression of the development which has occurred or to serve as base maps for further development studies. No rectification of photographs is carried out as the distortion which occurs towards the edges is considered insignificant for planning purposes.

Other maps

Responsibility for the production of all types of cadastral maps rests with the Survey Branch of the Department of the Interior. The more important of these is the map of the Canberra City District which shows all gazetted roads and their names, property boundaries, the cadastral description of all divisions, sections and blocks and the names of the more important public buildings and institutions. This map is available at a scale of 1 inch = 1,000 ft in two sheets and at scales of 1 inch = 800 ft and 1 inch = 600 ft in eight sheets.

The commission's cartographic staff produces maps of all neighbourhood units which could be termed cadastral maps but are in fact multi-purpose maps. These are prepared immediately upon receipt of survey data computed by the Survey Branch of the Department of the Interior from neighbourhood design plans. The scale is 1 inch = 200 ft (1:2,500) and the maps show 5 ft contour lines, roads and road names, block subdivisions, cadastral numbers of blocks and sections, and land use where determined (church and school sites, shops, open space etc.).

Initially, these maps are printed in monotone by dyeline reproduction methods. However, two-colour printing is carried out when little revision may be expected. For that reason contours are scribed immediately using .004 inch and .008 inch chisel scribers for 5 ft and 20 ft contours respectively and roads and block boundaries are fair drawn with drafting fountain pens. Nomenclature is added with transfer type lettering. A composite plastic transparency which serves as the master copy is obtained and this is amended as the need for revision arises. Dye-line transparencies of the master copy are used to produce dyeline prints. It may appear to be more economical to obtain monotone offset prints in short runs of, say fifty or 100; however, amendments of subdivisions occur quite frequently during the initial stages, and a delay of four weeks between the completion of the maps and receipt of offset prints can result in stocks of superseded maps. Unless this period can be reduced to one week, dyeline printing is the more satisfactory reproduction method.

An organization charged with the planning, development and construction of a city of Camberra's magnitude needs a great variety of maps and plans. Generally speaking it may be said that drafting work from the roughest felt-tip pen job to the finest scribing job is demanded.

Cartographers, survey and architectural draftsmen and a commercial artist make a good combination for a drawing office within a planning organization effectively to carry out the various requirements.

LARGE-SCALE MAPPING FOR TRANSPORTATION STUDIES OF THE METROPOLITAN AREA OF ADELAIDE

Paper presented by Australia[1]

Introduction

In May 1965, the South Australian Department of Lands was approached by the Department of Highways and Local Government as to the possibility of the preparation of large-scale topographical and photographic maps for use in a transportation study of the metropolitan area of Adelaide.

This transportation study, known as the Metropolitan Adelaide Traffic Study (MATS), was commenced in February of 1965. Its aim was to prepare a plan to meet the traffic requirements of metropolitan Adelaide for the next twenty years and it was scheduled to be finalized in February 1967.

Proposals

The only extensive modern mapping covering the Adelaide metropolitan area was that at scales 40 chains to 1 inch and 10 chains to 1 inch with 25 ft contours, plotted in 1957 from aerial photographs by the Department of Lands. This mapping, although satisfactory for indicating alternative proposals of route location over the whole area, was not sufficiently detailed or of a close enough contour interval for the detailed study and location of proposals.

The ideal requirement was for complete topographic maps at a scale of 200 ft to 1 inch with 5 ft contours over the whole area. This, however, would have involved the plotting of some 300 square miles of largely built-up urban, suburban and industrial areas, and would have been an impossible task for the Lands Department to plot and draft with its three Wild A5 autographs and limited photogrammatic staff in time to be of use to the MATS. It was estimated that the task could not have been completed until three years after the scheduled date of completion of the MATS.

After considerable discussion with the Highways and Local Government Department, it was decided that the only way to meet the scheduled final date was for transparent photogrammetric overlays to be prepared at a scale of 200 ft to 1 inch, showing only contours, spot heights and the street pattern, for the plotting photography to be enlarged as accurately as possible to 200 ft to 1 inch and the overlay and enlargement used in conjunction with one another for the detailed study of proposed route locations. The whole of the 300 square miles was to be photographed and aerotriangulated. Enlargements were to be prepared over most of it but the area to be plotted was to be reduced to cover that of immediate interest, some 160 square miles.

Even with this reduction in requirement, it was still evident that it was not possible for all the work to be carried

[1] The original text of this paper, prepared by M. G. Butler, Chief Surveyor (Topographical), Department of Lands, South Australia, appeared as document E/CONF.52/L.70.

out by the Lands Department in time. It was therefore decided that most of the plotting would be let to contract. The Lands Department was to be responsible for the photography, field control, aerotriangulation, preparation of enlargements and checking of contract plotting. The Highways and Local Government Department was to assist with field control and drafting.

Photography

The scale of the photography was influenced by two factors: the required contour interval and the scale of the photographic enlargements. These enlargements were to be at a scale of 1:2,400. The photographs were to be enlarged by means of a Wild VG1 enlarger with a maximum enlargement of 7 ×. Contact scale could therefore not be smaller than 1:16,800. The plotting was to be carried out with Wild A5 and A8 plotters. Allowing a "C" factor of 1,100 for individually heighted models, for 5 ft contours the flying height needed to be around 5,500 ft above ground level.

The photography was to be carried out with a Wild RC7a plate camera, 10 cm cone, which at 5,500 ft gave a contact scale of 1:16,750. This altitude satisfied both conditions and was adopted throughout.

Aerial markers consisting of 3 ft black squares painted on "sisalcraft" with a yellow enclosure were placed at all horizontal control points and most vertical control points. In areas where ground detail was lacking, exposure markers of yellow "sisalcraft" 24 ft long and 6 ft wide were laid down.

Photography was carried out exposing to preselected ground detail or to exposure markers to ensure parallel runs and precise overlap and sidelap.

To facilitate adjustment of the aerotriangulation and to fit in with priorities required by the MATS, the area was divided into seven blocks ranging in area from 20 to 90 square miles.

Several blocks were extended to cover a larger area than that specifically asked for by the MATS. The relatively small additional cost of the photography and aerotriangulation involved by this extension was far outweighed by the advantages of having photography and aerotriangulation control over the greater area.

Control

The photogrammetric models were controlled for position by block-adjusted aerotriangulation and by individually field-levelled height points for height.

The whole area was overlooked by the Mount Lofty ranges running along its eastern edge. A number of first-order triangulation stations in this range were visible from the area. The horizontal control of the blocks was therefore obtained by first-order tellurometer and angular measurements from these stations. From fifteen to twenty-five horizontal control points were fixed for each block.

Angular measurements were observed with Wild T3 theodolites, each measurement consisting of two sets of twelve arcs, each set being observed on different days. Distance measurements were observed with MRA2 and MRA3 tellurometers, each measurement consisting of two sets of thirty-six fine readings, each set being observed on different days.

Most fixes were a direct measurement from trigonometric station to control point or a tellurometer distance and short traverse. Length of sight varied from 3 to 30 km. Ninety-five control points were fixed.

Where possible, a cadastral permanent mark was fixed and used as a control point. Where this was not possible, a standard precast national control mark was emplaced. Care was taken to site and mark control points so that they could be used in any future survey co-ordination scheme in the metropolitan area.

Vertical control in the metropolitan area consisted mainly of levelling carried out by the Engineering and Water Supply Department for sewer and water reticulation. This levelling was not sufficiently extensive to be used for the vertical control. It was decided, therefore, to cover the whole of the area with a network of third-order levelling observed to national specifications.

Third-order loops totalling 180 miles were levelled.

Standard precast bench-marks 5 inches in diameter at the top, 12 inches in diameter at the base and 24 inches high were placed along these loops at intervals of ½ to 1½ miles. Standard deep marks, 12 ft of brass rod set in concrete, were placed at intervals of 8 to 10 miles and at loop junctions. Three hundred and sixty marks were emplaced.

The height-control points, either natural features or sisalcraft markers, four to each model over the areas specifically required by the MATS and elsewhere suitably spaced for Jerie adjustment, were connected to the third-order network by lines of levels observed to third-order specifications except in that they were levelled one way only. These lines of levels were marked in the same way as the main loops. Four hundred miles of this one-way levelling was observed and 485 control points heighted.

All the levelling was carried out with Zeiss Ni2 automatic levels and 12 ft wooden folding staves.

Aerotriangulation

Each block was aerotriangulated by the dependent pairs method, using a Wild A5 autograph with the Wild EK5a co-ordinate printer and IBM 026 card punch attachment. Runs ranged from five to eight per block, with number of models varying from eighty-two to 184 per block.

Both position and height were observed even though the models to be plotted were controlled individually by field heights. It is intended to adjust the aerotriangulated heights by the ITC Jerie analogue computer as time permits. This should give an interesting comparison between aerotriangulated and field heighting.

The area photographed and aerotriangulated covered some 328 square miles, whereas the area over which models were individually controlled for height covered only 157 square miles. If the comparison between the aerotriangulated and field heights is satisfactory, the aerotriangulated heights could be used to contour the remaining 171 square miles as the need arises without additional field control.

The aerotriangulation observations were adjusted by the Bervoets method of block-adjustment, using the IBM 7090 high-speed computer.

Plotting

The plotting was carried out by Wild A5 and A8 plotters. A total of 152 square miles was plotted, 59 square miles by the Department of Lands and 93 square miles by contract.

Each plotted sheet covered two models and thus formed a complete overlay to an enlargement of a relevant photograph of one of the models. Contours were plotted directly in ink. Spot heights were shown in an approximate 400 ft grid pattern and at street intersections. Street fences were the only detail plotted in the built-up areas. In the rural areas, where fence detail was sparse, the drainage pattern was added to enable the overlays to be fitted to the enlargements with some certainty. These were plotted in pencil for later inking up.

Departmental plotting rate varied from 21 acres per hour in the flatter built-up areas to 15 acres per hour in the hillier rural areas.

Considerable care was taken in checking models before forwarding to the contractor and in checking contract work.

Every height point was checked by observation in an autograph before forwarding to the contractor. This was done by setting up every other model in every other run to ensure that all field heights fitted.

Random checks were made on work received from the contractor. Sheets were selected at random and sixty heights observed on a model in a rectangular pattern at well-defined points on contours and at spot heights. Where the mse in height of a model was found to be greater than $\pm$ 1.7 ft, the adjoining models were also investigated. Twenty-five per cent of the sheets plotted by contract were thus checked. If it was considered that the quality of the plotting was poor or that the model had been incorrectly set up, the sheet was returned to the contractor for further investigation.

Drafting and photographic enlargements

The drafting work consisted of simply adding contour numbers to the plotted sheets, inking up the street fences spot heights and adding street names. This was done by hand using pen stencils.

The scaling of the photographic enlargements was carried out using the PUG pricked pass points. The plate to be enlarged was selected and the three pass points across its centre plotted on a sheet of Pagrafoil at the plotting scale of 1:2,400 from the aerotriangulated values. The plate was then placed in the enlarger and projected on to the Pagrafoil sheet and the magnification adjusted to give the best visual average fit of the three projected pass points against their plotted position. In the more undulating areas, this method resulted in positional errors in detail on the edge of the enlargments of up to 1 cm and made the accurate joining of the enlargements impossible. Over small localized areas, however, the scale was sufficiently accurate for the purpose required.

All the enlargements were prepared on Cronopaque. This was used rather than bromide paper because of its greater dimensional stability, flatness, strength and superior drafting surface.

Use made to date by the MATS of enlargements and overlays

The various alternative proposals for the location of freeways and their relation to the existing traffic system are indicated on the 40 chain to 1 inch, 25 ft contour plans covering the metropolitan area. A number of these proposals have been prepared and from them the final system will be decided.

Each one of these alternative proposals is examined in broad detail on the 10 chains to 1 inch series in conjunction with the 1:2,400 photographic enlargements. A possible route is selected and indicated on the 10 chain plan. The enlargements are then examined throughout the length of the route and areas of building and open spaces sketched on to the 10 chain plan. This examination positions the route to within definite limits.

The route is then designed in closer detail on prints of the 200 ft to 1 inch overlays from the contours and spot heights and by constantly comparing and examining enlargement and overlay. Cut and fill are thus determined, cross-overs and fly-overs broadly designed, grade and position of pavement decided and the various constructional proposals indicated on the prints in different colours.

At the present stage of design, the enlargements and overlays appear relatively satisfactory. The necessity for continually referring to overlay and enlargement rather than to one composite plan, though felt to be a drawback, causes no great inconvenience. The scale variation across an enlargement due to height displacement prevents the enlargements from being joined together and the design from being carried out on the enlargements themselves. They can be scaled only over small localized areas. They do, however, give a bird's eye view of the problems and have saved much field inspection.

The limiting of the overlay detail to contours and street fencing has made it possible to show the design proposals very clearly on overlay prints.

It is considered that, while the ideal requirement for the traffic study would be an orthophotograph with photogrammetric overlays showing contours, cadastral layout, buildings and street pattern and any or all combinations of these overlays, the enlargements and overlays prepared have met the immediate requirements of the MATS and been a major factor in enabling it to be completed at about the scheduled finalization date.

Agenda items 9 (a) to (h)

NEW HORIZONS FOR EARTH STUDIES FROM SPACE

Paper presented by the United States of America[1]

In the United States, during the first half of the nineteenth century, the surveys conducted by the Federal Government were exploratory in nature and confined almost entirely to the western part of the country. After the Civil War, increased westward migration emphasized the need for a more thorough exploration of the vast area west of the Mississippi. Consequently, between 1867 and 1869, Congress authorized four surveying expeditions to study the geology and topography of the territories. In 1879, these scientific surveys were consolidated into one organiza-

[1] The original text of this paper, prepared by Winston Sibert, United States Department of the Interior, Geological Survey, appeared as document E/CONF.52/L.15.

tion, the United States Geological Survey, charged with the investigation, surveying, and mapping of the nation's natural resources.

During the ensuing years, the relatively crude and time-consuming practices of those early exploratory ground surveys have been replaced by efficient mapping techniques which utilize aerial photographs and precision photogrammetric plotting instruments. Photogrammetric mapping reduces the need for ground surveys to establish basic ground control frameworks for the map, to obtain or confirm name and boundary information, and to complete ground detail that is obscured on the photographs by shadows or vegetation cover. Thus the means of obtaining and recording data for natural resources studies have been greatly improved.

On 21 September 1966, Stewart L. Udall, Secretary of the Interior, announced the intent of the Department of the Interior to apply space technology to the solution of many pressing natural resources problems being compounded by population and industrial growth. He outlined a programme aimed at gathering data on the natural resources of the earth from satellites carrying remote-sensing instruments. The initiation of this programme represents another giant step forward towards a better understanding of the earth's environment.

The advantages of remote sensing from earth-orbiting satellites have long been recognized by scientists working in the earth-science disciplines. The Geological Survey, in co-operation with the National Aeronautics and Space Administration (NASA), has for the past two years been investigating techniques for collecting and utilizing data from remote sensors. The course now seems clear: to make and execute bold plans for gathering data on the earth's resources, and to assess, inventory and disseminate these data in order to alleviate resource problems common to all nations. Programme EROS (Earth Resources Observation Satellites) is dedicated to this task.

The unique advantage of remote sensing from satellites is that it provides synoptic and repetitive coverage under nearly identical conditions of illumination. This advantage is most significant and applies to all earth-science disciplines. As each satellite will have a planned life expectancy of at least one year, a given area of the earth can be studied in each of the four seasons. By virtue of a sun-synchronous orbit, the imagery will be illuminated from a nearly constant sun angle.

The EROS programme will be evolutionary, that is, the resolution of the data produced by the various sensors is expected to be improved as new technological advances are incorporated. Ground-image resolution of some 100 to 200 ft is expected from the television camera system that will be used in the initial EROS flights. Through the evolutionary process, it is expected that direct-viewing instruments can be developed to provide ground resolution of 10 to 20 ft and that stable film-base material can be returned to earth for study and extraction of detail by various mensuration techniques. An intensive research programme will be conducted to develop the ultimate remote-sensing system as now conceived.

Earth-orbiting remote sensors will provide data useful to many scientific activities concerned with natural resources. The following are examples of potential uses as they apply to the various earth-science disciplines:

Oceanography—Wave formations, tidal formations, subaqueous formations, ocean stream charting, water temperatures.

Agriculture—Crop inventories, forest surveys, land utilization, diseased vegetation determination.

Environmental geology and mineral resources—Volcanic eruption prediction, tectonic analysis of earthquake-volcano belts, structural and physiographic features as prospecting aids, thermal anomalies as mineral deposit prospecting aids, geology of remote areas.

Hydrology—Shallow ground-water inventory and study, ground-water discharge, measurements of evapo-transpiration, reservoir sedimentation, water pollution.

Geography—Land use, transportation, morphology, population studies.

Cartography—Thematic or topical mapping, map maintenance, topographic mapping, small-scale mapping of remote areas, orthophoto-mosaics.

The capabilities of the initial EROS system for cartographic applications will be rather restrictive; that is, the derived data may be applicable only to small-scale charting of remote areas, such as Antarctica. As the sensors are improved and ground resolution of 10 to 20 ft is obtained, broader cartographic applications can be realized, particularly in the up-dating of maps on a revision cycle impossible to achieve by use of conventional aerial photographs.

Equally significant are the potential benefits that improved ground resolution and repetitive synoptic coverage would offer to geological, hydrological and geographic field studies. Remote-sensor data of optimum quality may well enable the various users to locate areas where field investigation is most likely to be productive. In many respects, the advantages thus afforded are comparable to those that aerial photography provided to mapping operations in relation to the practices of the early explorer.

Satellite techniques are, of course, complicated and the technical demands to be placed upon the remote-sensing equipment will be great. However, the recent NASA/Gemini photographic accomplishments, published throughout the world, have made it evident that remote sensing from orbital heights is technically feasible. Limited applications of Gemini photographs have already been demonstrated.

The information gained from the Earth Resources Observation Satellites will be made generally available to all concerned with studies and activities related to the development or conservation of natural resources, and all nations will thereby share in the benefits.

THE NATIONAL RESOURCES INVENTORY

Paper presented by the United States of America[1]

The United Nations has designated the 1960s as the Decade of Development. In this decade, the developing nations, with the assistance of the United Nations, the International Bank for Reconstruction and Development (IBRD), the United States Agency for International Development (USAID) and various other public, private, national and international institutions, have undertaken the most comprehensive series of programmes for economic improvement ever attempted.

These programmes require a high degree of national planning by the Governments concerned. The new reliance on formal planning procedures by central government agencies accelerates the pace of development and minimizes the problems of attaining national objectives. On the part of assisting agencies, national planning is essential to the efficient use of manpower and finances, focuses attention on critical developmental needs and reduces duplication of effort.

It has been recognized that a detailed understanding of central government finance, including the national balance of payments position, is a basic requirement in national planning. It determines the volume of developmental assistance to be made available to countries co-operating with bilateral or multilateral programmes, and determines a country's ability to absorb this assistance.

Equally important, but unfortunately often overlooked, is the need for adequate knowledge of a country's physical and human resources. The assembly and evaluation of comprehensive information on the people concerned and the land and natural resources available to then are essential to the efficient use of available development capital. The evaluation requires a detailed geographic interpretation of place and spatial associations, so that planners at all levels of government can consider the many separate facets of development in relation to national objectives. This body of fact may be designed the national resources inventory.

The inventory may be divided into two phases: general inventory of physical resources; detailed inventory of physical resources.

The general inventory of physical resources is an overview of all significant data required for general planning on a given country or region. It is designed to provide country planners, non-technical personnel involved in programme development, and high-level individuals concerned with policy, the bases for decisions relating to national planning and programmes. It includes information on natural and man-made features such as soils, vegetation, mineral and water resources, geology, existing and potential land use, sociological and population factors, transportation, utilities, industry, institutions, urban areas and climatological data.

The detailed inventory of physical resources is a generic term applied to the body of facts required to identify and evaluate more precisely the specific nature and extent of developmental projects, and the areas and features involved. It includes medium- and large-scale maps on geology, soils, forestry and land use and cadastral, geophysical and hydrological surveys. They are used to determine programmes for improvement of land evaluation and taxation procedures; land settlement and resettlement; better use of lands now devoted to agricultural production locations of electric power stations, dams, reservoirs and soil conservation areas; development of mineral resources; afforestation and reafforestation; construction of roads and airfields; and the locations and types of agricultural processing plants and other industries.

The detailed inventory is never really completed, nor are programmes undertaken simultaneously to provide all the information on all parts of the country. Production of data is programmed to meet priority needs, based on developmental projects. But the body of facts needs to be systematic in format and scope, so that information on one region of a country may tie in readily to an adjacent area.

The general inventory of physical resources is a relatively new concept, along with the idea of establishing national centres to accomplish both general and detailed inventories of resources. Therefore this paper will be devoted to discussing the scope of general inventories, and the operations of a central agency in the production of the studies.

At the fourth United Nations Regional Cartographic Conference in Manila, the prototype general inventory on the Dominican Republic was displayed and described. Since then, considerable progress has been made in refining the techniques and producing studies on a number of Latin American countries.

More recently, the concept has been extended to the Far East, where the Mekong Resources Atlas is being produced. The project is sponsored by the Mekong River Committee of ECAFE in collaboration with the Governments of Thailand, Laos, Cambodia and the Republic of South Viet-Nam, and the United States Tennessee Valley Authority. It is financed by the United States Agency for International Development.

The scope of the Mekong Atlas is extensive, as indicated in the annexed list. The subjects were included to meet the specific developmental planning needs for the Mekong basin. The list could be modified to meet peculiar needs, or to meet different economic and geographic aspects elsewhere in the world.

The inventories are loose-leaf volumes, containing base maps on the right side, each with a colour transparency overlay superimposed. All graphic information is portrayed at a common map scale. The transparencies can be removed from the volume and, by overlaying one or more subjects, the user can gain a composite picture of interrelated factors. On the left side there are loose-leaf sheets containing tabular and textual data. Subjects are covered separately, as in the case of the maps and overlays, and are tied in directly to the graphic materials.

The inventory is a coherent, systematic, uniform package in a form easily handled and used. It is easily maintained, and can be augmented readily with new subjects. It can be reproduced in part or as a whole, and published in large quantities, since reproduction materials are provided as part of the various projects. For example, the Government of Costa Rica arranged for publication of several thousand copies of the inventory on its country for use by governmental organizations, schools and international

[1] The original text of this paper, prepared by D. Y. Hovsepain, Chief, Geographic Branch Office, Chief of Engineers, Department of the Army, appeared as document E/CONF.52/L.23.

agencies and private firms which might be involved in developmental projects.

To establish these inventories, and to identify the documentation and sources involved, the Engineer Agency for Resources Inventories was established in 1963. It has a threefold mission: to acquire, catalogue and reference resources data; to prepare resources inventories, and to assist USAID by preparing analytical studies and supplying source data, and to provide these data on request to other organizations or institutions.

The Engineer Agency is organized into the reference, evaluation and analysis, and technical support branches.

The Reference Branch acquires catalogues and references natural and cultural resources data. This centralized activity is necessary to provide the information for resources inventory production. It also locates documents wherever they may be to avoid duplication of effort and to identify the body of facts available for other uses. It is a continuing process. The branch is not a large repository for documents. Approximately 3,000 selected items are held; about 10,000 articles and publications have been abstracted; and approximately 100,000 reference cards are maintained. The Agency has contacts with seventy United States institutions and libraries, many in-country agencies and various international bodies.

In the production of inventories, researchers in the Analysis and Evaluation Branch first use the information identified and located by the Reference Branch. The data are compiled at a common map scale best suited to the size and shape of the study area and supporting textual and tabular data are prepared. The base map is selected on consultation with the host country, the AID country mission and other organizations which might be involved. The initial compilations reflect areas of strength, weakness or absolute gaps.

The analysts then proceed to the country of study with the compilations. There they work with host country personnel in the various governmental agencies concerned AID consultants, and representatives of the United Nations and other international organizations which may be active in the region. In the case of El Salvador, the inventory represented the joint efforts of the Engineer Agency for Resources Inventories, several other United States agencies, twenty-four agencies of El Salvador and six international organizations.

The analysts use all sources to the maximum extent possible to supplement the initial compilations. All materials are then returned to the agency where the professional staff use the newly acquired and often unpublished information to strengthen or possibly revise the existing compilation.

The second compilation is returned for review by the host government agencies and the AID mission. In the case of Central America (SIECA) and the AID Regional Office for Central America and Panama (ROCAP) also review the materials. Any new data, not previously used, are incorporated at that stage.

The organizations and the Engineer Agency arrive at agreements that the materials, as finally compiled, should be as complete and up to date as can reasonably be expected. The Technical Support Branch of the agency then prepares the inventory for publication. In the case of Latin American studies, the inventories are published in a single volume, in Spanish and English.

In Latin America, the Engineer Agency has completed inventories on El Salvador, Costa Rica, Honduras and Nicaragua. In progress are inventories on Guatemala, Panama and Venezuela and a regional, single-volume inventory on the six Central American countries. In the Far East, the Mekong Resources Atlas, now in progress, should be completed next year.

These inventories are new and significant documents for the developing countries. They are important tools in the promotion of national and regional planning and the achievement of national objectives. For the first time, policy-makers, planners and others have the same composite, comprehensive document to serve as a standard base in national planning for each country and for regional action.

Annex

MEKONG RESOURCES ATLAS SUBJECT SCOPE

Subject	*Overlay and Map*	*Tabular Data*
I. NATURAL RESOURCES		
A. *Physiography*		
1. Hypsometry	Average elevation of terrain in categories, names of plains, hills, and mountain ranges	None
2. Surface configuration	Map units: river alluvions, plains, hills, mountains (with notes on slopes and relief); landform divisions	By landform divisions: size and extent, landform types, slope, local relief, drainage, pattern, elevation
B. *Geology*		
3. Geology (basic)	Standard geological map developed in accordance with situation in country	Summary and definition of map units
4. Geophysics	Gravity and/or magnetic data as contour maps. Seismicity map units: ratios, degree of seismic intensity compared to real extent of activity expressed as a ratio	General summary of physical conditions (present and historical)
5. Engineering soils	Map units: coarse-grained and fine-grained soils with sub-categories; general depths	By map unit: landform and location, soils profiles, suitability for various types of construction, traction capacity

MEKONG RESOURCES ATLAS SUBJECT SCOPE (*continued*)

Subject	*Overlay and Map*	*Tabular Data*
6. Construction materials .	By symbolization, such items as plants producing cement, cement products, plaster, flat-glass, brick and tile, lime kiln, gypsum quarries, asphalt and glass-sand deposits, areas with limestone suitable for cement, sand and gravel, laterite pits	By map unit: name of material, location, annual production, use and demand
7. Mineral resources . . .	By symbolization: locations of ferrous and non-metallic mineral deposits	By map unit: location, name of resource, production, geology, reserves, use of and demand for active or previously active known mineral deposits
8. State of ground	Map units: dry, moist and wet (with sub-categories, according to dry and wet years)	By map units: terrain, probable frequency and duration of states of ground and characteristics of ground in various states: probable greatest depth to which ground in most years may be dry, moist, wet
C. *Hydrology*		
9. Surface water resources	Show, by river drainage basin and shading, values of firm low flow, i.e. minimum low flow to be expected in various sections of country	Arrange by river drainage basin: (*a*) data on quantity of water, i.e. minimum mean and maximum values of flow; (*b*) data on quality of water, i.e., chemical analyses; (*c*) special problems of development of surface water resources
10. Ground water resources	Map units: fresh water generally plentiful; fresh water scarce or lacking	Map units: source and depth, quantity, quality, siting and development
11. Drainage	Show stream pattern by river drainage basin. By symbol: show present water usage (hydro-power, irrigation, water supply diversions, location of reservoirs, gauging stations). Show by symbol: location of irrigated land, swamps, marches, areas of seasonal flooding.	Arrange by river drainage basin. Discuss physical characteristics, i.e., area, slope, characteristics, ground cover, location and number of hydrological measuring instruments, special areas of seasonal flooding, width, depth of streams. Discuss régime, i.e., seasons of high and low flow, rainfall characteristics; values of maximum and minimum flow; flow frequency
D. *Land resources*		
12. Agricultural soils . . .	Soil types shown will be according to Great Soil Groups. Generally 10–12 units will be shown	By map unit: name, physiography, description, remarks
13. Land use and land-use potential	Map units: depending on country, following IGU categories, such as settlements, trees and other perennial crops, showing areas of homogeneous physical resources that can be expected to have similar yield of a group of specified products	By map unit: category and description of land-use category. Complete description legend. Comments on certain characteristics pertinent to country
14. Land classification . .	Map units: classification by purpose (for agriculture, forestry, pasture, swamps etc.)	Area description by map unit and by country
15. Soil classification and progress of surveys .	By symbolization: predominant soil type	Description, detailed soil types and suitability for agricultural purposes
16. Vegetation	Map units such as: dominant trees, shrubs, grass; cultivated vegetation and marsh and swamps. Sub-categories thereof	By map unit: vegetation type and distribution; construction use
17. Forest cover	Map units according to dominant forest types	By map unit: forest types; description of forests—(area, species, density, volume); exploration (present and future); policies and programmes
18. Rice land	Map units according to double-cropping	By map unit: irrigated or non-irrigated; yield, policies and programmes
19. Cadastral surveys . . .	By symbolization: location, extent and type of surveys	When necessary for additional details

Subject	*Overlay and Map*	*Tabular Data*
20. Mapping	Map units: general indication of coverage by series or individual sheets; town plans	When necessary to indicate names of sheets, scales, and date(s) of coverage
21. Aerial photography . .	Map unit: extent of coverage	When necessary to indicate projects or missions, scales, and dates
22. Geodetic surveys . . .	Map units: status of geodetic control horizontal and vertical; 1st, 2nd, and 3rd order delimited by symbol; date(s)	None
E. *Meteorology*		
23. Climate	Climatic zone map based on Koppen classification and a precipitation map with isohyets	Statistical summaries on: rainfall, relative humidity, cloud cover, visibility, surface winds, temperatures at selected locations
II. HUMAN RESOURCES		
24. Population.	(1) Density of population by map unit. (2) Distribution of population; rural by dot pattern and urban by scaled symbology	Summaries on: total population and area by administrative units; age-sex structure of population; urban-rural structure of population; economic activity structure of population
25. Ethnic and linguistic groups	Map units according to dominant ethnic and linguistic groups	Economic activities associated with ethnic groups; distribution of population by language groups
III. WATER RESOURCES DEVELOPMENT		
26. Present water use pattern and potential . .	Basin system (including main-stream and tributaries) by symbolization: present water usage in Lower Mekong basin as well as potential water usage, hydro-power, irrigation, water supply diversions; location of irrigated areas, present and potential. With respect to electric power by symbolization: schematic diagram of lines, line voltage; locations and capacity of principal power stations, thermal (steam and diesel) and hydroelectric, and principal sub-stations	For existing installations and those under construction: initial and final capacity of plants, national hydro-power plants, national power summary: by capacity, production, type, owner, current description, plant characteristics of generating plants and transmission lines; irrigable areas or irrigation systems and volume of water-supply diversions; for potential water usage similar data using best estimates; brief description of each hydroelectric power installation
IV. ECONOMIC INFRASTRUCTURE		
A. *Industries*		
27. Mineral industries . .	By symbolization: location and types of existing and planned mineral industries such as iron, tin, copper, cement, lime etc.	Brief description of mineral industries by country; total production and value of production and employment by principal mineral industry; estimates of production for planned industries
28. Agricultural processing industries	By symbolization: location and types of existing and planned agricultural processing industries, such as canning, copra, jute and kenaf, rubber (natural), sugar, tobacco curing etc.	Brief description of agricultural processing industries by country; total production and employment by principal industries; estimates of production for planned industries
29. Forest industries . . .	By symbolization: location and types of existing and planned forest industries, such as lumber, plywood, chipboard, fibre board, saw-mills, charcoal etc.	Brief description of forest industries by country; total production and value of production and employment by principal industries; estimates of production for planned industries
30. Light industries. . . .	By symbolization: location and types of existing and planned light industries, such as leather tanning, shoes, plastic and textiles	Light industries by country; total production and value of production and employment by principal industries; estimates of production for planned industries
31. Village industries . . .	By symbolization: location and types of existing and planned village industries, such as basket- and doll-making, embroidery, silkworm culture and silk weaving, pottery etc.	Brief description of village industries by country; total production and value of production and employment of principal village industries; estimates of production for planned industries

Subject	*Overlay and Map*	*Tabular Data*
32. Tourism	By symbolization: location and types of various tourist cultural attractions; selected recommended lodgings and eating places; parks; scenic attractions; sporting events, fairs, fiestas; ruins, historical sites etc.	Brief summary: 1st and 2nd class hotels, motels, boarding houses and related facilities; fairs, fiestas, dates and places of significance; major parks, sports and recreation areas; other tourist attractions; related data concerning transporation routes, road conditions and distance from major towns
B. *Transportation and communication*		
33. Highway	By symbolization: highway number, classification and alignment	By highway number: surfacing, width, alignment, condition (all-weather and dry-weather roads), classification (possibly in 3 classes)
34. Railway and airfields .	By symbolization:	
	(*a*) Reference number, gauge, track, alignment of railway	(*a*) By reference number: gauge, track, electrification route miles, rail weight, ties, ballast; general statements on passing tracks; radius of curvature; yards
	(*b*) Location, category (largest commercial craft handled)	(*b*) Ownership, runway characteristics, aircraft capabilities; services, fuel and communications facilities
35. Inland waterways and ports	By symbolization:	
	(*a*) Alignment, navigation limits, principal river ports	(*a*) By waterway: summary data on type craft using waterways general cargoes transported
	(*b*) Location; categorized as major, secondary or minor	(*b*) By port: unloading and clearance capacities; general statements on berthage and cargo handling facilities; maximum tonnage handled and daily capacity
36. Telecommunication . .	By symbolization: such facilities as telephone and telegraph centres; principal domestic radio and television broadcasting stations; radio relay terminals; radio relay links; open-wire telephone and telegraph lines	Tabular details on all telecommunication aspects; facility identification; location; call symbols, power output, frequencies; channels; equipment; capacity and/or adequate facilities
C. *Development institutions*		
37. Institutions for development of agriculture, industry, trade and finance	By symbolization: type and location of dedevelopment institutions, banks, industrial research and pilot plants etc.	Types and number of development institutions by country; in case of development finance or credit, capitalization and extent of operations and industries served
V. SOCIAL INFRASTRUCTURE		
38. Urban areas, including housing	By symbolization: location, administrative boundaries (state or province)	By urban area: brief summary data on location, elevation, population, area (within city limits, metropolitan area, area of maximum possible expansion) importance; public facilities; general description, urban pattern and remarks. Number of occupied dwellings with piped water inside, or outside but within 100 m from the dwelling
39. Rural development . .	By symbolization: rural areas where significant rural development programmes are being undertaken	Types, by country, of rural community improvement programmes, including village organizations, co-operative organizations, rural physical planning; percentage of population living in: (1) permanent dwellings; (2) substandard housing units classified as "rustic" or "not intended for habitation"; and (3) without shelter of any kind; improvement of rural health and sanitation, adult training, women and youth programmes etc.

MEKONG RESOURCES ATLAS SUBJECT SCOPE (*concluded*)

Subject	Overlay and Map	Tabular Data
40. Health, including nutrition	By symbolization: index to administrative units; location, type and number of hospitals and other health units by administrative divisions	Statements on general health and sanitation conditions; principal diseases; number of medical personnel by administrative divisions; bed capacity of hospitals, and other health units by administrative divisions; information on state of nutrition in both urban and rural areas
41. Education	By number for each administrative division: primary schools/teachers/students; secondary schools/teachers/students. By symbolization for location of teacher-training schools, colleges and universities	For primary, secondary and vocational education; number of schools, teachers and students (urban and rural) in public and private schools by administrative training; location, number of professors and students by administrative divisions. For colleges and universities: departments of study, number of professors and students

CARTOGRAPHIC MAPS IN EARTHQUAKE ENGINEERING AND THE PACIFIC TSUNAMI WARNING SERVICE

Paper presented by the United States of America[1]

Earthquakes and their effects on the earth's surface and on man-made structures are permanently recorded in many ways. From the earliest days, man described, with or without technical accuracy, his observations of the damage wrought by earthquakes around the world. Later, the writings were enhanced by instrumental recordings (seismograms), which for the first time provided a permanent measurement of ground motions. With the advent of photography, the seismograms were supplemented by actual photographs of earth movements (cracks along surface faults) and of damage to structures. The value of the photographs was closely tied to the experience of the photographer and the degree to which he recognized the engineering or scientific importance of the earthquake damage. Even today only a few of the thousands of earthquake pictures of the great earthquakes in Alaska, Japan, Chile etc. are actually useful for the engineering and scientific community.

The introduction of seismic studies and isoseismal maps (figures I and II) after the turn of the century was the first attempt to synthesize great amounts of detailed information in earthquake report writing. The isoseismal maps provide a quick analysis of the extent of the affected areas, the distribution of intensities and correlation with surface geology in very broad aspects. Seismicity maps, drawn on different projections, delineate geographical distribution of earthquakes on the continents, in the island arcs, and along the great oceanic ridges. In addition, these maps which detail such information as intensities, magnitudes, depths of focus and focal mechanism are excellent tools for summarizing earthquake information for use by the seismologist, geologist, engineer and public safety officers.

Very limited attempts through earthquake probability maps (figure III), such as that designed by the Coast and Geodetic Survey in 1948, have been made to simplify seismicity maps for the design and construction engineers. Even though these maps have not met with complete success, their continued usage by structural engineers and building code officials is evidence of their needs. Because of the demand for more accurate and detailed information of this nature, the Coast and Geodetic Survey initiated a programme over one year ago to produce an improved seismic probability map. After a year of study and experiment, it is still not fully understood how the map should be compiled, what it should contain, and how it will be presented.

As a first step in its preparation, the complete historical information about every known earthquake in the United States was reviewed. This was essential, as the published earthquake information had been compiled and analysed by persons of diverse background and experience, using different interpretations of intensities based on different scales, such as the Rossi-Forel and modified Mercalli. A comparison of old and recent earthquake information brought out the inadequacy of using only limited felt data to locate earthquakes. The old earthquake data necessarily placed the centres in populated areas, whereas the recent data, using felt and instrumental reports, frequently distribute the foci away from populated areas and closer to geological fault systems. All the historical data, such as felt and damage intensities, surface geological effects, instrumental epicentres and depths of focus, computed energy release and special remarks have now been placed on IBM computer cards. With such a reservoir of data, innumerable studies are possible and the results hitherto impossible to compile can now be presented. Maximum earthquake intensities and their relation to the known surface geology of the area are being plotted on United States base maps of different scales. This is probably the first time that such maps, containing complete seismic data and the related geological features, have been compiled for the entire United States.

The seismicity maps, although an extremely useful tool, do not convey sufficient information about energy distri-

[1] The original text of this paper, prepared by L. M. Murphy, Chief, Seismology Division, Coast and Geodetic Survey, appeared as document E/CONF.52/L.28.

bution in space and time. They give the number and location of the earthquakes but leave to the imagination the affected area and the influence of earthquakes remote to a given site. Even though an earthquake may never have occurred at such a site, that site may have been seriously affected by earthquakes within 25 to 50 miles. An attempt to portray this information is being made by the Coast and Geodetic Survey. Frequency-intensity graphs are being plotted for certain areas (250 miles radius) around cities with populations of 100,000 and above. These recurrence curves, as they are called, have been employed by recent United States and USSR investigators to delineate seismicity. The slopes of the curves give constants that are characteristic of the areas, thereby providing a technique for a simple comparison of seismic intensities. The data from these recurrence curves, intensities 6 and greater, will be plotted on a system of arbitrarily selected grids across the United States. Another approach that is being considered is to develop recurrence curves for known geological systems in the major seismic areas of the country. This may be more meaningful in estimating probability of occurrence as earthquakes are centred along geological fault structures which seem to have individual earthquake patterns.

In the United States seismologists and geologists emphasize the relation of earthquakes to geological faults. Many of the recent efforts by Soviet scientists have developed correlations between seismicity and geological features other than active faults. They believe earthquakes are one of the manifestations of the tectonic movements of the earth's crust, in particular its vertical oscillatory movements. Folding is produced by these tectonics and is due to plastic flow in layers lying between more rigid segments of the earth's crust. Three types of folding—block, injection and great compression—are postulated as primary earthquake-producing conditions. Particular importance has been placed on velocity gradients of the vertical movements and on boundaries between regions of different geological histories. In the United States, these tectonic applications have not been extensively employed because the large vertical velocity gradients are almost all across faults that are considered "active" and it is these faults that form boundaries between areas of differing geological histories. It therefore appears more realistic to map actual faults than to attempt to compute rates of vertical displacement in the geological past or to measure such displacements at the present time. Hence, the Coast and Geodetic Survey's efforts will be concentrated on tectonic mapping of earthquake effects in relation to the known geological faults of the country.

Another significant factor being developed in earthquake engineering mapping is the mapping of relative ground amplification factors. The real significance of these factors was dramatically brought to the attention of United States seismologists and engineers after the Alaskan and Japanese earthquakes of 1965. Fortunately, most construction in this country has been on structurally safe geological formations. However, with the advance of construction in heavily populated areas, structural engineers will be forced, in the not too distant future, to design structures for erection on less suitable geological foundations. In anticipation of this requirement, the Coast and Geodetic Survey initiated about two years ago a programme of field measurements which consisted of siting mobile seismographs on hard and soft rock. Simultaneous measurements are made of earthqake motions on these formations and then amplitude spectrum analyses are performed. To date, about thirty earthquakes have been recorded and some interpretations completed. Similar measurements will be made during the next few years in several seismic regions of the country, for example, New Madrid, Denver, St. Lawrence and Charleston. It is anticipated that gross amplication factors will be established for the measured geological formations. If the results of these field measurements are of sufficient detail and accuracy, they will be mapped; otherwise the information will be placed in suitable table format on seismicity or seismicity-geology maps.

Mapping is now playing a significant role in the operation of the Pacific Tsunami Warning Service. Shortly after the inauguration of the service, maps were made of the locations of earthquakes that generated measurable tsunami waves. These were used as guides for selecting tide and seismic stations whenever additional countries joined the warning service. In order to determine rapidly the ETA (expected time of arrival) for tsunami waves at the participating tide stations, maps were developed for tsunami travel times across the Pacific Ocean (figure IV). Originally these were computed on a desk calculator but more recently electronic computers have been employed. Through the use of the electronic computer, it is hoped that more parameters can be introduced in the computations, thereby providing more precise tsunami travel-time data. The demand for this information becomes more exacting as the number of participants in the service grow because of their increased reliance upon it for the protection of life and property.

At the present time, there is no acceptable method for predicting tsunami wave heights, even though the area of earthquake generation and the approximate energy release are known. Some research is being conducted, but there is no reason to expect a breakthrough in the immediate future. In the meantime, something must be done to assist the officials responsible for the protection of life and property. As a first step in this direction, maps are being prepared for Hawaii which show the coastal areas to be evacuated when the waves reach heights of different increments of 5 up to 50 ft. Such maps should be prepared by all countries and island groups that participate in the service.

In order to make these high-water-level maps more useful, the Coast and Geodetic Survey is preparing maps that show the observed wave heights of tsunamis since 1900 along the perimeter of the Pacific and the major islands. Although these data are sparse, they will be helpful in evaluating the approximate wave heights that might be expected at a given location. The assumption in the use of these data is that an earthquake of given magnitude and depth and region, upon recurrence, will produce essentially the same tsunami wave heights around the Pacific Ocean.

To determine more expeditiously whether an earthquake has generated a tsunami, limited studies have been made of the focal mechanism of these earthquakes. It was originally thought, and logically so, that dip-strike earthquakes would be the greatest source of tsunamis. However, investigations have not substantiated this statement, so that further studies of the source mechanism are required. Such information when available for maps would be invaluable for the warning service.

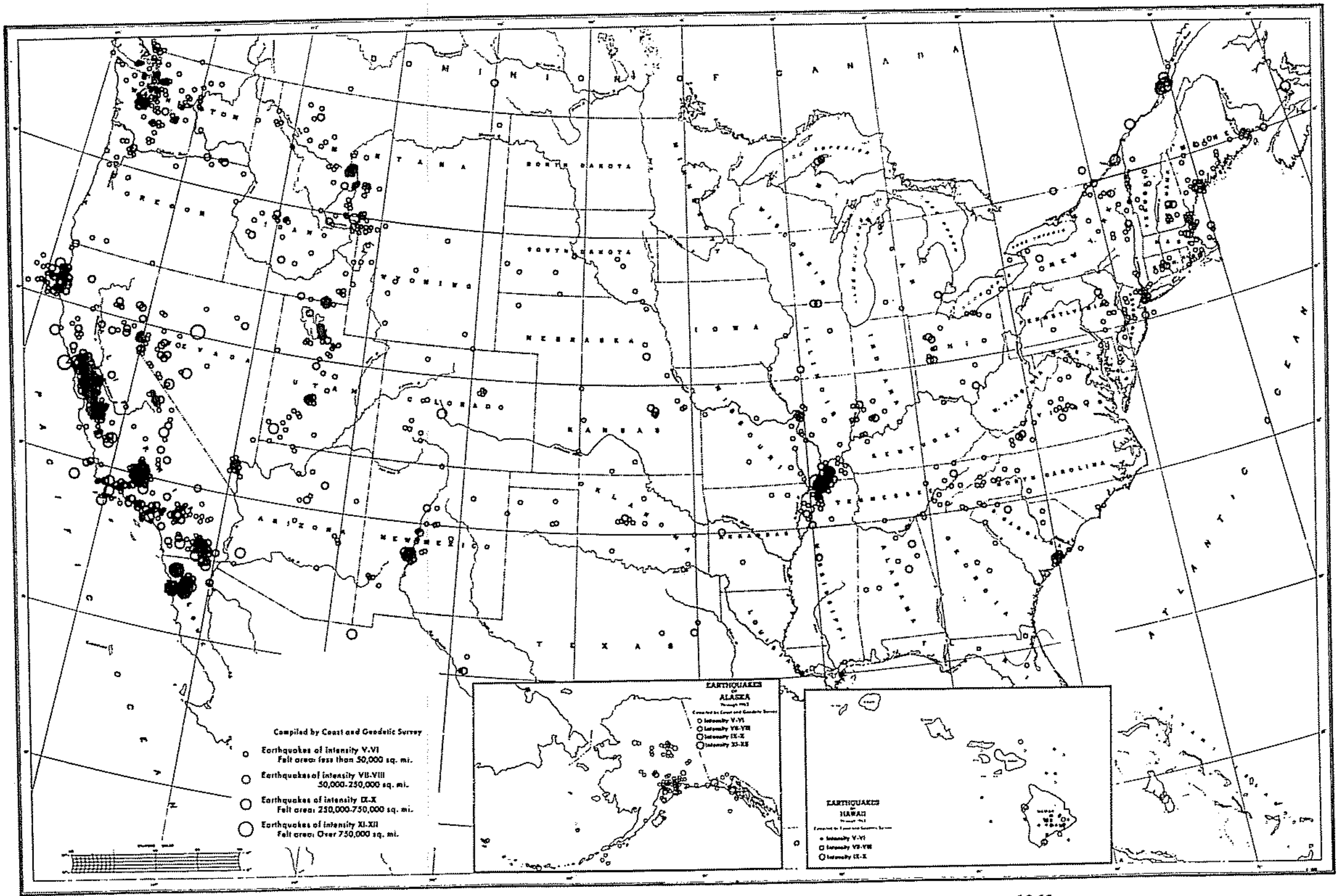


Fig. I—United States of America: Earthquakes in the United States prior to 1963

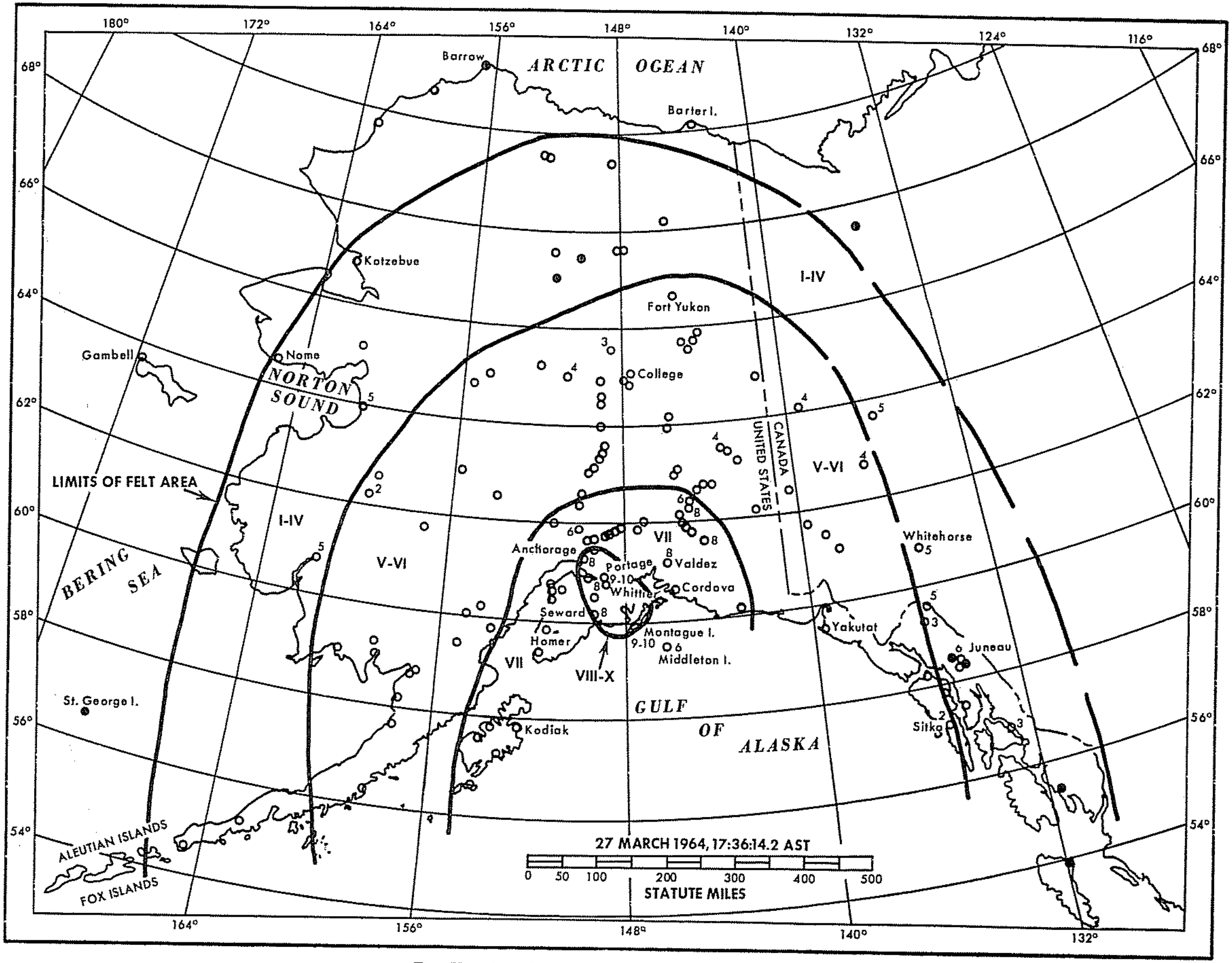


Fig. II—United States of America: Isoseismal map

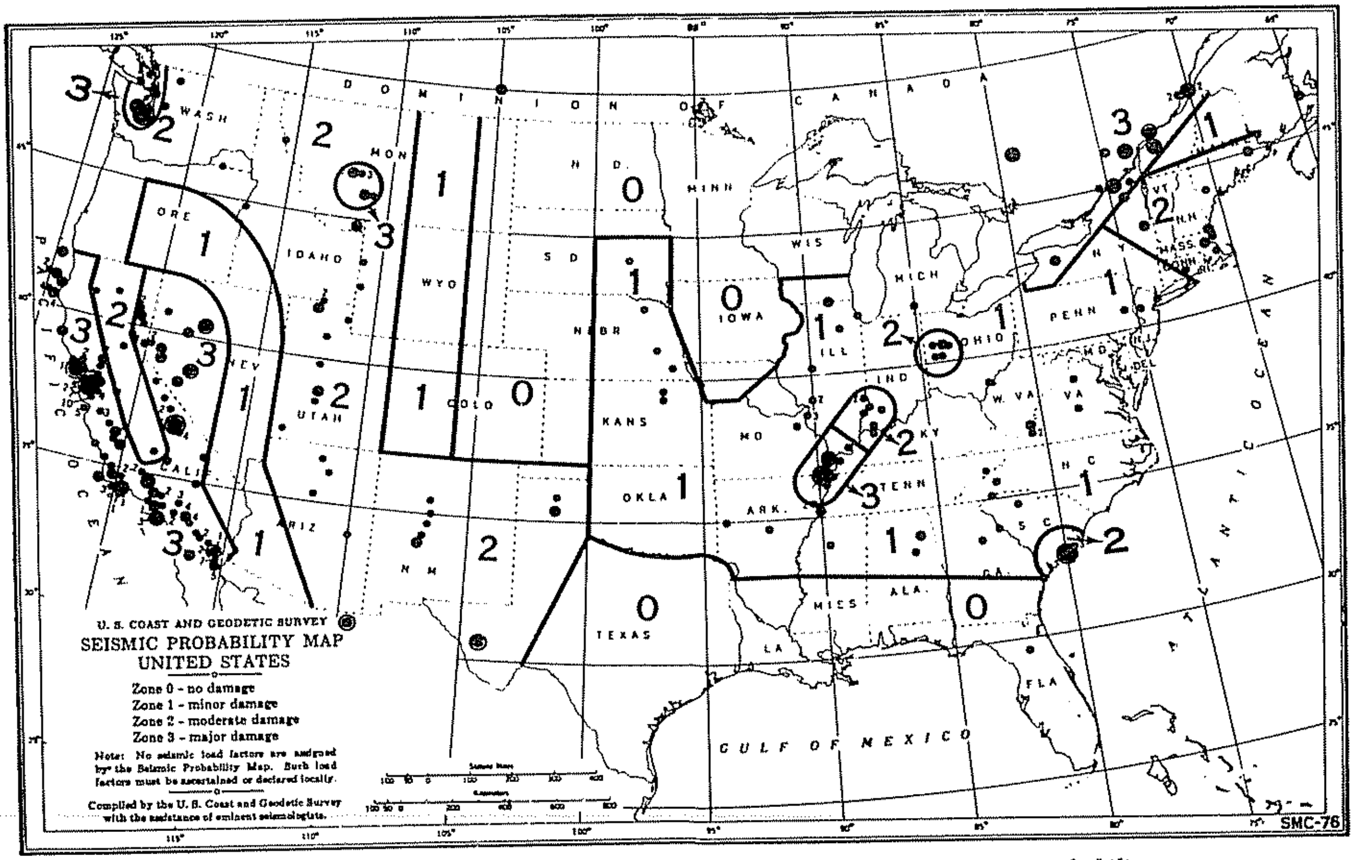


Fig. III—United States of America: Zones of approximately equal seismic probability

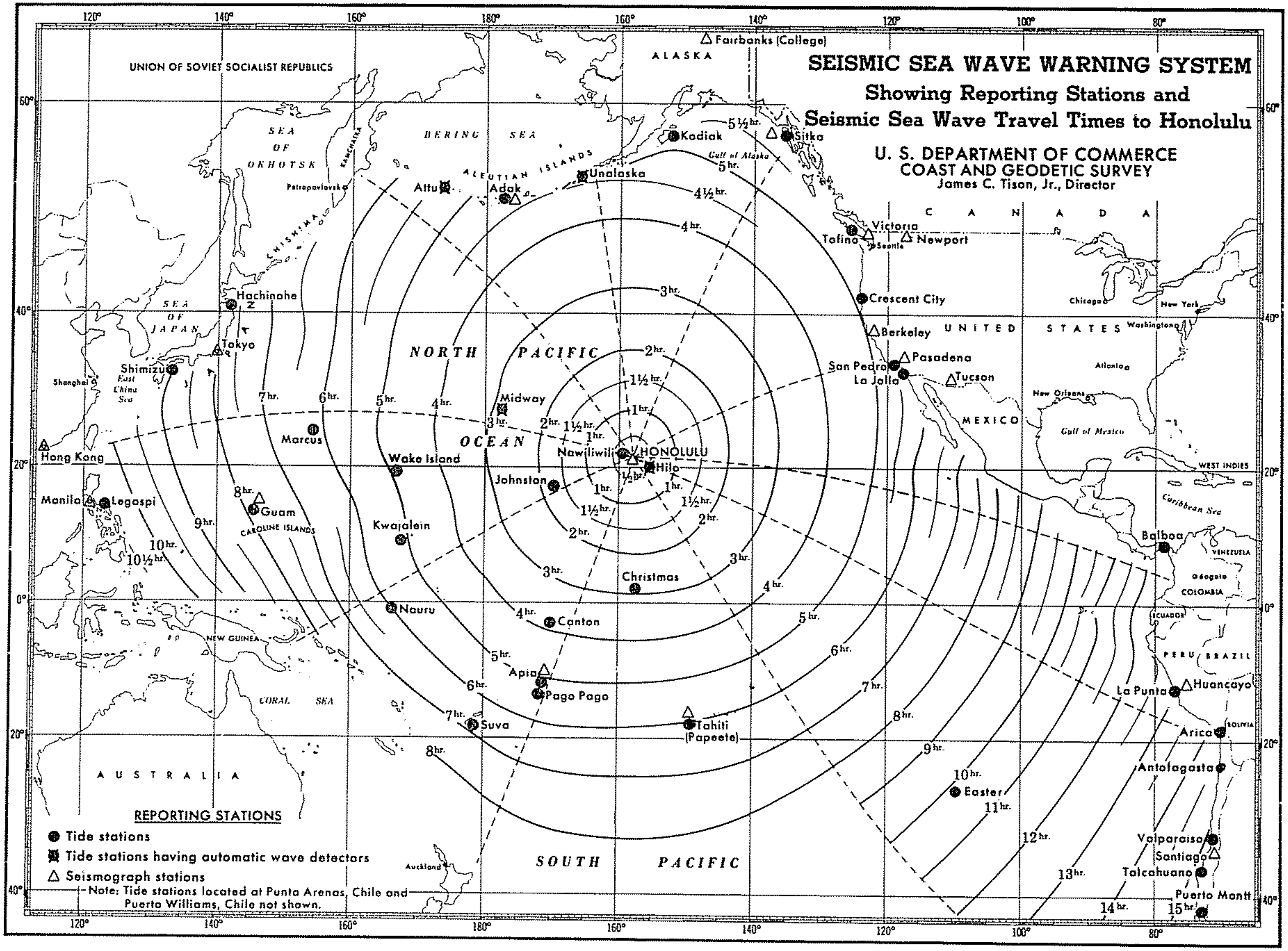


Fig. IV—United States of America: Seismic sea wave warning system, Sept. 1966

UNESCO ACTIVITIES IN THE FIELD OF INTEGRATED SURVEYS AND SCIENTIFIC MAPS FOR NATURAL RESOURCES RESEARCH

Paper presented by the United Nations Educational, Scientific and Cultural Organization[1]

Introduction

The general doctrine underlying UNESCO's natural resources programme is that stimulation of research and training relating to the natural environment and its potential will provide a sound basis for the evaluation and development of natural resources, particularly in the developing countries.

With this in view, a programme has been developed around such traditional disciplines as geology, hydrology, soil science, geomorphology and ecology. At the same time, efforts have been made to improve the methodology of studies aimed at a comprehensive understanding of the interactions of the various elements of the natural environment. The interdisciplinary approach necessitated by this objective is perhaps best exemplified by UNESCO's promotion of "integrated surveys" of natural regions.

With this programme, which is carried out in close co-operation with international scientific organizations and which is regularly described in the bulletin *Nature and Resources*, the following elements will be of particular interest to cartographers:

Methodology of integrated surveys and international training it the field;

Establishment of national, sub-regional and regional environmental or natural resources research and training institutes;

Preparation and publication of small-scale scientific maps, including standardization of legends and nomenclatures and correlation activities in the field.

Integrated surveys

For efficient land development, a combination of investigations concerning natural and human resources such as geological, soil, ecological and water surveys, as well as agricultural, economic and sociological studies is necessary. Each of them should be carried out by experts who are experienced in these fields. Simultaneously, however, the surveys must be planned and completed in such a manner that a comprehensive picture of the natural environment will result from which scientifically supported decisions for the planning and execution of development projects may be taken. The proper manner to achieve this calls first of all for an integrated organization of factor surveys in which well-balanced and efficient investigations on all pertinent aspects of the natural environment are carried out by a team of experts under the guidance of a highly qualified team-leader.

Secondly, experience has shown that, especially in developing countries with large and only partially explored areas, the quality of these surveys is significantly improved when modern air photographic techniques are systematically used to prepare base maps and interpret the photographs. In fact, this method must be called an indispensable tool, because the study of natural and man-made landscapes by means of such airborne methods, especially if carried out by a carefully chosen team of experts from various disciplines, will provide very sound background information for more advanced integration. Abundant evidence supporting these statements was collected for and made public at UNESCO's conference in Toulouse in 1964, the proceedings of which are being published.

Lastly, it is evident that mankind uses and modifies its natural environment in order to increase productivity and to improve living conditions. If we are to obtain maximum benefits from the results of integrated surveys, therefore, economic and sociological studies are another essential prerequisite for their successful planning and execution.

In the light of these observations, UNESCO, in close collaboration with non-governmental scientic unions and with national organizations having done pioneer work in this field, such as the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia, has developed a programme for supporting the improvement of the methodology for integrated surveys as well as stimulating their wider use in developed and developing countries. Some of the salient features of this programme are mentioned below.

Creation of international centres for integrated surveys

This idea, which was approved in November 1966 by the fourteenth session of the UNESCO General Conference, aims mainly at the organization of a special UNESCO-supported centre for integrated surveys at the International Training Centre for Aerial Surveys in Delft, Netherlands.

At this centre, courses are to provide training in the planning, organization and carrying out of integrated surveys of the natural environment, with emphasis on the problems arising in developing countries and with due consideration of the human factors. Reflecting the general remarks covering the nature of integrated surveys, three different types of courses are being envisaged:

One adapted to the need of forming team-leaders capable of directing the execution of an integrated survey;

Another to give additional specialized training to experts in the various disciplines who will have to participate in an integrated survey;

A third for administrators and other civil servants associated with the planning and organization of integrated surveys for development projects.

Special staff with long-term experience in integrated surveys are being charged with the preparation of curricula as well as with teaching.

In order to strengthen the activities of the Delft centre, it is also intended to associate with it other competent institutions, and the close co-operation of FAO is ensured. For instance, the necessary steps have already been taken for the establishment of a post-graduate training centre in applied geomorphology at the University of Sheffield, United Kingdom. Its programme would be planned in such a manner that it will complement the training given in Delft. Field work in developing areas, for example, is being planned jointly by the Delft and Sheffield centres. Similarly, a UNESCO-sponsored postgraduate training programme in integrated surveys of ecosystems and vegeta-

[1] The original text of this paper appeared as document E/CONF.52/L.94.

tion mapping is being planned at the Universities of Toulouse and Montpellier, France.

In April 1966, a first international seminar on integrated surveys of the natural environment was organized in Delft with a view to analysing the various methods proposed and to prepare the programme of the international course. The proceedings of this seminar will be published by the Delft Institute. A second seminar will take place in April 1967.

Regional training courses in integrated surveys

In order to supplement the long-term training to be centred at the International Training Centre in Delft and at other advanced centres of learning in Europe or elsewhere, short-term courses of a regional or national character are to be held in developing countries with the aim of acquainting as large a number of specialists as possible with the most modern methods of integrated surveys. UNESCO hopes, for instance, that the facilities of the Training Centre for Aerial Surveys in Dehra Dun, India, may be made available for such purposes. A regional course of this nature is also being planned in co-operation with the Delft centre and Sheffield University. In 1967, a regional seminar in Katmandu, Nepal, is being organized to bring together specialists from Asia in integrated studies of the natural environment of tropical mountain areas.

Creation of natural resources research and training institutes

While the activities mentioned so far aim at an improvement of integrated survey training on a world-wide or regional basis, many countries have found it necessary to plan similar projects on a more restricted level. After extensive discussions of this question with government and scientific circles in the developing member States, it was found appropriate in many cases to centre such training in special national or sub-regional natural resources research institutes. Their special functions will be the integrated study of resources in a particular natural environment. Seen from a scientific standpoint, these institutes would combine efforts directed towards conservation of natural resources with those aiming at their scientific exploration and exploitation.

When planning these natural resources research and training institutes, care will be taken to ensure that they do not compete either with the universities charged with the basic training of scientific personnel, or with the government technical services which carry out development projects properly speaking. On the contrary, particular efforts will be made to design their structure and functions in such a way that they can fill the dangerous gap existing between higher educational institutions on the one hand and government technical services on the other. They should concern themselves first with the semi-operational training of personnel specialized in the evaluation, exploration, exploitation and conservation of natural resources and, secondly, with promoting research directed towards an improvement of the methodology of integrated development surveys.

Similar institutions especially adapted in structure and function to the particular local problems and situations have already been created in several countries. The Arid Zone Research Institute of Jodhpur, India, and the Negev Arid Zone Research Institute in Beersheba, Israel, are cases in point. With the assistance of the United Nations Development Programme, it is hoped that similar institutions will be established or strengthened in a number of countries, and the United Nations Special Fund has just approved such a project for Iraq.

While it is not realistic to envisage a uniform model applicable to all situations, it nevertheless appears logical that in most cases the proposed institutes should be attached to universities or research organizations and should have four major functions:

To ensure, in consultation with the competent government authorities, a general analysis and inventories of existing potential natural resources, including publication of results;

To promote specific research in relation to the proposed development of selected areas;

To prepare interdisciplinary teams of specialists, while providing postgraduate training and training of technicians as required;

To collect and maintain complete documentation, including maps, reports and aerial photographs, relating to the natural resources of the area for which they are responsible.

The establishment of such institutes might of course not be required in countries where the same results could be achieved through appropriate integrated and co-ordinated planning of studies carried out by existing organizations, provided this activity is controlled by a nucleus of competent specialists.

Scientific maps and regional surveys

The preparation of comprehensive sets of scientific maps constitutes a fundamental approach to the integrated representation of the natural environment. At the same time, such maps provide the necessary general information and synthesis of knowledge which is necessary for research and training purposes as well as for the broad study of reserve development possibilities. For these reasons, UNESCO has co-ordinated its programme relating to small-scale maps with its general efforts to improve training and research for integrated surveys.

At the national level, efforts are being made to stimulate and aid the preparation and publication of modern national atlases for the developing countries in co-operation with the International Geographical Union (IGU). It is believed that the comprehensive representation of the natural and economic environment on these atlases will stimulate development through the necessity of collecting background data as well as through the publication and wide dissemination of data already available. Jointly with IGU, a study is being made of the optimum content of national atlases and of the problems involved in their preparation.

The preparation and (co)-publication of small-scale scientific maps, including their explanatory brochures, constitute a major element of UNESCO's programme, an activity particularly well-suited for international action. A list of projects completed or in an advanced stage of preparation follows as an example of results achieved:

(a) *Ecological and vegetation maps*

The bio-climatic map of the Mediterranean region at 1:5,000,000 covering Africa approximately to the 20th parallel, published by UNESCO jointly with the Food and Agriculture Organization (FAO) in 1963;

The vegetation map of the Mediterranean region at 1:5,000,000, now being printed and to be published in

1967/1968; it covers the same area as the bio-climatic map;

A second edition of the vegetation map of Africa at 1:10,000,000, to be published in 1968 jointly with Oxford University Press and the Association pour l'étude taxonomique de la flore d'Afrique tropicale (AETFAT);

The climatic atlas of Europe, to be published in 1968 jointly with the World Meteorological Organization (WMO);

Agroclimatological studies: in the framework of the joint FAO/WMO/UNESCO project, studies on the agroclimatology of selected areas have been undertaken, utilizing modern techniques of small-scale agroclimatological surveys; the first survey covering the Near East region was completed during the years 1960–1964; a second survey covering the Sahel region of West Africa was carried out between 1965 and 1966; the third survey covering the highlands of East Africa is under way;

(b) *Soil maps*

The soil map of the world. A joint project of FAO and UNESCO; a large number of sheets at the scale 1:5,000,000 have been prepared in draft form and will be ready for printing in the coming year; this project involves intracontinental and intercontinental field correlation of soil types;

World map of alkaline soils, 1:5,000,000; negotiations are under way with the Hungarian Academy of Sciences for preparation of the map, which would be of special importance to the arid regions of the world;

(c) *Hydrological maps and basin studies*

In the framework of a Special Fund project, an extensive hydrological study of the Chad basin, which concerns Cameroon, Chad, Niger and Nigeria, is under way; this includes the preparation of an hydrological map of the area and of an analogue model;

A similar project including a hydrogeological map is in preparation for the ground water of the continental intercalaire which concerns Algeria, Tunisia and parts of western Libya;

An hydrological study of the Pantanal area in the Upper Paraguay basin in South America which controls the regimen of the Rio de la Plata is under way as an example of a large-scale hydrological study in a humid climate.

An experimental hydrogeological map sheet covering Western Europe was published in 1966; several other hydrogeological maps are contemplated in the framework of the International Hydrological Decade;

A mathematical model of the lower Mekong river has been made for the Mekong Committee; this model can simulate normal and flood hydrological conditions in the basin;

(d) *Geological maps and correlations*

Among the maps which have been published or are to be printed for the twenty-third Geological Congress to take place in Prague in 1968 are:

Geological map of Africa at 1:5,000,000, co-published with the Association of African Geological Surveys, issued in 1964 (9 sheets and brochure);

Tectonic map of Africa at 1:5,000,000, co-published with the Association of African Geological Surveys, to be issued in 1968 (9 sheets and brochure);

Mineral distribution map of Africa at 1:10,000,000, co-published with the Association of African Geological Surveys to be issued in 1968;

Metallogenic map of Europe at 1:2,500,000, co-published with the French Bureau de recherches géologiques et minières in 1966–1969 (9 sheets); the map covers North Africa and the Near East;

Geological map of Europe at 1:5,000,000, to be co-published with the German Geological Survey to be issued in 1968 (2 sheets); the map covers North Africa and the Near East;

Central and west European sheets of the geological map of Europe at 1:1,500,000 to be co-published with the German Geological Survey in 1968 (8 sheets);

Geological atlas of the World at 1:10,000,000, co-published with the Commission for the Geological Map of the World, to be ready for publication in 1968;

Tectonic map of Latin America at 1:5,000,000 (in preparation);

Tectonic wall map of the world at 1:15,000,000 (in preparation).

Proper inter-regional correlation of geological units greatly facilitates the interpretation of the geology of border areas. A number of projects ranging from the specific correlation of stratigraphic units to studies on modern methods of absolute age measurement are therefore supported by UNESCO. Special mention should be made of the UNESCO itinerant symposium on West African granites, 10 to 30 March 1965, which is to be followed by comparative studies in north-eastern Brazil in 1967.

Another areas of activity is the standardization of legends, nomenclatures and terminologies, including the preparation and publication of (provisional) standard legends, dictionaries and lexicons, such as the following:

International standard legend for vegetation maps: project carried out jointly with the International Union of Biological Sciences and the International Geographical Union (first draft legend prepared in 1965);

International standard legend for hydrogeological maps: project carried out jointly with the International Association of Scientific Hydrology and the International Association of Hydrologists (first draft issued in 1963);

Multilingual dictionaries for hydrological terms, a joint project with WMO, the International Association of Hydrologists and the International Association of Scientific Hydrology (in preparation);

Standard legend for the metallogenic map of Europe at 1:2,500,000, in collaboration with the Committee of the Metallogenic Map of Europe of the Commission for the Geological Map of the World (issued in 1965).

SURVEY AND CLASSIFICATION OF THE SOIL AND LAND RESOURCES OF THAILAND

Paper presented by Thailand[1]

INTRODUCTION

Thailand's existence largely depends upon its natural resources. The natural resources survey was generally related to the characteristics of the physical configuration of Thailand's land surface, vegetative cover, land utilization and soils.

The main objective of the natural resources survey was to find out whether 50 per cent of the land surface of Thailand might be allotted to forest. If the area of forest was below 50 per cent, ways should be found of bringing forest land up to that figure. This objective was dictated by the recent destruction of forest trees in order that upland crops could be planted on land based upon the method of shifting cultivation. In other Asian and tropical countries shifting cultivation is the only method used both for the maintenance and the restoration of soil fertility of land used for the production of food crops. This practice is well-known but much disliked, because it reduces not only soil fertility but also soil depth; without proper method of soil conservation, floods gradually intensify and wash away the soil.

There was adequate governmental support for the programme and execution of the survey and classification of the soil and natural resources. For the evaluation and promulgation of laws governing the use of the surveyed areas, three committees were established: a technical committee, a junior committee and a senior committee. The duties of these committees are described below.

The technical committee examines and evaluates the data on vegetation, soils and maps obtained by the field parties. It is composed of senior staff from the land development, forestry, lands, mapping, interior, agriculture and rice departments.

The junior committee is composed of directors and/or deputy directors of the above-mentioned departments and most of the members of the technical committee. The function of the junior committee is to discuss the evaluations of the technical staff and submit its conclusions to the senior committee.

The senior committee is composed of some of the members of the technical and junior committees as well as some of the members of the Council of Ministers. The result of the decision of the senior committee is submitted to the Council of Ministers for consideration and, after approval, will automatically become a law to be published in the government *Gazette* and applied in the use of the land surveyed by the officers of the departments of forestry, lands and other departments concerned.

FIELD OPERATIONS

A six-year programme of field mapping was scheduled for the whole kingdom, whose approximate total area is 51,491,200 hectares. Of the seventy-one provinces, only those with forest lands were surveyed. The area to be surveyed included used, cultivated, and agricultural lands currently under cultivation. Each unit survey area is a province. Because of the great size of the area, a large number of personnel was needed to survey the area. In 1961, five teams were formed from the personnel of the ministries and departments concerned; they were trained and capable of carrying out mapping work under the guidance of the Department of Lands, Ministry of Interior. Each team was composed of five units each and each unit was manned by three or four persons who actually conducted the survey work. A technical staff was also created to conduct inspections of the survey areas of the different field parties. At the beginning of the survey, the technical staff undertook preliminary training for survey personnel in the methods used for the survey, the creation of daily survey areas for each party, co-ordination of each survey party with other parties so that boundary lines for forest, soil, etc., should coincide with each other party daily. Consultations and decisions were made finally and correctly every day.

Because of insufficiency of personnel, the programme created a one-year survey and mapping training course for high-school graduates. Approximately five months were allotted to classroom theoretical studies on the use of basic survey methods, forestry, soils and general agriculture. The other seven months were devoted to field work, during which trainees went with field units on mapping work.

When the Department of Land Development was created in 1963, under the Ministry of National Development, the whole project on the survey of natural resources was transferred from the Department of Lands to the Land Development Department. There was a slight adjustment of personnel who participated in the survey from the Department of Agriculture and the Department of Rice. Otherwise the different committees remained the same.

MAPPING METHODS

The field teams were equipped with aerial photographs, planimetric maps, compasses and metric measuring tapes, soil augers, plane-table-board mapping sets, hand levels, camping equipment and accessories, medicinal kits and other miscellaneous tools and field kits necessary for the study of vegetation, topography and soil characteristics. The aerial photographs and planimetric maps were officially procured from the Army Mapping Department of the Ministry of Defence. The equipment and miscellaneous accessories were obtained from local commercial firms and from foreign countries.

Aerial photographs approximately on a scale of 1:40,000 were usually used to help interpret the nature of the terrain, native vegetation, existence of shifting cultivation by hill tribes in mountainous regions with cultivable soil, as well as marginal lands which are officially forest reserves. The aerial photographs also reveal the probable kinds of geological formation. In the rapid execution of the survey, the aerial photographs were extremely helpful in the interpolation of areas between traversed lines and delineation of forest and non-agricultural lands on the planimetric maps. For detailed extrapolation of the characteristics of the surveyed area, pocket stereoscopes were used with the aerial photographs.

Planimetric maps, plotted from the aerial photographs, are on a scale of 1:50,000. They serve as the main sheet on which practically all the results of the survey on forest,

[1] The original text of this paper, prepared by Sarot Montrakun, Rice Department, Ministry of Agriculture, and Avadh Pimpand, Land Development Department, Ministry of National Development, Bangkok, appeared as document E/CONF.52/L.105.

soils, topography, type of government land ownership, water reservoirs with corresponding watersheds, farm settlements, military, industrial and agricultural lands, forest parks etc. are shown on the natural resources survey map. The area of each phase of land utilization was calculated in square kilometres with the corresponding percentages.

The compass is inevitably an important instrument used with the aerial photographs and maps in luxuriant tropical savannahs, grasslands and dense tree growths where lateral visibility is generally within 100 m even under an extremely clear sky and equally clear atmosphere. During the beginning of the monsoonal rains, low clouds reduce visibility to not more than 20 m.

In measuring distances, both metric measuring tapes and pacing with hand levels to correct slopes were used.

Soil augers (made locally from ordinary 1 inch wood auger with extension rods) were used to determine the approximate texture by feeling of each soil horizon within a depth of 1 m. Soil borings may be made as close as from 50–200 m apart, depending upon the nature of land relief, change of soil texture and colour.

Along lines of traverses, plane-table traverse board sets were used for convenience in plotting data on soil boundaries, forest areas, additive physical characteristics of the land not found on the base map such as important cart tracts, streamlets, newly established farmsteads etc. On vantage points, the plane table was a handy instrument for both triangulations and resections to locate the exact positions of the survey party in the survey area during the process of surveying.

Mapping area units were based upon provinces. There being seventy-one provinces, there are as many units. Each year, approximately eleven provinces should be mapped. For convenience of execution, provinces were subdivided into municipalities and often village chiefs assist in the location of municipal boundaries and aid in the location of traverse lines.

Daily traverses were planned by the field-party leaders three or four days ahead of the work of the mapping parties. The 1 : 50,000 maps were used where daily survey areas were to be established. The main corners for each survey area were located on the field by markers painted on trees or conspicuously painted wooden pegs one or two metres in height from the ground. These wooden markers were important points in checking the mapping work. A control error of about 1 per cent was allowed on the map, which was often checked daily by each party chief.

When the survey of a province was finished, the field sheet was sent to the cartographic section, where determination of the areas of different land-use types was made. Then the maps were reproduced in at least quadruplicate sheets. The chief of the land and forest evaluation survey wrote the report of the survey and presented it to the technical committee for examination and evaluation. When corrections had been made or errors had been found in the map, a resurvey was conducted by members of the technical committee, who went to the area in question for actual spot examination before the report and map were submitted to the junior committee. The latter, after further examination and consideration, sent the report to the senior committee. As soon as the senior committee approved the result of the survey of the whole province, at least one copy of the map was sent to the governor of the province concerned for immediate implementation.

Of the seventy-one provinces in Thailand, only sixty were surveyed, because in those provinces portions were still under forest cover. Physiographically, those provinces are generally hilly and mountainous. The flat lands are cultivated for rice and the marginal lands, which are generally on 1–3 per cent slopes, are used for the cultivations of corn, sorghum, fruits, cotton, kenaf, cassava, upland rice, sugar cane etc. In southern Thailand, rubber plantations are also generally located on lands of 1 to 3 per cent grade as well as on steep slopes of from 1 to 3 per cent grade with from loamy to clayey soils as well as various complexes of stony soils. Rubber trees sometimes have the characteristics of ordinary forest trees and hence are tolerated to exist similarly under forest conditions. The eleven provinces not surveyed are located either close or adjacent to Bangkok province and are within the Bangkok plain, where the topography is generally flat and the land used mostly for the cultivation of rice, fruit trees on raised plots, and a relatively small amount of vegetable gardening. The low, fairly well drained uplands are grown to fruits, corn, cotton, legumes and a few other crops.

Planting of upland crops by ordinary farmers using the shifting cultivation method created many problems for officials of the Royal Forestry Department, because many shifting cultivations were found on forest lands. Fortunately, police officers aid the forestry officers in enforcing the law governing agricultural and non-agricultural lands as delineated on the land resources map. It has not been easy for Thai farmers to understand the principles of forest and land conservation, but the Government has implemented measures to increase rice yields and other foot crops by the use of subsidized fertilizers, so that the farmers need not acquire more land to increase the amount of their produce to support their families.

The result of the six years' natural resources survey is shown in the table below. This shows that the sixty provinces actually surveyed have a total area of 31,464,100 hectares which are public lands; about 26,490,900 hectares have been delineated as forest lands. Within this forest land are small patches of rice lands as well as marginal cultivations between the rice areas and the surrounding forests. These small areas within the forest will never be allowed to expand once they have been legally defined as reserved forest areas. If farmers who do not have legal ownership infringe forest regulations, they are subject to warnings and/or eviction and are sent to properly authorized farm settlements. Farm settlements are part of the public lands where non-valuable timbers are found and the soils and slopes are suitable for the growing of crops.

The result of the survey indicated that 1,576,600 hectares were mapped for agricultural settlements from the surveyed areas. About 718,700 hectares are now under cultivation and the rest, about 857,000 hectares, are still under trees which are mostly of a non-valuable timber type.

A preliminary statement on the result of the survey of the natural resources of Thailand may be made as follows: from Thailand's total area of about 51,491,200 hectares, about 26,490,900 hectares or about 51 per cent is still under valuable timber.

Areas classifield under the survey of the natural resources of Thailand[a]

Year	Number of provinces surveyed	Area of provinces surveyed in hectares)	Privately owned land (in hectares)	Area actually surveyed (in hectares)	Forest land: Forest reserved area (in hectares)	Forest land: Cultivated land within forest reserved area (in hectares)	Farm settlements: Still under forest (in hectares)	Farm settlements: Land under cultivation (in hectares)
1961	8	7,502,000	4,373,700	3,128,300	2,473,800	593,800	44,600	16,100
1962	13	13,770,100	5,757,200	8,012,900	6,261,200	1,273,400	246,700	231,700
1963	9	10,812,100	1,873,800	8,938,300	8,231,200	367,000	175,500	164,700
1964	12	9,067,000	3,059,900	6,007,200	5,251,300	452,500	218,900	84,400
1965	8	4,450,900	1,374,000	3,076,900	2,641,100	207,200	158,600	70,000
1966	10	4,661,200	2,150,700	2,510,500	1,632,300	612,700	113,500	151,900
TOTAL	60	50,263,400	18,589,300	31,474,100	26,490,900	3,506,600	957,800	718,800

[a] Area of Thailand = 51,491,200 hectares.

AN INTEGRATED SURVEY AND MAPPING PLAN FOR THE REGIONAL DEVELOPMENT OF LAMPUNG

Paper presented by Indonesia[1]

INTRODUCTION

Population and economic pressures make it imperative that the earth's natural resources be efficiently explored, inventoried, developed and utilized. The operation of collecting information on the natural resources of an area for appraisal is the first step which logically must precede their actual utilization.

Lampung promises a new future for a great number of farmers from highly over-populated Java. The resettlement of Lampung started more than thirty years ago and, if it is carried out intensively, it will eventually reduce the population pressure on Java and provides a sources of labour for developing the region. According to information which has been collected from general surveys, Lampung has its potentials in minerals, timber, water-power and arable lands. More detailed surveys are required for further appraisals.

Komando Survey and Pemetaan Nasional (National Board for Technical Surveys and Maps), established on 7 September 1965 by Presidential Act No. 263, is responsible for co-ordinating thirty survey and mapping agencies

SURVEY AND MAPPING PLAN (1967–1969)

The province's administrative area is ±2,800,000 hectares. Its population, according to the 1965 census, is 1,973,228 persons.

Available maps of the province are more than twenty years old and must be revised. Furthermore, these maps are on small scales, which can be classified as following:

Type of maps	Scale	Number of sheets
General	1:250,000	4
Index	1:250,000	8
Topographic	1:100,000	40
General geological	1:200,000	10

The triangulation network covered only the mountainous western part (Barisan range), while the low eastern peneplain possesses a number of astronomic points. It is essential that the triangulation network should be extended to the lowland for the accurate topographic mapping of the region.

[1] The original text of this paper appeared as document E/CONF.52/L.125.

A survey/mapping plan has been devised according to the basic development plans of five directorates general and one branch of the army, as follows: Directorate General of Water Resources; Directorate General of Agriculture; Directorate General of Forestry; Directorate General of Rural Development; Directorate General of Resettlement and Agrarian Affairs; Army Resettlement Branch.

The final goals of the above-mentioned basic development plans are shown below.

River basin development

Growing requirement for water for irrigation, hydro-power and sanitary purposes require a sound plan in developing water resources.

Irrigation. The irrigated areas for rice-crops should be increased from 50,000 to 413,000 hectares. Present annual production is 354,820 tons, estimated annual production after the irrigation project is completed will be 2,642,300 tons.

Hydro-power. Three hydro-power projects for Way Sekampung, Way Umpu and Way Semangko will render a total of 310,000 kW. This estimate is based upon results of a joint survey conducted by the Directorate General of Water Resources and Nippon koei Ltd.

Sanitary water. The project dam of Sekampung will provide sanitary water for Tandjung Karang, Teluk Betung and Pandjang harbour.

Agriculture/Forestry

Dry arable lands which have been used for rice production can be used for perennial crops (pepper, coffee, rubber, palm oil etc.).

The forest logging project for 1967 includes an area of 65,000 hectares, with logs production of 100,000 m^3 round logs/year. Forest product industries depend on the availability of cheap power.

Resettlement projects

Present resettlement projects are based on agricultural activity. The extension of irrigated rice fields is hampered by the fact that the irrigation system is very limited.

Civilian resettlement projects for 1967–1969 cover a total area of 210,000 hectares. Army resettlement projects cover an area of 57,500 hectares.

Communication

At present roads are undergoing rehabilitation and repair. The Trans-Sumatra highway has been designed along the eastern slope of the Barisan range. This will be the main artery of land communication, connected with existing road networks with a system of feeder roads.

Geology/Mining

There are some indications that Sumatra Orgene and Lampung's Massif Cristalline have possibilities for the mining industry.

PLAN OF OPERATION 1967

Aerial photography

Total area to be photographed is 4,000,000 hectares, including those beyond the administrative boundary.

Topographic mapping

One million hectares will be sketch-mapped using the photogrammetric compilation method. This is a rush-programme for soil survey, land-use planning, forest inventory and geological survey. Sketch-map production will be at 1:25,000. The geodetic survey will be started in 1968.

Hydrographic survey

The hydrographic survey of the Way (river) Tulang Bawang, Way Seputih, Way Scmangko, Scmangko Bay and coastal waters near Pandjang will be completed during 1967 so that the possibilities of those rivers for inland waterways may be appraised and Pandjang upgraded as the main export harbour in Lampung Province.

United Nations technical assistance

Possibilities of obtaining United Nations technical assistance is being assessed by informal contacts with Mr. L. Mattson, the UNESCO representative, and Mr. Ahsan Uddin from FAO during their recent visits to Indonesia.

Assistance required will be in the form of supplies/materials for survey/mapping and in purchasing instruments.

Technical assistance which it is hoped to obtain from the United Nations Special Fund can be used for and summarized as follows:

	Amount (in $ US)
Photographic materials	38,850
Drafting materials	10,650
Mapping equipment	95,850
Spares for aircraft	48,330
Additional equipment for hydrographic survey	5,500
TOTAL	199,180

AGENDA ITEM 10*

Topical maps and national atlases

ATLAS OF TASMANIA

Paper presented by Australia[1]

With the tremendous expansion of scientific achievement over the past two decades, the acceleration of economic development has become a matter of considerable importance to all countries, particularly those of Asia and the Far East. In this regard the need for the expansion of basic topographic mapping was early recognized by the United Nations and such programmes were rapidly implemented in many countries and extended or revised in others.

Topographical maps are essential for the production of detailed topical maps, which include many subjects such as meteorology, geology, soils, hydrography, agriculture, population and transportation.

Topical maps are usually produced on relatively large scales to facilitate the study of particular regions, but it must soon become a matter of national concern that such detailed studies be condensed and presented in a more convenient form. This may be done by the use of maps alone or by using a combination of maps and descriptive text or commentaries. The latter may well be termed a "descriptive" atlas and it was considered that the use of this type of presentation would make possible a clear and reliable understanding of political, social and economic matters in regard to a country as a whole.

The Atlas of Tasmania may be thus classified and accordingly the observations below, which are based in particular upon this production, apply with equal validity to the planning and preparation of any similar publication.

Clearly a descriptive atlas is one which should have a fairly wide public appeal, be attractively produced, convenient and above all contain authoritative information presented in such a way that a free and unbiased interpretation of all relevant facts is readily obtainable.

Its editor and contributors must be carefully chosen and, in this regard, it will be noted that the editor of the atlas is a senior lecturer at the University of Tasmania and the majority of contributors are leading scholars. Such conditions, of course, impose upon an editor a very real responsibility to see that, while the commentaries are of interest to intelligent laymen, they remain essentially authoritative in content and may be used by government and other authorities for economic or educational purposes.

* An Indonesian paper, "Cartographic work in Indonesia 1964–1966", submitted under this item, is reproduced under agenda item 6 above.

[1] The original text of this paper, prepared by A. R. Love, Lands and Surveys Department, Tasmania, appeared as document E/CONF. 52/L.42.

Approval having been given to proceed with a publication of this type, preparation of a detailed assessment of cost of production must follow immediately, having due regard at all times to the limitation of available finance. In doing this, a number of factors have to be considered, such as: method of presentation of the contents; number of maps, type of map and number of colours to be used in printing them; number of diagrams and illustrations; quantity of textual matter; method of reproduction as a whole.

Having assessed these factors and given due consideration to the requirements of this type of publication, it was decided that a first-class sewn binding should be used and that the contents should follow the form of maps printed in several colours together with commentaries.

A special section of relatively large-scale topographic maps, complete with gazetteer, was to be included at the back of the atlas, thus providing the reader with a good topographic picture of the state and enabling him to identify places mentioned throughout the text. In addition to maps, a number of half-page photographs were to be included to illustrate certain physical and cultural characteristics of the country and, when necessary, each commentary was to be liberally illustrated by maps and diagrams.

In the compilation and presentation of the commentaries, it is most important that they should be arranged in such a way that a logical development of subject matter is achieved and also that the relative volume of material in each is carefully controlled to preserve a balanced presentation. Undoubtedly opinions will vary in regard to the relative importance of various subjects; nevertheless an editor must adopt firm principles in this regard and adhere strictly to them as naturally each contributor will expand upon his own theme if allowed to do so.

Probably the most significant feature of the atlas is the incorporation of each topical map as an integral part of its relevant commentary.

Generally in an atlas of this type all maps are bound together in a separate map section and it is necessary to keep referring back to a map from time to time. In the Atlas of Tasmania, this is not necessary and it will be found that the use of this method of presentation allows the reader to obtain information relative to his subject much more readily than would otherwise be the case.

The adoption of such a scheme, however, immediately posed a very real problem in regard to an economic method of reproduction. After studying the situation it was finally agreed that all textual matter would have to be printed by offset lithography instead of by the more conventional letterpress method. By doing this, the problem then resolved itself into a relatively simple one of page layout or imposition.

In planning the production of such an atlas entirely by lithography, the relationship of page layout to signature sheet size is of utmost importance. If sufficient care is taken, it may be found possible to arrange the disposition of commentaries and relevant maps in such a way that the coloured maps will be printed only on the first or second half of each signature sheet. Obviously if this can be achieved considerable savings in printing costs will result, as the halves without coloured maps will have to receive only one impression, the black.

Another important feature at this stage of planning is the number of pages to each signature sheet; the more pages, the more times the sheet will have to be folded. Consequently, the heavier the weight or thickness of paper, the fewer times a single sheet can be folded without causing some creasing of the pages.

It is therefore necessary to balance the weight or thickness of the paper against the binding of signatures of either a few or a number of pages. The more pages, the cheaper will be binding costs; on the other hand, in a publication of this kind, it is desirable that the pages should lie flat when the book is laid open upon a table. The fewer pages to a signature, the easier it will be to obtain this result.

Having due regard to all these factors and the limiting of pages to the size of 12 × 9 inches, it was decided to use Burnie offset quad crown 90-lb., a Tasmanian-made paper. It might have been desirable to use a slightly heavier paper, but, had this been done, difficulty would have been experienced in folding it satisfactorily.

The use of the quad crown sheets enabled eight pages to be printed on each half, which when folded gave sixteen pages to a signature.

An important feature in the economics of printing maps is the use of colour. Obviously, the more basic colours are used, the more expensive the ultimate production will be. It was necessary, therefore, to give very careful consideration to the selection of colours for every map. In maps such as geology and soils, standard colours are widely used in Australia for showing certain types and this tended to inhibit selection in these cases.

In order to facilitate selection of colours, a key chart was prepared which was printed in four basic colours apart from black, namely, red, blue, yellow and grey, of which 25 and 50 per cent tints were also used and numbered as follows:

1. 50 per cent yellow
2. 100 per cent yellow
3. 25 per cent red
4. 50 per cent red
5. 100 per cent red
6. 25 per cent blue
7. 50 per cent blue
8. 100 per cent blue
9. 50 per cent grey
10. 100 per cent grey

The inks used for colour key were:

Yellow—Collies balanced process yellow	535
Red—Collies balanced process magenta	315
Blue—Collies balanced process cyan	226
Grey—1 part process cyan, 2 parts black, 12 parts lakatine	226

In all, some sixty different colour panels were obtained, using only these four basic inks for printing. The chart was then used to select the required colours for each individual map, the number designating each panel showing what combinations were to be used in preparing the reproduction copies ready for the making of the printing plates. Thus panel No. 24, which is an orange, would be obtained by using No. 2, which is 100 per cent yellow, and No. 4, which is 50 per cent red.

By careful selection of colours from the colour key, it was possible to determine the minimum number of basic printing colours for each of the maps. Apart from map 11 and the 1:500,000 topographic maps at the end of the atlas, it was found that the majority of the topical maps could be printed using only four colours including black, but a minimum of five colours was essential in the case of map 4 (Geology), map 5 (Relief), map 6 (Soils), map 10 (Farming), and map 12 (Transport).

When a number of tints of different percentages are employed, care must be taken to see that the inclination of the stipple patterns does not cause interference and produce a moiré effect. Photomechanical proofs of map 5 (Relief) did in fact show this effect when one of the tints was printed over the hill shading. This was remedied by changing the inclination of the stipple pattern.

From the experience gained in the production of the Atlas of Tasmania, the remarks that follow may be worthy of note.

It is essential that the editor should have ample time to draw up detailed specifications covering the text and layout and also for the selection of suitable contributors. It will undoubtedly be found desirable to adopt a firm date for the submissions of commentaries, as adequate time is also essential for editing. This requirement will apply with equal force to the supply of data for the diagrams and topical maps. Experience has shown that authors tend to require more diagrams than originally estimated and their preparation can require a good deal of valuable drafting time.

It is worth noting that the majority of the full-colour maps show information which can be reasonably be expected to remain static or change only slowly over a period of, say, five years. Data which can be expected to alter fairly rapidly have been incorporated in black and white maps to simplify the job of revision.

Considerable statistical data are included in an atlas of this kind, but after a period of five years it will almost certainly be found that an appreciable proportion of these data will have lost their value and conclusions to be drawn therefrom may no longer be valid. It is essential, therefore, that the distribution of the atlas should be both wide and rapid if it is to realize its full potential.

The use of a two-colour press is desirable not only from the point of view of cost of production and problems of registration but also because a second colour could well be used in many diagrams. Owing to the very limited time available for the preparation of copy, advantage could not be taken of this in the Atlas of Tasmania, but it would undoubtedly have greatly enhanced the atlas.

In preparing diagrams which have heavy black lines, it is worth reducing the density of such lines by use of screens to avoid their showing through the paper.

The fullest use of every photomechanical aid available to the cartographer can be fully justified in a publication of this type. There can be no doubt, for instance, that the use of Photoact (photo-sensitized peel coat, cat. No. 453507, a product of Keuffel and Esser Co., Hoboken, N.J., United States), which is an expensive product in one sense, was completely justified. Not only did it make possible the compilation of complicated maps, such as geology, with relative ease and considerable speed, but its use also contributed in no small measure to the excellent registration obtained in the maps generally.

If planning and preparation is carefully carried out, such an atlas can be made to serve as a text book for the education of youth, thereby increasing the present and future potential of the country. In this alone justification could perhaps be found for its production, but the atlas also serves a wider purpose, informing the people as a whole of their national heritage and at the same time providing the basic data necessary for the attraction of capital investment which is so vital for the economic development of every country.

Annex I

ATLAS OF TASMANIA: STATISTICS

Number of copies: 10,000

Size: 12 × 9 inches.

Contents: 136 pages including 30 maps in colour and 106 diagrams in black and white, 77 of which incorporate maps. Also 16 half-page illustrations in black and white.

Paper: Burnie special offset quad crown 90 lb.

Signature sheets: Nine signature sheets were used, 8 pages being printed on each side for the first 8 sheets and 4 pages only on each side for the last sheet.

Binding: Sewn with fully bound covers. Winterbottom book cloth extra "S" design.

Dust jacket: Glastonbury Antique.

Printed: Roland Rekord two-colour press.

Production time: From appointment of editor to completion of fair drawings: 11 months; printing and binding: 5 months.

Production costs (in $A):

Planning and supervision	5,676.00
Draughting	12,610.00
Materials	1,466.00
Printing and binding	23,060.00
Total:	42,812.00

Number of colours used in printing maps: 4 colours—1, 2, 3, 7, 8, 9, 13, 14 and 15; 5 colours—4, 5, 6, 10 and 12; 6 colours—11 and 16 to 30.

Annex II

SAMPLE OF PAGE CONTENTS LAYOUT

Signature sheet A

i Title page
ii Date, printer, etc.
iii Foreword
iv Committee
v List of maps and figures
vi List of figures (cont.); list of plates
vii List of commentaries
viii Map 1. Position
1 Introduction
2 Weather and climate
3 Weather and climate
4 Map 2. Rainfall
5 Figure 6
6 Weather and climate
7 Weather and climate
8 Map 3. Temperature

Signature sheet B

9 Weather and climate
10 Weather and climate
11 Figure 13
12 Geology
13 Geology
14 Map 4. Geology
15 Geology
16 Geology
17 Geology
18 Map 5. Relief
19 Landforms
20 Landforms
21 Landforms
22 Landforms
23 Figure 23
24 Illustrations, explanatory notes
Illustrations

Signature sheet C

25 Explanatory notes—illustrations
26 Map 6. Soils
27 Soils
28 Soils
29 Soils
30 Vegetation
31 Map 7. Vegetation
32 Figure 26
33 Vegetation
34 Figure 28
35 Figure 28
36 Animals
37 Animals
38 Aboriginal population; Discovery and exploration
39 Discovery and exploration
40 Explanatory notes—illustrations
Illustrations

Signature sheet D

41 Explanatory notes—illustrations
42 Map 8. Land alienation
43 Land settlement
44 Land settlement
45 Land settlement
46 Population
47 Map 9. Population
48 Population
49 Population
50 Population
51 Population
52 Population
53 Service centres
54 Figure 53
55 Service centres
56 Explanatory notes—illustrations

Annex III

SAMPLE OF PAGE LAYOUT

Signature sheet	*First half*				*Second half*			
	(A1)				(A2)			
A	v	*Map* 2	1	*Map* 1	vii	2	3	vi
	iv	5	*Map* 3	i	ii	7	6	iii
	(B1)				(B2)			
B	13	20	17	16	15	*Map* 5	19	*Map* 4
	12	21	24	9	10	23	22	11

ANNEX III—*continued*

SAMPLE OF PAGE LAYOUT

Signature sheet	*First half*				*Second half*			
		(C1)				(C2)		
C	29	36	33	32	*Map* 7	34	35	30
	28	37	40	25	*Map* 6	39	38	27
		(D1)				(D2)		
D	45	52	49	48	*Map* 9	50	51	46
	44	53	56	41	*Map* 8	55	54	43
		(E1)				(E2)		
E	61	*Map* 11	65	64	63	66	67	62
	Map 10	69	72	57	58	71	70	59
		(F1)				(F2)		
F	77	84	81	*Map* 12	79	82	83	78
	76	85	88	73	74	87	86	75
		(G1)				(G1)		
G	93	100	97	*Map* 13	95	*Map* 14	*Map* 15	84
	92	101	104	89	90	103	102	91
		(H1)				(H2)		
H	*Map* 19	*Map* 26	*Map* 23	*Map* 22	*Map* 21	*Map* 24	*Map* 25	*Map* 20
	Map 18	*Map* 27	*Map* 30	*Map key*	*Map* 16	*Map* 29	*Map* 28	*Map* 17
		(I1)				(I2)		
I		125	124			123	126	
		128	121			122	127	

ATLAS OF AUSTRALIAN RESOURCES: AIMS, PLANNING AND PROGRESS

Paper presented by Australia[1]

Introduction

Work began on the atlas in 1951. The thirty map-sheets of the first edition were published in groups of five between 1953 and 1960. In 1961 it was decided to revise the atlas, a sheet at a time. Publication of each new sheet of this second series results in withdrawal of a sheet from the first series. Commonly the new sheet is a second edition but some new topics are being introduced (and old ones dropped) and some topics are being altered in scope by combination or division.

Five sheets of the second series have been published at the time of writing (November 1966), another five are in press or at advanced stages of preparation, and work has begun on another four.

The planning, compiling, designing and editing of this atlas has always been done by a small group of geographers in the Department of National Development, Canberra, with a supporting group of about the same number of cartographic draftsmen. For the first series, three geographers and four draftsmen spent most of their time on this task. Since commencement of the second series, the geographic staff of the Department of National Development has been increased to cope with other commitments but in effect the same number of people are involved in the preparation of the atlas. The Department's Division of National Mapping is now responsible for carrying out drafting, together with ancillary services (photography, plate-making, etc.).

Primary aims

The Atlas of Australian Resources is intended to provide a compact first reference to Australia's physical environment, economic activities and people. The map-sheets contain a great amount of information and, in addition, each is accompanied by a booklet, called a commentary, which is intended to sum up and interpret what its map-sheet shows as well as to add other relevant material.

The atlas has always been directed at a diversity of readers both in Australia and overseas—government administrators, businessmen, teachers, research workers and others who wish to learn about some aspect of Australia's resources or about various resources of some part of Australia.

To suit the varying requirements of such a wide range of readers, the map-sheets are available in three forms: folded once with a linen-strip mounting for insertion in the atlas loose-leaf binder; folded to the size of the commentaries for placing in atlas boxes; or as unfolded sheets. Prices are as low as they can be made and the map-sheets (with commentaries), loose-leaf binders and boxes may all be bought singly as well as in binder and boxed sets. Moreover, reduced prices are available to government agencies and educational bodies in Australia.

Complimentary copies go to various organizations throughout the world, including Australia's embassies and

[1] The original text of this paper, prepared by L. K. Hazlewood, Water Power and Geographic Branch, Department of National Development, Canberra, appeared as document E/CONF.52/L.71.

trade commissioner posts, selected libraries in Australia and overseas, and a number of mapping agencies with which there is a very useful system of map exchange.

The atlas is now being kept as up-to-date as practicable and its content is being gradually improved. Improvements embodied in the new sheets and their commentaries are of several kinds. More comprehensive and more exact information is available for many topics, as is readily apparent from a comparison of the first and second editions of "Soils" (1952, 1963), "Mineral Deposits" (1952, 1965) or "Geology" (1958, 1966). Secondly, the revisions of some sheets incorporate not only later information but also a more thorough and detailed analysis of that information than was attempted for the first edition, for example, the depiction of rural population on "Population Distribution and Growth" (1964) by uniform dots based on statistics for primary enumeration areas compared with the depiction of classed densities for rural local government areas (larger areas each composed of a number of primary enumeration areas) on "Population Density and Distribution" (1953). Finally, the assessment of the value of earlier maps and changes in major aspects of Australia's development should result in other improvements; an instance of both these aspects is the introduction of "Fish and Fisheries" (1965) into the second series of the atlas and the dropping of "Major Developmental Projects" (which, to be satisfactory, would require much more frequent revision than the programme allows).

The atlas is not intended to be a "planning atlas" nor a series of wall maps for teaching purposes, and it is far from being encyclopædic in scope. It has been correctly said by reviewers that it is utilitarian, which is further borne out by it predominantly descriptive approach; with only a few exceptions, mainly brief remarks in the commentaries, it provides little historical perspective.

The topographic base map and sheet layout

The standard map-sheet continues to consist of a single map of Australia at 1:6,000,000 on a sheet measuring 72 cm deep by 76 cm wide. For the first series, a polyconic map projection, formerly in common use for official maps of Australia, was used, but a specially devised simple conic projection with two standard parallels was adopted for the second series. The topographic base maps were completely revised at the same time and are being periodically brought up to date. Moreover, the base for a topic may be modified to suit its subject matter or to enhance clarity of presentation, for example by the addition or deletion of certain features or classes of features. Hence the names of many more capes, islands etc. than is usual are shown on "Fish and Fisheries" and railways were deleted from "Population Distribution and Growth" to enhance clarity of the fine detail shown.

Some topics involve a considerable diversity of data and do not require, or the available data do not properly permit, the locational precision that can be achieved on a map at 1:6,000,000. Several maps at smaller scales are then used. Hence base maps at 1:9,000,000 and 1:12,000,000 have been prepared for the second series from a selection of the material appearing on the new base at 1:6,000,000. The scales of these maps are simple ratios of 1:6,000,000 and they also have fully drawn graticules (like those of the 1:6,000,000 map). In planning such aspects of these maps, as well as in a number of other general changes made for the second series, valuable ideas were obtained from the handbook on national atlases prepared for the Commission on National Atlases of the International Geographical Union.

An innovation has been made for topics requiring as large a map scale as the sheet size readily permits and which concern things largely or wholly concentrated in the better watered, more populous areas of eastern and south-western Australia. This kind of layout consists of two re-centred sectional maps at 1:4,500,000 and a map of all Australia at 1:12,000,000. The latter map, besides showing the relative positions of the two sectional maps, can be used to present the remainder of the data and/or to present additional data on the topic. The sheets "Electricity" (1962) and "Population Distribution and Growth" (1964) are published instances, and "Forest Resources", second edition, will be another.

Because of this innovation and for other reasons, it is already clear that the completed second series of the Atlas of Australian Resources will comprise a smaller proportion of single maps of Australia at 1:6,000,000 than did the first series, which had twenty-five out of thirty such sheets. Nevertheless, most of the map-sheets dealing with aspects of the physical environment such as landforms, geology, surface water, underground water, soils and vegetation will be in this form, as will sheets on such topics as land use, mining and transport.

Selecting topics

One advantage of a thematic atlas such as the Atlas of Australian Resources, with its relatively small number of sheets and emphasis on presenting compactly only material of wide general interest, is the enforced careful weighing of the value of a topic in itself and as part of the atlas. Some topics are obvious necessities, and may be omitted only because of a great scarcity of data. Others need careful preliminary study, aided by discussions with outside experts, of the topic generally and of the more significant aspects of it which are suitable for depiction.

Especially in the case of statistically derived information, it is also often necessary to assess carefully the value of representation in map form. For example, a map which does no more than act as a locational framework for a few graphs representing aggregate amounts for very large and heterogeneous areas, such as the six states of Australia, is of no real value as a map, although there may be sound reasons in particular cases for including a small cartodiagram of this kind as a minor part of a map-sheet.

Map scale is also an important factor which may pose problems. Appropriate data for a topic may require only one map for its presentation, yet to depict the data in the best way available (for example, by point symbols such as uniform dots) at the scale that this implies for the Atlas of Australian Resources (1:6,000,000) may demand a degree of precision in plotting which cannot be attained.

Map-sheets covering the whole of Australia must often be based on data from a number of different agencies, such as state government departments, which collect the data on significantly different bases. A whole sheet may have to be severely modified or even abandoned because of deficiencies or even lack of data for one major area. (As the country is so large, it is beyond the capacity of a small group of geographers to remedy such deficiencies by even the most cursory field work.)

However, it is often remarkable how much can be achieved by patience and persistence in seeking out and piecing together published and unpublished data, whether in cartographic, photographic, numerical or textual form, or unrecorded and having to be obtained from persons with reliable and relevant experience. For example, a modification of the original map from which "Soils" (second edition) was drawn was the distinction made between ephemeral salt lakes (salinas) and other ephemeral lakes. Resorting mostly to examination of available photomosaics, the two categories were distinguished and the results independently confirmed. Another instance is the obtaining of data on privately managed forests and forest plantations for "Forest Resources" (second edition) (in preparation) by sending out letters to a number of private companies listed as owners in a trade directory. Thereby came information for the three eastern mainland states which could not more easily be obtained.

A valuable function of maps made in these circumstances may be to indicate what are literally gaps in knowledge as well as to sum up what is available. In a number of instances, others have been spurred to fill some of these gaps, or to use or develop on larger scale maps of smaller areas ideas which first appeared in the national atlas.

Again, some topics are of specific significance for Australia and others are not. Maps of race or language are of little value for Australia compared with some ECAFE countries; maps of underground water are of very much greater value for Australia than for many of the well-watered temperate countries of the world.

For an atlas with a ten-year replacement cycle, the data presented must not be unduly subject to rapid change. Hence "Major Developmental Projects", 1953, despite many past commendations, has been abandoned. An allied consideration is the differing rates at which maps may become obsolete, because of changes either in the things represented or in the state of knowledge of the topic. "Rainfall", for instance, is much more durable than was "Power and Fuel"; and "Mineral Deposits" (first edition), 1952, did not become obsolescent until the 1960s, when many important mineral deposits were discovered in rapid succession.

Cartographic treatment and design

It has already been said that cartographic devices which more fully exploit the peculiar capabilities of maps to symbolize spatial distributions are preferred, other things being equal, to those that are more in the nature of diagrams. Of course, other things are often not equal: the alternative choice at a given time may be that of having no map at all on an important topic. For example, "Agricultural Production", 1953, represents crop production by pie graphs showing imputed cash value at principal markets for forty-four large, arbitrary and mostly far from homogeneous areas. An indication of the relevant parts of each of these large statistical areas is given by the proportion of total land under crop in local statistical areas. On "Crop Production" (in preparation), using a broader grouping of crops (five compared with seventeen on the earlier map), similarly calculated cash values derived for some 500 relevant local statistical areas will be represented by a combination of uniform dots and proportional circles. These symbols will be placed within their small statistical areas with the help of a large and diverse amount of cartographic and other supplementary data.

A major issue in the preparation of many sheets for the Atlas of Australian Resources is the degree of complexity of representation to be attempted. For example, on "Mineral Deposits" (second edition), 1965, as on the first edition, all the mineral deposits represented are shown on the one map at 1:6,000,000. Colour and shape of symbol are very largely used to distinguish sixty-two different minerals, and symbol size distinguishes large from medium-sized and small deposits. The common alternative—to use several smaller scale maps with fewer commodities on each map is a simpler mode of presentation but would considerably reduce locational accuracy of statement and increase the difficulty of studying the spatial association of deposits of various minerals.

A related characteristic is the use of background material. For "Mineral Deposits" (second edition), two pale tints cover the land areas, indicating where metallic minerals of most kinds are likely to be found and where sedimentary minerals such as coal are likely. Likewise, the continental shelf of Australia is differentiated from the remaining sea areas, principally because of the significance of the shelf for petroleum exploration and discovery. Background material of this kind is explanatory of and supplementary to the main data depicted. A still simpler instance is the depiction of a few selected average annual isohyets on one of the four maps comprising "Croplands", to serve as a reminder of the dominant climatic control involved.

Visually similar in some instances is the use of quantitative symbols such as uniform dots to represent absolute quantities and subdued flat colours to represent classed ratios or the like. Commonly, the relationship expressed by the flat colours is a direct expression of what is already visually inherent in the map, such as density in the case of a map using uniform dots. Or some other quantitative relationship is shown which brings in other data: for example, rural population numbers in 1961 are shown on "Population Distribution and Growth" by uniform black dots, and flat colours show the rate of population change for the intercensus period 1954–1961.

In some cases the primary objective is to present absolute quantities, in others to represent ratios or other relationships, in still other cases both sets of data are judged to be of equal importance. In all cases the map contains built-in safeguards against forming mistaken interpretations of the relationships presented, for example, against attributing too much importance to large rates of change for small populations, or too little importance to the results of small rates of change for large populations.

The deliberate attempt made on most maps of the Atlas of Australian Resources to represent the more essential data more emphatically, and to represent the less essential or auxiliary material less obstrusively, is called by the editor the "multilevel impact".

With an increasing knowledge of the visual discrimination of symbols and colours by readers, a number of general principles in map design have gradually been formulated and applied. The symbols on "Population Distribution and Growth", 1964, which represent the populations of urban areas, for example, differ from those on "Population Density and Distribution", 1953, in several ways, quite apart from the use of variously coloured infills on the map to show rate of population change for the preceding intercensus period. Proportional squares are used instead of half-tone perspective drawings of proportional spheres; broader population size categories are used for the smaller symbols; and the larger symbols are accompanied by numerals expressing the populations represented. Another method used is a twofold variation between symbols to aid accurate discrimination; for example, in "Forest Resources" (in preparation), three sizes of symbols are to be used to represent three size classes of small plantations. Because the differences in size of symbol cannot (and should not) be markedly great, a second difference will also be used; the smallest symbols are shown in outline only, the medium sized ones also contain a central dot, and the largest ones are fully filled in.

Certain stylistic preferences have also gradually become established. The topographic base map has always been printed in one colour, but grey was adopted for the second series of the atlas in place of the sepia used for the first series. Fine percentage line or stipple screens are now usually used (133 lines per inch) and variations in colours for colour patches are obtained by darkening (by overprinting screens of the line grey used for the base) as well as by making colours paler by simple screening. Other variations for colour patches are often obtained by the use of easily visible negative patterns or overprinted patterns in another colour.

The derivation of colours for colour patches by overprinting two or three colours, for example, purple from red and blue, is currently used more sparingly than in many atlases. This is partly because of a preference for clear colours rather than for slightly darkened ones such as usually result from such subtractive colour-mixing. More important, however, are the difficulties of preparing hand-coloured drafts which are sufficiently realistic for design purposes and from which accurate predictions of screen percentages and the appearance of the printed map can be made. Hence also the pale blues used for sea areas, which have a marked influence on the general appearance of most map-sheets of the atlas, have usually been produced as full colours not used for any other purpose and likewise the pale yellows used as "neutral" land tints on many maps.

Some study has been made of systems of colour classification and theories of colour harmony, in particular the Ostwald system because of its degree of correspondence with printing techniques. However, no doctrinaire approach to colour harmony in map design has been adopted, although a number of simple principles have been confirmed and their application has, perhaps, become more deliberate than previously.

Conclusion

The place of the Atlas of Australian Resources in the mapping of Australia's physical, economic and human resources may be compared to the apex of a pyramid. As indicated in the paper on recent thematic mapping in Australia,[2] this is gradually becoming the case for such important topics as geology and soils, for which rapid advances in systematic coverage by field mapping are now taking place and more generalized maps at intermediate scales are also being produced. Progress is also being made in the production of regional thematic atlases or map series, such as the Atlas of Tasmania (1965) and the *Fitzroy Region, Queensland, Series* (see separate papers on these projects).[3]

The maps of the national resources atlas should thus, as its revision proceeds, become increasingly better based and should increasingly become in fact first references to comprehensive series and atlases of those larger scale thematic maps with the help of which Australia's development can be more soundly planned.

[2] See p. 401.

Annex

ATLAS OF AUSTRALIAN RESOURCES—CONTENTS (NOVEMBER 1966)

First series: 1952–1960

Physical features
Geology*
Mineral deposits (replaced)
Climatic regions
Temperatures
Rainfall
Drainage systems*
Conservation of surface water
Underground water*
Soils (replaced)
Vegetation regions
Dominant land use
Croplands
Agricultural production*
Distribution of stock
Forest resources*
Mineral industry
Power and fuel (replaced)
Manufacturing industries
Population density and distribution (replaced)
Population increase and decrease (1933–1947)*
Population increase and decrease (1947–1954)*
Immigration*
Railways
Roads and aerodromes*
Ports and shipping
Education facilities
Health services
State and local government areas
Major developmental projects (replaced)

Second series, 1962

Published:
Mineral deposits, 2nd edition
Soils, 2nd edition
Fish and fisheries
Electricity
Population distribution and growth

Unpublished:
Geology, 2nd edition
Surface water resources
Underground water, 2nd edition
Crop production
Sheep and wool
Forest resources, 2nd edition
Fuels
Immigration, 2nd edition
Roads and aerodromes, 2nd edition.

[3] See pp. 394 and 405.
* To be replaced by map in preparation.

REVIEW OF RECENT AUSTRALIAN THEMATIC MAPPING

Paper presented by Australia[1]

Introduction

Recent thematic mapping in Australia is described below under topic headings together with some general remarks on thematic atlases, as is done in a very summary and selective way in the general report on cartographic activities in Australia presented at this conference.[2]

Some of the maps mentioned were published before the last conference. The 250-page *Index to Australian Resources Maps: Supplement for 1960–1964* (1966), prepared by the Geographic Section of the Department of National Development, provides references to these maps as well as to maps published in the earlier part of the 1964–1967 inter-conference period.

As in many other countries, the rate of publication of thematic maps has been increasing rapidly. A striking indication of this fact is that the index for 1960–1964 is slightly longer than the index for the previous twenty years (see *Index to Australian Resources Maps of 1940–1959*, Canberra, Department of National Development, 1961).

Landforms

The landforms of large parts of northern Australia have now been studied and mapped at broad reconnaissance level for the surveys of the Division of Land Research, Commonwealth Scientific and Industrial Research Organization (CSIRO) (see annex 7 in the aforementioned general report on cartographic activities in Australia; also the section on land classification in the present paper). This material, in combination with soils and vegetation, is inherent in the land-system maps produced (mostly published at 1:1,000,000, or thereabouts), and all the more recent *Land Research Series* monographs also include geomorphic maps as such, usually at smaller scales.

The landforms of considerable areas have been broadly and descriptively mapped by geologists engaged in regional geological surveys. The main contribution has been by geologists of the Commonwealth Bureau of Mineral Resources in the 1960s, in the form of black-and-white maps, at about 1:1,000,000 to 1:1,500,000, in the explanatory notes accompanying 1:250,000 geological sheets (see the section on geology below).

In recent years, the number of university-level geographers specializing in geomorphology has increased significantly. Much more work on coastal geomorphology is being done; research workers in several universities and government authorities have recently decided to produce a geomorphic map of the Riverine Plain region of the Murray river system in New South Wales and Victoria; and a significant indicator of another line of research being actively pursued is the recent publication by the Royal Society of Tasmania of a *Glacial Map of Tasmania* at 1:250,000.

Geology

The national series of regional geological maps at 1:250,000 is being produced at an accelerating rate, mainly by the Bureau of Mineral Resources, Geology and Geophysics of the Department of National Development (see the conference paper, "Cartographic techniques in regional mineral exploration"[3] and annex 6 in the general report on Australia). The Geological Surveys of Western Australia and Queensland, which have collaborated with the Bureau of Mineral Resources in producing many of these sheets in their states, are now producing sheets in this series, as has always been the case with the South Australian Geological Survey. The Geological Survey of New South Wales has also been producing 1:250,000 sheets and Victoria has similar work in progress.

Production of standard geological sheets at 1:63,360 by most state geological surveys and by the Bureau of Mineral Resources (in the Northern Territory) has continued. Western Australia, however, is using the 1:50,000 scale and topographic sheet areas, and New South Wales has changed over to the 1:50,000 series.

A notable project in northern New South Wales is the publication by the University of New England, Armidale, of geological maps covering standard 1:63,360 sheet areas at 1:100,000; the first was issued in 1964 and seven have appeared so far.

A recent innovation has been the Bureau of Mineral Resources' sheets at 1:500,000, compiled from 1:250,000 field mapping and commonly comprising six to eight 1:250,000 sheets.

A further tier of geological maps between those already mentioned and maps of all Australia is provided by state maps, of which two new ones have been issued in the last three years, for Victoria (1964, at 1:1,000,000) and Western Australia (1966, at 1:2,500,000). In addition, a new geological map of Tasmania, at 1:1,800,000 has been published in the Atlas of Tasmania (1965); and the map-sheet, "Geology" (1966), in the *Fitzroy Region, Queensland, Resources Series*, is about to be published by the Department of National Development.

The four sheets of the Geological Map of the World (1:5,000,000), which together cover Australia and New Guinea (Australia and Oceania, sheets 6, 7, 11, 12), were published in 1966 by the Bureau of Mineral Resources, on behalf of the Commission for the Geological Map of the World. A second edition of the map-sheet "Geology" (1:6,000,000) is to be published by the Department of National Development in the Atlas of Australian Resources in early 1967.

A special feature on the reverse of the latter sheet is the set of index maps and references to regional geological maps published and in preparation at January 1965. Mapping progress by the Bureau of Mineral Resources since then can be seen from the index maps in the bureau's annual *Pictorial Index of Activities*, which also includes index maps on its geophysical, geochemical, hydrogeological and engineering surveys.

Climate

In the late 1940s, the Commonwealth Bureau of Meteorology began preparation of climatic surveys for each of the ninety-seven official regions set up by all states and in the

[1] The original text of this paper, prepared by the Geographic Section, Department of National Development, Canberra, appeared as document E/CONF.52/L.72.

[2] See above, under agenda item 6.

[3] See above, under agenda item 9 (*a*).

Northern Territory several years before. One-third of these surveys, mostly including a number of maps of at least one climatic element, have been completed and published, including two since 1964. To these should be added several studies of larger areas by the bureau and various other analyses, mostly those appearing in the *Land Research Series* of the Division of Land Research, CSIRO. The maps of climatic elements in the Atlas of Tasmania (1965) and the accompanying brief analysis of Tasmania's weather and climate constitute another recent contribution by the Bureau of Meteorology.

The *Land Research Series* monographs also include agroclimatic studies which, in recent years, have been improved with the aid of computer analysis. Similarly, the booklet accompanying the map-sheet "Climate" (1965, scale 1:1,000,000), in the *Fitzroy Region, Queensland, Resources Series* of the Department of National Development, begins with a general climatic survey and concludes with an agroclimatic study by the Division of Land Research (see conference paper, "Mapping the resources of the Fitzroy region, Queensland, Australia".[4]

The Bureau of Meteorology has recently published a revised set of sheet maps at 1:12,500,000 showing average monthly and yearly evaporation for Australia (1966), and a set of sheet maps (1964) at the same scale showing average monthly total radiation at the surface. The bureau also publishes each year an actual yearly rainfall map of Australia at 1:10,000,000, with actual monthly rainfall maps for the year on the reverse.

Soils

On the reverse of the map-sheet "Soils" (second edition), 1963, of the Atlas of Australian Resources, appears the most comprehensive guide ever published to soils mapping in Australia, in the form of index maps and brief references. Over 450 published and unpublished soils maps based on field survey are listed. Special mention is also made of the ten-sheet Atlas of Australian Soils, being prepared by the leading organization concerned with soil survey in Australia, the Division of Soils, CSIRO. This atlas, which uses a new classification of soils, is to be published in full by 1968—see the conference paper "Atlas of Australian soils".[4]

As with recent geological mapping, considerable numbers of soils maps are being produced at several levels of detail but generally not using the national topographic sheet areas. Most of these maps appear in the Division of Soils' *Soils and Land-Use Series* and *Soil Publications.*

The Division of Soils contributed to the *Victorian Year Book: 1964* (Melbourne, Australian Bureau of Census and Statistics, Victorian Office) a soil map of Victoria at 1:2,000,000 which is a somewhat simplified version of the Victorian parts of sheets 1 and 2 of the Atlas of Australian Soils and retains the new soils classification. In the Atlas of Tasmania (1965), however, the new soils map of Tasmania at 1:1,800,000, like the "Soils" (second edition) of the Atlas of Australian Resources, retains the Great Soil Group classification. In the map-sheet "Soils" (in preparation at 1:1,000,000), in the *Fitzroy Region, Queensland, Resources Series,* the soils boundaries shown are those to appear on sheet 4 of the Atlas of Australian Soils, but much of the nomenclature has been especially devised for this map.

[4] See below, p. 405.

Vegetation

As with geomorphic mapping, vegetation maps of one kind and another are produced by a number of organizations and individuals, at various levels of generalization, and not as part of a systematic scheme for eventually mapping all Australia.

A major contribution is being made by the state forest services to the mapping of areas of indigenous forest, as shown in the conference paper "The application of cartographic techniques to Australian forest development and management".[5]

As with landforms and soils, the vegetation of large areas, in northern Australia especially, has been studied and mapped at broad reconnaissance level for the land surveys of the Division of Land Research, CSIRO. This material is inherent in the maps of land systems produced for each area, and for some areas has also been published as smaller scale vegetation maps (as for the Leichhardt-Gilbert area of Queensland, 1964) or as maps of native pastures (as for the Alice Springs area of the Northern Territory, 1962).

Water resources

A notable recent hydrological map is "Surface Water Resources" (1965), at 1:1,000,000, the first topic to be published in the *Fitzroy Region, Queensland, Resources Series* of the Geographic Section, Department of National Development. Based largely on data obtained from the Queensland Irrigation and Water Supply Commission, its main contribution is the delineation of isopleths of run-off over the 100,000 square miles covered by the map (see conference paper "Mapping the resources of the Fitzroy Region, Queensland, Australia".[6] A map on underground water is also being prepared for the series.

The first map comprehensively depicting run-off for the whole of Australia in any detail will be "Surface Water Resources" (1:6,000,000), which is at an advanced stage of preparation for publication in the Atlas of Australian Resources (second series); see the conference paper "The mapping of surface water resources".[7]

In 1965, the map-sheet "Australia Underground Water" (1:5,000,000) was published as part of the Australian Water Resources Council's first review of the nation's water resources; see the conference paper "A map of underground water in Australia".[7] This map shows water quality by five salinity classes and whether the water is in unconsolidated rocks, porous rocks or fissured rocks. A version at 1:6,000,000 now being prepared for publication in the Atlas of Australian Resources will incorporate revisions provided by the contributors to the 1965 map, namely, state and Commonwealth water authorities and/or geological surveys.

Using an expansion of the methods of representation used for the above 1965 map of Australia and adding some information on mean stream flow, the Geological Survey of Queensland has begun preparation of a series of five hydrogeological maps which will cover nearly all of Queensland at 1:1,000,000.

The data on underground water being brought together and published in the explanatory notes of the 1:250,000 geological series and on the maps themselves are growing,

[5] See above, under agenda item 9 (*c*).

[6] See below, p. 405.

[7] See above, under agenda item 9 (*e*).

and in several states in particular detailed maps on underground water basins continue to be published.

LAND CLASSIFICATION

In the late 1940's CSIRO developed a method of classifying land in terms of land systems, a land system being an area or group of areas having a similar pattern of landforms, soils and vegetation. The results of the consequent broad reconnaissance surveys have been published in the *Land Research Series* and, with the exception of the Hunter valley of central New South Wales, are all in northern Australia and Papua-New Guinea (see annex 7 in the general report on cartographic activities in Australia and the conference paper "Application of cartographic techniques to the regional survey in Australia").[8]

Most of the maps of land systems made by CSIRO for the more sparsely settled areas of Australia have been published at 1:1,000,000 or thereabouts. In Victoria, the Soil Conservation Authority is also preparing maps of this type, usually at about 1:250,000; these maps, which show finer subdivisions in some cases, are published in detailed monographs.

LAND USE

In recent years, with only a few exceptions, there has been little land-use mapping based on field work or compiled directly from field knowledge. The main exceptions are maps prepared for the Hunter valley of east central New South Wales by the Hunter Valley Research Foundation (a non-government organization), and various maps of urban land use mostly made by university geographers. In consequence, there are few recent maps comparable with those produced in the late 1940s and 1950s in Tasmania, Victoria, New South Wales and Queensland.

A new map of Tasmania showing types of farming (1:1,800,000) appeared in the Atlas of Tasmania (1965). The South Australian Department of Lands continues to revise and issue in its annual reports the map of South Australia showing the principal land utilization zones (40 miles to 1 inch).

PRIMARY INDUSTRIES

Agriculture (crops and livestock)

Few significant maps on agricultural activities have appeared in the last few years.

In 1964, the Commonwealth Bureau of Census and Statistics issued seven three-colour maps at 200 miles to 1 inch (1:12,672,000) showing by uniform dots the distribution in 1962–1963 of the acreage sown to wheat, oats and barley for grain and the number of beef cattle, dairy cattle, sheep and pigs. These maps (except that for pigs) also appeared as black-and-white reductions in the *Commonwealth Yearbook*. The bureau's Victorian office published in that state's yearbook for 1964 four detailed black-and-white dot maps of Victoria also showing beef cattle, dairy cattle, sheep and pigs. The map of farming types in the Atlas of Tasmania (1965), at 1:1,800,000, is accompanied by nearly thirty black-and-white dot maps at smaller scales on crops and livestock.

The first two agricultural map-sheets for the second series of the Atlas of Australian Resources are now in preparation. One will show crop production at 1:6,000,000 by imputed gross values, together with storage facilities and exports; the other will deal with sheep distribution and breeds, wool production, lambing rates and marketing. The Geographic Section of the Department of National Development has also recently finished compiling the Australian map contribution for the World Atlas of Agriculture being published under the aegis of the International Association of Agricultural Economists.

Minerals and mining

Most maps on minerals are simple locality maps, and few are specifically concerned with one or more aspects of mining. "Mineral Deposits" (second edition 1965), of the Atlas of Australian Resources, is an exception: it shows at 1:6,000,000 some 1,250 deposits of sixty minerals in terms of mineral groups (major metals, fuels, etc.), economic importance in Australia during 1952–1963 and size of deposit. It also distinguishes deposits producing in 1962–1963 from those productive only before that period or never productive. The sheet "Minerals and Mining" (in preparation, four maps at 1:2,000,000), of the *Fitzroy Region, Queensland, Resources Series*, is briefly described in the conference paper "Mapping the resources of the Fitzroy Region, Queensland, Australia". The Commonwealth Bureau of Mineral Resources is preparing a metallogenic map of Australia for the Commission for the Geological Map of the World.

Forestry

Many forestry administrative maps are produced by the state forest services, the New South Wales Forestry Commission's forest fire map series at 1:50,000, using standard topographic sheet edges, being an example.

At smaller scales, the Queensland Department of Forestry has issued a new edition of its map on south-east Queensland showing areas under forestry control (1964), at 10 miles to 1 inch or 1:633,600; the New South Wales Forestry Commission has issued a new map of the state at about 22½ miles to 1 inch (1966) showing similar data, and the Forests Department of Western Australia has issued a map on Western Australia: forest areas of the south-west (1965), at 10 miles to 1 inch). These maps show Crown forestry reserves of various kinds and forestry administrative areas.

The Commonwealth Forestry and Timber Bureau, of the Department of National Development, has issued a similar map for all Australia at 1:6,000,000 (1964). Finally, in the Department's Geographic Section, a second edition of the map-sheet "Forest Resources" has been compiled, for issue in the Atlas of Australian Resources; see the conference paper "Atlas of Australian Resources—aims, planning and progress".[9]

TRANSPORT AND PUBLIC UTILITIES

Most of the central road authorities of the states publish in their annual reports relatively small-scale maps showing their main roads by the various categories used and also by road surface; the National Association of Australian State Roads Authorities publishes annually a black and white map of all Australia showing the surfaces of main roads. Various other thematic maps on roads appear from time to time, such as the publication every few years by the New South Wales Department of Main Roads of sets of maps showing traffic flows. A second edition of "Roads and Aerodromes", of the Atlas of Australian

[8] See above, under agenda item 9 (*b*).

[9] See p. 397 above.

Resources is about to go to press; this map-sheet shows Australia's principal roads by their official classification and surface, as well as depicting aerodromes classified in a broad functional way.

In its annual reports, the Commonwealth Department of Civil Aviation has for some years past included small-scale maps showing aerodromes, air routes, operators and air navigation aids.

The main small-scale map on railways is that published annually by Commonwealth Railways showing at 1:6,000,000 the routes and gauges of Australia's railway lines.

A significant development in the past few years is the publication by several university geographers of studies on rail freight movements and on port hinterlands in New South Wales and Victoria.

A considerable range of maps appears on various public utilities such as metropolitan water supply authorities. The most notable are the maps of electricity generating stations and power lines appearing in the annual reports of the state central electricity authorities and the Snowy Mountains Hydro-Electric Authority. Many of these maps also appear in the annual *Statistics of the Electricity Supply Industry in Australia*.

In 1966, the Geographic Section of the Department of National Development prepared the contribution on Australia for the regional energy map being prepared for publication by the Electric Power Section of ECAFE (proposed scale: 1:5,000,000). The material supplied largely comprises a revision of the relevant data on the map-sheet "Electricity", 1962, of the Atlas of Australian Resources (second series).

Population

A major map to appear on population distribution in Australia is the sheet "Population Distribution and Growth", 1964, of the Atlas of Australian Resources (second series). Two special features of this sheet, which is based on the 1961 census, are the depiction of full-blood Aborigines and, on the reverse, maps at 1:250,000 of the five most populous statistical metropolitan areas (see the conference paper "Atlas of Australian Resources—aims, planning and progress"). The Commonwealth Bureau of Census and Statistics has published maps of each state showing population numbers in urban areas and densities in rural local government areas.

In the *Fitzroy Region, Queensland, Resources Series* the map sheet "Population and Selected Services", 1966, shows a map of population distribution at 1:2,000,000 which, like the national map but with greater detail, is based on unpublished 1961 census statistics and maps for primary enumeration areas.

Thematic and other atlases

Most of the atlases or equivalent series of maps mentioned below are dealt with in conference papers. The progressive revision of Australia's national atlas, the Atlas of Australian Resources (Canberra, Department of National Development) is covered by the paper, "Atlas of Australian Resources—aims, planning and progress". Since preparation of the second series of this loose-leaf atlas began in 1962, five new sheets with booklet commentaries have been published, five titles are printed or at advanced stages of preparation, and work has begun on another four.

Technical aspects of the production of the Atlas of Tasmania (Hobart, Lands and Surveys Department, 1965) are described in the conference paper, "Atlas of Tasmania".[10] Edited by a senior geographer of the University of Tasmania, the outcome is a 130-page bound volume of high quality.

The serial, *Fitzroy Region, Queensland, Resources Series* (Canberra, Department of National Development, 1965–), of which four titles had been published by the end of 1966, is a recent development in Australian thematic mapping (see the conference paper, "Mapping the resources of the Fitzroy Region, Queensland"). It is to be followed by similar series for other large areas in north Queensland.

Planning of a loose-leaf Atlas of Resources of New South Wales, to be published by the Department of Decentralization and Development, Sydney, has been in progress for some time, and the first sheets are now in press. A senior geographer of the University of Sydney has been collaborating in this work. An unusual feature of this atlas is that a larger scale version of the map-sheets will be available for schools and other institutions.

The single-theme serial Atlas of Australian Soils has already been mentioned, as also the Australian contributions to the Geological Map of the World and the World Atlas of Agriculture.

Conclusion

In Australia, thematic maps are being produced by many organizations, on a wide range of topics, at many different scales and levels of detail, and in a variety of styles. A feature of the recent rapid increase in thematic maps is the growing emphasis on basic physical resources.

Increasingly, maps recording information from field surveys and photo-interpretation are being based on one or other of the national topographic series. Their preparation is being made easier by the recent rapid progress in topographic mapping, especially in the production of planimetric sheets at 1:250,000 and now also of the new 1:100,000 contoured maps and lithographed photomaps.

Maps of larger areas, apart from those of the entire country, are mostly those of a whole state. However, recent maps include further land system maps at 1:1,000,000, geological maps at 1:500,000, a series of soils maps at 1:2,000,000, and a thematic series (mainly at 1:1,000,000) of a Queensland region.

Maps of Australia have been produced on various topics. Increasingly, they are becoming small-scale summaries of a body of detailed, larger scale maps. This is particularly true of the maps of the Atlas of Australian Resources so that, among other uses, this series may be used as a guide to the status of Australian thematic mapping.

This review has shown that, although very worth-while progress has been made, a great deal of further work will be required before Australia has an adequate coverage of thematic maps.

[10] See above.

MAPPING THE RESOURCES OF THE FITZROY REGION, QUEENSLAND

Paper presented by Australia[1]

INTRODUCTION

In 1962, the Commonwealth Department of National Development began producing a series of maps under the title *Fitzroy Region, Queensland, Resources Series.* The purpose of this thematic series, which was requested by the Queensland State Government, is to summarize in maps and supplementary booklets the known resources of a region of nearly 100,000 square miles (260,000 km^2).

The production of the series is being undertaken by the Geographic Section of the Department's Water, Power and Geographic Branch (formerly the Resources Information and Development Branch). The Geographic Section has already had considerable experience of small-scale thematic mapping in producing the Atlas of Australian Resources. In producing the Fitzroy series, it is being assisted by many persons and organizations. In particular, there are the contributors of data, ranging from those who supply a single fact to those who provide a draft map and a text to accompany it. The Department's Division of National Mapping is carrying out drafting and providing ancillary services such as photography and plate-making. The Commonwealth Government Printer is printing the series.

The Fitzroy region was chosen as the subject of a resources map series because it was recognized as having a large potential for development. Although the region's population total is still small—only 169,000 in mid-1966—it increased by 12 per cent between 1961 and 1966. Apart from limited areas producing high-value crops (in particular the sugar-cane areas near Mackay) most of the region is used for grazing cattle and, to a lesser extent, sheep. The region includes some little used areas carrying a dense cover of brigalow (an acacia growing to heights of 40 to 80 ft) and having generally good soils capable of supporting pastures and, where moisture is adequate, grain crops such as wheat and sorghum. Rural production is being expanded by extensive clearing of brigalow, followed by the establishment of sown pastures and crops. The region's resources also include steaming and coking coal in enormous deposits, some of which are now being developed for export. The coal deposits also offer opportunities for increasing the production of electricity and establishing manufacturing industries.

Very few thematic maps had previously been made of the Fitzroy region or any part of it. Basically the task of producing the series was to collect all available information—that is, statistical and descriptive material as well as cartographic—analyse it, select the more important items, and design and produce maps to present them.

PRELIMINARY SURVEY OF DATA

Before making firm plans for the series, it was necessary to survey the data available. As an aid to recording these preliminary findings, a provisional base map was prepared and printed. The area included was made somewhat larger than that likely to be adopted finally. To avoid a special compilation, the relevent portions of four adjoining sheets of the 1:1,000,000 World Aeronautical Chart (ICAO series) were used for this purpose. Most of the normal topographic detail was retained and local government boundaries were added. This proved to be a simple and reasonably satisfactory way of preparing a base map for immediate use and thus deferred the need for a final base map until the requirements were more fully known.

Using this provisional base, overlays were prepared to show the coverage and nature of existing cartographic material. Information recorded included topographic maps, their scales, dates and whether contoured or not; cadastral maps, with scales and dates; airphotos and photomaps; thematic maps prepared from field surveys, which were mainly relatively large-scale maps of geology, soils and land use; and various office-compiled maps of parts of the area.

Copies of the provisional base were used to record readily available information about a number of topics, including transport routes, town populations and facilities, mining, rural production and manufacturing industries.

References to relevant publications were also prepared and the more important ones studied and summarized. The advice of persons familiar with the area was sought, particularly on such largely undocumented aspects as the spheres of influence of the principal towns.

PLANNING THE SERIES

Before proceeding further, the compilers were faced with a number of choices, most of them interrelated. The more important were:

Precisely what area should be mapped?
What scales should be used?
What format and general style should be adopted?
What topics should be included?

From the preliminary survey of data and discussions with Queensland government authorities, it was apparent that attention should be given principally to the Fitzroy river basin, in area about 55,000 square miles (140,000 km^2), which contains most of the undeveloped brigalow lands and coal reserves as well as having very considerable surface water resources. However, by itself the basin would not make a satisfactory region for a thematic map series. Along much of its length the basin's boundary is easily crossed; in particular, there are important transport routes to the east and south, and strong economic, administrative and social ties between the basin and neighbouring areas, especially along the coast. Similarly, the country to the north-west (part of the southern portion of the Burdekin river basin) appears to have fairly close ties with the Fitzroy basin and its neighbouring coastal areas.

These were some of the considerations that led to the adoption of a land area of approximately 100,000 square miles as the Fitzroy region for the purposes of this map series.

The other main factor considered was sheet size, which, obviously, was affected by map scale. In turn, the choice of map scale was influenced by assessments of the amount of detail to be shown about particular topics. A scale of 1:1,000,000 was adopted, but with provision for some sheets to carry four maps at 1:2,000,000. The scale of 1:1,000,000 gave a map of 24 by 20½ inches (61 by 52 cm)

[1] The original text of this paper, prepared by the Geographic Section, Department of National Development, Canberra, appeared as document E/CONF.52/L.73.

on a sheet of 30 by 22 inches, after allowing for margins and legend. General appearance and economy in plate-making and printing were also considered in the choice of sheet dimensions.

From the outset it was proposed to prepare a booklet to accompany each map-sheet. The main purpose of the booklet would be to supplement the information given on the map-sheet with text, statistics, diagrams, small maps and, if necessary, photographs. In part this provides for interpretation of the maps, but in addition it allows for the inclusion of data not conveniently shown on the maps.

It was decided to publish each map-sheet in a light-weight folder, together with its booklet. Initially ten map-sheets were envisaged but, as the project proceeded, two topics were subdivided, giving a total of twelve map-sheets in all. The choice of topics is not explained here, as it is closely related to the particular characteristics of the region. Reasons for some of them will be apparent from discussion that follows.

The maps are intended mainly for detailed examination (not as wall maps). Their preparation has involved the design of appropriate symbols and fairly liberal, but carefully planned, use of colour. Mostly these matters of general style were agreed upon in the early stages of the project, but some modifications have been necessary to handle particular topics.

Map preparation and content

As previously mentioned, the Geographic Section of the Department of National Development is responsible for the production of the series. The task is shared by three geographers under the direction of a geographer who is also the editor of the Atlas of Australian Resources. This group collects and analyses the information, designs the presentation and in many cases carries out the initial map compilation. It also edits and sometimes supplements the material for the booklets and supervises the final production of the map-sheets and booklets.

It was always intended that the series should be office-compiled, mainly using existing records of one sort or another. There were reports, statistics and maps published by Commonwealth, state and local government authorities and by private organizations. Furthermore, much useful information was known to be in unpublished records, particularly those of Queensland government departments; and it was expected that various experts would have useful unrecorded information.

This dependence on office compilation is closely related to the size of the area and the level of detail being attempted. Clearly it would have been well beyond the capacity of the small group of geographers engaged in the production of the series to attempt also to carry out field work on a wide variety of topics over an area of 100,000 square miles. Some field knowledge of the region was desirable, although in practice this has been mainly second-hand through contact with field specialists of various kinds.

At the time of planning the series, a number of organizations were engaged in or planning field work in the region. Valuable contributions of field data (much of it in advance of publication) have since been made by geologists, soil scientists, geomorphologists, ecologists, hydrologists, climatologists and others.

Final base maps

Even before the provisional base map was completed, work started on the final base map at 1:1,000,000. The area was then far from fully covered by up-to-date and sufficiently detailed topographic maps and therefore the task involved compilation from many sources. Fortunately, it was possible to reduce the extra work by compiling concurrently data on streams, roads, population, etc. Thus the final base (printed in grey on most maps) consists mainly of a selection of data from the more detailed compilations on specific topics. The 1:2,000,000 base map and the smaller scale bases used on some map-sheets and in several of the booklets were compiled from the 1:1,000,000 base.

Landforms (compiled)

As contoured maps are available for only a very small proportion of the region, this map was derived mainly from other sources, especially aerial photographs. Slope classes were compiled from a stereoscopic study of aerial photographs at an approximate scale of 1:80,000. A limited form of control of the photo-interpretation was attempted using the few 1:63,360 and 1:31,680 contoured maps available. Other components of this map are major landform zones and spot heights. There are also on the same sheet two small-scale maps, one dealing with terrain types at 1:3,000,000 and the other (at 1:4,000,000) showing elevation by formlines based mainly on spot heights compiled from all available sources. Most of the information on the major landform zones and terrain types was contributed by a geomorphologist of the Division of Land Research, Commonwealth Scientific and Industrial Research Organization (CSIRO), and is partly an interpretation of data obtained during recent land classification surveys in the region.

Geology (printed)

This map is a special case in that, for the most part, it presents a summarized version of more detailed work. Nearly the entire region has been mapped at 1:250,000, much of it very recently and as part of the assistance being given by Governments to the search for oil and other minerals.

The 1:1,000,000 map sheet was especially compiled for the series by a geologist of the Commonwealth Bureau of Mineral Resources with extensive field experience in the region. With its booklet, it will give the reader a broad appreciation of the region's major structures, formations and geological history. It thus serves as an introduction to the more detailed work, published mainly by the Bureau of Mineral Resources and the Geological Survey of Queensland.

The geological information has also been a valuable source of data for other topics, particularly landforms, soils, minerals and underground water.

Minerals and mining (compiled)

Largely because of the wide range of data to be shown, this map-sheet will consist of four maps at 1:2,000,000, dealing with coal and oil shale, petroleum and natural gas, minerals other than fuels and mineral production. The first three will show reserves in broad terms and give supplementary data on such aspects as the extent of coal measures.

The information for this map-sheet was assembled mainly from the geological and mining literature. Specialist advice was obtained on such matters as the current significance of earlier assessments of reserves.

Soils (final drawing in progress)

Like "Geology", this map-sheet was compiled by specialists—in this instance by two CSIRO soil scientists with extensive field experience in the region. However, the proportion of the region covered by soil surveys is still quite small. The mapping units used are soil patterns delineated on the basis of associated landscape by air photograph interpretation correlated with extensive field traverses, and depending in part on data available from other surveys. In all, 430 mapping categories are shown on the map and dealt with in the booklet, and these are grouped on the map-sheet into thirty-six classes, each distinguished by a distinctive colour and/or pattern.

Climate (published)

In addition to presenting data on rainfall, temperatures, evaporation and wind, this map-sheet gives details of the recording stations and their records.

Rainfall, for example, is shown by average annual isohyets, supplemented by selected point values and histograms showing monthly and annual variability. Information shown about rainfall recording stations comprises location, authority responsible for the records, type and frequency of recording and length of records.

The accompanying booklet contains a general description of the climate, supplemented by statistical tables and small one-colour maps, together with a contribution dealing with climate in relation to pasture and crop growth.

The main contributor was the Commonwealth Bureau of Meteorology, but material came from a number of other sources, especially the Irrigation and Water Supply Commission of Queensland and the CSIRO Division of Land Research.

Surface water (published)

Like "Climate", this map-sheet presents data about measuring installations (stream-gauging stations) as well as summarizing the results of gauging for the thirty-five years, 1926–1960. The information on water resources includes isopleths of average annual run-off derived mainly from average annual isohyets, using relationships between recorded rainfall and run-off. Histograms indicate the high variability of monthly and annual run-off of streams of this region.

Another interesting aspect of this map is that the selection of streams was based on estimates of size in terms of "stream order" determined from large-scale maps and photomaps.

Underground water (being compiled)

This topic is dealt with in four maps at 1:2,000,000, thus allowing presentation of information on a number of aspects—principally, water quality and yields and the depths and density of bores. The region is of interest because water occurs in a variety of rocks and because it includes portions of the Great Artesian Basin and several areas of high-yielding alluvium.

Information about water quality and yield is generally not available in detail outside areas with a high density of bores. As with the map, Australia: Underground Water (see the conference paper "A map of underground water in Australia"[2]), geological information is being used to extend the limited data available from bore records.

[2] See above, under agenda item 9 (*e*).

Land tenure (final drawing in progress)

This map will present at 1:1,000,000 data provided by the Queensland Department of Lands on cadastral maps at 2 or 4 miles to 1 inch. By the use of colour and the grouping of closely similar types of tenure into a total of eighteen classes, the map will show very clearly the region's tenure pattern.

Rural production (being compiled)

This sheet will consist of four maps at 1:2,000,000 dealing with land cover, crops, livestock and land capability respectively. At present only the first two are compiled.

Land cover has been plotted from photomaps at 1:63,360 prepared from aerial photography of the early 1960s. This material permitted classification into several broad categories.

The most significant aspect of crop production is the recent increase in area under crop, although the total area is still only a small percentage of the region. This increase for each local government area will be shown by graphs prepared from statistics of areas under the major crops over a period of nine years.

The unit areas for published livestock statistics (local government areas) are too large for mapping at 1:2,000,000. An attempt is being made to represent livestock distribution by dots plotted with the aid of unpublished statistics and ancillary information such as slopes, land cover and tenure.

Population and selected services (published)

This sheet also comprises four maps at 1:2,000,000.

Population numbers in cities and towns are shown by proportional squares and in rural areas by uniform dots. As mentioned in the introduction, the total population of the region is still less than 170,000. Nevertheless, unpublished census statistics and maps and other information were needed as aids to plotting.

Information on services covers education, health, electricity, gas and town water supply and sewerage. This information is presented by a variety of line and point symbols.

Roads and aerodromes (published)

Railways and ports (printed)

Two map-sheets were required to deal with transport, largely because roads closely parallel many of the railway routes.

Even for a relatively simple topic such as roads it was necessary to assemble data from many sources. The Queensland Department of Main Roads supplied details of the routes and types of surface of highways, main roads, developmental roads and secondary roads, and especially obtained from the thirty-five local government bodies similar information about local roads.

"Railways and Ports" shows the routes of railway lines (including the new Moura-Gladstone coal line), station and port facilities, and generalized bathymetric contours.

Both maps also give some information on limiting factors in the transport network, such as sections of road that may be impassable after rain and sections of line liable to flooding.

Conclusion

By the end of 1966, maps and accompanying booklets on four topics had been published, a further two maps had been printed and the preparation of the remainder was well advanced. As yet it would be premature to attempt an assessment of the success of the series, but comments received on its usefulness are very encouraging.

The series will provide an index to known resources data by bringing together information from many sources and presenting it in a form that can be consulted conveniently. It may also draw attention to gaps in knowledge.

Although of limited value for the detailed planning necessary in developmental projects, the series will present a wide range of information of value in the preliminary stages of planning. In particular it will offer research workers and planners and administrators in public and private spheres an understanding of the regional context in which to consider projects and possibilities. Thus, by highlighting possibilities and needs, the series should provide such people with a guide for determining priorities for more detailed investigation.

ATLAS OF AUSTRALIAN SOILS

Paper presented by Australia[1]

Introduction

The aim of the atlas is to portray the distribution of soils over the Australian continent. The atlas consists of ten individual soil maps, each of which is accompanied by a separate booklet. At the time of writing, three maps and their booklets have been published; five maps are in various stages of preparation; field work is progressing on one map, while field work for the final map will be commenced during 1967.

The project was conceived in the Division of Soils of the Commonwealth Scientific and Industrial Research Organization (CSIRO) during 1956. After preliminary investigations were made into the classification of soils and the means of mapping soils at the continental level, field work was started in earnest during 1959.

At the outset it was agreed that the atlas should be published at a scale of $1:2 \times 10^6$, which meant that final compilation of the soil data would have to be made at a scale of $1:1 \times 10^6$ in the divisional offices prior to final drafting. Previous soil maps of Australia that had been prepared at scales ranging from $1:19 \times 10^6$ to $1:5 \times 10^6$ were found to be inadequate for all but the most general considerations.

Two complementary series of maps, namely, the Australian Geographical Series (AGS) and the World Aeronautical Chart (ICAO) maps, both at a scale of $1:1 \times 10^6$, provided a uniform map coverage for Australia. The Australian continent was divided into nine more or less equal parts on the basis of these maps, leaving as a tenth portion the vast arid heart of the continent. In area, this portion is in fact about equal to four of the peripheral portions. These ten portions, shown in figure I, became the ten sheets of the Atlas of Australian Soils.

The two map series chosen as base maps had been compiled and drawn by the Division of National Mapping, Department of National Development, Canberra, which was approached, therefore, to undertake final drafting of the soil maps for the atlas. Printing of the soil maps and the accompanying booklets was to be handled by the Publications Section of CSIRO. When the first sheet of the atlas was ready for drafting early in 1960, discussions were held in the offices of the Division of National Mapping in Canberra to lay down general procedures for drafting and publication. These resulted in the continued co-operation of the Division of National Mapping, Department of National Development, and the CSIRO Publications Section with the CSIRO Division of Soils. Later the Melbourne University Press was approached to undertake the distribution and sale of the atlas maps as they became available.

The various procedures involved in the compilation of individual maps of the soils atlas will be discussed below.

Nature of a soil map

The distinctive character of a soil map is simply that it shows the kinds of soils present in an area and their distribution over that area. The soil distribution must be shown in relation to natural features, such as rivers, and to fairly permanent man-made features, such as surveyed roads, so that the users of the map may accurately obtain position for their purposes. This means that the soil map must have a sound geographical-*cum*-cadastral background over which the boundaries of the soil units can be drawn. The problems concerned with the production of a soil map are therefore those associated with the superimposition of one set of data over existing data. As stated, the Australian Geographical Series of maps has been used to provide the necessary background data for the individual maps of the Atlas of Australian Soils.

The more successful and most readily usable soil maps are those that show soil data in colour against a neutral (grey) geographic-*cum*-cadastral background. An integral part of the soil map is its legend, the colour blocks of which must faithfully correspond to the colours on the map.

Basic requirements

Perhaps the two most important prerequisites for the production of a soil map are, first a standard means of classifying soils accurately and consistently as soils (soils are sometimes classified as products of former or present environments), and secondly a standard method of mapping, that is, of delineating the boundaries between areas of different soils. Existing soil classifications such as the Great Soil Group were judged to be unsatisfactory because they did not provide for the range of soils known to exist, nor was their definition sufficiently precise to permit consistent recognition of the classification units. Existing methods of mapping soils over continental areas were inadequate because they relied too heavily on hypotheses relating soil distribution to environmental factors, especially climate.

[1] The original text of this paper, prepared by K. H. Northcote, Principal Research Scientist, Soil Survey and Pedology Section, Division of Soils, CSIRO, Adelaide, appeared as document E/CONF.52/L.77.

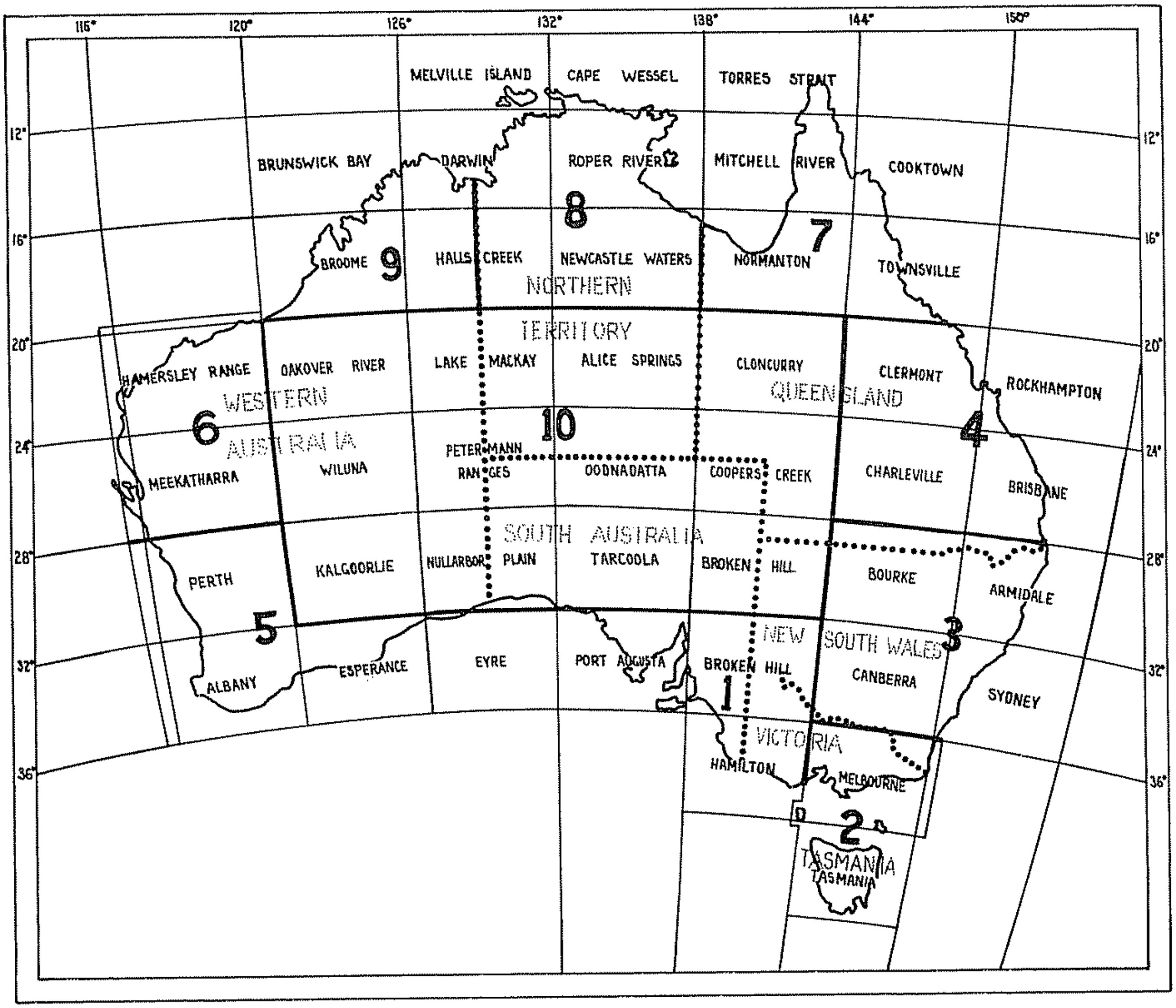


Fig. 1—Australia: The ten sheets of the Atlas of Australian Soils

Soil is a foundation material for many of man's activities. It grows his food and supports his homes, roads and so forth. Most people are familiar with changes in soil that are evident at the ground surface; but fewer people realize that soil properties change with depth. Yet it is this characteristic which helps to make soil a unique natural object capable of being classified. The vertical section through soil is termed the soil profile. Soil is composed of mineral materials derived from rocks and sediments and organic materials derived from flora and fauna. Chemical, physical and biological processes occasioned by water, temperature and time operating on these materials produce changes in the properties within the soil profile. These properties of colour, texture, structure, chemical composition, organic matter accumulation and so forth may be used to classify soil profiles, that is, to formulate a classification of soils based solely on their properties. Such a classification, termed the "factual key", has been used accurately by a number of pedologists and has provided a consistent classification from sheet to sheet of the soils atlas. Moreover, soils not previously known to exist have been accommodated by the key. Indeed, their likely occurrence was forecast in some cases.

Areas of individual soils may be mapped. But soil changes in the horizontal plane across an area of land are usually so numerous that the distribution of individual soils can be shown only on large-scale maps (1:50,000 and larger). For small-scale maps (1:250,000 and smaller), and especially for maps of continental areas ($1:1 \times 10^6$ and smaller), individual soils cannot be mapped. Instead, naturally occurring and recurring groupings or associations of several soils become the mapping units. The problem is to define a natural boundary. Experience and research have proved the usefulness of landscapes (landforms) for dividing land into recognizable soil units. In other words, major changes in landscape coincide with major changes in the soil population. This means that, for a given landscape, the soil population is specified and the most commonly occurring soil recorded as the dominant, or principal, soil for that landscape. This approach, which provides a standard mapping method, results in two legends. The more comprehensive of these describes each landscape with its soil population and is set down in a booklet which accompanies the map. The more general of the two legends is printed on the map. It lists only the dominant soils and provides the link between the map and its booklet.

Personnel

The collection and compilation of data for an individual sheet of the soils atlas is time-consuming. It requires a team approach. A team suitable for the task consists of one experienced pedologist and a technical assistant. One team will take from fifteen to thirty months to complete one sheet depending on its complexity and the amount of new soils data to be collected. More than one team may be used, but more than three teams on any one sheet would become unwieldy. Each team will require a vehicle, either standard or four-wheel drive, depending upon the nature of the terrain. The team can expect to have approximately three months in the field out of each twelve-month period. The cost of operating the personnel of one team for a twelve-month period varies between about $A11,000 and $A13,500; the vehicle cost for three months would vary between $A200 and $A400, assuming between 8,000 and 10,000 miles of travel and no major repairs. Some incidental expenses and contingencies should be allowed for. Of course costs increase a great deal when either fixed-wing aircraft or helicopters are used to cover particularly inaccessible areas. They have been used in two areas for limited periods, namely, Arnhem Land and Cape York peninsula, but are not generally recommended, as ground control is restricted.

When a number of teams are employed on different portions of such a work as the soils atlas, it is necessary for one pedologist to have responsibility for the whole task. He will co-ordinate the whole programme and will usually also lead one of the teams.

Preparations

The success of the field work in a project of this character depends on the thoroughness with which preparations are made. There are three facets, namely, accumulation and study of basic data; design of field traverses and an adequately equipped vehicle.

All the basic information relating to a particular sheet of the soils atlas, and relevant adjoining areas, must be collected and studied. This basic information includes: all available published and unpublished soils data, especially from soil surveys; all available geological maps, especially those at a scale of 1:250,000; photomaps, if available, at scales of 1:63,600 or 1:250,000, all available topographic or planimetric maps at scales of 1:250,000 or 1:253,440.

There are three principal objectives. The first is to have as complete a cover of the area at scales of 1:250,000 or 1:253,440 as possible, because maps at these scales are the ones upon which a preliminary compilation both in the field and in the office can most conveniently be made. Secondly, a knowledge of the geology (geological maps and photomaps) and topography (topographic maps and photomaps) enable some concept to be formed regarding the landscapes that will be encountered and the nature of the terrain generally. Finally, earlier soils data will provide the best information regarding the soils and their relationships to landscape features. As all this material is studied, an initial mental picture of landscapes and soils begins to take shape.

Field traverses are now designed to cover the area so that the full range of landscapes and soils is traversed. The aim is to cross each different landscape at least once, but preferably in two or more places. The traverses are arranged to cut across the grain of the country, that is, to pass from drainageway to drainage-divide and so on repeatedly. This results in cross-sections of the landscapes and allows correlations to be made between them and soils. The field traverses are drawn up in the form of a time-table, so that an even distribution of time and effort results throughout the area of study. A two-man team (pedologist and technical assistant) can budget for daily travel of 100 to 200 miles per day depending on the complexity of the terrain. This will permit ten to twenty soil examinations per day. In addition, special provision in the traverse time-table should be made for visits to other soil scientists who may supply information in the office or co-operate with field work in specified areas.

To ensure efficient operation of the field traverse time-table, the vehicle to be used must be in sound mechanical condition, have an accurate milage meter and be of such a type that it will handle the terrain to be traversed. It must further be adequately equipped with all scientific and personnel requirements. The scientific materials required on traverse include the following: all relevant maps, especially photomaps, topographic maps and geological maps as well as road or other route maps; field notebooks for recording observations; a copy of the factual key; a copy of the Munsell soil colour charts; texture and pH kits (the Raupach-Tucker indicator is the one used in this work); a bottle and applicator of diluted hydrochloric acid for the detection of soil carbonates; hand lens (×15) for soil examinations; plastic or other suitable bags for the collection of soil and other samples as required; spade and soil auger for soil examinations (the spade is used to dig a small pit to 12 or 18 inches in depth, then a 4-inch jarret-type auger is used); geological hammer.

If camping, adequate water and food supplies as well as bedding and tents are necessary. The need to camp varies according to the relative isolation of the areas being traversed.

Work in the field

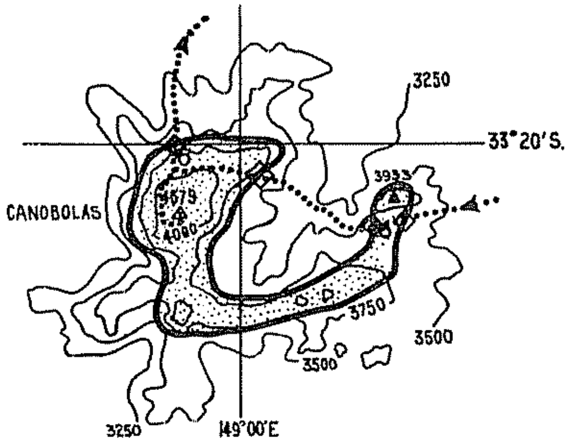
Once the area to be studied is reached, operations become continuous. All observations are recorded in the field note-books. The objective is to arrive at a correlation assessment between soil occurrence, geology, geomorphology and topography. Later this will allow extrapolations to be made from the line of traverse on the several bases of geology, topography, landform and photo-pattern.

During traverses, notes are made while travelling of the topography, landforms, geology and soils, logged against vehicle milage. Stops, also logged against vehicle milage, are made for purposes of identifying the soil. The stops are made at irregular intervals when the need to verify the classification of the soil becomes evident. At each stop, the soil profile is exposed. The properties of the soil profile are described and recorded and the soil is classified. At any one stop, more than one such soil examination may be made. Topography, landform and geology are recorded as well. The traverse is resumed, the pedologist now continuing to identify the soil by surface features which has correlated with the soil profile. Changes in these surface features indicate when further stops are necessary. Samples of soil or soil materials may be obtained when required, but it is not the purpose of these traverses to sample soils on a routine basis. This occupies too much time at any one site and would unduly interrupt the mapping programme.

The initial mental picture of landscape and soils which began to take shape in the pedologist's mind during the earlier preparations now becomes more definite. Sometimes it may be altered drastically. He returns from the field work with a clear knowledge of the landscapes and soils encountered on traverse, the correlations whereby they may be extrapolated, and field books full of facts.

Work in the office

The next task is to plot the data from the field note-books along the traverse routes on the most appropriate maps or photomaps, that is, on the medium which will allow for the best extrapolation of landscape units. The technical assistant usually plots the data. The pedologist now makes the extrapolation of the landscape units and gradually compiles them on maps or photomaps at scales of 1:250,000 or 1:253,440. The following three figures show the extrapolation of a landscape unit on the basis of topography, on the basis of geology and on the basis of photo-pattern. This process continues until all the data on the landscape and soils are shown on maps or photomaps at scales 1:250,000 or 1:253,440.



Traverse route

Major soil and landscape changes

Stops to classify soil and landscape

Extrapolated boundary

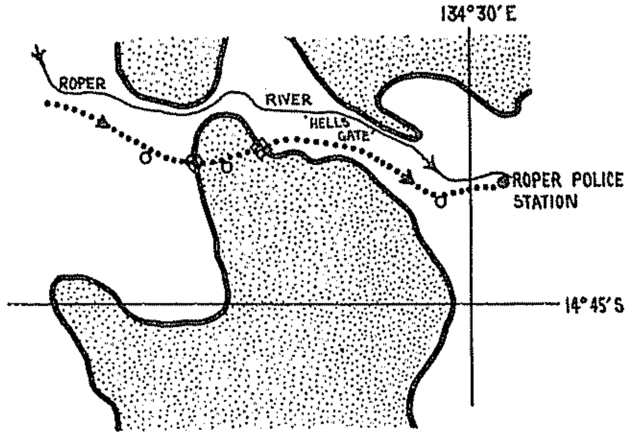
Contour lines

Mountainous - dissected plateau remnants dominantly shallow forms of organic loamy soils (Um 7-11)

Fig. II—Australia: Extrapolation of boundaries based on topography

(Bathurst 1:250,000 topographic map)

The landscape unit boundaries shown on the large-scale maps are now transferred to overlays of the appropriate $1:1 \times 10^6$ map, drawn on transparent material. The transparency shows a grid of latitudes and longitudes and



Traverse route

Major soil and landscape changes

Stops to classify soil and landscape

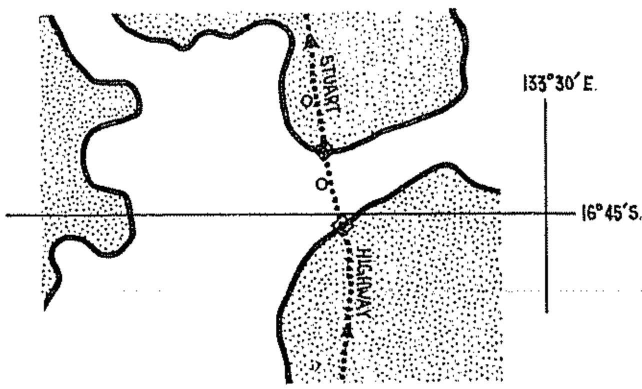
Extrapolated boundary

Alluvium - valley plains of cracking clay soils (Ug 5)

Proterozoic sandstones - hills and ranges of shallow sands and sandy loams (Uc 4-1)

Fig. III—Australia: Extrapolation of boundaries based on geology

(Urapunga 1:250,000 geological map)



Traverse route

Major soil ana landscape changes

Stops to classify soil and landscape

Extrapolated boundary

Uniform textured, pale coloured areas - open plains of cracking clays (Ug 5)

Blotchy, dark areas - undulating terrain of red and yellow earths (Gn 2)

Fig. IV—Australia: Extrapolation of boundaries based on photomap pattern

(Daly Waters photomap, 4 miles per inch) coastlines where appropriate. The transfer of boundaries is made optically, using a Fotokopist Omnigraph III.

Meanwhile, the pedologist has made descriptions of each landscape unit. The descriptions record the following points: landscape; dominant soils; associated soils; minor soils; any related items. These descriptions will make up Legend 2, which will form the main part of the booklet for that map sheet. In writing up Legend 2, the dominant soil for each unit was nominated on the basis of the most common occurrence as revealed by traverse records and all the other available soils data. The dominant soils are the basis of Legend 1 which appears on the map sheet. At this stage, a letter-number symbol based on dominant soils is given to each landscape unit. These letter-number symbols are shown on the map and provide the key to the descriptions given in Legend 2. The letter-number symbols are placed on the $1:1 \times 10^6$ transparencies.

Dominant soils are either given a separate colour, or two or more dominant soils of similar character are given the same colour, but are then separated by the letters of the letter-number symbols. The colours are taken from the CSIRO standardized colour chart which represents sixty colours obtained by using four basic colours: yellow, red, blue and grey and overprinting with 25 and 50 per cent litho-screens. By this means, a standard colour scheme is maintained throughout the soils atlas. Dye-line copies, of the $1:1 \times 10^6$ transparencies are made and coloured by hand, using printer's inks mixed to represent the colours of the CSIRO colour chart. During the colouring process, errors in transfer from the original compilation maps to the $1:1 \times 10^6$ maps are corrected.

Boundaries of landscape units are now transferred from the transparencies to copies of the appropriate printed $1:1 \times 10^6$ maps. Final checks of the whole map manuscript are made. Accessory material for the map, including a reliability map, is assembled. The reliability map shows five grades of reliability for the soils and landscapes based on the nature and volume of the data available.

The whole of the material is now assembled for dispatch to the Division of National Mapping, where final drafting of the map will be made. The items sent forward for each $1:1 \times 10^6$ map are as follows: one ICAO or AGS map at scale $1:1 \times 10^6$, showing boundaries of all units; one transparent overlay, showing boundaries and symbols of all units; one coloured dye-line; reliability map and its legend; index map for that particular sheet of the soils atlas; compilers' statement; legend No. 1; title for that particular sheet of the soils atlas.

Drafting is carried out to permit publication at a scale of $1:2 \times 10^6$.

Concurrently, material has been assembled for the accompanying booklet which, when typed, will be sent to the Publications Section of CSIRO for printing. The booklet material includes the following: introduction; legend 2 (descriptive list of the mapping units); table 1 (brief description of the soils for the given sheet of the soils atlas); table 2 (list of soil names previously used by various workers compared with their classification by the factual key); table 3 (selected references to published laboratory data for representative soils); acknowledgements; references to papers and maps consulted during compilation.

Finally, it must be stressed that each map manuscript and its booklet has been correlated and co-ordinated with each previous sheet of the soils atlas, so that all the sheets can be joined to form a soil map of the whole of Australia at the publication scale.

MAP REPRODUCTION TECHNIQUES USED FOR THE ATLAS OF AUSTRALIAN SOILS

Paper presented by Australia[1]

The present paper supplements the preceding paper on the Atlas of Australian Soils and describes the drafting and reproduction techniques used by the Division of National Mapping in the production of maps for the atlas.

Preliminary planning

As a result of investigations made prior to the commencement of mapping in 1960, the adoption of a conical projection for the series was recommended. At that time it was not intended that all sheets should be produced at a common scale, so that the question of joining all sheets together did not arise. As tables for the Polycarie projection were available, that projection was adopted for reasons of expediency.

General procedures for the drafting and printing of the maps were laid down as a result of discussions between the Division of National Mapping, the Division of Soils, Commonwealth Scientific and Industrial Research Organization (CSIRO), and the Publication Section, CSIRO.

Generally, the Division of National Mapping was made responsible for the provision of topographic base maps, fair drawing of soils information from drafts supplied by Soils Division, CSIRO.

It was arranged that printing should be handled by the Publications Section, CSIRO.

Production

Sheets 1, 2 and 3 of the atlas published between 1961 and 1965 were drawn on the polyconic projection as planned. In 1965, production of a 1:2,500,000 map of Australia based on material from the existing 1:1,000,000 series maps was commenced by the Division of National Mapping. The new map was compiled on a simple conic projection and led to the availability of a suitable base map for the remaining seven sheets of the soils atlas.

There had previously existed a difficulty with sheet 10 of the proposed atlas, the shape and size of which made it unsuitable for drawing on a polyconic projection. While a change of projection introduced minor inconsistencies at the edges of sheets already printed, these edges were short, and the advantages of having a compilation already available for the remaining sheets, and being able to join all sheets in the series into a composite map, made the change to the simple conic projection worth while. In addition, the difficulty with sheet 10 was eliminated.

[1] The original text of this paper, prepared by B. E. Goodrick, Chief Cartographer, Division of National Mapping, Department of National Development, Canberra, appeared as document E/CONF.52/L.79.

Sheets 4 to 10 are currently being drawn on the new projection, the bases being prepared from the 1:2,500,000 compilation for the Map of Australia.

Annex I, which is a work-flow chart showing the various steps in production of sheets 4 to 10, illustrates the main steps by all three organizations engaged in production of maps for the Atlas of Australian Soils.

Within the Division of National Mapping, control of all stages of production of the maps is maintained by the use of checking forms designed to ensure completeness and correctness of every phase of the work (see annex II).

Method and materials

Line work is produced by negative scribing over guide images on rust coloured stateline scribecoat.

Colour keys are prepared in accordance with a standard colour chart prepared by the Publications Section, CSIRO, on transparent oyafilm prints, of the soils boundaries, using Staidtler ommichrom pencils.

Open-window negative masks for all colours are prepared using pre-sensitized peel coat imposed to the soils boundaries for the more complex masks, and cut and peel material for masks of more simple shapes.

Colour proofing is carried out using watercote dyes on lofthite by exposing through negative screens and staples of known printing strengths to obtain the required hues and colour combinations.

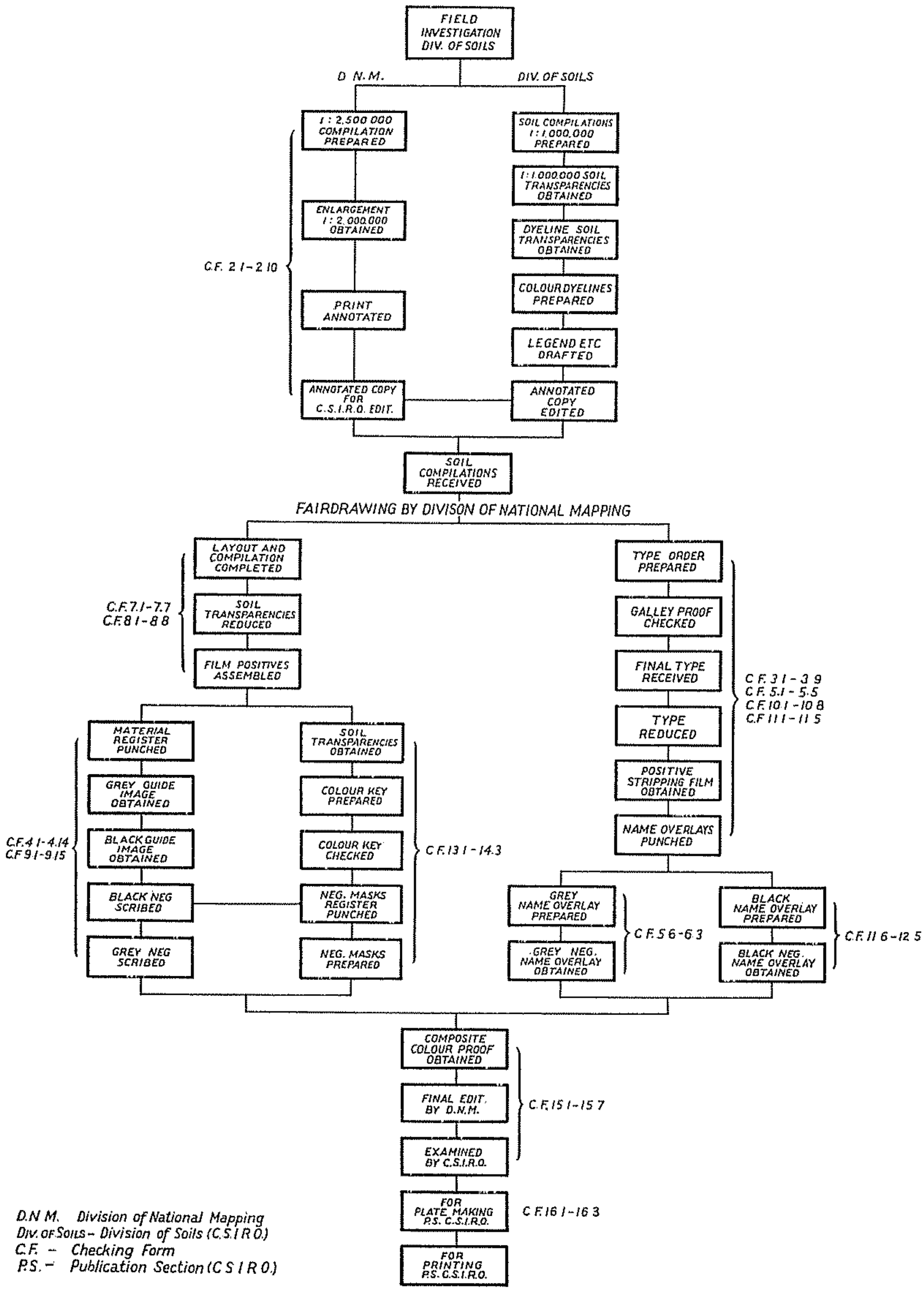
Registration of all line work and colour tints is ensured by a stud register system, sheets being prepunched, with studding maintained through all stages including platemaking.

Annex III shows a sample portion of one of the printed sheets of the atlas.*

* See pocket at end of volume.

Annex I

WORK FLOW CHART



Annex II

DIVISION OF NATIONAL MAPPING

ATLAS OF AUSTRALIAN SOILS

Map name

Map No.

Project No.

Each action will be initialled on completion in line space provided.
Checks will be initialled in squares by officer indicated.

		D.F.M.	S.L.	C.C.
1.	Information on project file and auxiliary project record seen and understood	___		
2.	Preparation of dark grey base			
2.1	1:2,500,000 Australia compilation masked off	___	☐	
2.2	Grey base negative—			
	Ordered		___	
	Received		___	
	(Stick for enlargement provided)			
2.3	Grey base map negative—retouched	___		
2.4	Dye-line copy of grey base—			
	Ordered		___	
	Received		___	
2.5	Road information—checked	___	☐	
2.6	Dye-line copy "written up" (see previous samples)	___		
2.7	Approximate neat line drawn	___		
2.8	Dye-line copy checked		☐	
2.9	Dye-line copy examined			
	Dispatched		___	___
	Received		___	___
2.10	Dye-line copy corrected and checked	___	☐	
3.	Dark grey base—type listing (see previous sheets as samples)			
3.1	Water features (rivers, lakes, etc.) listed	___		
3.2	Place names (towns, homesteads etc.) listed	___		
3.3	Relief features (mountains, hills, etc.) listed	___		
3.4	Geographical values listed	___		
3.5	Type list checked against the typed legend No. 1		☐	
3.6	Type list examined—		___	
	Dispatched to Mr. Chamberlain		___	
	Received from Mr. Chamberlain		___	
3.7	First galley proof—		☐	
	Corrected and checked	___		
	Corrected galley proof returned		___	
	Received and filed	___	___	
3.8	Second galley proof—		☐	
	Corrected and checked	___	___	
	Corrected galley proof returned		___	
	Received and filed		___	
3.9	Final copy received and filed	___	___	

		D.F.M.	S.L.	C.C.
4.	Preparation of material			
4.1	Stabilene sheets (2) cut, punched and identified (black and dark grey negs.)			
4.2	Cronaflex sheets (2) cut, punched and identified			
5.	Dark grey scribed negative (1)			
5.1	Film neg. of grey base punched, identified, checked			
5.2	Guide image of grey base—			
	Ordered			
	Received			
5.3	Graticule and neat-line corners scribed (check against draft layout and black base)			
5.4	Water features (rivers, shorelines, etc.) scribed			
5.5	Populated places (towns, villages etc.) scribed			
5.6	Running features (roads, railways etc.) scribed			
5.7	Landmark features (mountains etc.) scribed			
5.8	Adjoining sheet edges checked			
5.9	Registration marks and colour patch scribed (check against black scribed neg.)			
5.10	Dark grey names retouched (register against dark grey name overlay)			
5.11	Masking limit line and lay line drawn			
5.12	Grey scribed negative checked			
6.	Name overlay for dark grey base (positive)			
6.1	Final pulls of dark grey names assembled			
6.2	Reversed film negative of name assembly			
	Ordered			
	Received			
6.3	Reversed stripping film positive of name assembly			
	Ordered			
	Received			
6.4	Stripping film positive waxed and covered			
6.5	Neatline corners transferred from black negative			
6.6	Type stick up			
	N.B. Check spelling and size of each name when "sticking up" type against—			
	(*a*) ICAO sheets (tick off)			
	(*b*) Dye-line name copy (tick off)			
6.6.1	Geographical values			
6.6.2	Cities, towns, homesteads, etc.			
6.6.3	Rivers, lakes, seas, etc.			
6.6.4	Islands, points, etc.			
6.6.5	Mountains, hills, etc.			
6.7	Dark grey name overlay checked			
7.	Dark grey name overlay negative (2)			
7.1	Contact film negative of grey name overlay			
	Ordered			
	Received			
7.2	Film negative retouched			
7.3	Film negative identified, punched and registered against black scribed negative			
8.	Preparation of draft layout			
8.1	Legend panel of dominant soils drawn			

		D.F.M.	S.L.	C.C.
8.2	All other panels drawn			
8.2.1	Index map			
8.2.2	Reliability map			
8.2.3	Important notes			
8.2.4	Compiler's statement			
8.3	Neatline and border drawn, graticule and paper size to be considered and drawn			
8.4	Scale drawn			
8.5	Colour patches drawn			
8.6	Registration marks drawn			
8.7	Completed draft layout checked			
9.	Preparation of black base			
9.1	Coloured dye-line copies checked against			
9.1.1	Typed soil keys (legend No. 1)			
9.1.2	Transparent copies of dominant soils			
9.2	Joins of adjacent copies checked			
9.3	Correction overlay prepared			
9.4	Correction overlay checked			
9.5	Following materials dispatched to Mr. Northcote for verification on			
9.5.1	Draft layout			
9.5.2	Transparent copies of dominant soils			
9.5.3	Coloured dye-line copy (with discrepancy overlay attached)			
9.5.4	Typed legend No. 1 (2nd copy)			
9.6	Materials (9.5.1–9.5.4)—			
	Examined			
	Dispatched to CSIRO			
	Received from CSIRO			
9.7	Reduction of transparent copies (soil boundaries (reduction stick))			
	Ordered			
	Received			
9.8	Transparent copies assembled:			
9.8.1	Neatlines and border drawn			
9.8.2	Rectangular panels of legend No. 1 drawn			
9.8.3	Index map and panels drawn			
9.8.4	Reliability map and panels drawn			
9.8.5	Circles for colour patches drawn			
9.8.6	Registration marks drawn			
9.8.7	Scale drawn			
9.8.8	Reduced soil boundaries cut and stuck on black base			
9.8.9	Black base checked			
9.9	Contact negative of black base			
	Ordered			
	Received			
10.	Black scribed negative (3)			
10.1	Guide image of black base			
	Ordered			
	Received			
10.2	Instructions for scribing understood			
10.3	Joins of assembled sheets and missing parts of soil boundaries recompiled			
10.4	Soil boundaries scribed (break lines where required)			

		D.F.M.	S.L.	C.C.
10.5	Rectangular panels of legend No. 1 scribed			
10.6	Reliability map and panels scribed			
10.7	Index maps and panels scribed			
10.8	Neatline and border scribed			
10.9	Scale scribed			
10.10	Registration marks scribed			
10.11	Circle for black colour patch scribed			
10.12	Scribed soil boundaries checked against the adjoining sheets			
10.13	Masking limit line and lay line drawn			
10.14	Items 10.3–10.13 checked for accuracy and completeness			
10.15	Corrections completed and checked			
11.	Black type list			
11.1	Instructions for type listing read and understood (refer to previous sheets)			
11.2	External type listed			
11.2.1	Map title and number			
11.2.2	Area			
11.2.3	Scale			
11.2.4	Map projection			
11.2.5	National mapping note and project No.			
11.2.6	Printers' note			
11.3	Internal type listed			
11.3.1	Legend No. 1—dominant soils			
11.3.2	Index map			
11.3.3	Reliability map and sources of data			
11.3.4	Important notes			
11.3.5	Compilers' notes			
11.3.6	Symbols of soil classification			
11.3.7	Listed symbols ticked off on dye-line copies			
11.3.8	Listed symbols counted and assessed for number of pulls			
11.4	Xerox copy of all listed type obtained and filed after checking			
11.5	Corrected original copy of type listing—			
	Dispatched			
	Received			
11.6	First galley proof—			
	Received			
	Checked and corrected			
	Corrected galley proof returned			
	Received and filed			
11.7	Second galley proof—			
	Received			
	Checked and corrected			
	Corrected galley proof returned			
	Received and filed			
11.8	Final pull (copy) received and filed			
12.	Black name overlay (positive)			
12.1	Final pulls of black name overlay assembled			
12.2	Reversed film negative of name assembly			
	Ordered			
	Received			

		D.F.M.	S.L.	C.C.
12.3	Reversed stripping film positive of name assembly—			
	Ordered		____	
	Received		____	
12.4	Stripping film positive waxed and covered	____		
12.5	Neatline corners transferred to cronaflex sheet from black scribed negative (name overlay)	____		
12.6	Type placement N.B. Check spelling and size of each name when positioning against— (*a*) Corrected draft layout (*b*) Typed legend No. 1 (file copy) (*c*) Transparent copies of soil boundaries		____	
	12.6.1 Title, sheet No. and area		☐ ____	
	12.6.2 Scale, map projection		☐ ____	
	12.6.3 Printers' note		☐ ____	
	12.6.4 National mapping note and project No.		☐ ____	
	12.6.5 Legend No. 1 Dominant soils		☐ ____	
	12.6.6 Index map		☐ ____	
	12.6.7 Important notes		☐ ____	
	12.6.8 Reliability map and sources of data		☐ ____	
	12.6.9 Compilers' note and CSIRO stamp		☐ ____	
	12.6.10 Symbols of soil classification		☐	
12.7	"Zip-a-tone" positioning		____	
	12.7.1 Index map and panels		☐ ____	
	12.7.2 Reliability map and panels		☐ ____	
	12.7.3 Black areas covered by red tape		☐	
12.8	Black name overlay checked		☐	☐
12.9	Corrections completed and checked	____	☐	

13. Black name overlay negative (4)

		D.F.M.	S.L.	C.C.
13.1	Contact film negative of name overlay—			
	Ordered		____	
	Received		____	
13.2	Negative retouched	____		

	D.F.M.	S.L.	C.C.
13.3 Negative identified, punched and registered against black scribed negative			
13.4 Masking line drawn			
13.5 Black name overlay negative checked			
14. Colour key preparation			
14.1 List of colour combination for every masking unit prepared and filed			
14.2 List for accuracy and completeness checked			
14.3 Ozofilm copies (6) for colour keys—			
Ordered			
Received			
14.4 Tinting of colour keys (on Ozofilm)			
14.4.1 Large black dot tinted			
Small black dot tinted			
14.4.2 Grey solid tinted			
Grey line tinted			
14.4.3 Yellow solid tinted			
Yellow line tinted			
14.4.4 Blue solid tinted			
Blue line tinted			
Blue dot tinted			
14.4.5 Red solid tinted			
Red line tinted			
Red dot tinted			
tinted			
tinted			
tinted			
tinted			
tinted			
tinted			
14.5 All tinted colour keys checked			
15. Negative masking			
15.1 sheets of peel coat cut, identified and punched			
15.2 Auto-negative of black scribed negative—			
Ordered			
Received			
15.3 Guide images on peel coat from auto-negative—			
Ordered			
Received			
16. Colour proof			
16.1 Reproduction material checked and listed on auxiliary project record			
16.2 Screens checked and listed			
16.3 Proof			
Ordered			
Received			
16.4 Proof checked			
16.5 Proof—			
Dispatched to CSIRO			
Received from CSIRO			

	D.F.M.	S.L.	C.C.
16.6 Corrections completed			
16.7 Corrections checked			
17. Reproduction material despatched			
17.1 Consignment note written and checked			
17.2 Parcel checked and prepared			
17.3 Letter written and dispatched			
17.4 Printed copy received and filed			

THEMATIC CARTOGRAPHY AND COMPREHENSIVE SCIENTIFIC REFERENCE ATLASES OF THE USSR (1964–1966)

Paper presented by the Union of Soviet Socialist Republics[1]

The progress of the national economy, its planning, its comprehensive study and the development of natural resources all create a demand for thematic maps.

During its nearly half-century of development, Soviet cartography has achieved considerable progress in thematic mapping. Special national maps at different scales, special and comprehensive atlases of the USSR as a whole and of its individual Republics and regions are being prepared.

Soviet thematic maps and atlases have already been adequately described in geographical and cartographical publications and there is therefore no need to dwell upon them at length. We shall accordingly confine ourselves to a description of only those thematic maps and atlases that were published in the USSR in the period 1964–1966.

New hypsometric and geological maps have been made. As is known, a hypsometric map of the USSR at a scale 1:2,500,000, giving a very detailed presentation of land and sea topography, was published in 1949. Small-scale hypsometric maps inserted in various world and regional atlases were compiled on the same basis.

A tectonic map of Europe at a scale 1:2,500,000 compiled by the joint efforts of many countries was published in the Soviet Union in 1964. This map is far superior to all previous maps issued in the USSR and other countries in its scientific presentation, content and cartographic methods used.

Considerable progress has been achieved in regard to bathymetric charts. In 1964, a bathymetric chart of the Pacific Ocean at a scale 1:10,000,000 was published, in the compilation of which new comprehensive data was used. This chart gives a more scientifically based interpretation of major features of submarine relief than is found in any previously issued chart. The Atlas of the Antarctic presents several bathymetric charts of the southern ocean at 1:10,000,000 (1966). Similar charts of the Indian and Atlantic oceans are being prepared for print.

As before, extensive geological mapping is being carried out. Large-scale, medium-scale and small-scale maps are being made for the whole of the USSR territory and its individual regions. The Soviet Union is taking part in the compilation of a world geological map at 1:5,000,000 scale.

Soil and geobotanic cartography is making steady headway. A soil map at a scale of 1:1,000,000 for the whole agricultural zone is in preparation. Summary soil maps are included in all world and regional atlases. The majority of the Republics and regions of the USSR possess medium-scale soil maps. Much work is being done for the compilation of large-scale land-quality maps. The V.V. Dokuchaev Soil Institute has made an original of a general 1:8,000,000 map of soils and agricultural chemistry of the USSR.

As far back as 1950, a general vegetation map of the European part of the USSR, at a scale of 1:2,500,000, was published in the USSR. That map was followed, in 1956, by a 1:4,000,000 vegetation map of the USSR. During the past three years, a series of regional maps of central Asia, northern Kazakhstan and the Baltic regions have been published. Work is being continued on the USSR geobotanic map at a scale 1:4,000,000. General vegetation maps of the world, of continents, of the Soviet Republics and regions have been included in atlases.

In 1956, a general forest map at 1:2,500,000 was published in the USSR which greatly influenced the compilation of forest maps for comprehensive atlases. Work is continuing on a forest map at 1:1,000,000, likewise on a number of medium-scale forest maps of Soviet Republics and regions, and on the first USSR forest atlas.

Topographic mapping is constantly increasing. Small-scale topographic maps are printed in many comprehensive regional atlases. The Leningrad State University has elaborated a project for a topographic map of the USSR at 1:4,000,000 scale.

A major problem is the efficient utilization, conservation and reproduction of natural resources. Maps are therefore prepared for the evaluation of natural resources; they include geological and mineral resources, soil, agricultural, land reclamation and other maps. Such maps are issued in comprehensive atlases, or separately. So far, a sketch-map of soils and agricultural chemistry and a number of botanical indicator charts have been published. A map of the agroclimatic regions of the USSR at 1:4,000,000 is in preparation.

A notable achievement in the field of physical cartography was marked by the publication of two major atlases: the physical and geographical world atlas (1964), and the atlas of the Antarctic (1966). For the first time in the history

[1] The original text of this paper, prepared by the Chief Administration of Geodesy and Cartography, Ministry of Geology, appeared as document E/CONF.52/L.99.

of world cartography, the physical and geographical world atlas presents a summary of our knowledge in various branches of investigation of the nature of the world as a whole, and of individual continents. The Atlas of Antarctica is based on the latest available data gathered and on reports of expeditions made by Soviet and foreign scientists during the past ten years.

Both these atlases illustrate the achievements of Soviet physical geography in studying different natural features: they include many new types of maps plotted according to original methods. The publication of these atlases may serve as an illustration of the progress of Soviet geography and cartography.

On the basis of the population census of 1959, new 1:2,500,000 maps were compiled of population density and urban growth. In 1964, a map of population density was issued at 1:4,000,000. More and more frequently new types of population maps—such as maps of man-power resources and of employment of population in different branches of the national economy—are presented in comprehensive regional atlases.

Ethnographic cartography is making progress too. Following the publication of ethnic maps of large regions of Asia, a summary composite map of nations of the world at a scale 1:15,000,000 was published on the basis of the linguistic principle. Eight hundred different nations are shown on this map. In the compilation of ethnic maps, a method of simultaneous presentation of population density and ethnic composition (nationality) is applied to the same map.

The publication of the first Soviet atlas of the world's nations (1964), compiled by the Institute of Ethnography of the USSR Academy of Sciences, is an important landmark in the development of Soviet cartography. Maps of nations, population density and distribution of towns are included in the said atlas for all the regions of the globe. The major nations are shown by using different colours, medium-sized nations by alternating coloured strips and smaller nations by symbols. The maps of this atlas show the distribution of some 1,600 nations.

The economic mapping of the USSR has been continued. At the present stage of development of the national economy the most important need is for economic maps for planning and administration. Old types of maps of branches of the economy and general economic maps are being improved, and new types are being published.

Work in agricultural cartography continues as well. New types of land-utilization and land-evaluation maps at large, medium, and small scales are compiled. A procedure of compiling medium-scale land-utilization maps of the Soviet Republics and regions has been worked out.

The series of general agricultural maps has been enlarged by a new agricultural map of the Uzbekistan SSR, at 1:1,000,000 scale (1965). It shows the great success in agricultural development achieved by the fortieth anniversary of the Uzbekistan SSR.

Recently, new agricultural atlases have been issued: the atlas of the Transcarpathian region (1964) and the atlas of the western region of the Ukrainian SSR (1965). Both are in black and white, but they nevertheless contain much useful information; they include, in particular, new maps of land evaluation, and of prime cost and labour consumption in agricultural production.

The compilation of comprehensive regional atlases of the Soviet Republics and regions has proceeded satisfactorily. During the seven-year plan period, more than twenty atlases have been published. Some of these are scientific reference atlases, the others are intended for regional investigations.

In 1964, a scientific reference atlas of the Georgian SSR was published that comprised a large set of physical, geographical and social-economic maps. The scientific reference atlases of the Transbaikal region, North Kazakhstan, the Karaganda region and of some other Soviet Republics and regions are being prepared for print.

Seven regional training atlases of different Republics and regions were published from 1964 to 1966. Ten more such atlases are now being prepared for publication.

In accordance with practical needs, new types of social-economic maps are elaborated in the USSR, such as maps of land utilization, qualitative and economic land evaluation, land reclamation, application of chemistry in agriculture and population. Some maps of this kind have already been published in comprehensive atlases.

A special feature of Soviet thematic maps is that all the phenomena shown therein are presented in their historical context and evolution. Publication of a new atlas of the development of the national economy and culture in the USSR would be timed to the fiftieth anniversary of the Great October Revolution.

A special feature of this atlas is that all economic and cultural phenomena are mapped in comparison with those of the pre-revolutionary period. The atlas will not only show Soviet progress during the past fifty years but it will also give a forecast of economic and social development under the new five-year plan (1966–1970).

The mapping of the national economies of foreign countries continues at a growing rate; wall and desk reference maps for foreign territories are published; comprehensive atlases of large regions and of individual States are prepared. Of considerable interest is the Atlas of the United States of America (1966), containing new economic maps that reflect the social relations in the world's largest imperialist Power.

Comprehensive atlases of Africa, Latin America, southern Asia and of the countries of the Near and Middle East are in preparation.

The economic development of the USSR, the problems connected with the scientifically based distribution of productive forces and the satisfaction of the growing requirements of the working people call for the further development of thematic cartography.

The most important tasks facing Soviet cartographers are the following:

Compilation and publication of a series of specialized reference atlases of natural conditions, population and economy at scales 1:2,500,000 and 1:1,000,000;

Compilation and publication of comprehensive reference atlases of the USSR, its Republics and regions, improvement of the contents of these atlases and of compilation methods;

Intensification of economic mapping of other countries, that is, an elaboration of reference atlases of individual regions and States.

The compilation and publication of a Soviet economic reference atlas of the world is planned. It will show social and economic conditions in different types of countries. With the publication of this atlas, the series of large Soviet atlases of the world will be completed.

ATLAS OF ANTARCTICA

Paper presented by the Union of Soviet Socialist Republics[1]

A cartographic volume of the Atlas of Antarctica was published in the USSR in May 1966. (A summary of the most important information on the nature and history of the investigation in the Antarctic will be issued in 1967.)

The Atlas of Antarctica is a geographic atlas of a scientific reference type representing, in great detail and from many points of view, natural environments and the history of investigation in the southern polar region.

The internal dimensions of the unfolded atlas sheet are 52 × 66 cm. The atlas has about 500 map titles, graphs and figures, covering 225 pages. The maps of the Antarctic are largely drawn at 1:20,000,000 scale while those of the Antarctic mainland are at 1:10,000,000 scale. The whole of the coastal area of the mainland is presented on the 1:5,000,000 map. More closely studied areas are shown on considerably larger scales (1:1,000,000, 1:500,000, 1:100,000, etc.).

The atlas maps are based on cartographic and aerial survey data either available in the USSR or received from other countries, as well as on those obtained from the studies made by survey ships, Antarctic research stations, air flights and trips of tractor sleds undertaken farther inland.

The atlas falls into three parts: introduction, general description and studies in individual Antarctic regions. The maps included in the introduction show the geographic position of the Antarctic, the history of its investigation and previous map coverage. The general description includes various special maps of the Antarctic or of the Antarctic mainland as a whole. The third part comprises various maps covering the most closely studied areas of the Antarctic, classified according to region.

The atlas includes a great number of general geographic maps representing general features and topography. Special features of the natural environment of the Antarctic are largely responsible for the character of the maps showing the structure of the glacial shield. These maps differ from the common geographic maps depicting land according to content and general aspect. The series of large-scale general geographic maps is of particular interest. These maps detail and illustrate the glacial surface and bed-rock out-crops. The maps are accompanied by a number of aerial photographs, land pictures and supplementary special maps. These materials, as a whole, make up the series of standards (keys) which help present special features of the most typical parts of the mainland.

The aerononomy maps (phenomena in the upper layers of the atmosphere) and those of earth physics are numerous and up to date in their content. They include maps on earth magnetism, gravity and seismicity. This part includes maps and graphs which have not been published previously and are unavailable in the atlases issued. Among these are maps of the ionosphere which, apart from their scientific value, are of great practical importance, since they are necessary for calculating the conditions of radio communication, as well as graphs of cosmic radiation and earth currents.

Then come geological and relief maps. The former show the geological age of the mainland rocks and properties of ocean-bottom sediments, whereas the latter reveal geomorphological features and topography of the Antarctic mainland and those of the southern ocean floor. The content and general features of the maps also reflect peculiarities of the mapped area. The geological maps show, in addition to the characteristics of bed-rock within the Antarctic mainland, the age of the glacial cover. The relief of the glacial surface and subglacial topography and the Antarctic mainland are presented in the hypsographic maps. This is the first time that a series of maps showing the quantity and chemical composition of the mineral suspension in the oceanic waters of Antarctica have been included in the atlas.

Maps of radiation balance, temperature, atmospheric pressure and winds are included in the section on climate. A number of the elements are shown not only at the level of the earth surface but also at the upper levels; this is highly important as far as the conditions of air navigation are concerned. The maps of meteorological situations, recurrence of cyclones and anticyclones, and climatic zoning are of great interest.

The maps of the mainland glaciation show the types of glaciers, conditions for ice formation and physical properties of the ice. Many of the glaciological maps indicate the conditions of glacier formation, movement and temperature régime. They make it possible to consider the glacial balance in different parts of the mainland, the possibilities of movement on the ice and of building various types of constructions.

The oceanographic maps show the dynamics and physical and chemical properties of the ocean waters. The charts characterize deep sea-bed levels and a number of hydrogeological profiles illustrate the vertical sections of those levels.

Biological maps acquaint us with the distribution of the living organisms in the Antarctic, namely, animals and plants, food fish and seaweed. An attempt has been made to present the likelihood of finding species of mammals (whales, seals and others) in different parts of the ocean. Finally, maps of topography and physical and geographical regions show general natural characteristics.

The atlas is a guide to the comprehensive study of the nature and history of the investigation in the southern polar region. As such, the Atlas of Antarctica will undoubtedly be used in universities and research institutions for the study of manifold phenomena, for planning and carrying out new studies as well as for the practical utilization of the natural resources of the Antarctic.

The atlas is useful for broad sections of readers who wish to have different kinds of information on the Antarctic, which currently arouses great interest. Readers find in the atlas answers to many interesting questions on different branches of the natural sciences and history of geographic discoveries; they also acquaint themselves with valuable results of the investigations of the southern polar region. The publication of the Atlas of Antarctica illustrates the success of peaceful international scientific collaboration in geographic studies of the most inaccessible and inadequately

[1] The original text of this paper, prepared by the Chief Administrator of Geodesy and Cartography, Ministry of Geology, appeared as document E/CONF.52/L.103.

surveyed region of the earth. The example of such fruitful collaboration deserves to be followed in many other spheres of human activity.

Most important natural boundaries were determined in the course of the production of the atlas, and the physical and geographical zoning of the Antarctic and Antarctic mainland was carried out at the same time. The coastline of the ice shelves and glaciers is accepted, in the present atlas, as an external boundary of the Antarctic, whereas previous maps had shown a "stony" Antarctica. This boundary is now the most surely established and practically proved. Under Antarctic conditions, the ice may be considered a form of rock. The shoreline of the mainland, ice shelves and glaciers is quite constant, and the glaciers serve as a field for human activity. They are used for the berthing of ships, for the transportation of goods and for raising buildings and constructions. In this connexion, it is necessary to determine the nomenclature of geographic features located in the rear of the glacial shelf. Nautical terms ("island", "strait", "bay", etc.) previously used for adequately known features are replaced by land terms ("dome", "glacier", "glacial bay", etc.).

Analysis of the findings of the polar expeditions has made it possible to specify the location of the main frontal zones of the ocean and at the same time to determine a number of related hydrogeological, hydrochemical and biological characteristics. The atlas sheets show the south ocean as an oceanic basin with an absolutely independent and specific hydrological and glacial régime. The term "southern ocean" has long been used in both domestic and foreign literature to designate southern polar oceanic waters bordering on the sub-tropical convergence zone in the north. The southern ocean and new seas are clearly delineated and precisely plotted on the maps of the present atlas. The selection of exact names for a number of geographic features in Antarctica which have been studied by expeditions of some countries at different times and the delineation of the boundaries of "lands" and "coasts" defined in the period of previous investigations of the mainland, are important subjects for further studies.

ATLAS OF SWITZERLAND

Paper presented by Switzerland[1]

The Atlas of Switzerland is a major new geographic and cartographic standard work on Switzerland, published by the Swiss Federal Topographic Service, Wabern, Bern. For the first time, the physical and socio-economic features of this country are mapped in one work and can be studied in relation to one another: topographic relief, geology, soils, climates, plant and animal life; demography, linguistic and denominational distribution; settlement types; agriculture and forestry, industry, trade and commerce, communications, education, etc.

This study presents a comprehensive analysis of the natural resources, historical development, and present-day demographic, economic and social structures of Switzerland. Resulting from the close co-operation between scientific research and cartography, the work will be of major importance not only to science, public education and government agencies, but also to business, industry and other interested parties. National atlases have long been recognized as indispensable reference works for the impartial assessment of material resources and economic structures, and the increasing demand for such publications is a strong indication of the current need for such surveys.

When completed, the atlas will consist of eighty-six large-size double-page plates containing more than 300 coloured maps, the principal ones being drawn at the scale of 1:500,000. In accordance with the language structure of Switzerland, the title panels will be in German and French. The explanatory texts will also be given in Italian.

The organization of the atlas has been entrusted to the Swiss Federal Institute of Technology, Zurich, and is supervised by an editorial committee appointed by the Swiss Government. For the compilation of map contents, the editors have been able to secure the co-operation of numerous government agencies, research and educational institutions, professional associations and individual scholars. The work was initiated at the suggestion of the Assocation of Swiss Geographical Societies.

The members of the editorial committee are: E. Imhof, former head of the Department of Cartography, Swiss Federal Institute of Technology, Zurich; H. Gutersohn, head of the Department of Geography, Swiss Federal Institite of Technology, Zurich (representing the Association of Swiss Geographical Societies; E. Huber, director, Topographical Survey of Switzerland, Wabern; A. Meli, director, Swiss Federal Office of Statistics, Bern, and E. L. Paillard, Lausanne).

The atlas will be published as a non-bound collection of maps in nine instalments of about ten large multicoloured map-plates each. Explanatory texts will be printed on the reverse sides of the plates. The format of the plates is as follows: open, 30 × 20 inches; folded, 15 × 20 inches. The first instalment of eleven plates was published in the spring of 1965 and the second instalment (ten plates) in the summer of 1966.

The eighty-six plates of the atlas will contain the following groups of maps:

Plate Nos.	*Subjects*
1–3	Topographic and political surveys (3 maps)
4–19	Physical geography: geology, geomorphology, soils, climate, lakes and rivers, fauna and flora (about 57 maps)
20–22	History (about 5 maps)
23–35	Demography, distribution of religious denominations and languages, socio-economic structures (about 35 maps)
36–47	Settlement types and urban geography, including Geneva, Lausanne, Bern, Basle and Zurich (about 50 maps)
48–57	Agriculture, forestry and rural engineering (about 30 maps)

[1] The original text of this paper, prepared by E. Imhof, appeared as document E/CONF.52/L.118.

Plate Nos.	Subjects	Plate Nos.	Subjects
58–59	Natural resources and power industry (about 5 maps)	75	Educational institutions (1 map)
60–69	Industry, commerce and trade, tourism (about 28 maps)	76–78	Physical and socio-economic regions; national planning (about 10 maps)
70–74	Railways, waterways, road and air traffic, communications (about 8 maps)	79–86	Regional maps (about 35 maps)

REPORT ON THE THEMATIC MAP SERIES AND ATLASES IN JAPAN

Paper presented by Japan[1]

COMPILATION OF THEMATIC MAP SERIES AND ATLASES

In Japan, several types of thematic map series and atlases have been published in the past twenty years.

A Geographical Map Series at 1:800,000 scale was compiled by the Geographical Survey Institute in 1946–1950.

This series of map sheets aims at giving a clearer picture of the natural and cultural features of Japan, consisting of seven types of thematic maps, namely, land use, landform classification, electricity, agriculture, traffic, population density, labour population and urbanization. Each sheet was compiled utilizing the same base map with standardized accuracy. These series of sheets contributed towards pioneering a national atlas series of Japan.

The economic atlas of Japan was then published by the Zenkoku-Kyoiku-Tosho Co., Ltd., in 1954. This atlas was compiled from the Geographical Map Series published by the Geographical Survey Institute and other materials published by governmental agencies. It contains sixty-one thematic maps at scales from 1:500,000 to 1:1,000,000, including subjects such as history, geology, soil, land use, population, agriculture, forestry, industry and mining, transportation, public facilities, finance, land development, etc., together with explanatory text and statistical data. This was one of the most representative atlases at that time.

THEMATIC MAPS AS A SOURCE OF NATIONAL OR REGIONAL ATLASES

For specialized purposes, many types of thematic maps have been compiled at topographic or chorographic scales in the past fifteen years, chiefly by public agencies, such as the Geographical Survey Institute, the Geological Survey, and the Economic Planning Agency. Some of the principal maps are indicated below:

Geological map series at 1:50,000, 1:200,000 and 1:500,000 scales by the Geological Survey, the Economic Planning Agency and prefectural governments;

Landform classification map series at 1:25,000, 1:50,000 and 1:500,000 scales by the Geographical Survey Institute and the Economic Planning Agency;

Land-use map series at 1:25,000, 1:50,000 and 1:200,000 scales by the Geographical Survey Institute, the Hokkaido Development Bureau and prefectural governments;

Water-use map series at 1:50,000 scale by the Geographical Survey Institute and the Economic Planning Agency;

Lake chart series at 1:10,000 scale by the Geographical Survey Institute;

Forestry map series at various scales by the Forestry Agency;

Population map series at 1:1,000,000 scale by the Statistical Bureau;

Agricultural map series at 1:200,000 scale by the Ministry of Agriculture and Forestry;

Electricity map series at 1:600,000 scale by the Ministry of International Trade and Industry;

Road traffic map series at 1:500,000 scale by the Road Bureau of the Ministry of Construction and the Geographical Survey Institute;

Map series on disaster prevention at 1:10,000, 1:25,000 and 1:50,000 scales by the Science and Technology Agency and the Geographical Survey Institute.

Map series on land development plan, regional plan and city plan at scales from 1:25,000 to 1:500,000 by governmental and local planning agencies.

Most of these map series have been compiled to support nation-wide development plans and, especially those at topographic scales, cover only important areas for development or conservation planning. However, they are very useful for the compilation of national or regional atlases.

NATIONAL OR REGIONAL ATLASES

Several published atlases and map series have already been mentioned at the beginning of this report. Two atlases currently in preparation are described below.

Atlas for National Land Development

This atlas is currently being compiled by the Japanese Land Development centre. Its contents are classified into ten subjects: nature, population, regional structure of funds, regional structure of production, location of industries, communications, regional structure of living, present status of social facilities, metropolitan areas and their functions, and land classification. Approximately 900 sheets of manuscript maps, approximately 300 sheets of manuscript graphs and about 700 statistical tables have already been completed by forty staff members of universities and the centre. The results will be issued in the near future.

Educational Atlas for Japan

The Japanese Educational Information Centre is currently compiling the standard atlas of Japan to meet geographical education requirements at the level of senior high school graduates. Approximately one-third of all the plates have already been compiled and are now in the reproduction process.

The Geographical Survey Institute compiled three sheets of the IMW covering the main islands of Japan in August 1966. The institute is currently engaged in the compilation of the district map series at 1:500,000 scale. This series

[1] The original text of this paper, prepared by Masayoshi Takasaki, Geographical Survey Institute, appeared as document E/CONF. 52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10, 12 and 13.

consists of seven sheets covering the main islands of Japan. The two series will be quite useful as base maps for a national or regional atlas of Japan.

In addition to these recent activities concerning atlases, the working group on atlases was organized in February 1966 as one of five working groups of the Japanese Cartographers' Association. The group decided to conduct research on a standard national atlas of Japan as its main project. The Japanese Cartographers' Association also held a panel discussion on 3 September 1966, on a regional atlas of the Pacific region, inviting five geographers from four countries who participated in the eleventh Pacific Science Congress, and discussed the character, style and subjects of a national atlas of Japan. Participants were S. P. Chattergee (India), A. C. Gerlach (United States of America), S. Leszycki (Poland), H. Boesch (Switzerland) and M. Hsu (United States of America).

As mentioned above, experience has been gained regarding atlases and map series. Plans for a standard national atlas of Japan will be developed in the near future. The main task is to establish a national atlas organization as soon as possible. In our opinion, the organization should be composed of two authorized groups. One should be a supervisory committee to develop a general plan, determine subjects of the atlas and formulate other policy matters; the second should be a working group to collect source data, to conduct basic research and to compile and draft maps, explanatory notes and statistical data for the atlas.

GENERAL SOIL MAP OF THAILAND

Paper presented by Thailand[1]

Introduction

The first systematic study of the soils of Thailand was made by R. L. Pendleton and published in a report together with a "provisional map of the soils and surface rocks of the Kingdom of Siam". This map, published first in 1963, has, with very slight alterations, been reprinted several times since, and was presented at the Fourth United Nations Regional Cartographic Conference for Asia and the Far East in 1964.

In presenting his map, Pendleton emphasized its provisional character, both in regard to the cartographic aspect and to the type of soil classification used. Hence it was decided to establish a new soil map of Thailand, rather than try to revise the existing one.

Collection of data for this map started in 1961. Pilot studies and surveys of seven selected areas were carried out in 1964 and 1965. In 1965, the establishment of the new general soil map was formalized in a project in which the Department of Land Development, Kasetsart University (Department of Soils) and the Applied Scientific Research Corporation of Thailand were the participant agencies. The project not only includes the establishment of the new general soil map of Thailand, but will also continue as research in the morphological, analytical and genetic properties of the main soils of the country.

Procedures

Existing information

A critical study was made of Pendleton's soil survey work, which furnished important data for incorporation in the new soil map. Use was made of data from soil surveys, both published and being edited, carried out since 1961 by the Ministry of Agriculture and since 1963 by the Department of Land Development Soil Survey Division. These surveys are at scales varying from reconnaissance (1:250,000) to detailed (1:20,000 or larger). Especially for north-eastern Thailand, much survey information of a detailed reconnaissance nature (1:100,000) was available.

Information on geology and physiography was obtained from the 1:2,500,000 reconnaissance geological map of Thailand by G. E. Brown *et al.* In the last stage of the preparation of the map, use was made of the new 1:750,000 geological map of north-eastern Thailand.

Base documents

For field surveys and map drafting, existing military topographical maps were used, as follows: series L 708, AMS at the scale of 1:50,000; series L 509, AMS at the scale of 1:250,000; where available, use was made of the revised second or third edition of this map; series 5308, AMS, sheets 3 and 4, at 1:1,250,000.

At the time of the preparation of the general soil map, the maps of series L 708 and L 509 were not available for the area south of the 7th parallel. For that area, use was made of ¼ inch and 1 inch scale maps; respectively series GSGS 4218 and GSGS 4690.

For air-photograph interpretation, use was made of the 1953–1955 AMS air-photographic cover of the country north of the 12th parallel and, where available, of an older RAF cover for the southern areas. The scale of these photographs varies from approximately 1:40,000 to 1:60,000. In restricted areas of the country, more recent air-photographs and uncontrolled mosaics were available for consultation. Air-photographs indexes of the above covers, at a scale of from 1:240,000 to about 1:320,000, were used for general delineation of mapping units.

Field work

During the five years of preparation of the new soil map, most areas of the country were visited by one or both authors. Along all main roads, and a good score of the accessible secondary roads and smaller tracks, linear surveys were carried out and notes made on surface forms (geomorphology), rocks, vegetation and land use, and on soils and their pattern of occurrence. Major soils were studied in selected representative sites in greater detail, and a considerable number of profiles were described and sampled for further analytical study. In seven selected areas, the linear surveys were extended to reconnaissance surveys, and maps were prepared at a scale of 1:250,000. These pilot surveys resulted in the establishment of a working legend of the units, distinguished on the new map.

[1] The original text of this paper, prepared by F. R. Moormann, FAO Adviser to the Government of Thailand, and Santhad Rojanasoonthon, Kasetsart University, Bangkok, appeared as document E/CONF.52/L.122.

In various parts of the country, air reconnaissance by commercial and government planes completed the field work.

Use of air photographs and maps

Extensive use was made of air photography for determination and location of the various soil patterns distinguished during the field work. A complete stereographic air-photographic interpretation of the country could not, of course, be carried out, nor was such an interpretation necessary for the establishment of the map. Air-photographs of restricted areas were studied in detail for each of the major soil patterns forming the basis of the map legend. Particularly in areas where the soil pattern either did not conform at all, or not exactly, with the patterns determined in the field studies, quite detailed air-photographic studies were carried out. Once the patterns were established, however, a close study of the air-photograph index sheets was sufficient for the purpose of delineating the various map units.

Certain elements used in the legend could very well be determined and delineated on the 1:50,000 topographical maps; topography (steep land, rolling and undulating land, level land); land-use (forest land with poor and/or shallow soils, shifting cultivation, land with deeper, non hydromorphic soils, upland crop-land and deep, more fertile soils, rice land with hydromorphic soils etc.). Thus, a detailed study was made of all available AMS maps, series L 708, scale 1:50,000 and, for the extreme south of Thailand, of the GSGS maps, series 4690, scale 1 inch to 1 mile.

Map compilation

Field data, data from air-photographs and from existing soil maps were compiled on the series L 708 and GSGS 4690 maps. From these data, the boundaries of the map units were drawn on the 1:250,000 scale maps (AMS L 590) and, south of the 7th parallel, on the $\frac{1}{4}$ inch maps (GSGS 4218). Where necessary, boundaries were corrected by further field surveys and by air-photograph interpretation. A further reduction to scale 1:1,250,000 was done by hand, using the 10,000 m Universal Transverse Mercator grid (zone 47, Everest spheroid) as reference. In the process of this reduction, a certain amount of simplification was applied, soil boundaries were straightened somewhat and very small unit areas were generally omitted.

Further reduction to scale 1:2,500,000 for the purpose of preparing a simplified version of the new general soil map was done photographically.

Contents

On the new general soil map of Thailand, twenty-three basic map units and two phases have been distinguished. It should be emphasized that these map units are not "pure"; in each unit area some, and in many cases considerable inclusions of other map units may be present. Thus it is not certain that, in a given spot, the soil indicated on the map is indeed found there. However, it may be assumed that, for each unit area, the indicated soil (or group of soils) is the predominant one.

The elements used in defining the map units are threefold: the dominant soil or association of soils; the broad group of parent material and the landform as expressed by the general topography of the unit area.

Soils

The level of generalization of the soil units used in elaborating the map legend is the Great Soil Group, as defined in the United States literature.

The Great Soil Groups mentioned in the legend are mostly taken from Dudal and Moormann; additional groups, important in Thailand, are described by Rojanasoonthon and Moormann. The criteria used in describing and classifying the Great Soil Group are those set forth in the new United States Department of Agriculture soil classification system. Map-unit areas which do not show one dominant soil, but are composed of two or even more important Great Soil Groups, are defined as associations of Great Soil Groups. Poorly defined soil areas with complex soil conditions are indicated as miscellaneous soils and land types.

The following Great Soil Group forms an element in the legend of the new soil map.

Regosols
Alluvial soils
Peat and muck soils (organic soils)
Low-humic gley soils
Grumusols
Rendzinas
Brown forest soils
Noncalcic brown soils
Red-brown earths
Grey podzolic soils
Red-yellow podzolic soils (the presence of abundant laterite gravel was indicated as a separate phase for north-eastern Thailand)
Reddish-brown lateritic soils
Reddish-brown latosols
Red-yellow latosols

Other Great Soils Groups, such as solodized solonetz soils, humic gley soils and groundwater podzols, were observed in Thailand; their occurrence is, however, so limited that they could not be indicated on the general soil map.

Parent materials

Groups of parent materials were distinguished mainly on the basis of their importance in regard to the soils which formed on them. Thus the classification of parent rocks is hardly a systematic petrographic one, since petrographically very different rocks (such as granites and quartzite phyllites) may produce similar soils, and *vice versa*. The main groups of parent materials distinguished for use in the map legend are:

Beach and dune sand
Recent alluvium, subdivided in fresh water river and lacustrine alluvium, brackish water alluvium, marine non saline alluvium and marine saline alluvium
Semi-recent alluvium
Old alluvium (non-calcareous or only slightly calcareous)
Marl and limestone alluvium
Montmorillonitic clay from alluvium, marl and basalt
Residuum and colluvium from acid rocks (most granite, sandstone, quartzite phyllite, etc.)
Residuum and colluvium from intermediate rocks (andesite, some granite, most gneiss, most shale etc.)
Residuum and colluvium from basic rocks (basalt, limestone etc.)
In the case of reddish-brown latosols, the rock could be specified as basalt because in south-east Asia this Great Soil Group is almost exclusively found on materials derived from basalt.

It should be emphasized that, under the climatic conditions prevailing in Thailand, the occurrence of soils formed on *in situ* residue is very rare. Most commonly the parent materials of the soils has been dislocated considerably, and thus could with reason be considered as colluvium or colluviated residuum.

Topography

The topography indications in the legend follow soil slope classes of the United States Department of Agriculture Soil Survey Manual: level, dominant slopes 0 to 1–3 per cent; undulating, 1–3 to 5–8 per cent; rolling, 5–8 to 10–16 per cent; steep (including hilly and very steep): more than 10–16 per cent.

The topography as presented in the legend is indicative for the dominant landforms, especially if interpreted in conjunction with the parent material: level to undulating lands are coastal beaches and dunes and various sedimentary terraces; undulating to rolling lands are peneplained areas, foothills, plateaux in the mountainous regions, some incised terraces and a single basalt plateau; steep lands are mountains and hills.

Soil management grouping

For the benefit of the agronomist with a lack of training in soil classification, the map units have been grouped broadly in classes which give a general indication of the dominant texture, the natural drainage and the general fertility status and thus are meaningful in terms of soil management. Eight classes have thus been distinguished; a ninth class of miscellaneous soils and land types, predominantly steep land, has been added.

Presentation

The new general soil map of Thailand shown in manuscript at this conference will be printed at scale 1:1,250,000 in the course of 1967; it will be sponsored by the Land Development Department, Kasetsart University, and the Applied Scientific Research Corporation of Thailand.

A simplified edition at scale 1:2,500,000 is also to be produced in 1967; this map will be published in the Atlas of Topical Maps sponsored by the Royal Thai Survey Department.

The explanatory text to accompany the new general soil map of Thailand is being elaborated.

AGENDA ITEM 11*

Aeronautical charts

SIMULATED PROCESS PRINTING OF AERONAUTICAL CHARTS

Paper presented by the United States of America[1]

DISCUSSION

In the printing of maps and charts by offset lithography, a separate printing plate is conventionally required for each chart or group of features that appears in a separate colour. As the number of feature categories increases, so does the number of colours required to distinguish them, with a corresponding increase in the number of printing plates needed to imprint these colours one after another on the paper. As many as ten, or even more, different printing plates might be required for some charts. Each plate, of course, calls for a separate run through the press; the more plates, the more press runs.

On the other hand, the normal "process printing" principle involves only the three basic colours of yellow, magenta and cyan, in the combinations of which, with black, all other colours and shades can be obtained. The Aeronautical Chart and Information Centre (ACIC) is employing this principle, but in modified form, to combine the effects of two or more printing plates to produce additional, different, colours or shades representing certain other features. Separate printing plates—and consequently separate press runs—for these other features are thereby made unnecessary. Because it is not a true three-colour process, the ACIC technique is termed "simulated process printing".

In the simulated process methods, the "line" features, such as roads, contours, drainage and the like, are printed in their established single colours or shades, from one plate each. This is done to preserve the engraved precision and sharp distinctiveness of these features. However, by selectively adding the screened images of certain other features to both of a given pair of printing plates, the added images will overprint one another during the press runs, and the two plates so used can be made to produce, by the combination of their two colours, a third colour, without the necessity of a separate press run. This technique is especially effective for "tint features". For example, by placing the screened land tint image on both the drainage (blue) plate and the city tint (yellow) plate, the blue and yellow overprint each other and combine to produce the green land tint. A separate press run for the green image is therefore made unnecessary.

It may be useful to emphasize that the process printing colours of yellow, magenta and cyan are not used, as such. The inks used are the regular lithographic inks in the shades normally used to print the various aeronautical chart features by the conventional methods. Some adjustments in choice of shades may be made to adapt production to the peculiarities of the method, but no attempt is made to produce the full range of the colour spectrum from the three basic colours alone, as would be the case in "pure" process printing. The choice of what shades to combine to create additional shades is made from those which will do the most satisfactory job within the requirements of aeronautical chart design and production.

ADVANTAGES AND DISADVANTAGES

An advantage of the conventional chart lithographing method (that is, a separate press run for every differently coloured feature) is that each feature can be treated independently. The colour shade for each feature can be designed for specific visual effects, and be reliably reproduced in standardized printing inks. (In the simulated process method, the colours of more than one feature must be taken into account in selecting colours for the features, for some, at least, will directly affect certain others.) The primary disadvantage of the conventional method is the higher cost resulting from the greater number of press runs needed.

The great advantage of the simulated process method is the elimination of some of the press runs, which significantly reduces the cost of production. The savings realized are considerable, inasmuch as the number of plates and press runs eliminated can range from one to three on jobs of five to ten colours. Since the average plate-press run requires nine man-hours, a saving of nine to twenty-seven man-hours is realized on each job which formerly took 45 to 90 man-hours to print. A labour saving of about 20 per cent is thus effected. A secondary, but significant, advantage is that there are fewer pieces of material to be handled and transported when shipping reproduction material (when some of the composing is performed on negatives rather than on the plate). The primary disadvantage of the simulated process method is a partial limitation on colour selection which may make compromises necessary in the colour design of the chart.

APPLICATION

Chart products to which the method is currently applied are: 1:1,000,000 scale Operational Navigation Charts (ONC), and the 1:500,000 scale Pilotage Charts (PC).

Application to date has avoided the simulation printing of features symbolized by thin lines (contours, roads, railways, etc.), and of type (place names, figures etc.).

* An Indonesian paper, "Cartographic work in Indonesia, 1964–1966", submitted under this item, is reproduced under agenda item 6 above.

[1] The original text of this paper, prepared by the Aeronautical Chart and Information Centre (ACIC), United States Air Force, and submitted under agenda items 11 and 13, appeared as document E/CONF.52/L.16.

This is because of the registration problems involved in exactly overprinting two such images. However, when the line symbol, or type information, can be included with other features of the same colour which are being screened for the simulation treatment, but is itself to appear on only one of the plates, it may be screened along with the other symbology, and so printed. In such a case, no registration problem occurs, and a separate press run for the line or type information is eliminated. For example, a grey contour plate has been eliminated by screening this feature and combining it with the black plate. The screening produced the wanted grey tone for the contours. Users of the method will be alert for such situations which can be exploited to eliminate press runs wherever feasible.

The most popular application so far has been in the production of land tints. By screening the land-tint area images and placing them on both the blue drainage plate and the yellow city-fill tint plate, the combination of blue and yellow produces the desired light green land tint without the necessity of a separate press run. In addition, of course, the blue and the yellow are each printed in their own turn.

There is really no hard and fast rule about what must be combined with what. As in the example of the grey contour lines, the user can be alert for whatever opportunities the particular situation provides to eliminate as many press runs as may be consistent with the requirements of the finished product. However, the opportunity for and feasibility of certain combinations (such as blue and yellow to make green) occur more frequently than others and thus become more or less standard procedure.

TECHNIQUE

The composing may be accomplished on the printing plate itself, or a composed negative may be produced by combining several others and the printing plate exposed through this, for each combination concerned. At ACIC, because all the intermediate work material is available, it is usually more convenient to compose on the plate. Moreover, because of the incessant revision required for aeronautical charts, it is practically mandatory at the originating agency to keep the basic reproduction pieces separate, for convenience in making changes to the chart information.

The attached printing specifications show details of the operation. One of each pair of these diagrams shows the features (first column) which would be composed upon a single printing plate for conventional lithographic printing. The other shows how the same features are still further combined, a greater number of them to a single plate, for simulated process printing. Intermediate columns in both examples indicate the masks and screens to be used, when applicable. A pair of such specifications are attached for each of two major chart series: the 1:500,000 scale Pilotage Charts (PC) and the 1:1,000,000 scale Operational Navigation Charts (ONC). Similar specifications are being prepared to extend the simulated process method to additional chart series.

DEVELOPMENT

It seems probable that the half-tone shaded relief and screened vegetation/woodland features can also be produced without necessity of separate press runs for them. Successful sample printings of shaded relief, which normally would be printed by means of a separate "grey plate", were prepared by overlaying the 90°-oriented shaded relief half-tone negative on to a 200-line, 34 per cent, 30° screen, and compositing it with the black plate. The vegetation/woodland vignette feature, which normally would be printed by means of a separate "green plate", has been successfully obtained by compositing the 30°-oriented vegetation/woodland vignette image on to the yellow (city-fill tint) plate, and the same image, with a 200-line, 25 per cent, 50° screen, on to the blue (drainage) plate. The superimposed images, in each case, have produced effective portrayals of the features concerned.

Specification for simulated process printing of PC chart series

Feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and ink number*
1. Border	None	None		
2. Graticule with aero holdout	None	None		
or				
2a. Graticule	Aero holdout	None		
3. Culture with aero holdout	None	None		
or				
3a. Culture	Aero holdout	None		
11. Contours	None	200-line, 45%–60°		Black, ACP 0001
12. Topographic names	None	200-line, 45%–60°		
13. Cultural names	None	200-line, 45%–60°		
14. Tidal flats, open window	None	ACIS tidal flats symbol		
or				
14a. Tidal flats, pre-screened symbol	None	None		
15. Sand (dry), open window with water and city tint holdout	None	ACIS sand symbol and 200-line, 45%–60°		
or				

Specification for simulated process printing of PC chart series (*continued*)

Feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and ink number*
15a. Sand (dry), open window	Water and city tint holdout	ACIS symbol and 200-line, 45%–60°		Black, ACP 0001
or				
15b. Sand (dry), pre-screened symbol with water and city tint holdout	None	200-line, 45%–60°		
or				
15c. Sand (dry), pre-screened symbol	Water and city tint holdout	200-line, 45%–60°		
16. Distorted surface area, open window with water and city tint holdout	None	ACIS lava symbol and 120-line, 25%–60°		
or				
16a. Distorted surface area, pre-screened symbol with water and city tint holdout	None	120 line, 25%–60°		
or				
16b. Distorted surface area, open window	Water and city tint holdout	ACIS lava symbol and 120-line, 25%–60°		
or				
16c. Distorted surface area, pre-screened symbol	Water and city tint holdout	120-line, 25%–60°		
4. Drainage	None	None		Blue, ACP 201
5. Water tint, open window	None	120-line, 45%–45°		
or				
5a. Water tint (vignette attached)	None	None		
6. Georef	None	None		
7. UTM	None	None		
8. Swamps, open with water and city tint holdout	None	ACIS swamp symbol		
or				
8a. Swamps, open window	Water and city tint holdout	ACIS swamp symbol		
or				
8b. Swamps, pre-screened symbol with holdout of water and city tint	None	None		
or				
8c. Swamps, pre-screened symbol	Water and city tint holdout	None		
9. Rice, open window with holdout	None	ACIS rice symbol		
or				
9a. Rice, pre-screened with holdout	None	None		
or				
9b. Rice, open window	Water and city tint holdout	ACIS rice symbol		
or				
9c. Rice, pre-screened symbol	Water and city tint holdout	None		
10. Sand (wet), open window	None	ACIS sand symbol		
or				
10a. Sand, pre-screened symbol (wet)	None	None		
25. Level area with water and city tint holdout	None	120-line, 5%–60°		
or				
25a. Level area	Water and city tint holdout	120-line, 5%–60°		
17. Roads with aero holdout	None	None		Brown, ACP 510
or				
17a. Roads	Aero holdout	None		
18. Boundary Ovp, open window	None	120-line, 45%–45°		
or				
18a. Boundary Ovp, pre-screened	None	None		

Specification for simulated process printing of PC chart series (*concluded*)

Feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and Ink number*
19. Shelf ice (polar)	None	120-line, 17%–30°		Grey, ACP 404
20. Pack ice	None	Pack Ice Pattern (oriented parallel to head and foot of printed chart) and 120-line, 17%–30°		
21. Shaded relief with water and city tint holdout	None	None		
or				
21a. Shaded relief	Water and city tint holdout	None		
22. Vegetation, open window with water and city tint holdout	None	120-line, 45%–30°		Green, ACP 315
or				
22a. Vegetation, open window	Water and city tint holdout	120-line, 45%–30°		
or				
22b. Vegetation, open window with water and city tint holdout	Level area negative as mask	120-line, 45%–30°		
or				
22c. Vegetation, vignette with water and city tint holdout	None	None		
or				
22d. Vegetation, vignette	Water and city tint holdout	None		
or				
22e. Vegetation, vignette with water and city tint holdout	Level area negative as mask	None		
or				
22f. Vegetation, vignette with water, city tint, and level area holdout	None	None		
or				
22g. Vegetation, open window with water, city tint, and level area holdout	None	120 line, 45%–30°		
23. Aeronautical	None	None	→	Blue, ACP 214
24. City fill	None	None	→	Orange, ACP 902
25. Level area with water and city tint holdout	None	120-line, 17%–75°		Yellow, ACP 606
or				
25a. Level area	Water and city tint holdout	120-line, 17%–75°		
26. Low relief with water and city tint holdout	None	120-line, 10%–75°		
or				
26a. Low relief	Water and city tint holdout	120-line, 10%–75°		
or				
26b. Low relief with water, city tint, and level area holdout	None	120-line, 10%–75°		
27. Moderate relief with water and city tint holdout	None	120-line, 45%–45°		
or				
27a. Moderate relief	Water and city tint holdout	120-line, 45%–45°		
28. High relief with water and city tint holdout	None	None		
or				
28a. High relief	Water and city tint holdout	None		

Where the negatives of individual features are furnished in different ways (with or without particular holdout masks), the various ways the negatives are furnished are listed. Each variation is noted with a lettered suffix to the feature identification number and all variables for a specific feature are boxed.

Specification for conventional printing of PC chart series

Feature identification	Mask to be registered with feature negative before plate exposure	Screen tint to be applied with feature negative before plate exposure	Features composed on one plate	Colour of ink and ink number
1. Border	None	None		Black, ACP 0001
2. Graticule with aero holdout	None	None		
or				
2a. Graticule	Aero holdout	None		
3. Culture with aero holdout	None	None		
or				
3a. Culture	Aero holdout	None		
4. Drainage	None	None		Blue, ACP 201
5. Water tint, open window	None	120-line, 45%–45°		
or				
5a. Water tint, vignette attached	None	None		
6. Georef	None	None		
7. UTM	None	None		
8. Swamps, open window with water and city tint holdout	None	ACIS swamp symbol		
or				
8a. Swamps, pre-screened symbol	Water and city tint holdout	None		
or				
8b. Swamps, open window	Water and city tint holdout	ACIS swamp symbol		
or				
8c. Swamps, pre-screened with water and city tint holdout	None	None		
9. Rice, open window with water and city tint holdout	None	ACIS rice symbol		
or				
9a. Rice, pre-screened symbol with water and city tint holdout	None	None		
or				
9b. Rice, open window	Water and city tint holdout	ACIS rice symbol		
or				
9c. Rice, pre-screened	Water and city tint holdout	None		
10. Sand (wet), open window	None	ACIS sand symbol		
or				
10a. Sand (wet), pre-screened symbol	None	None		
11. Contours	None	None		Grey, ACP 403
12. Topographic names	None	None		
13. Cultural names	None	None		
14. Tidal flats, open window	None	ACIS tidal flats symbol		
or				
14a. Tidal flats, pre-screened symbol	None	None		
15. Sand (dry), open window with water and city tint holdout	None	ACIS sand symbol		
or				
15a. Sand (dry), open window	Water and city tint holdout	ACIS sand symbol		
or				
15b. Sand (dry), pre-screened symbol with water and city tint holdout	None	None		
or				
15c. Sand (dry), pre-screened symbol	Water and city tint holdout	None		

Specification for conventional printing of PC chart series (*continued*)

Feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and ink number*
16. Distorted surface area, open window with water and city tint holdout	None	ACIS lava symbol		Grey, ACP 403
or				
16a. Distorted surface area, pre-screened symbol with water and city tint holdout	None	None		
or				
16b. Distorted surface area, open window	Water and city tint holdout	ACIS lava symbol		
or				
16c. Distorted surface area, pre-screened symbol	Water and city tint holdout	None		
17. Roads with aero holdout	None	None		Brown, ACP 510
or				
17a. Roads	Aero holdout	None		
18. Boundary Ovp, open window	None	120-line, 45%–45°		
or				
18a. Boundary Ovp, pre-screened	None	None		
19. Shelf ice (polar)	None	120-line, 17%–30°		Grey, ACP 404
20. Pack ice	None	Pack ice pattern (oriented parallel to head and foot of printed chart) and 120 line, 17%–30°		
21. Shaded relief with water and city tint holdout	None	None		
or				
21a. Shaded relief	Water and city tint holdout	None		
22. Vegetation, open window with water and city tint holdout	None	120-line, 45%–30°		Green, ACP 315
or				
22a. Vegetation, open window	Water and city tint holdout	120-line, 45%–30°		
or				
22b. Vegetation, open window with water and city tint holdout	Level area negative as mark	120-line, 45%–30°		
or				
22c. Vegetation, vignette with water and city tint holdout	None	None		
or				
22d. Vegetation, vignette	Water and city tint holdout	None		
or				
22e. Vegetation, vignette with water and city tint holdout	Level area negative as mask	None		
or				
22f. Vegetation, vignette with water, city tint and level area holdout	None	None		
or				
22g. Vegetation, open window with water, city tint, and level area holdout	None	120-line, 45%–30°		
23. Aeronautical	None	None	→	Blue, ACP 214
24. City fill	None	None	→	Orange, ACP 902
25. Level area with water and city tint holdout	None	120-line, 25%–45°		Green, ACP 316
or				
25a. Level area	Water and city tint holdout	120-line, 25%–45°		

Specification for conventional printing of PC chart series (*concluded*)

Feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and ink number*
26. Low relief with water and city tint holdout	None	120-line, 10%–30°		
or				
26a. Low relief	Water and city tint holdout	120-line, 10%–30°		
or				
26b. Low relief with water, city tint and level area holdout	None	120-line, 10%–30°		
and				
25. Level area with water and city tint holdout (to be used with item 26b)	None	120-line, 10%–30°		
or				
26c. Low relief with level area holdout	Water and city tint holdout	120-line, 10%–30°		Yellow, ACP 606
and				
25a. Level area (to be used with item 26c)	Water and city tint holdout	120-line, 10%–30°		
27. Moderate relief with water and city tint holdout	None	120-line, 45%–45°		
or				
27a. Moderate relief	Water and city tint holdout	120-line, 45%–45°		
28. High relief with water and city tint holdout	None	None		
or				
28a. High relief	Water and city tint holdout	None		

Where the negatives of individual features are furnished in different ways (with or without particular holdout masks), the various ways the negatives are furnished are listed. Each variation is noted with a lettered suffix to the feature identification number and all variables for a specific feature are boxed.

Specification for the simulated process printing of ONC chart series

Feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and ink number*
1. Border	None	None		
2. Graticule (projection) with aero holdout	None	None		
or				
2a. Graticule (projection)	Aero holdout	None		
3. Culture with aero holdout	None	None		
or				
3a. Culture	Aero holdout	None		
4. Contours	None	200-line, 25%–45°		
5. Contour values	None	200-line, 25%–45°		
6. Sand (dry), open window with water and city tint holdout	None	ACIS sand symbol with 200-line, 25%–45°		
or				
6a. Sand (dry), pre-symbolized with water and city tint holdout	None	200-line, 25%–45°		Black, ACP 0001
or				
6b. Sand (dry), open window	Water and city tint holdout	ACIS sand symbol with 200-line, 25%–45°		
or				
6c. Sand (dry), pre-symbolized	Water and city tint holdout	200-line, 25%–45°		
7. Lava (distorted surface area), open window with water tint and city tint holdout	None	ACIS lava symbol, 120-line, 25%–45°		
or				
7a. Lava (distorted surface area), pre-symbolized with water tint and city tint holdout	None	120-line, 25%–45°		
or				

Specification for the simulated process printing of ONC chart series (*continued*)

Feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and ink number*
7b. Lava (distorted surface area), open window *or*	Water and city tint holdout	ACIS lava symbol, 120-line, 25%–45°		Black, ACP 0001
7c. Lava (distorted surface area), pre-symbolized	Water and city tint holdout	120-line, 25%–45°		
8. Drainage	None	None		Blue, ACP 201
9. Georef	None	None		
10. Water tint (open window) *or*	None	120-line, 45%–45°		
10a. Water tint (vignette attached)	None	None		
11. Swamps (open window), with water and city tint holdout *or*	None	ACIS swamp symbol		
11a. Swamps pre-symbolized with water and city tint holdout *or*	None	None		
11b. Swamps, open window *or*	Water and city tint holdout	ACIS swamp symbol		
11c. Swamps, pre-symbolized	Water and city tint holdout	None		
12. Rice, open window with water and city tint holdout *or*	None	ACIS rice symbol		
12a. Rice, pre-symbolized with water and city tint holdout *or*	None	None		
12b. Rice, open window *or*	Water and city tint holdout	ACIS rice symbol		
12c. Rice, pre-symbolized	Water and city tint holdout	None		
13. Sand (wet), open window with water and city tint holdout *or*	None	ACIS sand symbol		
13a. Sand (wet), pre-symbolized with water and city tint holdout	None	None		
13b. Sand (wet), open window *or*	Water and city tint holdout	ACIS sand symbol		
13c. Sand (wet), pre-symbolized	Water and city tint holdout	None		
23. Level area with water and city tint holdout *or*	None	120-line, 5%–45°		
23a. Level area	Water and city tint holdout	120-line, 5%–45°		
24. Low relief with water and city tint holdout and level area holdout *or*	None	90-line, 3%–60°		
24a. Low relief with level area holdout *or*	Water and city tint holdout	90-line, 3%–60°		
24b. Low relief with water and city tint holdout *or*	Level area holdout	90-line, 3%–60°		
24c. Low relief	Water, city tint and level area holdout	90-line, 3%–60°		
14. Roads with aero holdout *or*	None	None		Brown, ACP 510
14a. Roads	Aero holdout	None		

Specification for the simulated process printing of ONC chart series (*continued*)

Feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and ink number*
15. Boundary overprint open window	None	120-line, 45%–45°		Brown, ACP 510
or				
15a. Boundary overprint pre-screened	None	None		
16. Topographic names	None	None		
17. City tint (composed on to ACP 606 yellow plate)	None	None		
18. Aeronautical	None	None	→	Blue, ACP 214
19. Shelf (polar) ice	None	120-line, 17%–30°		Brown, ACP 519
20. Pack ice	None	Pack ice pattern (oriented parallel to head and foot of printed chart) and 120-line, 17%–30°		
21. Shaded relief with water and city tint holdout	None	None		
or				
21a. Shaded relief	Water and city tint holdout	None		
22. Vegetation, open window with water and city tint holdout	None	120-line, 45%–30°		Green, ACP 315
or				
22a. Vegetation with water and city tint holdout (vignette attached)	None	None		
or				
22b. Vegetation, open window	Water and city tint holdout	120-line, 45%–30°		
or				
22c. Vegetation (vignette attached)	Water and city tint holdout	None		
or				
22d. Vegetation, open window	Level area negative as mask plus water and city tint holdout	120-line, 45%–30°		
or				
22e. Vegetation, open window with water and city tint holdout	Level area negative as mask	120-line, 45%–30°		
or				
22f. Vegetation (woods vignetted attached)	Level area negative as mask plus water and city tint holdout	None		
or				
22g. Vegetation with water and city tint holdout (woods vignette attached)	Level area negative as mask	None		
17. City tint	None	None		Yellow, ACP 606
23. Level area with water and city tint holdout	None	120-line, 17%–75°		
or				
23a. Level area	Water and city tint holdout	120-line, 17%–75°		
24. Low relief with water, city tint holdout and level area holdout	None	120-line, 5%–45°		
or				
24a. Low relief with level area holdout	Water and city tint holdout	120-line, 5%–45°		
or				
24b. Low relief with water and city tint holdout	Level area holdout	120-line, 5%–45°		
or				
24c. Low relief	Water, city tint holdout and level area holdout	120-line, 5%–45°		
25. Moderate relief with water and city tint holdout	None	120-line, 25%–15°		
or				
25a. Moderate relief	Water and city tint holdout	120-line, 25%–15°		

Specification for the simulated process printing of ONC chart series (*concluded*)

Feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of and ink number*
26. High relief with water and city tint holdout	None	120-line, 45%–15°		Yellow, ACP 606
or				
26a. High relief	Water and city tint holdout	120-line, 45%–15°		

Where the negatives of individual features are furnished in different ways (with or without particular holdout masks), the various ways the negatives are furnished are listed. Each variation is noted with a lettered suffix to the feature identification number and all variables for a specific feature are boxed.

Specification for conventional printing of ONC chart series

Conventional ONC feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and ink number*
1. Border	None	None		Black, ACP 0001
2. Graticule (projection), with aero holdout	None	None		
or				
2a. Graticule (projection)	Aero holdout	None		
3. Culture with aero holdout	None	None		
or				
3a. Culture	Aero holdout	None		
4. Contours	None	200-line, 25%–45°		
5. Contour values	None	200-line, 25%–45°		
6. Sand (dry), open window with water and city tint holdout	None	ACIS sand symbol with 200-line, 25%–45°		
or				
6a. Sand (dry), pre-symbolized with water and city tint holdout	None	200-line, 25%–45°		
or				
6b. Sand (dry), open window	Water tint and city tint holdout	ACIS sand symbol with 200-line, 25%–45°		
or				
6c. Sand (dry), pre-symbolized	Water tint and city tint holdout	200-line, 25%–45°		
7. Lava (distorted surface area), open window with water tint and city tint holdout	None	ACIS lava symbol, 120-line, 25%–45°		
or				
7a. Lava (distorted surface area), pre-symbolized with water tint and city tint holdout	None	120-line, 25%–45°		
or				
7b. Lava (distorted surface area), open window	Water and city tint holdout	ACIS lava symbol, 120-line, 25%–45°		
or				
7c. Lava (distorted surface area), pre-symbolized	Water and city tint holdout	120-line, 25%–45°		
8. Drainage	None	None		Blue, ACP 201
9. Georef	None	None		
10. Water tint (open window)	None	120-line, 45%–45°		
or				
10a. Water tint (vignette attached)	None			
11. Swamps (open window), with water and city tint holdout	None	ACIS swamp symbol		
or				

Specification for conventional printing of ONC chart series (*continued*)

Conventional ONC feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and ink number*
11a. Swamps pre-symbolized with water and city tint holdout	None	None		
or				
11b. Swamps, open window	Water and city tint holdout	ACIS swamp symbol		
or				
11c. Swamps, pre-symbolized	Water and city tint holdout	None		
12. Rice, open window with water and city tint holdout	None	ACIS rice symbol		
or				
12a. Rice, pre-symbolized with water and city tint holdout	None	None		
or				
12b. Rice, open window	Water and city tint holdout	ACIS rice symbol		Blue, ACP 201
or				
12c. Rice, pre-symbolized	Water and city tint holdout	None		
13. Sand (wet), open window with water and city tint holdout	None	ACIS sand symbol		
or				
13a. Sand (wet), pre-symbolized with water and city tint holdout	None	None		
or				
13b. Sand (wet), open window	Water and city tint holdout	ACIS sand symbol		
or				
13c. Sand (wet), pre-symbolized	Water and city tint holdout	None		
14. Roads with aero holdout	None	None		
or				
14a. Roads	Aero holdout	None		Brown, ACP 510
15. Boundary overprint open window	None	120-line, 45%–45°		
or				
15a. Boundary overprint pre-screened	None	None		
16. Topographic names	None	None		
17. City tint	None	None	→	Yellow, ACP 606
18. Aeronautical	None	None	→	Blue, ACP 214
19. Shelf (polar) ice	None	120-line, 17%–30°		
20. Pack ice	None	Pack ice pattern (oriented parallel to head and foot of printed chart) and 120-line, 17%–30°		
21. Shaded relief with water and city tint holdout	None	None		Brown, ACP 519
or				
21a. Shaded relief	Water and city tint holdout	None		
22. Vegetation, open window with water and city tint holdout	None	120-line, 45%–30°		
or				
22a. Vegetation with water and city tint holdout (vignette attached)	None	None		
or				
22b. Vegetation, open window	Water and city tint holdout	120-line, 45%–30°		Green, ACP 315
or				
22c. Vegetation (vignette attached)	Water and city tint holdout	None		
or				
22d. Vegetation, open window	Level area negative as mask plus water and city tint holdout	120-line, 45%–30°		
or				

Specification for conventional printing of ONC chart series (*concluded*)

Conventional ONC feature identification	*Mask to be registered with feature negative before plate exposure*	*Screen tint to be applied with feature negative before plate exposure*	*Features composed on one plate*	*Colour of ink and ink number*
22e. Vegetation, open window with water and city tint holdout	Level area negative as mask	120-line, 45%–30°		Green, ACP 315
or				
22f. Vegetation (woods vignette attached)	Level area negative as mask plus water and city tint holdout	None		
or				
22g. Vegetation with water and city holdout (woods vignette attached)	Level area negative as mask	None		
23. Level area with water and city tint hold-out	None	None		Green, ACP 311
or				
23a. Level area	Water and city tint holdout	None		
24. Low relief with water and city tint hold-out	None	120-line, 34%–60°		
or				
24a. Low relief	Water and city tint holdout	120-line, 34%–60°		
or				
24b. Low relief with water, city and level area holdout	None	120-line, 34%–60°		
or				
24c Low relief with level area holdout	Water and city tint holdout	120-line, 34%–60°		
or				
24d. Low relief with water and city tint hold-out	Level area tint holdout	120-line, 34%–60°		
25. Moderate relief with water and city tint holdout	None	120-line, 45%–45°		Buff, ACP 503
or				
25a. Moderate relief	Water and city tint holdout	120-line, 45%–45°		
26. High relief with water and city tint hold-out	None	None		
or				
26a. High relief	Water and city tint holdout	None		

Where the negatives of individual features are furnished in different ways (with or without particular holdout masks), the various ways the negatives are furnished are listed. Each variation is noted with a lettered suffix to the feature identification number and all variables for a specific feature are boxed.

A NEW CONCEPT FOR THE COLOUR-PROOFING OF AERONAUTICAL CHARTS

Paper presented by the United States of America[1]

FOREWORD

This paper includes a number of terms that have meanings that are slightly different from their original definition; therefore, a glossary defining usage relative to this particular proofing system is supplied below.

Manuscript: A pre-punched sheet of material which bears an image containing all cartographic detail and symbology as compiled by cartographers.

Plate: A film negative, film positive or scribecoat sheet as related to a specific colour separation; so-called because it results in the lithographic plate which prints the particular colour separation concerned.

Pre-punched: Said of film and plastic sheets which are slotted or punched before application of any imagery. A number of sheets, so punched, can be firmly fixed in relation to each other (i.e., registered) by stacking them upon cylindrical pins which pass through the corresponding holes punched in each.

Post-punched: Said of film and plastic sheets which are slotted or punched by a conversion template after imagery has been applied.

Wipe-on colour: A photo-sensitive colour solution that is applied to a plastic sheet by wiping it on with a cloth or sponge, to obtain an image in a selected colour. Successive coatings can be applied and developed to obtain multicoloured copy for review purposes.

Pipe line: That series of operations and span of production time which is required to produce a chart. Span normally will be calendar time.

[1] The original text of this paper, prepared by the Aeronautical Chart and Information Centre, United States Air Force, and submitted under agenda items 11 and 13, appeared as document E/CONF.52/L.17.

Call: A request that a certain correction be made.

Type/type plate: The chart information depicted in printed type, such as place and feature names, contour values, grid and graticule figures, descriptive notes, etc. The colour separation which bears this information.

Introduction

Through the years, the Aeronautical Chart and Information Centre has endeavoured to develop colour separation review proofing systems and media that are flexible enough to adjust to major evolutions and improvements in cartographic products. The technical personnel responsible for the development of cartographic support materials have tested and evaluated a variety of proofing systems and materials. A range of products has been used from the simplest paper ozalid to sophisticated composite colour proofs.

The wipe-on colour proof, developed in 1953, has been most reliable; however, it has limitations. For example, product developments requiring increased line density, multiple colour tints etc., have made it necessary to remove certain plates from the negative set and proof them by individual separations, which are in turn registered to the water-coat proofs for the performance of the composite colour separation reviews. If, during one of these proofing operations, correction calls are made, it is necessary to reproof the entire negative set, rather than merely those annotated for correction.

Proofing studies are constantly being carried on to improve working methods, to lower costs and, most important, to shorten production time. An ideal all-encompassing proofing system would be extremely valuable for eliminating errors during the colour separation quality review. It would serve the needs of the cartographer, the negative engraver, the plate-maker and the pressmen, along with others involved in chart production. Obviously, the ideal proofing system must have the desired qualities of composite proofing but not create new problems and complications.

In their quest for a more suitable system of proofing, our technicians had both general guideposts and specific goals. The general guideposts are almost universal in their application to research and development projects: (*a*) What do we want that the present system does not provide? (*b*) What will the proposed method accomplish that the present method will not? (*c*) Will there be an over-all cost advantage with the proposed system? (*d*) Will the proposed method create new problems and complications?

The specific goal was for a unique proofing system, which would first, prepare a proof set that would not require total re-proofing when only one or two of the colour separations needed corrections; secondly, provide proofing media that could be utilized for composite and/or individual separation reviews, as desired (this combination would retain the main benefit of the colour proof); thirdly, reduce the production pipe-line time.

In August 1966, with the assistance of a manufacturer of commercial photographic film, a long step was taken towards achieving the ideal proofing system. The new method is a progressive in-process proofing system. The material which made this system possible is pre-sensitized colour (negative to positive) .004 polyester film. This material is dimensionally stable, has no shelf-life limitations and is heavy and rugged enough to withstand the handling it must undergo from initial negative to final press plate review. Eight image colours are available, and the developing is quick, consistent and accomplished with the minimum of chemicals and equipment.

The most important advantage of the new system is that colour separations can now be individually reviewed and corrected. Composite reviews can be made, with as many separations as desired. Also, only those separations requiring major change need reproofing after corrections have been made. These procedures are accomplished with ease because ACIC utilizes a three-point, universal centre-registration punch system and all raw film stock is pre-punched so as to fall into registration automatically when stacked on pins.

The capability of making plate corrections without having to reproof is important not only because of the over-all reduction in production time, but also because it allows much tighter production scheduling. The range of time to be spent on colour separation review and correction is considerably reduced.

Method and Application

As already mentioned, the method has been described as progressive in-process proofing ("progression" meaning advancing or becoming effective by successive stages; "in-process"—an ACIC term—meaning a proof or review which is accomplished at any time during colour separation procedures for a chart product; these two terms are key factors in the operation of the system).

The following paragraphs will discuss the proofing/reviewing of one complete chart assignment from its inception as a manuscript through press plate review.

The process starts after cartographers have prepared a chart manuscript on pre-punched material and transmitted it to negative preparation personnel for colour separation.

A negative engraver will engrave on a pre-punched coated polyester sheet the hydrographic line features which require screen fill on final product. From this engraved sheet, a film positive is prepared for open water tint (converted to open window negative) after which the remaining line features are engraved on the same sheet. A transparent blue colour positive of the completed hydrographic plate is made in the photographic laboratory and forwarded to the cartographer for in-process inspection. The colour positive is reviewed against the manuscript and corrections are annotated on the positive, using an ink marker.

Progression/in-process

Step 1. The cartographer retains the colour positive of the hydrographic plate. Pending receipt of the next colour positive, he performs any necessary major up-dating. Therefore, when corrections are applied to the hydrographic engraving, they will include the latest information available. Negative engravers will engrave the culture separation, obtain a film positive of it for city fills, road fills etc., and a red colour transparent positive for review. The colour positive is submitted to the cartographer, who reviews it against the manuscript.

Step 2. Hydrographic and culture features are reviewed against each other and corrections are annotated on the red or blue plate, or both. Again, the cartographer retains the colour positives and applies up-dating where required. Negative engravers will engrave the hypsography separation, obtain a film positive for the relief tints and a brown colour transparent positive for review. The brown colour positive is submitted to the cartographer, who reviews it against the manuscript.

Step 3. The hypsography plate is reviewed against the hydrographic and cultural plates and corrections applied.

The order of rotation of the engraved plates is at the discretion of the engravers, but in all cases the cartographer will have the three major plates in his possession prior to corrections.

Now that the major construction of the chart has been completed, the colour positives are returned to the engravers for corrections and completion of the product will proceed.

Negative engravers will correct line-work plates, obtain open window negatives for items requiring screen tints and obtain one set of colour transparent positives.

In addition to the colour positives, screened black matte positives of relief tints and type plate are obtained. These colour positives and matte positives receive a colour separation review by cartographers who annotate corrections on the individual separations. Cartographers will at this point indicate which separations require reproofing, if any, and forward all material to engravers for corrections.

Negative engravers will make corrections to the engravings and film negatives and reproof those plates designated by the cartographer.

Upon finalization of corrections, negative engravers will release all negatives/engravings to plate-makers, who in turn will prepare the required press plates. The plate quality reviewer will use the individual colour positives/matte positives to ensure that all imagery appears on the proper press plate.

Relief tints matte positive

A new method of tint proofing has been incorporated in this system: tints are expressed as tones of screened black rather than by colour.

Land tint proofs are prepared on matte material by composing all open window negatives on a single sheet using alternating screens and angles. The sample assignment below requires six separate tints:

Tint No.	*Line screen*	*Tone (percentage)*	*Angle*
1	120	10	45°
2	120	25	60°
3	120	17	45°
4	120	38	60°
5	120	58	45°
6	120	46	60°

It has been found that, when preparing open-window negatives with "butting" tints and proofing in colour, misregistration cannot be detected readily. But, with the method described, small errors can be detected immediately, since a tint overlap will cause a moiré pattern to appear, and any gap will show up as an absence of screen.

Type plate matte positive

Type information is lithographed along with its appropriate colour line plate.

Review of type on previous composite colour proofs has been difficult to perform because each was in a different colour. The type proof, in the new system, will be a composite matte positive of all type.

Instead of colour, screened black will denote the feature category of the type concerned. An example is shown below:

Hydrography	120-line screen	25 per cent tone
Hypsography.	120-line screen	58 per cent tone
Culture and border	120-line screen	Solid

Conclusion

The combination of several elements: transparent colour positive media, progressive in-process proofing review, and the "universal" film-register punch, have provided a flexible and unique production tool. To say that this system is the ultimate would not be true but, on the other hand, it has proved ideal for present chart production conditions.

Use of the system is for the most part confined to the 22 × 29 inch joint operational graphic assignments at this time. The large 42 × 58 inch Pilotage Chart and Operational Navigation Chart assignments will be programmed into the system in late 1967.

MAINTAINING CURRENT BASE INFORMATION FOR AERONAUTICAL CHARTS

Paper presented by the United States of America[1]

The problem of presenting up-to-date base information to users of aeronautical charts has plagued chart producers for many years and is becoming more complex as modern technology enables man literally to change the appearance of the earth's surface overnight.

As a producer of aeronautical charts, the United States Air Force (USAF) Aeronautical Chart and Information Center (ACIC) has as one of its many responsibilities the maintenance of current base information on aeronautical charts. This responsibility is discharged through the maintenance of knowledge programme, which functions through research specialists who maintain a comprehensive and authoritative personal knowledge of the availability, reliability and utility of source materials and the status of cartographic activities within an assigned geographic area of responsibility. This knowledge is accumulated and maintained through continuous study and review of source materials and finished products on the area.

The maintenance of knowledge programme consists of: (*a*) maintaining a knowledge of the value of cartographic information; (*b*) evaluating source material for charting and chart maintenance programmes; (*c*) establishing and maintaining remedial action files and master correction copy; (*d*) initiating action to notify chart users when hazardous information is found, and (*e*) recommending revision or recompilation of ACIC products.

The prime objectives of the maintenance of knowledge programme are to improve the compatibility and reliability of the aeronautical chart bases, and to keep them as up to date as possible within the demands of production and user requirements.

[1] The original text of this paper, prepared by the Aeronautical Chart and Information Centre (ACIC), United States Air Force, appeared as document E/CONF.52/L.18.

Two tools, the cartographic information folio and the remedial action file, have been adopted for operating the maintenance of knowledge programme.

The purpose of this paper then, is to explain these tools and how they are used in the maintenance of knowledge programme.

Quite naturally, the accuracy of the final cartographic product can never exceed that of the source materials available. It follows, therefore, that the first of the tools would be one containing an analysis and evaluation of the available source material. This tool is the cartographic information folio, a collection of cartographic information that covers a specific geographic area. The USAF World Aeronautical Chart is used as the basic frame of reference for the folios.

The cartographic information folio provides graphic indexes keyed to a 1:1,000,000 scale base. Each index portrays specific information needed to meet the requirements of the USAF charting programmes. Each folio contains ten basic indexes or overlays, as shown below.

1. *Selected horizontal and vertical control source*

This overlay portrays the best horizontal and vertical cartographic source available for the area covered.

2. *Horizontal accuracy of selected source*

This overlay indicates the horizontal accuracy, in feet, of the selected source. Also included is the datum on which the source is based and any relationship to a preferred datum for the area, if the source is not on the preferred datum.

3. *Vertical accuracy of selected source*

This overlay is similar to the preceding one. The vertical accuracy of the relief is indicated in feet. The contour interval shown on the source, the accuracy of spot heights, and the datum on which they are based, along with any correction factor necessary to reduce them to mean sea level, is also shown.

4. *Alternate source*

The purpose of this overlay is to indicate sources which, because of their scale, are more practical for certain medium-scale or small-scale compilations than the basic selected sources. Generally, these selected alternate sources will have incorporated the basic selected sources, and are on a par for their scale. Examples might include British 1:253,440 scale maps compiled from the British basic 1:63,360 scale maps, or USAF Aeronautical Approach Charts in areas where they reflect the basic selected source. It is not required that the whole folio area necessarily be covered by an alternate source. In areas not covered, it is assumed that the basic selected source has no alternate. Conversely, it is conceivable that there could be various forms of alternate coverage and more than one overlay required to portray it.

5. *Supplementary source*

A source which can be used for up-dating basic sources or for the addition of features and detail as required is indicated on this overlay. This may be a source of a later date than the selected source, but not as accurate horizontally, and therefore not usable as a basic source.

6. *Selected town plans and town classification*

Town plans selected to supplement the basic source and information needed to classify populated places are indicated on this overlay. The town plans, in some instances, are of a later date than the basic source, and will show the expansion that has taken place since the basic source was produced.

7. *Boundaries*

This overlay could in some instances be the most important overlay in the folio. Due to the political situation that may exist in a particular area, it is very important that the boundaries be properly portrayed on an aeronautical chart, so that an inadvertent violation of a country's air space does not take place. This overlay indicates the source, when it is other than the basic source, that will be used for the delineation of boundaries.

8. *Roads and railroads*

Indicated on this overlay will be those roads which meet the criteria as outlined in the individual chart specifications, to be shown as primary. Listed in the margin will be those sources, usually road maps, that may be used in determining the road network to be shown on a chart. The classification of railroads is also shown when it differs from that shown on the basic source.

9. *Geographic/grid co-ordinate corrections*

Information required to transpose geographic/grid co-ordinate values of the source to that on which the chart is to be positioned will be shown on this overlay. The information may be in the form of an iso-correction graph, or a schematic diagram indicating the map-sheet corner values.

10. *Chart feature/checkpoint overlay*

A very important source for charting information is textual material that consists of books, pamphlets, periodicals and reports. This information is useful for portraying, identifying, classifying and evaluating chart features or other source materials. It is on this overlay that this type of information is indicated. In addition, those features that are unique and outstanding check points in an area are indicated on this overlay.

This, then is the content of the first tool in the maintenance programme and it is used in two ways. It is used by the research specialist to recommend the sources that are to be used to produce a new chart, and it is the basis for establishing the second tool, the remedial action file.

The remedial action file consists of one copy of each current USAF Navigation and Planning Chart and each is identified as the remedial action copy.

Each remedial action copy is evaluated, using the information contained in the cartographic information folio, for compliance with the criterion established for three major factors.

The first of these factors is the horizontal positioning of chart features. The features are checked for position against the best positioning source available.

The second factor is the vertical accuracy of the relief information portrayed on the chart.

The third factor is the planimetry. Planimetry consists of three parts; completeness, configuration, and currency. Completeness is the degree to which the chart includes significant features of the chart design. Configuration is the similarity of the features portrayed on the product to actual ground characteristics within the limits of scale. Currency pertains to the age of information. The currency is normally expressed in terms of the calendar date of the information, but in certain instances the research specialist is able to arrive at a weighted appraisal based upon his knowledge of the area. For example, information pertaining to a remote region may be considered current when reliable indicators reveal that there has been little or no significant change in the area.

The evaluation of these charts is expressed in terms of the category, or degree, to which they satisfy the requirements for their intended use.

A category A or "optimum" chart is one that cannot be significantly improved for its designed purpose. A chart in this category meets all horizontal, vertical and planimetry requirements.

A category B or "adequate" chart is one that could be improved, but satisfies the major intended purpose for which it was designed.

The category C or "usable" chart contains deficiencies, but not to the extent as seriously to affect utility for its major intended use.

A category D or "inadequate" chart is one that contains inaccurate and/or incomplete information to the extent that utility for its major intended purpose is seriously affected.

The last category, E or "unreliable", is for those charts that are inaccurate or incomplete in the light of a newly acquired source, to the extent that they cannot be used for their intended purpose. Charts that cannot be evaluated, for whatever the reason, also fall in this category.

As each chart is evaluated, it is categorized for each of the major factors, and then given an over-all evaluation that is consistent with the lowest category assigned for the three major factors.

After all the charts in the remedial action file have been evaluated, one chart for each geographic area is selected as a master correction copy. This is the chart that is most accurate and up to date and is usually categorized as high as, or higher than, the other charts covering the same area.

Before the second tool is ready for use, there is one more step to be taken. This step is the comparison of all the charts for a given geographic area with the master correction copy. During the comparison, all differences are annotated on the appropriate chart. Each annotation consists of a numbered circle, in red, placed adjacent to the feature to be corrected, or, in the case of a missing feature, in the location where it is to be added. The description of the correction or addition is keyed by the same numbered circle in the left margin or on the reverse side of the chart. The following information is included in the description: identification of source, including date, from which obtained; classification of source, if any; initials of research specialist making the annotation and date of the annotation.

It is at this point that the actual process of maintaining current base information begins.

It is general policy that all charts be maintained on a selective basis in preference to a systematic basis; therefore, as new information is received, in the form of a later date map source, textual material, or comments submitted by chart users, maintenance action is initiated. This new material is evaluated and compared with the remedial action copy. Corrections or additions that result from this new material are annotated and identified on the remedial action copy in the same manner as those found during the comparison of the remedial action copy with the master correction copy. If any of these corrections or additions are evaluated as hazardous, that is, a feature whose incorrect portrayal or omission would cause gross misidentification or place an aircraft in danger, they are identified by a special arrow stamp placed next to the feature. Corrections or additions noted by the arrow stamp must be applied to the next printing of the chart, and each chart carries a notation to this effect at the head of the list of corrections on each chart.

In addition to the requirement that a hazardous condition be corrected at the next printing, action is initiated to notify the chart-user of the condition. The vehicle for notifying the user is the *Chart Up-dating Manual* (CHUM). This is published once a month to inform all Air Force agencies, and other authorized agencies which receive aeronautical charts from ACIC, of all significant additions or corrections affecting flying safety and have become known on or before the twenty-third day of the previous month. This listing is cumulative and is continued in the CHUM until such time as the chart is revised or a new edition published.

The receipt of a new information may also result in the revision and/or recompilation of a chart. This action is initiated when the accumulation of significant additions or corrections which affect flying safety reach the point where it becomes impractical for the user to transfer them from the CHUM.

To maintain an adequate supply of a particular chart, the number of copies that would normally be required to supply user demands for a six-month period are held in reserve. When this reserve falls below the level required, action is initiated to replenish the stock. This action consists of reviewing the remedial file copy of the chart and recommending a straight reprint, or a revision to make any additions or corrections noted in the CHUM.

Although the maintenance of knowledge programme satisfies present demands for maintaining current base information on aeronautical charts, the future will no doubt require more rapid and efficient methods of getting current information into the hands of the user. Investigations into the possiblities of introducing an automated system of chart maintenance is under way; however, the key to the success of any maintenance system will still be the comprehensive and authoritative personal knowledge by research specialists of the availability, reliability and utility of source materials, and the status of cartographic activities within an assigned geographic area of responsibility.

DEVELOPMENT CONCEPT FOR VISUAL AIR NAVIGATION CHARTS

Paper presented by the United States of America[1]

Introduction

The guidance furnished herein is used in the United States as the basis for the development of Visual Air Navigation Charts, primarily for use by general aviation, but also to include all segments of aviation which operate by visual reference to the ground (visual flight rules).

A representative profile of the operational environment and equipment for this type of flying in the United States is shown below.

Approximately 90 per cent of the aircraft are single-engine, 1 to 5 place craft. The trend shows a slight increase in the number of multi-engine aircraft, but a slight decrease in the number of visual flight rules (VFR) flight plans filed by these aircraft.

Most flying is done for business and pleasure, these two purposes accounting for approximately 75 per cent of all the hours flown. Instructional purposes rank third, with about 11 per cent.

Almost 80 per cent of this flying is performed during daylight hours.

Almost two-thirds of flying hours are accounted for by cross-country flights.

Average speed is approximately 140 knots (160 mph), with almost 20 per cent of the aircraft operating in the 150–175 (170–195 mph) range.

Almost two-thirds of all flights are conducted at 6,000 ft or less above terrain; about 5 per cent over 10,000 ft.

About one-third of cross-country flying is along airways, although almost 80 per cent of aircraft use airways at some time.

Services provided by flight service stations (FSS) are regularly used by 46 per cent and occasionally used by 20 per cent of cross-country flights.

Less than 5 per cent of hours flown are under instrument flight rules (IFR), although a high proportion of aircraft are equipped for instrument flight.

Very few of the aircraft are auto-pilot equipped; however, those who have them use them for almost two-thirds of their cross-country flying.

Seventy-five per cent of aircraft are equipped with VHF transmitters and receivers.

About 12 per cent of the aircraft have simultaneous VHF communications and omninavigation capability, and well over half have this capability alternately.

About 25 per cent of aircraft are able to make limited use of instrument landing procedures (ILS), but less than 10 per cent are able to take advantage of the lowest minimums possible through use of the glide slope.

The number of aircraft equipped with distance measuring equipment (DME) units is small, but lower cost units available now are leading to wider acceptance.

The average experience level of general aviation pilots is approximately 1,000 hours.

The average cross-country flight is approximately 350 miles long.

The chart requirement concept is based upon the type of aircraft, speed, altitude, distance, communication and navigational equipment, and experience level cited above.

Format

Reduction of bulk and increase in utility are two elements of the over-all concept upon which this development is based. Therefore the charts will be printed back to back, top to bottom, so that a pilot can fly to the common edge of one chart and continue his navigation by picking up his course on the reverse side directly opposite the point at which he left the chart. This feature doubles the area covered by a single sheet and halves the total number of sheets to be carried. It also increases convenience in the cockpit. The charts will be folded into a 5 × 10 inch format identical with the instrument chart (*En route* Chart) series, so that storage and recovery are standardized and simplified.

The charts will also feature a bleeding edge on the north and east edges to facilitate joining or matching adjacent charts for flight planning purposes.

Chart identification, a miniature index of the particular chart and its relationship to adjacent charts, a simplified legend of items which are not self-explanatory and insets of dense urban areas to facilitate terminal use will be shown in the margin and chart panel. This panel will be a 5 inch strip along the left side of the face and reverse sides of the chart so that one panel will face outward when the chart is folded.

Base (general)

The key consideration in selection and portrayal of all base detail is visual significance from the air. The chart compiler must imagine that he is looking down at the ground from approximately 6,000 ft, simulating the view of the pilot. His primary field of vision is contained within an approximately 45° depression angle. This is a general limitation within which smaller size detail is recognizable and can be related to the chart. Larger, more prominent features can be recognized at flatter angles; however, there are fewer of those features. The field of vision within the 45° "cone" is represented by a 6,000 ft radius circle on the ground; within a 70° "cone" by a 16,000 ft radius circle. In actuality, only a pie-shaped segment of about 120° is visible ahead and below at a given moment.

When it is considered that it takes about one minute at 140 knots for an object to "move" from a 70° to a 45° angle, and about another 30 seconds for some part of the aircraft to block it from view, not much time is available for recognition of individual features. This condition, of course, is compounded by increased speeds and/or lower altitudes.

It becomes apparent that, unless a unique feature or pattern visible on the ground can also be identified on the charts, the brief view of a road, railroad, lake or town means little. It is the continuing, unfolding reference—the sequence of anticipated detail and the relationship of one feature to another, the direction, distance, pattern and time lapse—which is meaningful. Conversely, the inclusion of minor, common features detracts from the importance of significant features. They dilute, obscure and confuse.

[1] The original text of this paper, prepared by the Flight Information Division, Air Traffic Service, Federal Aviation Agency, appeared as document E/CONF.52/L.19.

These must not be selected. Wherever feasible, current aerial photography should be used for selection of detail.

Cities

Selection

This varies in accordance with general density or sparsity of area. In dense areas, some of the smaller city and town names may be omitted. In very dense, and particularly where there is no defined relationship with other features, or a poorly defined relationship, the city or town symbol may also be omitted. If a minor populated place is located at a river bend, or crossroad, or near a lake, for example, it should be shown to differentiate that point from another nearby river bend, crossroad or lake which might otherwise be mistaken for it. In sparse areas, all small cities and towns should be shown. The compiler must constantly be aware that it is the unique which is significant. He must be thinking of the over-all ground pattern and how the various elements will be combined on the over-all compilation. He is not a specialist in the selection merely of cities and towns.

The only large city in an area is unique for that reason alone. If there are two smaller cities not too far apart, it is the relationship—distance and bearing—of one to the other which differentiates them. It may also be relationship to other detail. If both are along a river, but only one has a bridge, the bridge must be shown. If there is a prominent factory to the north-east, or a race-track, or a drive-in theatre, these should be shown.

Portrayal

The detailed shape of a city is usually not too significant. A great deal of time and effort are normally expended on the determination of the visual outline and the compilation and drafting of this complex information. Yet in application there is little operational benefit to warrant the effort or expense. As previously mentioned, the larger city is recognizable solely because it is the only one of such size in the area. The detail may serve to locate an airport, but this is not the primary purpose of the chart. A larger scale local chart for terminal navigation should be used as a supplement, or reference made to the inset portrayed on the panel. The major purpose of this chart is for *en route* navigation. Therefore the shape of large cities may be generalized. The name need not be overly prominent, and should be keyed to a population classification. Names are secondary and used for planning, reference or reporting and not for navigation.

The insets should be of the largest cities within the chart area, with the emphasis placed on portrayal of information which is significant for terminal use. This portrayal should be more detailed than that on the chart itself and should depict all airports within and in the vicinity of the city, major roads and railroads prominent from the air, showing overpasses and underpasses. Prominent structures which are of checkpoint value should also be shown.

Smaller cities and towns have greater similarity, and are therefore more difficult to recognize than large cities. Even so, detailed shapes are not required. Unless the aircraft flies directly over the city, its shape is distorted by perspective. Furthermore, continuous change takes place and the most careful depiction of detailed shape becomes vague with time. What should be shown is the characteristic shape. A check of the aerial photograph will best disclose this general form. Is it elongated, stretching along a riverbank? Is it rectangular, or crescent shaped, or oval shaped? If the city or town has such a characteristic shape, it should be shown as such, oriented in the correct direction. However, care should be exercised in portraying the relationship of part of the city shape to other features. Perhaps it is bound on one side by a river, road or railroad. The straight edge of the city should be shown against a linear feature or a curved side against a bend of a river. If the shape is nondescript, it may be shown by a symbol appropriate to its size.

Roads and railroads

Selection

A major network of the primary transportation system should first be selected. This consists of turnpikes, dual-lane highways, main-line railroads and primary roads which connect major cities in the area. From this main network, the secondary lines should be extended when necessary for geographic association. Clover-leafs should be shown when they are distinctive. Underpasses and overpasses should be shown when they serve to differentiate one crossroad from another. Cuts and fills should be shown when they are prominent. Highways numbers or names of rail lines should not be shown. Roads or railroads through cities should not be shown, except in insets where the transportation network is significant from the air.

Portrayal

Roads should be shown in the following categories: dual lane (divided highways), primary roads, secondary roads. These categories should be determined primarily by prominence and visibility from the air. Thus width, surfacing and continuity of characteristics should be considered in making these decisions. A supplemental factor is the size of populated places linked by these roads, although account should be taken of the trend in modern road-building to bypass cities. Railroads should be shown as multitrack or single track. Significant sidings should be shown. Freight and marshalling yards which are prominent should be shown by a representative pattern to scale when they are large enough or somewhat exaggerated when necessary to depict. Care and judicious cartographic licence should be exercised in deviating from true position in cases where the normal exaggeration of symbols does not permit depiction through narrow limits. In these cases, relative position should be maintained by sufficient shifting of all the conflicting elements. Furthermore, the deviation from true position should be gradually introduced and resumed so that the basic character of the feature(s) is not altered. Of utmost importance is the necessity for also displacing cultural features, such as a prominent building or race-track, so that they retain their relative position. It is most confusing to a pilot to find a checkpoint on the wrong side of a road, railroad, river etc. It casts sudden doubt on the accuracy of his navigation, because the tendency is to accept the accuracy of the chart. It subsequent checking convinces the pilot that the chart was wrong, his confidence is shaken and his future judgement affected.

Checkpoint features

Selection

Certain small cultural features are extremely significant in visual navigation. It may not always be the feature itself which is so important, but the relationship to other nearby features. The relationship may be distinctive, whereas each feature individually may be very ordinary. Drive-in theatres, factories, towers, race-tracks or large buildings are examples. One of these features, for example, south-west of a town can differentiate that place from another similar one nearby. Judgement must be used in selecting these checkpoints. Each one should be meaningful.

Portrayal

A pictorial representation of the checkpoint should be shown rather than a nondescript symbol accompanied by a functional name, such as "school", "factory", or "institution". The pilot needs description rather then function. When he sees a feature on the ground and looks for its counterpart on the chart, an image conveys the similarity immediately. Otherwise, he has to go through the mental processes of first finding the symbol, reading the functional label, and finally trying to decide what the feature looks like. It is very likely that he will not be able to distinguish the preceding structures from the "prison", "estate" or "sanatorium" which also appears on current charts. Reference to recent aerial photography or availability of other suitable source material is essential for this application.

Hydrographic features

Selection

The basic network of rivers, major lakes and coastlines should first be developed. Additional hydrographic features should then be added as necessary to supplement all the related features. Hydrography is an additional element which will sometimes, because of its uniqueness, provide checkpoint information, but more often will be significant because it helps to differentiate another feature. If two roads are roughly parallel and too far apart to be visible simultaneously, one might be mistaken for the other. But if a stream runs alongside one of the roads, it would provide the necessary additional reference to make positive identification, in which case it should be shown. The small lakes and rivers, properly selected, can make the over-all presentation much more effective.

Portrayal

The blue fill of double-line streams and lakes should be darker than that conventionally shown. This contrasts better against the general chart background and makes this detail easier to see.

Relief

This is a very important chart element, because it serves two functions other than navigation: route selection and terrain clearance. Either of these is at least as important as navigation; combined, they constitute a very important reason for proper portrayal of relief. For route selection, knowledge of heights and shapes of terrain along a proposed course may influence a pilot to select an alternate route by means of which he may circumvent a dangerous height, or take advantage of level areas which may serve as emergency landing places. The type of aircraft, weather forecast and pilot experience are all additional factors which would affect the decision.

As for terrain clearance, as long as a pilot can see potential danger, he will avoid it. Since we are dealing with flying under VFR conditions, visibility minima normally would ensure that terrain hazards would be seen. What causes difficulty is a lowering ceiling and/or decreasing visibility which may develop on the way. When flying towards higher terrain, a lowering ceiling may squeeze him dangerously close to the ground. Or the higher terrain may rise steeply, as in hilly or mountainous areas, and penetrate or come close to the overcast. This may effectively form a barrier which will not allow safe navigation. The best procedure in these circumstances, agreed upon by all aviation experts, is to make a 180° turn. However, a less experienced pilot may continue; or become locked in by adverse conditions behind him. There are thus conditions when knowledge of high terrain, without searching for spot elevations or some other time-consuming method, becomes very valuable. Terrain clearance heights should be shown within each 30′ area of the chart. This height should be the highest known elevation within the area, rounded off to the next higher 100 ft, plus 100 ft. This should serve to alert the pilot quickly to a safe altitude and provide a safety margin for temperature and barometric changes which may affect his altimeter.

For navigation purposes, the pilot requires a rapid appreciation of the relative heights and shapes of terrain. He generally cannot pinpoint his position solely by reference to relief features. Supplementary information is usually needed. However, flying across a series of ridges, a pilot can generally relate chart portrayal to terrain. A major peak, under conditions of good visibility, can be seen from as far away as 50 miles.

Basically, a generalized pictorial display by shaded relief is required for orientation. This should not be so dense as to conflict unduly with portrayal of other features, particularly the air overprint. A pattern of spot elevations at significant tops and along ridges is also necessary to indicate differences in height, and in some cases actual height. Contours are not required. This information tends to obscure and adds little data valuable for operational flying. Most pilots are not sufficiently skilled at map-reading to use contour information properly—and it is too time-consuming even if they are fairly proficient in interpreting them.

Aeronautical overprint

To understand the relationship of the aeronautical information and the base information, we must again put ourselves in the position of the VFR pilot and realize how he navigates. Actually, he navigates by a combination of methods which he varies according to conditions: dead reckoning (DR), which involves flying at certain headings and air-speeds and keeping track of time. By applying wind direction and velocity, the pilot has a general idea of track over the ground, ground speed, drift angle, position and estimated time of arrival (ETA). We say "general" and "approximate" because his knowledge of changing wind conditions is inexact, and dead reckoning (DR) navigation can be no better than knowledge of wind. Pilotage, therefore, is primarily used. This refers to recognition of ground features by comparison with the chart. A known location becomes a "fix". As an example of the close relationship between DR and pilotage navigation, a "fix" is used to adjust the approximations of DR navigation; whereas DR navigation is used the better to enable the pilot to make the series of "fixes" required in pilotage. The extent of each is dependent upon the type of area, the experience of the pilot as a navigator and the extent of use of radio aids. This is the third element of VFR flying and depends upon the equipment aboard the aircraft, the knowledge of the pilot and, to a lesser degree, the area. The area is not too significant, because there is such a comprehensive network of radio aids within the conterminous United States.

Airway and navigational aids

Most of the aircraft in the general aviation category are equipped with LF and VHF receivers and transmitters. This equipment permits use of most navigational aids, such as LF radio ranges, VOR's, beacons, and commercial broadcasting stations. UHF frequencies are mostly for military usage and cover certain communication channels and navigational aids such as TACAN.

Radio navigation requires certain supplementary information. We conventionally refer to this data as the *aeronautical overprint*. It basically is not information which the pilot must see on the ground, although airfields are an exception. It is information which the pilot uses in conjunction with his instruments and navigational equipment, primarily radio. If we refer to the representative profile of VFR flying, we see that about one-third of cross-country flying is along airways. *En route* airways (not alternate) should then be depicted, along with two related components of an airway, designation and radials. The navigational facility upon which the airway is based should also be shown by symbol and identified by name. In addition to airway flying, a pilot uses these navigation aids for obtaining radio bearings. He may cross two bearings to obtain a radio "fix" or cross a bearing with a linear feature on the ground, such as a road, river, or railroad to obtain a known position. Radio ranges, commercial broadcast stations and beacons are also used. In order to use these aids, their ground position, name, call sign and frequency must be known. Conventionally, each type of aid is symbolized, named to provide identification, and the frequency shown to enable the pilot to tune in.

Two problems are encountered by this practice: the added information tends to clutter the face of the chart, particularly in dense areas; and the information tends to change more rapidly than the semi-annual revisions of the chart A number of approaches are possible and have been attempted or considered in the past to alleviate these problems. All have certain serious drawbacks. To publish call signs and frequencies in a separate publication revised more frequently than the charts is one method. But pilots consistently prefer to have the information right on the chart. Having pilots consult the latest publications and note changes is another method. A few pilots do; most do not. Revising the charts more frequently is a suggestion, but this becomes extremely expensive when it is considered, for example, that there are eighty-eight sectional charts and many colours of each to run through the presses. One solution might be to print large quantities of bases, to be overprinted later by revisions. But this means large stocks to be stored and various related complications.

In spite of all the alternatives available and the lack of immediate resolution to the question, certain areas of improvement are open. These are in portrayal and type placement. Type should be small, yet highly legible. Placement should ensure ready relationship to the facility. Overprinting of other detail should be avoided. Terminal data, such as GCA or ILS and their frequencies, should be shown on the inset and omitted from the chart face.

The normal pilot practice is to use the information on the chart as if it were all up to date. When it has changed, the pilot will: (*a*) use another facility (for VFR use there is generally a choice); (*b*) obtain the current information, or (*c*) contact a nearby FSS or other facility and ask for the information.

These practices have evolved over the years and become acceptable for VFR flying. Since dependence upon radio facilities is but one of several navigational methods, currency of information is not as critical as for IFR flying.

Airfields

In addition to being used for take-off and landing at an intended (or alternate) destination, an airfield is used for two other operational functions: as an *en route* navigation checkpoint or an emergency landing field. Thus we have terminal, navigation and emergency functions for airports. In addition, there is a planning function. A pilot wanting to fly to a certain city would first find the airport which serves that city. In addition, he might plan his route so that he would have maximum choice of emergency fields if it should become necessary. Our interest is primarily in the navigation and emergency aspects of airfields, although every airfield potentially serves the other functions as well.

Selection

All airports should be shown in accordance with current criteria in use for sectional charts, except minor airports in the vicinity of cities which will be shown in the insets. In this case, the minor fields will be shown in the inset portrayal only to relieve some of the clutter in the dense area. They are not necessary for *en route* navigation (since there are better airports nearby). For terminal or planning use, portrayal on the inset will suffice.

Portrayal

Existing symbolization will be retained. It has proved effective, is familiar to users, and has been standardized by various agreements. If the airport name is that of a nearby city, and is close enough so that it would not be associated with any other city, the city name will suffice for both. It would also be useful for a pilot to know the location of FSS in order to contact the nearest one. Since most FSS are located at airports, the airport name should be asterisked, underlined or otherwise symbolized to indicate location of an FSS. In the few cases where an FSS is located within a city, the city name should be similarly symbolized.

Special use air-space

The VFR pilot must have knowledge of air-space reservations so that they can be avoided as required. Normally, pilots will plan their flights so as to circumnavigate such areas. Occasionally, they may desire to fly through. Since not all these areas extend through all altitudes, it may be perfectly legal and proper to go through at certain altitudes or times. The backs of present sectional charts contain the various restrictions, but include a note cautioning the user to consult supplementary publications for information more recent than a given date (the cut-off date of the information shown on the chart).

The proper procedure is, thus, not to accept the information on the chart as necessarily correct, but to obtain the current data. Many pilots do this by querying the FSS. They may do this prior to take-off if an FSS is located conveniently or after they get into the air. All air-space reservations which apply within the low altitude structure (which extends to 18,000 ft) and their identifications will be shown. A marginal note will instruct the pilot to contact the nearest FSS for obtaining latest information regarding air-space reservations and/or clearance for flying through.

Controlled air-space

It is necessary for the VFR pilot to know the extent of controlled air-space, since different visibility requirements and procedures apply. Control zones, airport traffic areas and controlled air-space with variable floors must be depicted whenever they apply within the low altitude structure. This is a complex system which must be portrayed in a manner which leaves no doubt as to the intent and which does not unduly conflict with other portrayals. Improvements are required, particularly in the portrayal of controlled air-space with variable floors.

Isogonic lines

These should be shown by full degrees only and indicate values.

Conclusion

It is intended that the producer of these charts exercise the widest latitude in developing symbols, portrayals and other techniques which will combine in a superior chart which satisfies the requirements indicated to the fullest degree possible. At the same time, we are interested in economy: economy of compilation, of drafting, of reproduction and of time required for producing the chart and finally economy of the end product. A saving which may seem minor in one chart will be significant in an entire series. Restriction to five or fewer colours, for example, will be a significant saving because five colour presses would be able to handle the entire run. Of course, judicious use of screens, tones, etc. within the five-colour limit will greatly extend the potential of effective portrayal.

While the concept previously described is based upon conditions within the United States, it is considered that it is also largely applicable to conditions in other countries. Where differences lie is, perhaps, in the area of the aeronautical overprint. The concept brings out the relationship between visual and instrument navigation. This relationship may not be the same in all countries. The United States has evolved an extensive and complex national air-space system for instrument flight. This is utilized to some degree as an aid for visual flight.

A similar development is no doubt in progress in other countries in response to the needs of users. Time will gradually reduce the differences. Meanwhile, all can benefit by sharing their experiences.

APPLICATION OF AUTOMATION TO AN AERONAUTICAL CHARTING PROBLEM: A CASE STUDY

Paper presented by the United States of America[1]

The Coast and Geodetic Survey publishes and maintains aeronautical charts of the United States in fourteen series at scales from 1:250,000 to 1:6,250,000. The number and complexity of charts have increased considerably in recent years, and production schedules have become much more compressed and rigid. All production operations, including processing and dissemination of chart information, have heretofore been performed by manual methods. The need for a more rapid response in information processing and ever increasing work loads without a commensurate increase in resources demand changes in present methods if production responsibilities are to continue to be met.

Four series of visual charts, designed for navigation with reference to ground features, consist of a specialized topographic base on which aeronautical information is overlaid. The visual charts presently include eighty-eight sectional charts of the conterminous United States and Hawaii at scale 1:500,000; sixty-two WAC charts of the conterminous United States and Alaska at scale 1:1,000,000; twenty-eight local charts of selected terminal areas at scale 1:250,000; and four jet navigation charts of the conterminous United States at scale 1:2,000,000. A VFR/IFR (visual flight rules/instrument flight rules) planning chart of the conterminous United States is also published at a scale of 32 nautical miles to 1 inch.

The charts for instrument flight may be classified in two divisions according to their planned usage in the *en route* or terminal phase of flight. Because the instrument charts are designed for flight without visual contact with the ground they contain virtually no topographic information; for the same reason, however, aeronautical information relating to electronic navigational facilities and communications is more detailed than that on the visual charts. Much aeronautical information, however, is common to both the instruments charts and the aeronautical overprints of the visual charts and to the several chart series within the two primary divisions.

The charts for *en route* instrument flight include twenty-eight *en route* low-altitude charts of the conterminous United States at scales between 10 nautical miles and 20 nautical miles to 1 inch, for *en route* flight at altitudes below 18,000 ft MSL; four high-altitude charts of the conterminous United States at 38.5 nautical miles to 1 inch, for flight at or above 18,000 ft MSL; 4 *en route* charts of Alaska; one *en route* chart each of the Caribbean area and Hawaii; and area charts at scales of 5 or 6 nautical miles to 1 inch for *en route* flight in terminal areas where complete depiction requires a scale larger than the *en route* low-altitude charts. Controller charts of the conterminous United States at scale 1:500,000, and of selected areas at scales 1:1,000,000 and 1:250,000, similar in content and portrayal to the *en route* navigation charts, are provided for the use of air traffic controllers. In addition to this coverage of United States territory, a series of seven aircraft position charts at scales from 1:5,000,000 to 1:6,250,000 are published covering transoceanic international routes of United States air carriers. The aircraft position charts feature long-range navigational aids such as LORAN and CONSOL, but include also the more conventional short-range facilities for landfall approaches and transition to *en route* charts.

Instrument approach procedure charts for the terminal phase of instrument flight, are published for each airport for which the Federal Aviation Agency has established an instrument approach procedure. These charts vary in number as procedures are established or discontinued. There are at present over 2,000 charts showing approach procedures for approximately 950 airports.

The peculiar nature of air navigation makes the pilot heavily dependent (and in the case of instrument navigation, completely dependent) upon accurate and current information on his charts. For this reason, aeronautical charts must be revised as frequently, and issued as promptly after revision, as production considerations allow. Sectional

[1] The original text of this paper, prepared by D. P. Beatty, Coast and Geodetic Survey Environmental Science Services Administration (ESSA), appeared as document E/CONF.52/L.27.

and local charts are revised semi-annually, a group of each being scheduled for issue every 28 days. The planning chart and aircraft position charts are also revised semi-annually, and the world aeronautical charts and jet navigation charts are revised annually. Any of these charts may also be revised out of schedule if major changes so require. All *en route* charts, including the area and controller charts, are revised and re-issued every twenty-eight days, in accordance with the Federal Aviation Agency scheduling of effective dates of air-space changes. Instrument approach procedure charts are revised whenever the Federal Aviation Agency issues a revised approach procedure or changes occur in certain other categories of chart information. Effective dates of new or revised procedures are scheduled every seven days. Each chart is revised on average 2.2 times per year, resulting in the publication of approximately eighty-five instrument approach procedure charts each week, or 4,400 per year.

All charts which are revised at twenty-eight day or seven-day intervals on the basis of the effective dates of Federal Aviation Agency regulatory actions must be in the hands of users before the effective data. This requires close and precise scheduling of all operations, including reproduction and distribution. Aeronautical information on all charts is continually up-dated after revision is begun until the drawings are released for reproduction.

In all, the Coast and Geodetic Survey is required to publish over 6,000 revisions per year of approximately 2,300 different aeronautical charts. Geographic coverage of individual charts ranges from instrument approach procedure charts, the neat-lines of which are only 4.85 by 3.40 inches at 1:500,000 scale, to planning charts, which cover the entire conterminous United States, and aircraft position charts, which span entire oceans. The number of corrections at each revision varies widely among chart series and individual charts according to the extent of coverage, type of chart, density of aeronautical facilities in the area, and period between revisions. Thus the number of corrections on any one chart revision may be only four or five or several hundred. It has been estimated that 35,000 corrections are applied annually to the aeronautical information of the eighty-eight sectional charts alone.

Procedures in effect heretofore for the processing of changes in aeronautical information have involved much scanning of documents by many employees and extensive recording of changes by hand in files and on chart copies. An Aeronautical Information Branch in the Aeronautical Chart Division receives all incoming aeronautical data, evaluates it for pertinence and any obvious discrepancies, and disseminates it in multiple copies to the three cartographic branches. The primary source of aeronautical information is the National Flight Data Centre of the Federal Aviation Agency, from which daily lists of changes to aeronautical facilities are received in narrative form by teletype. Additional items of data are received from other agencies, from the public and from foreign sources (for aircraft position charts and for those parts of other charts which extend into neighbouring countries). These additional items of data are incorporated in the lists of changes which are disseminated daily to the cartographic branches or disseminated by circulating the documents themselves to the branches. The lists or documents consist of changes, additions, or deletions in aeronautical facilities, any item of which may be applicable to one or more charts but not necessarily to any individual chart or chart series. That is, in respect to a given chart, an item may not apply to that geographic area or may concern a type of facility which is not shown on that series of charts. Furthermore, the narrative data as disseminated are not worded as changes to charts, but must be so interpreted. Interpretation and selection of the source information must be made by each compiler.

As the daily lists of changes and other documents are received in the cartographic branches, copies are distributed to individual cartographers and technicians, each of whom is assigned the maintenance of a chart series or a block of charts within a series. These employees then scan the listings for items which are pertinent to their charts and record those items as corrections on the appropriate chart "standards". The "standard" is a copy of the current edition of a chart on which all corrections since the date of that edition are noted. At the time of a scheduled revision the standard, or a copy of it, serves as the draftsman's copy for revision of the drawings.

Master files of airports, electronic navigational aids and communications, and flight hazards (high structures which constitute potential obstructions to flight) are maintained on cards in the Aeronautical Information Branch. The master file cards, one for each facility, contain all information needed for charting; for example, for each airport the card would include the name, associated city and state, geographic position, type of ownership, elevation, runway lengths and surface, lighting, servicing, and various special items. Copies of the lists of changes which are sent to the cartographic branches are also used in the Aeronautical Information Branch to maintain the master files by entering corrections manually. To avoid excessive visits and calls to the Aeronautical Information Branch, the cartographic branches have also found it necessary to maintain additional files of selected aeronautical data in their several working areas.

It had been recognized for some time that these procedures for processing aeronautical data, although they accomplished their purpose well, were wasteful in duplication of effort and excessive hand work. Many different compilers must read through the same list of changes each day, and each must scan through an average of fifteen pages of changes to identify and record the minority of changes which apply to the charts in his area of responsibility. The system also presents possibilities of error either through the missing of a change or through different interpretations of the same narrative by two or more compilers. The problem has been aggravated by an unspectacular but steady annual increase in the volume of changes and by difficulties in recruiting qualified cartographers.

Development of aircraft capable of higher, faster and longer range flight and the mushrooming growth of air traffic have created needs for additional types of charts and many more facilities for navigation and air traffic control. Methods which were suitable for the maintenance of fewer, simpler charts are no longer adequate. These problems naturally suggested applications of automatic data processing.

Among all the many eventual possibilities for automation of cartographic processes, it appeared that the processing of aeronautical data for charts offered the greatest opportunity for early implementation without the need of extensive development time and for realization of nearly immediate benefits at reasonable costs.

In 1965, the Planning Research Corporation was engaged by the Coast and Geodetic Survey to conduct a comprehensive operations research study of the aeronautical charting activities of the Coast and Geodetic Survey. The corporation was asked to examine all aspects of the aeronautical charting programme and recommend changes in any areas of organization or procedures where the programme might be improved. It was specifically requested that the study include examination of the feasibility of applying automation and/or automatic data processing to the aeronautical charting programme, with evaluation of alternate solutions.

The Planning Research Corporation in its final report recommended two steps in automatic data processing for implementation as soon as possible. These were the automation of the airport, navigational aid and flight hazard files by means of a punched-card system and the production from the automated files of change listings for the revision of charts. Equipment has been acquired, and preliminary steps such as design of cards, processing of the manual files for conversion, training of employees, programming, and test runs have progressed at the time of writing near the point of key-punching the cards which will constitute the aeronautical data files.

Because of the close scheduling of aeronautical chart revisions and the requirements for currency of chart information, the essential element of the central information source is rapid response. Information must be at hand when needed; delay of a day or a few hours can be critical. To achieve such response it is necessary that the equipment required to support the data system be located within the Aeronautical Information Branch. The data-processing system and the supporting equipment were chosen with this in mind.

Punched-card equipment was chosen because file volumes are below the level of 100 million characters commonly used as a rule-of-thumb criterion for selecting computer rather than card systems; the cost of card-handling equipment is modest; and the equipment could be located in the working area, immediately available to meet user needs.

The punched-card system will provide an early and low-cost capability to meet current data-handling needs more expeditiously and economically. Also, however, the card files can be automatically converted to magnetic tape for computer operation whenever required by increased volume of aeronautical data, the introduction of other types of data into the system, requirements for mathematical computation, or the ultimate development of full automation through graphic data processing. Further, much or all of the punched-card equipment would still be required to prepare both data and programme inputs for a computer system. Thus the punched-card system represents an evolutionary step towards sophisticated automation, and creation of punched cards would not be wasted because they would be used to create the computer files of the future.

The following equipment has been installed to implement the initial card-punch system: printing card punch IBM 026; electronic typing calculator IBM 632, including typewriter IBM 614, calculating unit IBM 631, card reader IBM 641; collator, IBM 087; sorter, IBM 082.

The primary operational purpose of the system, apart from the processing, storage and maintenance of the data as such, will be the production of change listings for use in the revision of charts. A change listing will consist of all changes applicable to a specific chart (and no other changes) for a given period of time, which will normally be from the date of the last change listing furnished for that chart. Change listings may be produced at a specified time prior to each scheduled revision and again for updating immediately prior to release for reproduction; at several intervals between revisions for those charts which are revised only semi-annually or annually; or on demand. Trial in actual chart production will determine the optimum scheduling of change listings for the charts of each series.

Cartographers and technicians in the cartographic branches will use the change listings to record changes, including graphic plotting of positions, symbol selection and other necessary information for the draftsman, on the various chart standards. The standards, after review, will then be delivered to the draftsmen for correction of drawings as heretofore. As the incoming data will have already been analysed and reviewed in the Aeronautical Information Branch, it will not be necessary for either compiler or the reviewer to refer back to original sources or files or to maintain duplicate reference files in their own areas.

The advantages of using change listings may be summarized briefly as follows: compilers and reviewers will receive only information pertinent to each of their individual charts; information received will be reviewed and checked centrally by the responsible analysts; information received will be current and will be received when needed by compilers or reviewers; all information affecting a specific chart being produced or reviewed will be received in one consolidated form; lists can be rapidly checked against each of the relevant standards by a reviewer with the assurance that he has in hand all changes pertinent to that standard.

In addition to the change listings produced on regular schedules for the revision of charts, the punched-card system will provide the capability of producing specialized listings as required. Examples of specialized listings, representing recent actual requirements, are a listing of all airports in the United States having hard-surfaced runways 5,000 ft or more in length; and listings with all pertinent data, and no other, for all airports, navigational aids and flight hazards within a given geographic coverage for the construction of a new chart. Using the manual files, any task comparable to these examples requires long searching and laborious copying of the filed data.

The punched-card files will include three major divisions. These are the airports, numbering approximately 9,500; the navigational aids, numbering approximately 3,500; and the flight hazards, numbering approximately 12,000. Necessary charting information for each airport, navigational aid or hazard includes a number of items of data, the numbers varying rather widely both among the three major divisions and from one individual facility to another within the divisions. Each type of facility is common to more than one chart series, and many individual airports and navigational aids are common to all the series.

The basic punched-card file is the master deck. The master deck will include first a master card, containing the programmes for the automatic reading and typing of the contents of the cards in the master deck. For each airport, navigational aid or hazard there will then be a header card containing selected basic information for that facility; a trailer card containing additional basic information; one or more trailer cards containing the sheet identifiers of each of the several chart series to which the facility applies, and additional trailer cards as required for supplemental data or remarks. The number of cards for each facility is variable. An estimated 175,000 cards will have to be key-punched to create the master deck initially. The master file will be kept current each day.

A visual file for each of the three major divisions, showing selected basic information for each facility, will also be maintained for visual reference. The visual file cards will be printed automatically from the master deck, and each will be reprinted from the master deck whenever cards in the latter are revised. The visual files will also be kept current each day.

For the initial creation of the master deck, analysts will enter information from the existing manual files of airports, navigational aids and hazards on a multiple-card layout form for each facility. This form contains on one sheet spaces for entries on a header card and a number of trailer cards. The entries on the multiple-card layout forms will then be used to key-punch the cards of the master deck. The same means will be used subsequently to prepare master file cards for new facilities as information is received from the Federal Aviation Agency and elsewhere.

The change listings for chart revisions will be printed automatically from a "change-list file" for each chart series. The cards for the change-list file will be key-punched from creation sheets prepared by the analysts as information is received. The analyst will first analyse and check the incoming data and prepare the proper message to indicate the change, using codings for standard message forms. He will at the same time prepare a creation sheet for key-punch revision of the appropriate card or cards of the master deck. After verification, the change-list cards will be duplicated in sufficient copies to provide one for a change-list deck for each of the chart series to which each change applies. As change listings are scheduled or requested for a chart of any series, they will be printed from the cards in the change-list file for that series. The change-list files will be kept current and complete daily.

The foregoing brief outline of procedures in applying automation in a relatively simple form to a single cartographic problem has purposely omitted such details as the establishment of card formats and detailed procedures. The reasons for this omission are, first, that these details would not necessarily be applicable to conditions or problems of another country or cartographic agency and, secondly, that the complete details are still being tested and have not been finally formulated at the time of writing.

This relatively simple sally into the field of automation as applied to aeronautical charting is considered a realistic and immediate solution to a single pressing problem. It is nevertheless envisaged as a first step towards wider and more sophisticated applications as cartographic requirements, economic considerations, and the state of the art make further developments necessary and practicable.

A COMMON APPROACH TO IMW AND ICAO MAPPING

Paper presented by Australia[1]

This paper describes the fundamental approach used to produce two series of maps, as economically as possible, using common compilation and reproduction media where practicable.

Australian commitment

The resolutions of the International Map Committee assembled in London in 1909, including one which resolved that the Governments of Canada and Australia should produce 1:1,000,000 maps of those Dominions, were submitted to the Commonwealth Government for approval; thus the Commonwealth assumed responsibility for the mapping of Australia and its territories at 1:1,000,000 scale, as part of the IMW.

Australia is responsible, by agreement with other countries signatory to the Convention on Civil Aviation of 1944, for charts covering the whole of Australia, Lord Howe and Norfolk islands and New Guinea east of longitude 138° E. By agreement with the United Kingdon, Australia has taken over responsibility for the Cocos islands and Guadalcanal sheets (see index map, p. 453).

The Division of National Mapping produces sheets of the WAC (World Aeronautical Chart), ICAO, 1:1,000,000, for the Department of Civil Aviation in conformity with specifications laid down in Annexure 4 to the Convention on International Civil Aviation.

Progress of 1:1,000,000 mapping

In the period 1926 to 1940, nine sheets of the IMW covering the south-eastern quarter of Australia were published by the Department of the Interior.

During the war of 1939–1945, and in the immediate postwar years, IMW production in Australia ceased because of inadequate topographical information and shortage of trained personnel.

In 1954, the Australian Geographical Series (AGS) was introduced as a temporary substitute for the IMW. The series was produced from modified WAC manuscripts and covered the whole area mentioned in the preceding section. In 1965, the AGS series was discontinued and the Australian commitment to the IMW again became active.

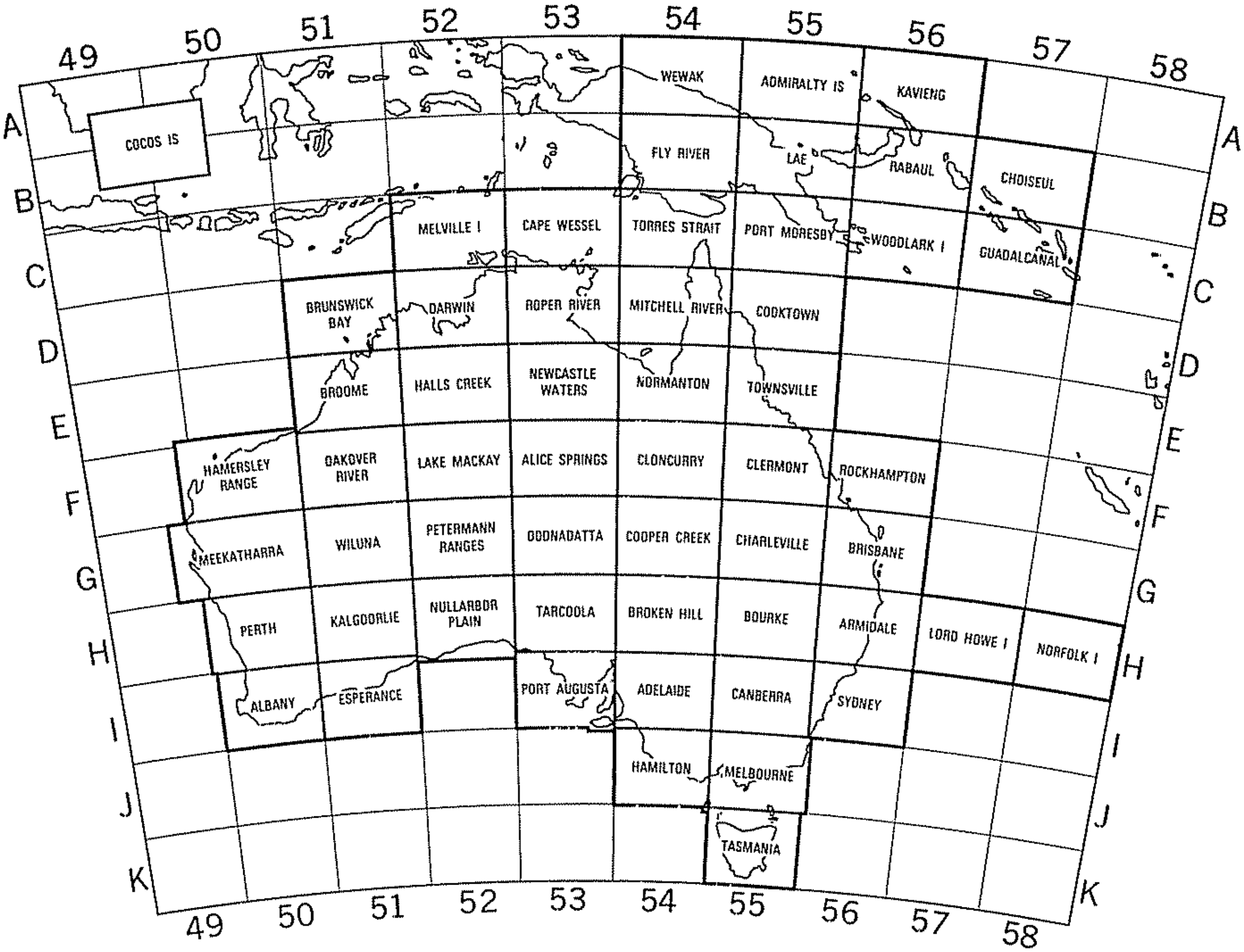
Prior to 1966, 56 first edition, 55 second edition, 44 third edition and 19 fourth edition WAC charts had been produced.

As a result of international and national conferences, detailed studies were made on the relationship between ICAO/WAC charts and the IMW. The International Geographical Union appointed a special commission in 1949 which concluded that the ICAO/WAC charts could not fulfil the purpose for which the IMW was produced and *vice versa*.

This question was examined by the Bonn conference in 1962 and it was agreed that the conclusion remained valid, nevertheless, a close study revealed certain common features.

It was agreed at the Bonn conference that, if certain changes in specifications were made, a common basic

[1] The original text of this paper, prepared by B. E. Goodrick, Chief Cartographer, Division of Mapping, Department of National Development, Canberra, and submitted under agenda items 11 and 12, appeared as document E/CONF.52/L.75.



Australia: Index map

topographical map could be devised from which two separate publications could be produced.

NEW FORMAT MAPS AND CHARTS

The Division of National Mapping began a detailed investigation of the IMW and WAC relationship in early 1966 and a dual system of production was devised (see annex I). The prototype maps, which are still subject to change, became available in late 1966.

The compilation for the IMW and WAC charts is produced for each international map area from the 1:250,000 maps series. Four separate sheets comprise the base compilation: the topographic detail, consistent with mapping at 1:1,000,000 but excluding roads; all roads and tracks required for any class of map at 1:1,000,000 (these are edited before inclusion on IMW or WAC); contours at intervals required for IMW; contours at intervals required for WAC.

At the Montreal ICAO Conference in April/May of 1966 the differences between ICAO and IMW specifications were eliminated wherever possible.

Bearing in mind, first, that the IMW is defined as a map of comprehensive and general character aimed at providing as much planimetric, orographic, hydrographic and political information as the scale will permit and, secondly, that the WAC is devised primarily as an aid to visual navigation from the air (the features chosen on the charts have a landmark value which is applied to the features selected for inclusion), the prime object of the division's map design experiments was to create legible maps without scarificing important topographic or other information. To achieve this end, it was considered that:

(*a*) Small, sharp condensed lettering over pale background tints was desirable;

(*b*) Fine, sharp line work in bright colours over a pale background was preferable to heavily accentuated line work;

(*c*) Hypsometric and bathymetric tints should ascend and descend visually in colour strength;

(*d*) The relief should be general in character and consist of generalized contours, with hypsometric tints, supplemented by relief shading of the terrain;

(*e*) The external marginal information should be subordinated so that emphasis is given to the map information;

(*f*) The division should consult with the Department of Civil Aviation with the object of rationalizing symbols and layout and modernizing the WAC chart for present-day requirements.

Modern cartographic techniques were used throughout the production experiments.

All line work was scribed, using the finest possible line dimensions, consistent with importance, visual requirements and final reproduction.

Tints were made from "open window" strip masks and interposed line and dot screens, of known printing percentages.

Special scribing aids were devised to facilitate scribing of the complicated WAC graticule and the flat curves of the projection.

Symbol templates were made from a specially designed template cutter. Small circles were scribed using custom-made sapphire tools in a Willemsen Electric Dot Cutter.

Photoset type was prepared on positive strip films and mounted on overlays with adhesive wax.

Several symbols were changed or modified after discussions with the Department of Civil Aviation. Many of these symbols may be used for both IMW and WAC.

Non-perennial streams were changed from the conventional dash and three dots to a fine pecked line.

A symbol for a wheat silo was devised, as the department considers wheat silos to be excellent visual navigation aids.

Roads are scribed in a full line and printed in red on both maps; these were previously printed in grey on WAC charts. Roads are classified as "primary", "secondary" and "other roads", for both IMW and WAC.

Certain symbols not considered significant for WAC purposes have been eliminated from the specifications, namely, sunken rock, breakers along a shore, currents and the primary road shield and number.

The fair-drawing and reproduction processes are controlled through each phase of production, using checking forms designed to control both quality and completeness.

The production method is divided into main operations as follows, with checking forms provided for each; initial preparation; scribing; masking; type overlays; relief shading; final preparation.

Annex II shows a typical checking form.

Annex III shows a section of a printed map on the new format, using material from the previous edition and new scribed work where necessary.*

The programme aims at coverage of the major air routes with the new format as quickly as possible and the whole of Australia and New Guinea in four years.

* See pocket at end of volume.

Annex I

Key colour plates

2.1—BLACK

IMW graticule negative — IMW/WAC culture negative — WAC graticule negative —

Town circles
Railways, stations, etc.
Spot elevation symbols
Buildings, etc.
Order WAC photo-positive

↓

WAC type overlay

IMW/WAC feature names
IMW/WAC hand drawn symbols
IMW/WAC stick-on symbols
WAC spot elevations
WAC external type, etc.
Order WAC photo-negative

↓

WAC type negative

Retouch negative
Mask non-applicable WAC type, etc.
Order IMW photo-positive

↓

IMW type overlay

IMW external type, etc.
IMW spot elevations
IMW hand drawn symbols
IMW stick-on symbols
Order IMW photo-negative

2.1—BLACK (*continued*)

IMW graticule negative — IMW/WAC cultural negative — WAC graticule negative

↓

IMW
type negative

Retouch negative
Remove masking from WAC negative.

IMW black plate ← → WAC black plate

Materials: 1 scribed negative
2 film positives
2 film negatives
2 D/demy plates

Note: Photo-negatives and photo-positives will be pre-register punched prior to processing by the Photo-litho Section.

2.2—DARK BLUE

IMW/WAC
drainage negative

Rivers and streams
Shorelines
Waterholes, wells, tanks, dams, bores, swamps etc.
Bathymetric contours (IMW)
Order WAC photo-positive

↓

WAC
type overlay

IMW/WAC feature names
IMW/WAC hand drawn symbols
IMW/WAC stick-on symbols
Order two photo-negatives

IMW
type negative
Mask overlap areas
Retouch negative

↓

IMW
dark blue plates

WAC
type negative
Delete bathymetric contours
Retouch negative

↓

WAC
dark blue plates

Materials: 1 scribed negative
1 film positive
2 film negatives
2 D/demy plates.

Note: Photo-negatives and photo-positives will be pre-register punched prior to processing by the Photo-litho Section.

2.3—DARK BROWN

IMW
contour negative

↓

IMW
dark brown plate

WAC
contour negative

↓

WAC
dark brown plate

IMW/WAC
sandridge negative

2.4—DARK RED

IMW/WAC
road negative

Primary roads
Secondary roads
Other roads
Mask overlap areas for IMW plate

2.4—DARK RED (*continued*)

↓

IMW
dark red plate

Remove masks from negative for WAC plate.

↓

WAC
dark red plate

2.5—ELECTRIC BLUE

WAC
aeronautical information negative

Isogonals
Miscellaneous
Order photo-positive (pre-punched)

↓

WAC
type overlay

Type
Hand drawn symbols
Stick-on symbols

↓

WAC
electric blue negative

↓

WAC
electric blue plate

Materials for Dark Brown, Dark Red, Electric Blue plates, paras 2.3, 2.4, 2.5 refer:

2.3 3 scribed negatives
2 D/demy plates

2.4 1 scribed negative
2 D/demy plates

2.5 1 scribed negative
1 film positive
1 film negative
1 D/demy plate

2.6—GREY-VIOLET

IMW/WAC
relief shading drawing

↓

IMW/WAC

half tone negative

Prepared as shown on checking form
Mask overlap areas

↓

IMW
grey-violet plate

Remove masks from negative

↓

WAC
grey-violet plate

Materials: 1 airbrush drawing
1 half tone negative
2 D/demy plates

Annex II

IMW/WAC SERIES CHECKING FORM No. 5
RELIEF SHADING

Map Name

Map No.

Series

Edition

		Dfm	SL.	CC
1.	3M colour key/film positive prints received	____		
2.	Preliminary investigation complete*	____	____	
3.	Highlight and shadow plan complete*	____	☐	
4.	Sample area complete*	____	☐	☐
5.	Sample area approved*			☐
6.	Preparation:			
6.1	3M colour key/film positive registered	____		
6.2	Manuscript registered	____		
6.3	Neatline corners/work edge marked	____		
6.4	Colour patch position marked	____		
6.5	Shorelines delineated	____		
6.6	Prominent features plotted	____		
6.7	Prominent features between countour interval checked against 1:250,000 maps for shape	____		
6.8	Named mountains, spot elevation positions between contour interval plotted	____		
6.9	Items in para. 6 checked	☐	☐	
7.	Relief shading:			
7.1	Stage 1 complete	____		
7.2	Stage 2 complete	____		
7.3	Stage 3 complete	____		
7.4	Stage 4 complete	____		
7.5	Overlap and adjoining edged checked/amended	____	☐	
7.6	Tomal range and density satisfactory		☐	
7.7	Excess detail in highlight/shadow areas amended	____	☐	
7.8	Main watershed/river system emphasized	____	☐	
7.9	Contrast adequate		☐	
7.10	General conformity with previous and surrounding areas items in 7.1 to 7.10 checked		☐	
7.11	Drawing approved			☐
7.12	Amendments effected/checked	☐	☐	
8.	Preparation before photography:			
8.1	Drawing cleaned back and front; excess eraser crumbs removed both sides	____		

* If applicable.

		Dfm	SL	CC
8.2	Drawing on mounted white paper; angled 30 degrees to the horizontal if applicable	____		
8.3	Same size scale line centred horizontally, measurement in an even number of cmm. clear of work area (¼ inch each side). Vertical centres marked	____		
8.4	Drawing projected with Visqueen	____		
8.5	Items in para. 8 checked	☐		

		P/grapher	SL/PL	SL/IMP	CC
9.	Photographic				
9.1	Grey scale positioned	____			
9.2	Negative size correct	____			
9.3	Exposure time	____			
9.4	Flash time	____			
9.5	Developing time	____			
9.6	Dot size structure satisfactory		____		
9.7	Negative approved/accepted		☐	____	____
10.	Negative preparation:				
10.1	Area outside neatline opaqued (½ inch band)	____			
10.2	Colour patch cut in	____			
10.3	Register circles inserted	____			
10.4	Tone deleted from:				
10.4.1	Sea areas	____			
10.4.2	Perennial lakes	____			
10.4.3	Double line steams	____			
10.4.4	Highest point box	____			
10.5	Golden rod mask prepared/positioned	____			
10.6	Colour patch and register circles exposed	____			
10.7	Applicable items in para. 10 checked	☐	☐		
10.8	Final register checked		☐		
10.9	Lay lines, masking limit line	____			

AGENDA ITEM 12*

International Map of the World on the Millionth Scale (IMW)

PREPARATION OF THE INTERNATIONAL MAP OF THE WORLD ON THE MILLIONTH SCALE FOR JAPAN

Paper presented by Japan[1]

INTRODUCTION

In pursuance of the project of the International Map of the World on the Millionth Scale (IMW), three sheets covering the main parts of Japan were prepared from 1964 to 1966 by the Geographical Survey Institute (GSI).

This map series is useful as a small-scale basic general map for national studies and as a base map for thematic maps on a national scale.

Recent editions of the 1:200,000 scale regional map were used as source maps for the compilation. The selection standard for these source maps was based on three points. The first concerned appearance and legibility. Islands, low-water limits, reefs, etc., were selected from this standpoint. In this case, the relationship between the subject matter in the derived map and that in the source map was also considered. For example, all rivers designated by a double line in the source map were shown. The second concerned functional features. The classification and selection standards defined by official data were given preference. For example, roads, railways, populated places, ports, lighthouses and high towers were evaluated from that standpoint. The third concerned the distribution pattern of the subject matter, such as mines, mineral springs, etc. Official statistical data were analysed to meet the selection standard.

Selection standards of annotated features were based on the same criteria as those mentioned above. For example, included were rivers with a length of 30 km and over or a drainage area of 200 km^2 and over, lakes with an area of 10 km^2 and over, significant promontories, islands with an area of 10 km^2 and over, islands where important lighthouses and/or fishery bases are located and islands isolated from the main islands.

Modifications were made in the international specifications of IMW (1962) to make them compatible with the regional characteristics of Japan.

RELIEF FEATURES OF HYDROGRAPHY

Auxiliary contours of 25 m, 50 m, 300 m and 700 m supplement the principal contours. A 25 m instead of a 20 m contour was adopted as an auxiliary contour to avoid insufficient interpolation. Principal contours were shown by continuous lines while auxiliary contours were shown by broken lines. Hypsometric tints, in principle, comply with those stipulated in the international specifications, except that white hypsometric tint was used instead of violet for zones above 3,000 m. Dark green hypsometric tint was used for the zone between 0–50 m as necessary. Hill shading was also used not only to depict mountain ranges, but also to depict low hills and terraces in the flat areas to emphasize relief.

Active volcanoes and representative mineral springs are significant landmarks in the physical features of Japan. The conventional symbol for a mineral spring is the same as that used in the topographical map series for Japan. The symbol for an active volcano was specially designed. Reefs and shoals, including tidal flats, isolated rocks, sand and gravel and mud were shown by conventional symbols recommended for the base map of the World Aeronautical Chart (ICAO) 1:1,000,000.

Bathymetric contours, soundings, names of bathymetric features etc. were compiled from the latest nautical charts of the Hydrographic Office of Japan (JHO) and the lake charts of GSI. Soundings were indicated by dots so as not to alter the bathymetric features around Japan.

CULTURAL FEATURES

Transportation

Roads and tracks

Classes of roads stipulated in the international specifications were applied to the road network of Japan. Dual highways were applied to Japan's national expressways with the use of the conventional symbol for interchanges. Primary roads were applied to Japan's "former primary national highways" with route numbers. Secondary roads were applied to Japan's "former secondary national highways" and "principal local roads" with traffic of 500 motor vehicles and more during twelve daylight hours. Other roads were applied to Japan's other "principal local roads" and important local roads. Traffic data was obtained from the general traffic volume survey of 1962 published by the Road Bureau, Ministry of Construction. Trails or tracks were applied to Japan's well-known mountain routes.

Railways

Railways are classified according to gauge in the international specifications. In Japan, however, they were

* An Australian paper, "A common approach to IMW and ICAO mapping", submitted under this item, is reproduced under agenda item 11 above. An Indonesian paper, "Cartographic work in Indonesia, 1964–1966", submitted under this item, is reproduced under agenda item 6 above.

[1] The original text of this paper, prepared by Kei Kanazawa, Geographical Survey Institute, Tokyo, appeared as document E/CONF.52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10 and 13.

classified according to their functions. A heavy line with ticks indicating number of tracks was designated for a main line of the national railways. A thin line with ticks indicating number of tracks was used for a long branch line (10 km and over) of the national railways and a long line (5 km and over) of public or private railways. A thin line with single ticks on one side was used for a long line (5 km and over) of passenger-carrying cableways and aerial cableways. Railway stations were not shown except for those of the new Tokaido line.

Other transportation

Conventional symbols for airports were applied to officially designated civil airports. In Japan, since sea traffic is a major transportation medium, seaports were represented by specially designed symbols, namely "important ports" and "other ports".

Populated places

Three major categories of symbols were used to represent populated places.

Conventional symbols of relative administrative importance were applied to the local administrative system of Japan. A town of first importance was applied to the capital of a prefecture. A town of second importance was applied to a city. A town of third importance was applied to a town or village. A town of fourth importance indicated in the international specifications was applied to "other populated places", that is, a nucleus in a city or a town where it was necessary to indicate the location. The general shape of the area represents the outline of a "densely inhabited district" (area with about 4,000 inhabitants or more per km^2), if it was larger than the conventional symbol. Six classes of populated places were shown by letter size and type style. The first five classes were graded principally by the density of the population of cities, towns and villages: 1,000,000 and over; 300,000 and over; 100,000 and over; 30,000 and over; and under 30,000. The sixth class means "other populated places" mentioned above. Population data were based on the 1960 Population census. All cities and important towns and villages were shown. Approximately 80 per cent of the total number of towns and villages (2,359 out of 2,955) were represented.

Miscellaneous

Symbols for prefectural boundaries, high towers and coal mines were designed. Prefectures are the largest administrative units in Japan. Coal mines were indicated separately from other mines. Representation of high towers followed the specifications required for the World Aeronautical Charts.

Although rice fields are important features in Japan, they were not shown. Rice fields occupy a majority of the flat areas, and insertion of the symbol would have greatly obstructed representation of other features.

Geographic names

Names annotated on this map were as agreed upon by the Joint Committee on Geographical Names between GSI and JHO. The official romanization system (Kunrei Siki) was used. Each sheet of this map series shows a comparison table of this system with the original Hepburn and modified Hepburn systems, which are also currently in use. A glossary of generic terms used on each sheet is given in both Japanese and English.

Cartographic procedures for preparation of sheets

Compilation was done on a synthesized plastic sheet laid over the base map. Each overlay was assembled and collated and then photographically reduced to 1:1,000,000 scale.

Drafting was done by separate line-scribing, photo-composed letters were pasted on, stuck up, the photo-etched peel-coat process was used for masking, and an air brush was used for hill shading.

Thirteen shades of hypsometric tint were obtained by five press runs, using the plates prepared by combining solid tint, dots, lines and cross-screened tints of four colours. A screen with 120 lines per inch (48 lines per cm) was used. Printing was done by using the roller offset printing machine in the following order: grey for printing index maps etc., on the reverse side of the maps; brown for contours; dark greyish brown for hill shading; yellow for colour tints; orange for colour tints; purplish blue for lines of hydrographic features; light blue for colour tints; light blue for solid colour tints; dark blue for colour tints; dark yellow for populated areas; dark grey for line work; red for line work; black for lettering.

AGENDA ITEM 13*

Review of techniques and recent developments in the processes of converting cartographic manuscripts into published maps

THE NUMERICAL MAP

Paper presented by the United States of America[1]

INTRODUCTION

The purpose of this paper is to point out the need for a new type of map and the reasons why our standard maps cannot fulfil all our present-day requirements. This paper will also attempt to point out some areas of change, some areas of controversy and some areas of compromise.

First, a definition of "numerical map" is in order. A numerical (or digital) map represents, in discrete numerical form, all the information which can be obtained from a graphic map. For instance, the elevation of any point on the earth's surface (which has been mapped, of course) can be obtained directly from a numerical map by designating the X, Y co-ordinates of the point. The same elevation would be obtained from a graphic by interpretation and interpolation of contour lines. A numerical map will store co-ordinates and mathematical formulas which define stream paths, roadways, outlines etc. There is nothing to see in a numerical map, but the information is there and available.

Why is such a map needed? Basically, it is the advent of the electronic computer, particularly, the recent advances in manufacturing techniques, which have made computers more available to use for engineering and planning. Unfortunately, computers require the information on which they operate to be presented in, or eventually to assume, numerical (digital) form. Consequently, present graphic maps cannot be used directly by computers; thus there is need for a numerical map.

Considering planning in its broadest sense, that is, an orderly method of achieving some objective, the basic reason for maps is for planning. Road maps, navigation charts, topographic maps, thematic maps of all kinds are examples of maps which are basically used for planning.

QUANTITATIVE AND QUALITATIVE INFORMATION ON MAPS

The information so profusely put into a map can be separated into two basic categories: qualitative and quantitative. The qualitative information is useful in many ways, but it cannot tell how much, how far, how big, or how wide. And it does not really have to; the road map, for instance, does not have to show that the four-lane highway has 12-ft lanes.

The quantitative information shown or implied on graphic maps as contours, outlines, locations, etc., must be measured to be useful. Once it has been measured, then some kind of mathematical manipulation can be applied to obtain additional information, such as slopes, volumes, areas or distances. It is this measurement capability that is the most troublesome to build into a map. Accuracy standards could be greatly relaxed if measurements did not have to be made on a map.

As difficult as it is to obtain, quantitative map information is the most useful for detailed planning and the most amenable to computer manipulation.

COMPUTERS AS ENGINEERING/PLANNING TOOLS

This leads to a consideration of the role of the computer as an engineering/planning tool, particularly in areas employing maps and map information. Certainly, civil engineers in highway work employ computers on tasks such as earthwork computations, horizontal and vertical layout designs, and the like. The current concern over water supply and pollution problems will require many detailed plans of run-off patterns, flood plains, drainage systems, etc. Military problems of communcation, logistics and tactics are all being subjected to computer-oriented automation.

A characteristic of all these problems is the need to make several tries at a solution using a mass of data for each trial run. Another characteristic is that the data can be very hard to obtain. Any civil engineering student can remember the mass-diagram exercise and the trouble involved in collecting and manipulating the data.

The strong point of the computer is its speed at manipulating data which can offer an engineer/planner many trial runs without an exorbitant time penalty. However, these trials can be made only if the data are available, and that is where the map-makers have failed the engineer/planner. By the simple process of making maps as we do, we in the map-making business have quite effectively removed this powerful tool—the computer—from the hands of the engineer/planner. It is time we gave it back.

MAP DATA SELECTION BY COMPUTER

What are some of the tasks a computer can perform that make it worth while to adapt a map to it? A computer

* Two United States papers submitted under this item, "Simulated process-printing of aeronautical charts" and "A new concept for the colour-proofing of aeronautical charts", are reproduced under agenda item 11 above.

[1] The original text of this paper, prepared by William C. Aumen, Army Map Service, Corps of Engineers, appeared as document E/CONF.52/L.20.

can select data from a map for display to a user. For instance, a request for a line map of all the first-class roads in an area can be satisfied by the computer very simply and rapidly. In fact, the request can be made more complex by asking for only the first-class roads, which have an average grade of less than 5 per cent, and maximum grades of 10 per cent, which have no bridges of under 15 tons capacity, no widths narrower than 10 ft, and no curves of less than 200 ft radius. A computer could extract the required information from files and plot out a line map of the routes as fast as the plotting mechanism would go. Some of the information used in selecting the routes would not appear on a normal map, specifically the bridge capacities, roadway widths and curve data. This illustrates the ability of a computer to interrogate more than one source for the data to satisfy given parameters. Thus intelligence of classification files become a working part of the map.

Another example of computer selection of data would be in answer to the query: "How many hilltops within these given boundaries exceed 500 m in elevation?" In this case, a simple typewritten answer might suffice, such as "None" or "Ten". This answer could be followed by another instruction such as: "Plot their locations and number each hilltop". Then, after inspection, the cross-sections (profiles) of specific hills could be requested for display. This example is to point out the ability of a computer to do a job which can be done now by any normal map user; but the computer can do it at a far greater speed and without fatigue.

The computer is also capable of responding to queries with the output medium selected by the user. The previous examples can be used to illustrate this facility by specifying that the line map of first-class roads be drawn on paper; the routes between cities on plastic with notes typed on a typewriter; the hilltops could have typewriter output, followed by cathode-ray-tube display of the profiles; finally, there could be a line-drawing of the hill positions and the profiles of a selected hill or hills.

The output, in all these examples, goes to a user who is external to the computer. There are many requirements for map data to serve as the basis or as part of the data for the computer solution to a problem. Preliminary route selection for highways, for instance, requires investigation of grade, earthwork, curves, bridges, etc.

MAP DESIGN CONSIDERATIONS

With these many opportunities for a computer to aid the engineer/planner in using map data, it seems that a very strong effort is in order to provide the map data in a more acceptable form. What are the implications of providing a numerical in addition to a graphic map? Perhaps the first heretical thought is that the accuracy standards for the production of line maps should be reduced. Similarly, the concern over material stability should lessen. In other words, why expend a disproportionate amount of time on precise map production if the need to measure from the map no longer exists? The measuring can be done from the numerical map, which is much more precise than the graphic map.

This is not to advocate a reduction in compilation accuracy; quite the contrary. Compilation accuracy should increase. Compilation should be made at the largest scale possible, and compilation and classification should be tied even closer together. The change in procedure should be applied to the form in which the original compilation is retained in that the basic record should be numerical. From this base, scale changes and data extraction could be made towards smaller scale, less accurate compilation. The important point is the collection and retention of the most accurate data available.

There are many other points to consider, such as the need to continue the use of colours to delineate or emphasize features on a map. If the computer can select and display only features of interest, then the need for colours to aid the user in selecting this information is not as great. The same point can be made about the use of symbols.

When the basic reason for using these aids (colours and symbols) is examined and found to be to crowd more information on to the map, and at the same time to provide the senses with the means of separating one detail from another, the ability to utilize computer speed and logic to select and display only the desired information becomes quite intriguing. With this type of aid it should be possible to retain and present to the user much more information than is now possible, simply because it is not necessary to display it all on the same piece of paper at the same time.

The emphasis so far has been on the possibility of producing a new type of map. The use of digital data for construction of a conventional graphic map is a distinct probability which needs close scrutiny by the cartographic profession to determine how best to use this new technique. It seems quite apparent from present studies that a very substantial human effort will remain in graphic mapping for a long time to come. The test will be in our ability effectively to apply the computer as an aid in map-making.

In summary, there exists a requirement for map data in a form other than graphic. Specifically, there is a real need for numerical versions of standard maps in a form suitable for electronic computer use. Because of the virtues peculiar to the numerical map, it is necessary to take a very critical look at existing map standards and production techniques. It is also necessary to consider the standards and techniques which will have to be established for numerical maps. The title "cartonumeric" is suggested as a new discipline.

The map-making industry has been challenged; it must throw away tradition and prejudice and apply sound judgement coupled with advanced ideas to meet this challenge.

A SIMPLE SILK SCREEN EQUIPMENT FOR LIMITED MAP REPRODUCTION

Paper presented by Australia[1]

INTRODUCTION

While screen printing is an old and proven process, and modern automatic machines provide up to a thousand impressions an hour with fast forced drying, to date development of a limited scope reproduction equipment has not been directed towards screen printing. There has been interesting development in the electrostatic printing field but, as a simple inexpensive means of resolving the problem of short-run printing of maps and overlay under field conditions, the Royal Australian Survey Corps introduced the screen equipment described in this paper.

The user requirement on which design and development of the equipment was based is as follows: simple light-weight construction with ease of maintenance; quickly assembled and dismantled; to fit into a Land-Rover utility when crated; each crate to be maximum of two-man lift; capable of hand operation at 150–200 impressions per hour; capable of printing and overprinting in good register a map sheet 29 × 22 inches of up to six colours.

The advantages of introducing this equipment for the production of maps, sketches, overlays, etc., in the field, in quantities up to 500 runs, are: low capital cost of press and ancillary equipment; subject to qualified supervision, extensive training of operators is not required; the ability to move the equipment by air or road and to become operative within one hour of setting down time.

DESCRIPTION OF EQUIPMENT

The screen-printing equipment introduced by the Royal Australian Survey Corps provides for economy in construction and maintenance, and parts are easily replaceable. Working parts have been reduced to a minimum to avoid complicated mechanisms; standard screen frames are used.

The basic action of the screen-printing machine is orthodox and, as it was primarily designed to be light-weight and complementary to lithographic printing facilities, it is hand-operated.

The main table, which is 62¼ inches wide, 49¼ inches deep and 2½ inches thick, is perforated for suction action to hold the paper flat against the table. The suction unit functions automatically when the screen frame is lowered just prior to the printing stroke operation. Power for the suction mechanism is provided by a 240V, 50 cycle A/C motor.

The main table is supported by two metal collapsible trestles which raise the complete assembly to a working height of 37 inches.

The main table slopes forward towards the operator to ensure the maximum ink flow.

The screen frame is mounted to the rear of the main table with provision for carrying the ink applicator (squeegee). The metal screen frames are fitted with quick release clamps to enable easy exchange of frames for multicolour reproductions. The screen frames when fitted are counter-sprung for ease of manipulation and automatically locked and released at the commencement and completion of each stroke.

[1] The original text of this paper, prepared by Lt. Col. H. M. Hall, Royal Australian Survey Corps, appeared as document E/CONF. 52/L.74.

The ink applicators are rigidly constructed and operate on adjustable ball races. There is provision for the interchange of 14 and 24 inch applicator blades and micrometric pressure adjustment of the blades is incorporated.

The minimum and maximum printing dimensions are 8 × 10 inches and 29 × 22 inches respectively. The maximum acceptable paper size is 36 × 24 inches.

The equipment, when dismantled and crated, is designed to fit into a standard Land-Rover long-wheel-base utility. The complete assembly comprises five cases, as follows:

Crate 1—Main frame, (64 × 49¾ × 4 inches).

Crate 2—Supporting trestles, framework and ink applicators (64 × 16 × 9 inches).

Crate 3—Screen frames, and space for 13 rolls of sensitized film (47 × 34 × 9 inches).

Crate 4—Counter-balance weights (3) (17⅛ × 5⅞ × 4⅞ inches).

Crate 5—Vacuum motor, tools, bolts etc. (22 × 17 × 21 inches).

No crate exceeds 120 lbs in weight.

ANCILLARY EQUIPMENT

There is of necessity a requirement for a quantity of ancillary equipment which is not described in detail in this paper. The more important items are listed below.

Printing down frame

A special light-weight aluminium model is available in Australia with hand or motor pump for vacuum operation.

Light sources for photo-stencil preparation

There are available in Australia suitable light-weight light sources such as carbon arc, pulsed xenon, quartz iodide, or mercury vapour. Each is designed for specific requirements and no one type can be specifically recommended at this stage.

Drying equipment

Electric motor hand-driers are essential for speedy drying of photo-stencils. It is also necessary to provide portable light-weight drying frames to allow the ink impressions to dry if "set off" on the backs of sheets is to be prevented.

Screen tension devices

To ensure even tensioning of the fabric over the screen frame, a tensioning device is necessary.

TECHNICAL PROCESSES

Stencil preparation

The first stage of the screen process is the preparation of the photo-stencil of the manuscript, and for this purpose the original drawings must be in positive form on a reasonably transparent base. In some cases detail is drawn on matte or semi-matte drafting film and type added by hand-lettering or by the use of Letraset—a letter transfer technique by burnishing—or by the use of photographically prepared type suitably adhered to a clear base material.

When better quality reproduction is required, scribing methods are often employed. The scribing or engraving technique uses needles (or cutters) tipped with sapphire or carboloid to remove the emulsion neatly and uniformly from areas where cartographic detail is required on an emulsion-coated clear film.

An impression of the basic manuscript is produced by coating the scribing emulsion with a Watercote dyeproof coating and exposing to ultra-violet light, with the manuscript negative in close contact. The image is developed with water and a dilute solution of common ammonia. Each colour is now scribed on a separate coated sheet, using the mechanically prepared photographic image as a guide.

As the scribed sheets are in negative form it is necessary to convert them to positive by chemically dyeing the engraved areas and removing the emulsion, leaving the black image on a clear base or, alternatively, photographically contacting the scribe sheets to obtain film positives. (To date, only polyvinyl type scribing bases such as the British Astrascribe will accept dye solutions. Polyester bases are unsuitable for dyeing and therefore require to be contacted to positive). It should be remembered that, if the scribe sheets are dyed, then no further scribing can take place on that sheet as the emulsion has been removed.

Where two map colours can easily be separated it is sometimes convenient and economical to produce both images on one stencil. The unwanted colour is temporarily deleted. The screen image is then recovered and the unwanted areas deleted for the second printing.

Exposures

Exposures for photo-stencil preparation can be made with arc lamps, pulsed xenon, quartz iodide or mercury vapour lighting equipment. Timings for exposure are critical where fine detail and dot screen presentation are the requirement; much will depend on the type of light source and distance from the copy, but some experimentation will be necessary to obtain the best result. On the other hand, development is not critical provided the operator ensures that all the unexposed gelatine is completely cleared before applying the pigmented tissue to the screen mesh.

SCREEN FABRICS AND PHOTO-STENCIL MATERIALS

Experts in the screen-printing field are now of the opinion that, compared with nylon, the polyester monofilament fabric with greater tensile strength provides better register and is less liable to denting. Perhaps the more significant fact is that polyester fabrics are considerably less influenced by humidity than nylon or perlon.

We have found from limited experience that an extra-fine-weave nylon fabric of 460 threads to one inch is suitable for map and overprint reproduction and is capable of printing "type matter" down to 6 pt bold and 85 line dot screen. Particular emphasis should be given to the best angles to reproduce dot screen (stipple) images. Either 60° or 30° angles to the horizontal are considered satisfactory to offset the loss of detail when printing from fabric woven at zero to 90°.

All gelatine-pigmented coatings are susceptible to moisture or high humidity. The Swiss manufactured Ulano-super preparation (presensitized) photo-stencil has a special coating on the emulsion side to prevent deterioration of the gelatine-pigmented tissue in high humidity areas and this has been found satisfactory.

INKS

Inks for screen-printing operations rate a special mention. Printing speed, printing stock and screen-mesh size are factors which mainly determine the type of ink. It has been found that, for general map reproduction, an ink formulated to dry in about 30 minutes under adverse conditions of high humidity is desirable.

The viscosity of screen-printing inks is greatly affected by humidity and temperature. It is therefore essential to obtain from manufacturers details of their products and the correct additives to use under specific climatic conditions before attempting production.

CONCLUSION

Screen printing is making inroads on the competitive commercial field for low-cost short-run printing. It is becoming difficult to distinguish between normal lithographic/letterpress work and that produced by a screen. As a simple, economical equipment for special purpose printing it has proved indispensable.

It is not intended that screen printing be planned as a substitute for lithographic reproduction, but rather as complementary to it. When the printing runs or the number of colours required exceed the economic capacity of the screen, the more expensive and sophisticated equipment becomes necessary. The introduction of the screen equipment for our particular role is proving very successful, and it is quite probable that other map-producing agencies may be faced with a similar problem which can be economically resolved in the same way.

SOME AUSTRALIAN MAP PRODUCTION TECHNIQUES

Paper presented by Australia[1]

This paper will present a general description of the methods of map production at present being used by the Division of National Mapping, supplemented by methods and experiences of some of the state mapping agencies as reported at the meetings of the technical sub-committee of the National Mapping Council, the annual forum in which technical methods are discussed and, if possible, standardized throughout Australia.

[1] The original text of this paper, prepared by N. L. G. Williams, Assistant Chief Drafting Officer, Division of National Mapping, Department of National Development, Canberra, appeared as document E/CONF.52/L.76.

DRAWING TECHNIQUES

Scribing bases

The approach to map production changed radically in this country with the introduction of the scribing technique. Most mapping agencies adopted the negative scribing method, using sapphire-tipped tools on polyester based scribe-coat. A polyvinyl base was used in the early stages, but this material was quickly discarded because of its tendency to shatter under certain conditions. When the vinyls were in use, some agencies were converting their negative scribed images to positive by chemical dye reversal

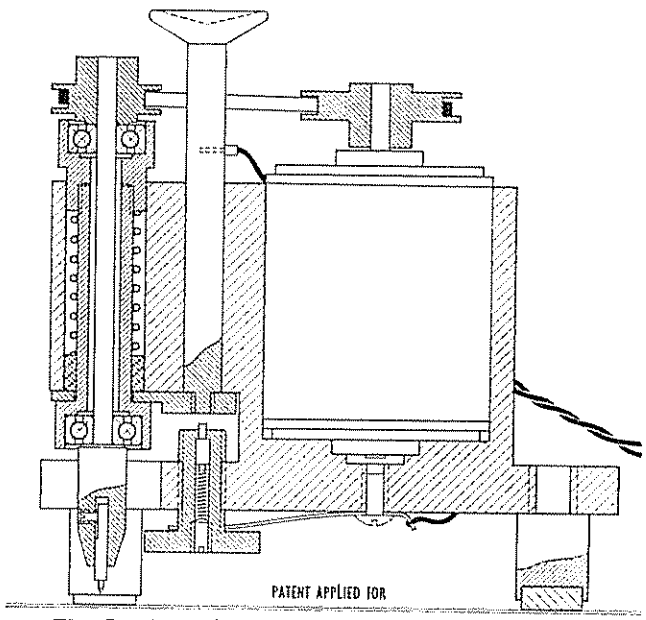


Fig. I—Australia: Willemsen dot-cutting machine

for eventual printing by deep-etch process. To most users of the new methods, this approach seemed to negate the advantages gained by scribing. The positive method was discarded eventually when the esters were in common use, as scribe-coat on this base was found to be chemically inert and did not therefore permit positive reversal.

Scribing tools

Sapphire-tipped tools are in use by most Australian mapping agencies and were favoured chiefly because they do not require sharpening and therefore standard line widths can be maintained. Some carboloy tips are in use.

In the early stages it was found that chipping of sapphire tips occurred through careless handling, but this was overcome by first, the issuing of cartographic instructions on correct handling of tools, secondly, the bedding of tool shafts in thick cork for both identification and protection when not in use, and thirdly, the use of foam plastic sheeting to protect tool-holders.

Drafting aids

It was inevitable that draftsmen using the new techniques should develop ideas on the improvement of existing tools and other drafting aids. Officers of the Division of National Mapping are particularly fortunate in this respect in having the services of a scientific instrument maker to convert their ideas into practical realities. As a result, many new instruments appeared on the drafting tables, such as: the power-driven dot-cutter, first operated by battery, but later adapted for power mains operation; the automatic spacer for the dot-cutter; the long adjustable curve for graticule scribing; the self-adjusting scriber for use with the adjustable curve; the symbol template punch.

Drafting furniture

Drawing office furniture underwent a change with the new drawing office procedures. The drafting table was redesigned to serve also as a light table. Although some preferred a top which could be adjusted for angle, the majority favoured the flat top. The type developed and used by the Division of National Mapping features a cold light source located in a sliding drawer. Some states experimented with tables and chairs at a normal clerical working height, but agencies generally did not favour this rather radical departure from traditional drawing office furniture.

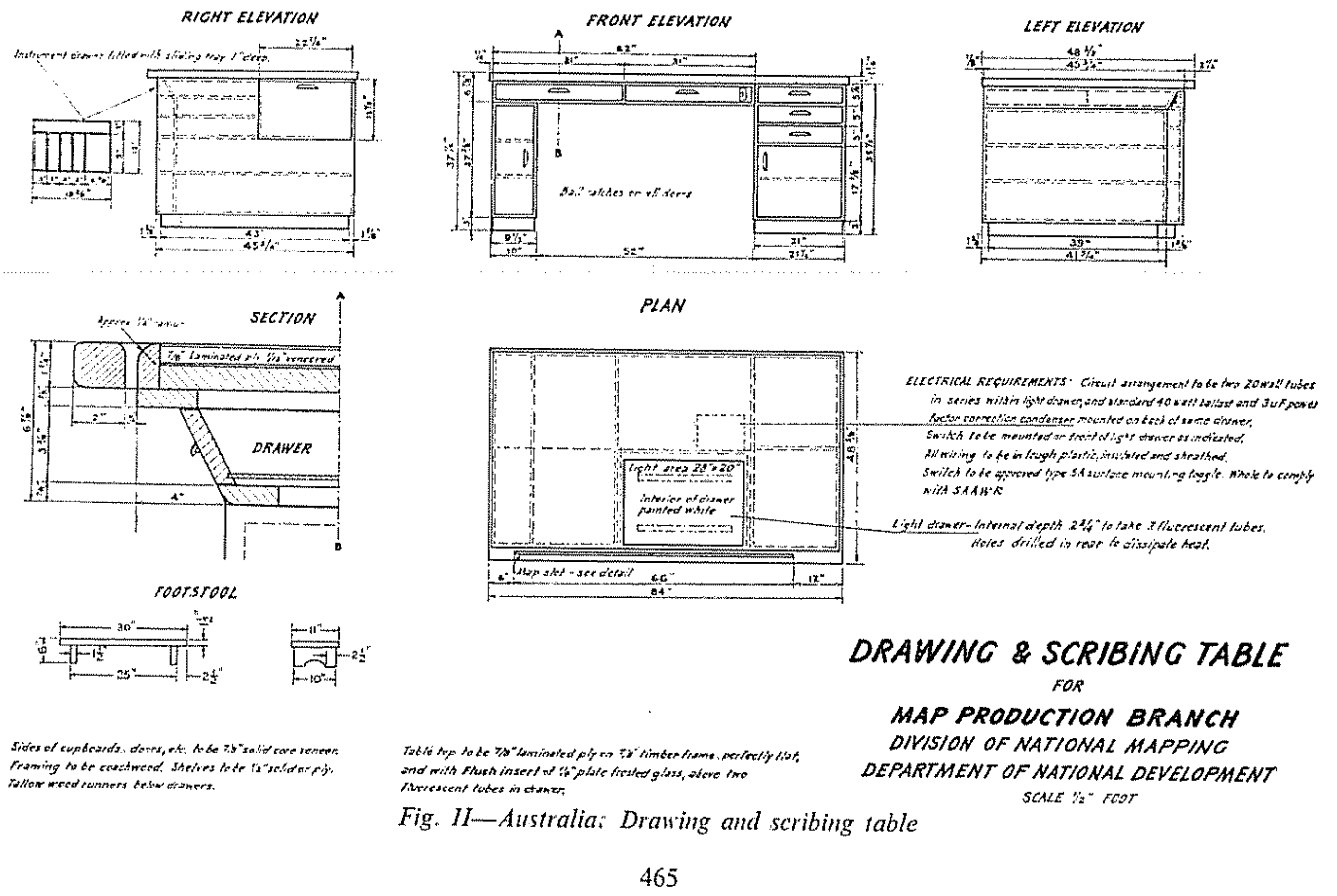


Fig. II—Australia: Drawing and scribing table

Masking

Masking as carried out in Australia can be divided into three categories: (*a*) negative and positive ink masking; (*b*) cut-and-peel techniques; (*c*) photomechanical strip mask techniques.

The choice of process for a particular task depends on the nature and complexity of the map, taking into consideration the amount of unwanted line work on the key image to be retouched out and justification for preparing a separate key image sheet.

(*a*) Ink masking is carried out on matte polyester film on which a non-photographic blue guide image has been printed (for simple work the guide image is eliminated by register), punching the mask sheet with the key drawing and tracing areas over a light-table. When a positive mask is required, the areas are inked in on the reverse side with special plastic inks. For a negative mask, an ink verge of the area is produced and the balance masked out with golden rod paper. Experience has shown that, whenever contact screens are used in conjunction with golden rod masks, care should be taken to cut the golden rod back at least ½ inch from the screened areas to ensure proper contact in the frame. It has also been found that, when screens are to be used with masks for plate-making, best results are obtained by masking to the inside of lines, as exposure light has a tendency to undercut when the screen is interposed between the contact side of the original and the sensitized surface of the machine plate.

(*b*) Cut-and-peel techniques are carried out on commercially prepared coatings in reverse, using either a .004 to 006 inch scriber or a swivel-headed knife.

(*c*) Photomechanical strip masks are produced by exposing a presensitized peel-coat film through a positive original copy, the key lines being etched out during processing. Care must be taken, as the exposed line has a tendency to thicken during development.

Pre-punching for register

All base materials required to make up the reproduction material for a map area are pre-punched before any work is commenced. This enables any combination of working sheets to be placed in perfect register at any stage through to the final colour proof. Most mapping agencies use a two-hole system at the top of the sheet. Punching is carried out with a specially designed punch to take ¼ inch diameter brass studs. The stud centre can be ground down to accommodate various combination thicknesses.

Some agencies use a third hole or slot at the sheet bottom as an additional holding point, but it is found that, with most film bases up to 30 × 24 inches (a normal working size for series mapping), two top holes only are sufficient. The use of special studs of limited height enables studding to carry through to the plate-making stages.

Relief shading

The Division of National Mapping uses the shading technique to portray relief at many scales. At the larger scales it is used to supplement both contouring and layer tinting.

Training of suitable personnel was a problem in the early stages, as it was difficult to find a person combining a good knowledge of topography with artistic ability—prime requisites for relief shading. A system was initiated, starting with training in the basic elements and following through well defined production steps which were subject to check at each stage. This training programme paid dividends as the division now has 18 per cent of the work force of the Map Production Branch capable of producing satisfactory relief shading work.

The Royal Australian Survey Corps and others experimented with the production of relief models in wax or plastic for subsequent photography. Some results were successful, but did not achieve general acceptance on a national basis as a substitute for the shaded drawing.

The artist's air brush is the instrument used, accented if required by pencil work in the shadows on the drawing or by spraying out highlights at the negative stage. Compressed air is supplied from a large central compressor unit through ½ inch copper pipes mounted overhead and thence through flexible plastic tubes to the drafting tables. Small mobile compressor units were originally used for this work, but they were disturbingly noisy in the drawing office and required frequent attention to maintain their rather inadequate air output.

Many base materials were used for relief shading, with varying success. White translucent matte plastic sheeting was first tried, with the key drainage pattern drawn in light blue. It was difficult to drop out this unwanted key image during photography, and the opacity of the material made checking difficult. It was also found that variations in whiteness in this plastic rendered standardization of photographic procedure almost impossible.

Paper board with an aluminium laminate was then tried, with the key image embossed by hand using a blunt point. This overcame the problems of eliminating the guide image during photography, but this material was completely opaque and preliminary checking against line detail was impossible.

All these problems have now been overcome in the division by the use of matte transparent polyester drafting film which can be superimposed over the drainage sheet to eliminate the need for a key image and simplify checking. During photography, a white backing sheet is used and a consistent result is obtained.

Draftsmen engaged on relief shading are required to prepare a preliminary investigation chart, a highlight-and-shadow plan and area treatment samples before commencing the drawing of an area. During the drawing stage, control is maintained by rigid adherence to a standard checking form. This is necessary as, apart from loss of valuable production time, it is difficult to make corrections to a finished relief drawing. All relief drawings are referred to field surveyors familiar with the terrain for final check before acceptance.

Type-setting and placement

Most Australian mapping agencies are using photo-setting equipment to produce type direct on to positive stripping film—usually reverse-reading to facilitate contact printing. There is a wide variety of machines being used for this purpose, ranging from large keyboard equipment to small dialing machines. As a result, there has been no standardization of type faces. Monotype and linotype faces are mostly used, but some agencies use matrices which have been especially hand-drawn for the purpose.

The favoured method of type placement is by wax adhesive. Some agencies are using electrically operated waxing machines to coat the back of the film, but the Division of National Mapping is using a specially designed "container-heating" device.

This equipment is very cheap and unsophisticated when compared to its electrically driven counterpart, but is extremely efficient in its operation. It can easily be made by modifying a standard 1 gallon oil container, or by manufacturing one out of sheet copper to avoid rusting. Flexiwax or microwax is grated into chips and dissolved in shellite in the approximate proportion of one part wax to four parts solvent. This is poured into the tray of the heating device, which has been previously filled with hot water. The film to be waxed is immersed in the liquid, following the curve of the tray. When the coating has solidified on the film, a protective sheet of tissue paper is placed on both sides.

The wax-coated stripping film is mounted on a clear plastic overlay sheet, which is contacted to produce a reproduction negative.

Photography

Most mapping agencies are equipped with a process camera capable of producing negatives up to 40 × 30 inches. With so much drafting work on plastics, it is almost essential for a camera to be fitted with a copyboard capable of handling transparent as well as reflection copy.

Illumination is usually by carbon arc, although pulsed xenon is rapidly gaining favour, particularly with new camera installations where carbon dust and heat can have a detrimental effect on reversing mirrors, lens surfaces and other exposed accessories. Quartz iodide lights are also in use for reproduction of line work, but carbon arc and pulsed xenon are preferred for half-tone work.

Apart from the advantage of being much cooler in operation, the colour temperature of xenon is a constant 5,400° Kelvin, thus giving the high intensities and colour temperature of carbon arc without the latter's inherent disadvantages.

The production of an acceptable half-tone negative from a relief drawing demands a high standard of competence from the photographer. To assist him in this exacting task, the draftsmen are required to supply drawings which have been standardized in both background colour and treatment. Previously the division used a two-exposure system for photographing relief drawings—the main exposure of 350 units at F22 with a "bump" exposure of 7 to 12 units at the same lens stop to obtain a highlight dropout. Processing time was $2\frac{3}{4}$ minutes at 68°F. However, when the bump exposure was used on a low density range drawing, a loss of detail occurred in the middle tones.

The method presently being used eliminates the bump exposure. A densitometer reading is taken to determine the main exposure. A reading is also taken of the grey scale highlight and the main exposure is based on these comparative readings. Additional units are added to compensate for the missing bump exposure and the processing time is 3 minutes at 68°F.

Colour proving

Photomechanical methods are preferred for obtaining colour proofs. The Division of National Mapping uses a negative-to-positive method which is most suitable for proving negative-scribed sheets, but other agencies use deep-etch dyes and processes to produce colour proofs from positive copy.

Plate-making

The presensitized aluminium plate is the type favoured by agencies using negative reproduction material. Those using positive material use the deep-etch process, particularly when the machine run is lengthy. The direct positive plate is also in use, but, generally speaking, most maps are printed from negative-to-positive presensitized plates.

Printing

Most map printing in Australia is done by the Commonwealth and State Government Printing Offices and the Royal Australian Survey Corps. The Commonwealth Government Printer is equipped to produce maps up to a maximum size of 43 × 60 inches. An interesting development in map printing is the use of a small silk screen printing press by the Royal Australian Survey Corps to meet the need for a light-weight, highly mobile press. This unit is

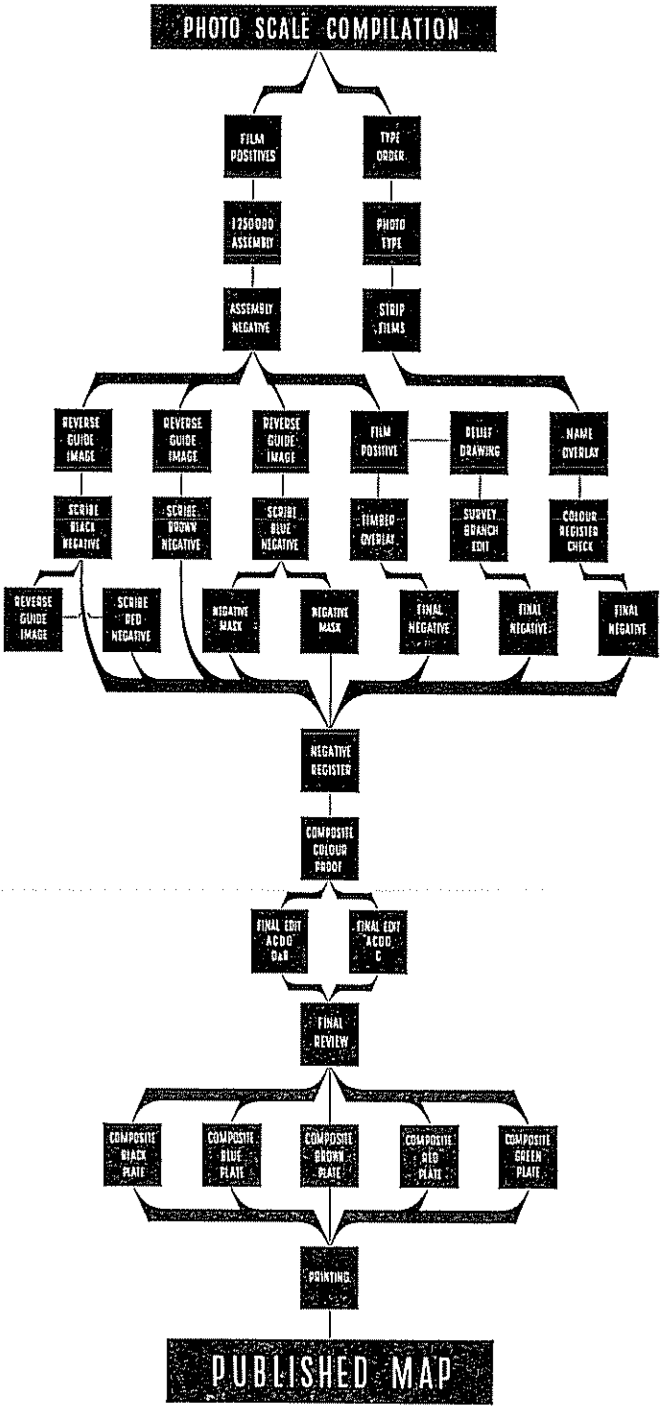


Fig. III—Australia: Work flow chart, standard topographic mapping, 1:250,000 Australia series capable of printing maps of from 8 × 10 to 25 × 35 inches. It is ideally suited for short-run printing and overprinting of existing maps, where cost and portability are important factors.

Management techniques

Through all these phases of map production a very tight system of management control is employed. There are many individual steps in series mapping (see the work flow chart for the 1:250,000 topographic series) and strict control of each step is demanded.

In the Division of National Mapping, this is achieved by:

(*a*) Compilation and issuance of cartographic instructions to cover all processes; copies are issued to all section leaders and are available to sectional personnel so that they may be familiar with the total requirement for all tasks undertaken;

(*b*) Use of checking forms especially drawn up for each task covering completion and acceptance of all phases of production through to the final printed map;

(*c*) Writing up of a complete and accurate history of each map area, recording basic information used in compiling, origin and accuracy of control, nomenclature source, field notes, compilers' comments on interpretation, map symbols and general topography, and any other information which can assist the scribing draftsman to produce a complete and accurate representation of map detail;

(*d*) Maintenance of a record system and punch cards to record personnel involved, time taken, materials used, and other relevant data which can be instantly retrieved for the extraction of work statistics.

PREPARATION OF RELIEF SHADING FOR TOPOGRAPHIC MAPS

Paper presented by the Federal Republic of Germany[1]

It is the purpose of relief shading on topographic maps to give a plastic, true-to-life picture of the terrain features and to illustrate the abstract contour lines for the inexperienced map-user. With decreasing scale, relief shading supplements the largely generalized contour lines represented at greater intervals, thus providing the experienced map-reader with additional information.

Relief shading is a picture without measurable information. Its effect is purely psychological and depends on the ability of the map-reader to transform the two-dimensional picture into a stereoscopic impression. Depending on personal disposition, this ability is of different intensity and is furthermore influenced by personal experience. Moreover, the effect of relief shading is determined by a number of other factors, such as method of representation, purpose of the map, remaining content of the map, technique of shading, reproduction and printing techniques, conditions of illumination when reading the map etc.

METHOD OF REPRESENTATION

For topographic maps, we generally use the method of hill-shading with oblique illumination. Depending on requirements, this method may be slightly modified. In addition to appropriate shading with oblique illumination, therefore, we use a hill-shading with oblique illumination but without shady tones in the plane, or a shading with oblique illumination combined with slope shading (for very small features).

The basic elements of a hill shading with oblique illumination are: direction of illumination, angle of light incidence, and air perspective. The direction of illumination used in most cases is west-north-west, turning to north-west and west-south-west, depending on the position of the hill to be shown on the map. If the change in the direction of a mountain necessitates a strong shifting of the direction of illumination, then the shaded drawing shows a spot without stereoscopic effect. This portion of the drawing is kept as small as possible. The angle of light incidence is kept flexible, too, so that it can be varied according to the steepness of terrain features. On the average, this angle amounts to 30° from the horizontal. The phenomenon of air perspective in a horizontal direction in the dense atmosphere above the earth's surface, which is familiar to the human being at least in his subconscious, is transferred to the vertical. The map-user feels that terrain features which are represented on the map in strong dark-light contrasts are closer and consequently higher than the same features represented in less contrasting colours.

When making use of the three components of direction of illumination, light incidence and air perspective, we apply a general rule for the preparation of hill shading with oblique illumination. That rule is that each change in direction, each marked change of slope, and each essential difference in elevation must entail a change of the tonal value in relief shading. The highest parts of the illuminated slopes remain without any shading.

WORKING BASE

As the working base for the preparation of relief shading, we use the contour plate combined with hydrography. The generalization of contour lines begins at 1:25,000 scale. In the derived maps at 1:50,000, 1:100,000 and 1:200,000 scales, the forms of contour lines are still further generalized. Typical minor forms and terrain crests may disappear owing to the contour interval applied. It is difficult to achieve coherence of major landforms only with contour line representation. It is therefore desirable, for a correct interpretation of contour lines, that the cartographer who performs hill shading should have a general knowledge of the geomorphological relief features. Before beginning with the actual preparation of the shading, he familiarizes himself with the most important geomorphological features of the terrain to be graphically represented. If necessary, he makes a planimetric sketch of the main geomorphological features. Geological maps, maps of landforms (topical representations) and morphological descriptions should be used as source material. Most valuable information can be derived from series of aerial photographs at the appropriate scales, when viewed through a stereoscope. But

[1] The original text of this paper, prepared by F. Christ, Institute for Applied Geodesy, Frankfurt a.M., appeared as document E/CONF. 52/L.83.

their applicability for the direct transfer of features ends at scales 1:50,000 and 1:100,000 of general topographic maps. In map scales ranging from 1:100,000 to 1:200,000, aerial photographs with picture scales of 1:20,000 to 1:60,000 can be used only for checking the shaded drawing.

Shading technique

As a rule, relief shading is executed manually, but the technique applied varies. The following drawing instruments and materials are used: pencils of different degrees of hardness with wipers; brush-pencils with ink or colour ink; pencil and wiper combined with brush-pencil and ink; air-brush with ink or colour ink; air-brush combined with brush-pencil and ink. The following drawing bases are used: cardboard and photographically sensitized cardboard (partially metal lined); transparent or white (opaque) foils. The working base is applied on to the drawing base as a blueprint on the front or reverse side, or as a silver-bromide copy (grey or brown). With transparent foils, the contour lines and hydrography may be placed underneath. In general, the shading for topographic maps is made in black and white. The working scale of the shading extends up to a 30 per cent enlargement of the working base.

Preparation of relief shading for the general topographic map at 1:200,000

A combined film negative of contour lines and hydrography is printed at 1:150,000 scale. A grey-brown pilot copy of contour lines and hydrography is made on a white silver-bromide paper by means of the combined negative. The shading is drawn in bright grey tints by means of an air-brush and thinned waterproof black ink. Major landforms, minor forms and terrain crests are elaborated by means of an air-brush, a brush pencil, ink diluted to different grey tints, a rubber eraser and a pencil eraser. Major forms are co-ordinated by means of an air-brush. Border zones are compiled for the junction of neighbouring sheets. (The tinting and drawing of relief shading is not done in one run for the entire map sheet, but portion by portion.) The brightest and the darkest grey tints are checked by means of a reflection density guide or a reflection densitometer in order to observe the limiting values. Contour lines and hydrography are washed out in a reducer bath. Compilation is completed by accentuating the deepest shades with pencil and tempera ink. Corner register marks and theoretical sizes for reproduction are indicated.

The following equipment is used: bromide paper, Teliko 06, matte, normal, with aluminium lining (furnished by Elsässer, Kirschberg/Bern, Switzerland); Paasche air-brush "AB" (furnished by Paasche, Chicago, United States of America); Hiekel air-brush, model H1; compressed-air cylinder or compressor; marten-hair brush pencils Nos. 2 and 3; Pelikan Indian ink Perltusche, black, waterproof; Günther Wagner Pelikan tempera colour, black; Faber pencil eraser "Perfection" 7058; Kodak reflection density guide; reflection densitometer, Gretag portable D1 (furnished by Gretag, Switzerland); reducer: potassium ferrocyanide with sodium thiosulphate and water.

Reproduction

Just as different drawing techniques may be used for the preparation of relief shading, so different methods are used for its reproduction. For this reason we deal here only with the reproduction of hill shading for the 1:200,000. The shading of this map is printed in three colours, as follows:

Grey: tone plate—all shaded parts including flat bottoms of valleys;

Grey-violet: enforcing plate—shaded slopes only;

Yellow: plate showing illuminated parts of the terrain—illuminated slopes only, with the exception of glaciers.

Accordingly three screened film diapositives are made from the drawing of hill shading.

The working procedure is described below.

Continuous-tone photography of the shading is executed with reduction of the theoretical size. The average range of density shown on the negative (measured by means of a grey scale photographed in the same process) is approximately 1.5. The average gamma value is approximately 1.0.

The diapositive tone is contact-screened from the continuous-tone negative, with screen position of 75°, range of density (measured by means of a grey scale screened in the same process) extending from 0.6 (lowlands) to 1.1 (high mountains); white zone of the grey scale 0.0, gamma value 0.5 to 0.9.

The diapositive enforcing plate is contact-screened from the continuous-tone negative, with screen position of 45°, range of density (measured by means of a grey scale screened in the same process) extending from 0.45 (lowlands) to 0.8 (high mountains), white zone and first grey gradation of the grey scale 0.0 gamma value from 0.4 to 0.75.

Direct screen photographs are made of the diapositive illuminated slopes of the terrain. A black and white contact print (steep gradation) is made from the continuous-tone negative on photo cardboard. Valley-bottoms are masked with borders blurring in continuous tones by means of brush-pencil, air-brush, Pelikan ink and tempera colour on the copy. A direct screen photograph is made of the masked copy, using a glass screen, the screen position being flat. The screen negative shows screen illuminated slopes and unscreened shaded slopes and valley-bottoms. The screen negative equals the screen diapositive showing illuminated slopes of the terrain.

The following equipment is used: Klimsch Commodore process camera (furnished by Klimsch, Frankfurt a.M., Federal Republic of Germany); contact printing cabinet; point-light printing lamp; contact screen Kodak magenta, 60 dots per cm; glass screen, 54 lines per cm (round) (furnished by Klimsch); grey scales, Kodak and Gevaert; film, Dupont Cronar commercial CCS-7, Cronar COS-7; Klimsch Universal Densomat.

Plate-making and printing of relief shading

The colouring of relief shading, the reproduction of screen tones and the maintenance of inking at a constant level during the printing process are of decisive importance for the final effect of relief shading on the map picture. The procedures applied for the printing of hill shading differ little in the relevant technical institutions. Only the number of printing inks used is different, ranging between one and three.

The procedure for plate-making and the printing of relief-shading for the general topographic map 1:200,000 is described below.

Astralon copies of the three film diapositives, "tone", "enforcing plate" and "illuminated parts of the terrain", are prepared by positive process with simultaneous masking of road fillings and water bodies. Printing plate copy of the three Astralon foils is made onto micro-grained aluminium plates (pre-sensitized or sensitized in own laboratory). Printing down is done by positive process. Reproduction of screens on the plate is checked by means of PDI signal strips (Printing Development Incorporated). Printing is done in a single-colour or two-colour offset press in grey, grey-violet and yellow. Printed copies are checked by means of PDI control strips. Colouring is checked by colour densitometer Gretag portable D1.

Conclusion

The method used for relief representation on most topographic maps—shading with oblique illumination—corresponds to the classical method of representation applied in all graphic arts. The technique of drawing relief shading may be still further improved by a drawing instrument which combines the advantages of drawing pencil and air-brush.

Reproduction techniques and offset printing are in continuous development. But in modern offset printing, too, the scale of tonal values still shows a slight flattening. For this reason, maps with an abundance of content often require two colours for the printing of the shaded tones of a hill shading. Here there still exists a possibility of improving the quality of printing which would be particularly useful for relief shading.

CARTOGRAPHIC TECHNIQUES DEVELOPMENT

Paper presented by China[1]

Mapping techniques have been improved so that map reading may be facilitated.

Shading relief has been added on 1:250,000 scale topographic maps and parts of topical maps. The shading relief when shown together with gradient tints and contours on the map will present a three-dimensional view. This method will not only clearly show the terrain, but also make the map appear more pleasing to map readers.

A pictorial map has been developed on an experimental basis. The process of map-making includes the shaping of photo-mosaics, photo-mechanical colour separation of features, separate drawing of roads, contours, co-ordinates and geographic names. The map, when completed, will show features more sharply than would be possible with conventional symbols. This technique has been developed in the United States.

[1] The original text of this paper appeared as document E/CONF. 52/L.116.

REPRODUCTION OF MAPS AND AERIAL PHOTOGRAPHS

Paper presented by Japan[1]

Developments in materials and instruments have produced a number of changes in procedures for map reproduction and printing of aerial photographs. The increase in annual demands for maps and in the number of colours for a sheet has necessitated changes in map-printing schedules.

The present short report shows the current status of reproduction activities in the Geographical Survey Institute (GSI).

Printing of aerial photographs

The institute annually supplies 80,000 to 100,000 copies of prints or enlargements of aerial photographs. In addition, approximately 20,000 copies are prepared for GSI use. The institute is equipped with three argon printers, two electronic printers, one rectifier and one electronic enlarger. The electronic printers and enlarger are of an automatic dodging type provided with automatic exposing devices. The enlarger is so designed, at our specific request, as to make automatic enlargement of from one to seven times of the vertical type. For other ranges (smaller than contact size and larger than seven times), it may be operated manually as horizontal type.

Thermostatic baths are installed and automatic processing devices for photographic paper are now in preparation.

Drafting

Surveyed or compiled manuscripts are elaborated to final drafting ready for succeeding reproduction processes.

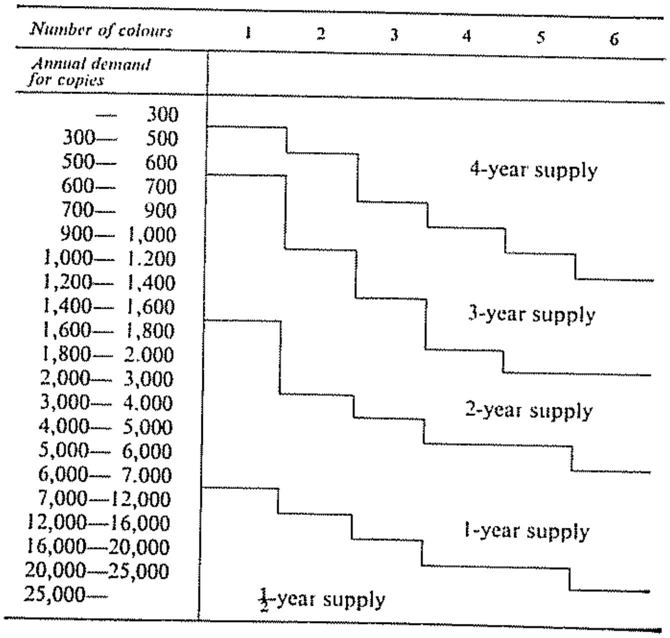
For multicoloured maps, traditional methods such as pen-and-ink drawing on drawing paper and colour separation on plate or negative film have been replaced, for the most part, by new methods: scribing on synthesized plastic sheet for each colour separation; pasting of photo-composed lettering and masking by peel-coat. These methods were introduced into the routine work in 1956 and a punch system on each colour separation and mask was adopted in 1966. Single-coloured maps (large-scale maps such as 1:2,500 and 1:5,000 maps and lake charts) are drawn with pen and ink on a synthesized plastic sheet, on which photo-composed lettering is pasted also.

The recent use of a synthezised semi-transparent plastic sheet, in place of drawing paper, for surveyed or compiled manuscripts made it possible to transfer the image of the manuscript on to a scribing sheet by contact printing directly from the manuscript by diazo method. This procedure eliminates the process of photographing a manuscript.

For proof-reading, colour separation drafts are compiled by a bichromate method on a synthesized plastic sheet in

[1] The original text of this paper, prepared by the Geographical Survey Institute, Tokyo, appeared as document E/CONF.52/L.121. Additional papers bearing the same symbol were submitted under agenda items 6, 7, 8, 9, 10 and 12.

Table 1. Annual supply, annual demand and number of colours



different colours. The same method is applied to prepare the base map for revision survey.

The institute has developed a new method of masking by dyeing a gelatine-coated film. Prior to dyeing it, a portion to be left transparent is drawn with acryl lacquer. If the dyed portion is made visually transparent, it is easy to read proof on the film itself. This method is quite effective for complicated patterns and has been applied to the 1:25,000 land condition map (thirteen to sixteen colours with approximately thirty masks) and the 1:50,000 land use map (eight colours with twenty masks) with satisfactory results since 1965. It is to be extended to other thematic maps.

PROCESS FILM AND PLATE-MAKING

Since 1961, the master plate for making printing plates has been replaced by process film from copper or zinc plate. A method has been developed for frosting the polished surface of a copper plate by surface treatment. The method has made it possible to photograph copper plates directly. Films for all sheets of the 1:50,000 topographical map, the 1:200,000 regional map and 80 per cent of the existing 1:25,000 topographical map have so far been completed.

Moreover, the adoption of the punch system for final drafts makes it easy to compile them into one sheet of process film for each colour, including separation for half-tone when necessary. This procedure saves considerable labour and time in making plates for printing.

Printing plates are made chiefly by the albumen method. Since 1965, plates have gradually been replaced by aluminium from zinc, the problem of retouching on an aluminium plate having been resolved by choosing suitable ink for drawing on it. Retouching on the plate is more or less inevitable. Presensitized aluminium plates are used in part.

At the same time, all the light sources for contact printing, photographing or plate-making have been replaced by iodine or xenon discharge lamps from carbon arc lights. Use of the zirconium arc lamp of point-like source type allows multiple printing of positives.

PRINTING OF MAPS

The annual supply of maps is 5 to 6 million copies of about 3,500 kinds. In addition, approximately 1 million copies are printed at special request from other governmental agencies.

The institute is equipped with six single-colour, one two-colour, and one four-colour offset printing machines. Five or six machines are usually operated. In view of the demand and the capacity of supply, the institute has adoped a policy of printing from a half-year supply to a four-year supply, depending upon the annual demand and the number of colours for one sheet.

Because of the small demand, large-scale maps and lake charts are prepared as blueprints by diapositive method on request.

Table 2. Annual number of lots to be printed

Supply (or stock)	*Number of sheets*	*Number of printing*	*Number of lots to be printed*
4 years	1,704	1/4	426
3 years	420	1/3	140
2 years	504	1/2	252
1 years	808	1	808
½ year	139	2	278
TOTAL	3,575		1,904

AGENDA ITEM 14

Automatic extraction, recording and processing of cartographic data

SOME ASPECTS OF ELECTRONIC COMPUTING AND PLOTTING

Paper presented by Israel[1]

INTRODUCTION

This communication deals with certain aspects of the transition from manual to automated methods of processing survey data, based on the experience in the Survey of Israel, which is a relatively small surveying and mapping agency. It is felt that the application of automation should first be directed to those tasks which cause production bottle-necks because they are time-consuming in character, or where a shortage of trained personnel is the main problem.

A gradual transition from conventional to electronic methods was started approximately three years ago. These activities may be divided into three areas: systems analysis and programming, data processing with the aid of a high-speed computer and automatic plotting.

SYSTEMS ANALYSIS, PROGRAMMING AND DATA PROCESSING

A small section was created to deal with these tasks, and was given several basic directives, namely:

To assign priorities according to the needs of the agency;

To take advantage, wherever possible, of existing programmes;

To work on the assumption that the agency would have no computer for its own use until this was economically justifiable and that until such time it would utilize the services of an outside bureau;

To ensure that the transition was gradual, without major organizational changes, and did not interfere with the flow of work.

The first problem encountered was the utilization of programmes existing in other organizations and available to us. Our initial approach was to try to take advantage of the available programmes as ready-made material and utilize them on the basis of the programme description and operating instructions.

This approach proved unacceptable for several reasons. First, it is difficult to operate a programme in production without a testing period and without learning its characteristics and the exact nature of each phase. This in itself takes almost as much time as writing a new programme. Secondly, there is very seldom identity in the form of input of various agencies (for example, the sexagesimal or centesimal systems in surveying instruments and forms of field records), moreover, the requirements vary regarding output (accuracies, checks, physical form). Thirdly, there may also be variations in the equipment for which the programme has been written; this results sometimes in different programming language, sometimes in different capacity of computer memory etc. Taken individually, these factors necessitate relatively minor modifications to the existing programme, but in combination would usually result in a greater expenditure of time than would be needed for the preparation of a new programme.

We therefore adjusted out initial approach and decided in most cases to write our own programmes, utilizing only certain routines or outlines from outside sources.

Another problem encountered was that of basic input data. The general convention is that field records should, as far as possible, be punched directly on cards or tapes without a manual intermediate process which, besides being time-consuming, is liable to introduce an additional source of mistakes. This aspect requires the special attention of the systems analysis engineer. The latter must seek, on the one hand, to ensure the efficient punching of data and, on the other, not to jeopardize the efficiency of field work by introducing a form of recording which would be inconvenient to the field surveyor or substantially different from what he has been used to in his extensive experience. We have encountered this problem in the programme for levelling cross-sections for road planning. The programme computes elevations in the cross-sections and arranges the output in the form of punched cards, which include plotting instructions for the electronic coordinatograph. It is therefore necessary to match the instrument height at each station with the appropriate staff readings.

Our experience shows that the levelling field book planned by the systems engineer answers the theoretical requirements very well but is too complicated for the field surveyor to use in standard production work. The field book was experimentally tested before introduction but it appears that the test results were not representative. During the preliminary stages of programme running we explained to the field survey party chiefs how to use the new field book, and the explanation was accompanied by a practical demonstration. This was understood and willingly accepted, but after a few months' experience we realized that in many cases the instructions were not being strictly followed and some of the field surveyors claimed that the new system of recording slowed the work down by up to 50 per cent. The matter is now under analysis and revision and it appears that the form of field recording will have to be modified, taking into consideration both

[1] The original text of this paper appeared as document E/CONF.52/L.14 and Add.1.

field experience and the punching aspect, to make the whole system work efficiently.

The punching aspect is also of great importance in the programme of computing rectangular co-ordinates of details surveyed by the offset method, which we are now preparing with a view to the automatic plotting of detail in cadastral mapping.

We have prepared and introduced the following programmes as routine processes:

Computation of precise levelling, which results in automatic processing costs being only one-quarter of those of manual processing, besides releasing technically trained personnel for other tasks;

Computation of resections where the savings are similar to the above, with the addition of all combinations being considered;

Formation and solution of normal equations and adjustment of triangulation networks, where the task of manual computation is often beyond the ability of an agency to carry out within a reasonable time;

Computation of astronomical latitude and azimuth, where the computation costs have been cut to one-sixth.

We are also using a programme for the computation and adjustment of aerial triangulation strips and blocks which we obtained through the courtesy of the National Research Council of Canada, and which computes and adjusts an average length strip in less than one-quarter of an hour on the IBM 1620 computer as against six days by manual computation. With the card punch connected to the photogrammetric equipment by means of the EK 5 electronic read-out device, there is almost no manual handling of data.

We are also using a programme for computing traverses, written in SPS language for the IBM library and slightly modified by us, but this programme is now due to be re-analysed and programmed for the IBM 360 computer, taking into consideration our requirements. The present programme, run in the IBM 1620 computer, shows a very considerable reduction of computation costs (one-sixth of the manual) but it still involves approximately ten working days in the manual preparation of 1,000 traverse stations for computation in the computer. We therefore use this programme only on fairly large networks of traverses such as those required for cadastral purposes. After the modification of the programme, we hope to achieve greater efficiency and cut the manual handling to a minimum. We should like to stress here the importance of having all the programmes which an agency uses written in the same language of the most universal kind, such as Fortran IV, which can be introduced to a number of computers likely to be available to the agency.

This is particularly important if the agency has no computer of its own but relies on the use of a service bureau.

We have had the experience that the service bureau we use changed its computer from IBM 1620 to IBM 360. This necessitated the discarding and rewriting of all programmes written in the SPS language, which is unsuitable for the 360 computer as well as the adaptation of programmes written in Fortran II for the 1620 to the 360.

Another aspect of primary importance is the existence of a complete write-up for each programme, which includes description of the programme, flow chart, statement list and operating instructions. The absence or incompleteness of such a write-up may present a serious difficulty, especially if the personnel concerned changes.

Finally, we have encountered difficulty in finding people who are experts in the profession of surveying, systems analysis and programming combined. We have the impression that the combination of professional proficiency and systems analysis is the most important, with programming playing a relatively minor part. The general approach to the professsional problem, the theoretical and practical knowledge of factors and aspects involved eventually influence the success or failure of automation. The programming itself can be carried out on the basis of the general pattern and a clear statement of requirements.

Automated plotting

The Survey of Israel has acquired an electronic co-ordinatograph known as the Coradomat, made by Coradi AG, Switzerland. This is an x, y, precision plotter, equipped with a provision for pricking, drawing or pick-up of co-ordinates. A printing device can be attached to the pricking or drawing head, which makes it possible to print a selection of numbers, letters and symbols in conjunction with scoring or drawing. The movement of the head mounted on a carriage is governed by feeding successively x, y, rectangular co-ordinates of known origin of each point to be recorded, by means of punched cards which contain suitable instructions. If points are to be connected by straight lines, a linear interpolation device is switched on, which drives the carriage along the line connecting the two points based on tangent of the direction obtained from $\triangle x$ and $\triangle y$ of the two points in question. Speed of carriage travel is approximately 2.5 cm/sec with linear interpolation and 4 cm/sec without. Although manual operation is possible, it is not used in production work and the co-ordinatograph input should be automatically fed through a card-reader. Thus suitably arranged output of the high-speed computer becomes input for the electronic co-ordinatograph.

The Survey of Israel has in operation at the present two types of tasks on the Coradomat, namely, the preparation of scored field sheets for cadastre and the plotting of cross-sections for road-planning.

Scoring

The scoring of field sheets in cadastral work is the operation which precedes plotting in detail. It involves drawing of the grid lines and scoring all the control points (trigonometric and traverse) which fall within the block to be plotted. This operation is performed by the Coradomat in two stages. First, the grid is drawn, with the carriage driven by a master set of punched cards prepared by us in such a way that the grid lines can start from any desired line at value intervals of 10 m (for 1:1,250 scale) or 20 m (for 1:2,250 scale). The grid framework being completed, the carriage stops automatically and a drawing tool is replaced by a pricker. All the computed control points are then fed in on the cards and the scoring proceeds, each point being made by a prick on the sheet surrounded by a suitably selected printed symbol and automatically printed point number alongside.

This work used to be carried out on a manually operated co-ordinatograph and required, together with checking, on the average a day's work. The automated system permits the same work to be performed within an average of twenty minutes, with better graphical appearance, thus increasing very considerably our capacity in this work, which caused bottle-necks and stoppages in production in the past.

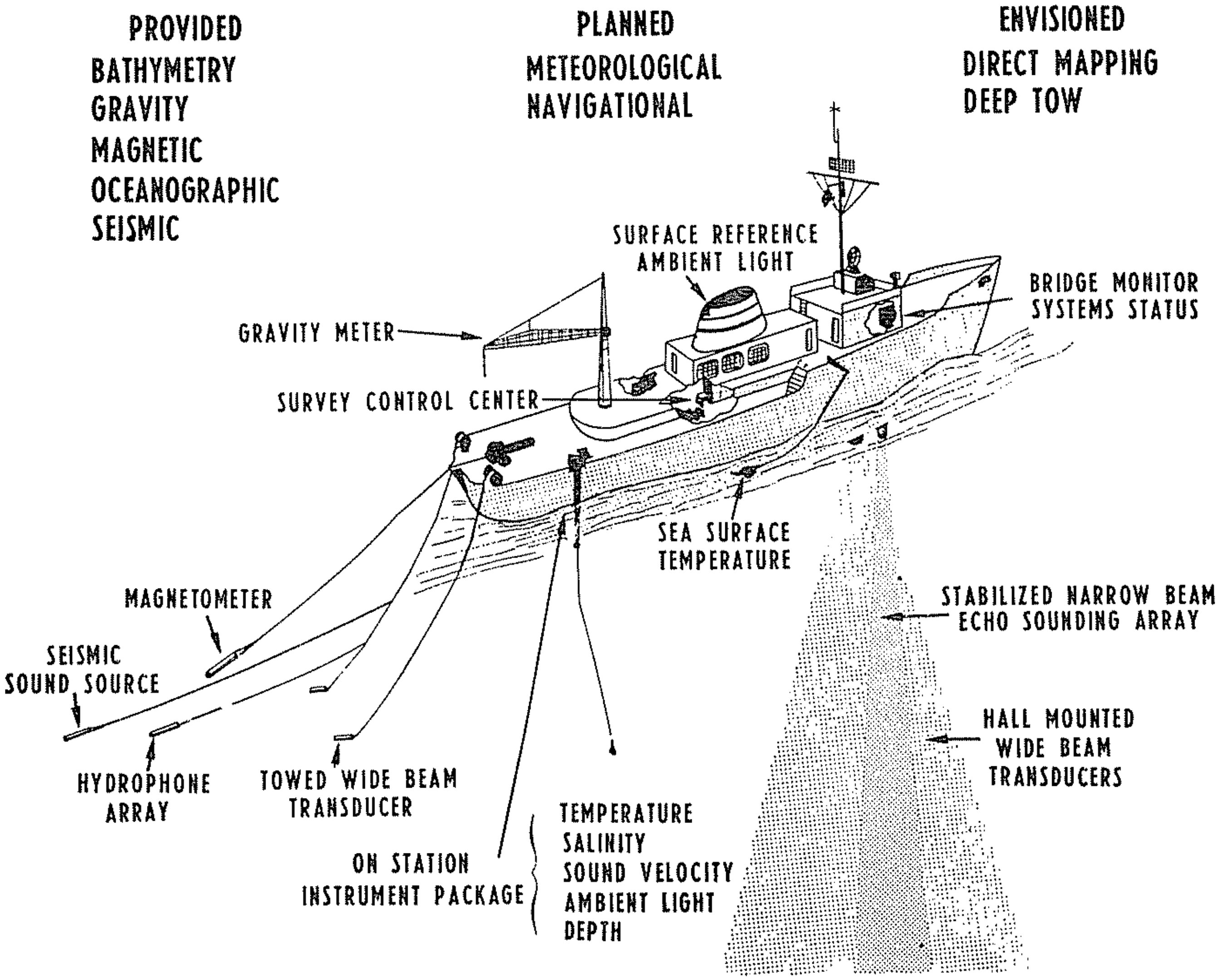


Fig. I—United States of America: Shipboard survey system

maps; aerial mapping photography for a variety of users; and electronically positioned mapping photography for accurate large-scale maps. The products of this system should provide:

Distance measurements up to 500 nautical miles accurate to ±15 ft for horizontal control;

Terrain profiles for vertical mapping control accurate to ±10 ft;

Photography for 1:50,000 scale maps with 90 per cent of the nadir points accurate within 24 ft of their true positions.

A requirement exists for mapping 19 million square miles of the earth's surface. Working under agreements arranged by the State Department, Air Force and Navy personnel are engaged in world-wide operations, acquiring the mapping and survey data. Nine RC-130 aircraft are programmed to complete 600,000 square miles of mapping photography and measure over 200 lines up to 500 miles in length each year. The RC-130 will be replaced by RC-135 aircraft, each of which can complete 500,000 square miles of electronically controlled photography per year.

Field surveys

Field survey instruments are used in the collection of geodetic data by all three services. For example, field Army artillery units down to battalion size depend quite extensively on such instruments as part of their fire control procedures. Missile-launch sites and instrumenting missile test ranges require continual surveys for position and direction. The 1381st Geodetic Survey Squadron, Marine artillery units, Navy survey parties, Army field topographic units and Army Map Service field parties all use electronic distance measuring equipment, astronomic position equipment, theodolites, levels and the like.

Extra-terrestrial systems for the NASA space programme

The seventh acquisition area to be considered is for mapping, charting and selenodetic support of National Aeronautics and Space Administration programmes. NASA, with the Mercury, Gemini, Ranger, Surveyor, Orbiter and Apollo projects, will place a man on the moon during this decade. The Lunar Orbiter, in particular, will photograph nine areas around the lunar equator, resulting in a large amount of raw data which will be made into maps and detailed studies needed for the final selection of the Apollo astronauts landing site.

Under an agreement between the Department of Defence and NASA, the department will furnish all mapping, charting and selenodetic support for this effort. This will require a considerable expenditure of man-years and resources and will result in a large amount of data relative to the lunar surface.

Current holdings

The tremendous amount of data collected by these systems flows into the libraries of the Army Map Service, NAVOCEANO and the Aeronautical Chart and Information Centre. It enters in every conceivable form—photographs, documents, hand-drawn analogue sheets, charts, glass slides, microfilms, hand punch cards, machine punch cards, magnetic tapes. It is the task of the three production centres to extract data from this hodge-podge, process it and analyse it for storage, retrieval and later use.

The following chart shows the general types and quantities of library source materials stored in our three data centres. These holdings fluctuate with the growing accession rate of new materials, items which are loaned or circulated, and destruction of items which are no longer useful.

Library source material statistics

	Type of material	*Current inventory holdings*
1.	Maps	2,500,000
2.	Aerial charts	50,000
3.	Hydronautical charts	35,000
4.	Books, publications	310,000
5.	Periodicals	135,000
6.	Intelligence documents	350,000
7.	Mapping photography (film form, print form)	9,788,000
8.	Geodetic control:	
	Horizontal stations	4,200,000
	Vertical stations	2,100,000
9.	Gravity data observations	460,000
10.	Magnetic data points (airborne, shipborne)	95,000,000
11.	Bathymetric data points	565,000,000

This vast amount of raw material is used as the basic for providing the services and productions required within the Department of Defence. Some of the principal cartographic products and services resulting from these data are:

(*a*) Department of Army and Army components (see Army Map Service catalogues); standard topographic maps (1:50,000; 1:250,000; 1:1,000,000); miscellaneous planning maps (small scale); city maps: town plans (including TAC CTA bases); terrain models, plastic relief maps; goedetic data books (trigonometrical lists); place name indexes (gazetteers); goedetic surveys (including satellite tracking); geodetic studies; Department of Defence geodetic library; Department of Defence map library; flight information publications; air-ground charts (1:250,000); photo-maps, map substitutes.

(*b*) Department of Navy and Navy components (see NAVOCEANO catalogues); nautical charts (various scales, ranges); air navigation charts (1:2,000,000 and smaller); air target charts (1:200,000); tactical target charts and graphics; amphibious assault charts (1:50,000); sea navigation manuals, handbooks; sea-plane approach and landing charts; mine counter-measures charts; anti-submarime warfare support surveys and graphics; Polaris systems support surveys and graphics; ocean area magnetic and gravity surveys and studies; hydrographic oceanographic surveys; satellite tracking (Doppler, optical); cartographic aerial photography; Department of Defence nautical chart library; Department of Defence magnetic library.

(*c*) Department of the Air Force components (see ACIC catalogue); standard navigation charts (1:250,000; 1:500,000; 1:1,000,000); miscellaneous planning and long-range navigation charts; air target charts (1:200,000); tactical target charts and graphics; missile target data cards; missile launch site surveys and data; aircraft systems guidance products; radar trainer simulator graphics; flight information publications; air navigation and airfield data; weather charts; cartographic aerial photography; airborne electronic geodetic control surveys; satellite tracking (optional); geodetic-photogrammetric studies for missile targeting; Department of Defence air chart and gravity data libraries.

How do we use these raw data in the production of these many products? There are basically five steps in map and chart production: data research; compilation; colour separation; reproduction; distribution.

Data research or research on materials for a particular map sheet may take as long as three months and require searching over 650 different files of information.

The second step in map-making takes about three times as long and involves the preparation of a manuscript with rigid accuracy requirements in terms of measurements. These measurements are obtained in one of three ways: photogrammetric techniques using aerial mapping photos; recompiling and revising existing maps from mapping photography; from map sources themselves. This step requires between 800 and 1,200 man-hours for a typical map sheet and includes both creative and mechanical processes. Rigid specifications are followed in making the base manuscript, which is then turned over to the negative engravers for colour separation.

In the third step—colour separation—the map symbols are depicted in their finished state and separated with respect to the final colours on a map in order to furnish the customer with the most readable form for the particular information that he needs. These colours and symbols must take into account human factors—both sociological and psychological—this ensures that the data are interpreted at the map surface so that they mean precisely what they are supposed to mean. A precoated plastic sheet, with the manuscript copied on it, is engraved to show one category of detail and each category of detail is shown in a distinctive colour. From 500 to 900 man-hours are typically required for this step.

The map or chart is now ready for reproduction in the quantities desired. Today most of this is accomplished by conventional lithography, passing the map or chart through a press cylinder revolution for each colour required. In some cases this may require a dozen press impressions for a single sheet to show all the different categories of detail.

In addition to stocks from the three major producers, stocks come in to Department of Defence inventories from many field plants, contractors, and co-operating

AGENDA ITEM 15

Geographical names, including matters for reference to the United Nations Conference on the Standardization of Geographical Names*

NOTES ON STANDARDIZATION OF GEOGRAPHICAL NAMES IN AUSTRALIA

Paper presented by Australia[1]

AUTHORITIES

Essentially, the responsibility for place names in Australia rests with the respective state governments and the Northern Territory Administration and, in respect of the Australian Capital Territory, with the Minister for the Interior.

In the Territory of Papua and New Guinea, the Territory Administration is the appropriate authority, while the Commonwealth Minister for External Affairs is responsible for approving place names in Australian Antarctic Territory.

Details of the various boards and committees dealing with geographical names are set out in annex I.

NATIONAL AND INTERNATIONAL CO-ORDINATION

The National Mapping Council of Australia has the function of co-ordinating Commonwealth and state mapping activities and in pursuance of this function provides a forum for the exchange of ideas on the standardization of geographical names.

The council has adopted a "recommended procedure for the recording of nomenclature on a national basis"; a copy of these recommended procedures is annexed to this paper (annex II).

Under the Australian Constitution, the Commonwealth has full responsibility for external affairs.

The Commonwealth Division of National Mapping provides the secretariat for the National Mapping Council and in this capacity disseminates to the states and territories copies of those United Nations papers on standardization of names which it receives through the Department of External Affairs.

During the last three of four years, some positive action has been taken in some of the states and territories to widen the scope and powers of appropriate nomenclature authorities.

To some extent, this action has resulted from council discussion and the dissemination of United Nations technical reports.

The division also takes action to ascertain the views of members of the council and other appropriate authorities as a basis for the preparation and presentation of national views on the standardization of geographic names.

GAZETTEERS

Current action on the preparation of gazetteers is summarized in annex III.

Annex I

BOARDS AND COMMITTEES CONCERNED WITH GEOGRAPHICAL NAMES

QUEENSLAND

Designation

Queensland Place Names Board.

Address

The Secretary, Queensland Place Names Board, Survey Office, Department of Lands, P.O. Box 234, Brisbane, North Quay, Qld.

Members

The Surveyor General (Chairman) and four members of the Queensland Place Names Committee, which serves as an advisory committee. The membership of this committee is as follows: the Surveyor General (Chairman) and three officers, one each from the Departments of Education, Main Roads, and Railways, plus eight nominees, one each from the Anthropological Society, the Historical Society, the Library Board, the Local Government Association, the Oxley Memorial Library Committee, the Post Office Historical Society, the Royal Geographical Society of Australasia, the Geological Society of Australia and two persons nominated by the Senate of the University of Queensland. The functions of the committee are to advise the board with respect to: the general work of the board; any particular matter of investigation or research; any matter which the board refers to the committee for advice.

Powers and functions

To adopt rules of orthography and nomenclature and to standardize pronunciation in respect of place names in Queensland;

To investigate and determine the priority of the discovery of any geographical feature;

Subject to the Act, to consider and determine any proposed alteration in a place name;

To assign a name to any place in Queensland;

To alter the name of any place in Queensland by substituting another name, or by correcting the spelling of the name thereof;

To omit from official maps and records the name of any place;

To compile and maintain a gazetteer;

To make inquiries and recommendations on such matters relating to the naming of places in Queensland as may be referred to it by the Minister;

To prepare and publish an index of names of places in Queensland with a record of their origin and history;

* In its note E/CONF.52/L.80 on the United Nations Conference on the Standardization of Geographical Names, the Secretariat drew attention to the report of the group of experts which met at Headquarters from 21 March to 1 April 1966 preparatory to that conference. That report is reproduced in *United Nations Conference on the Standardization of Geographical Names*, vol. 1 (United Nations publication, Sales No.: E.68.I.9), annex III.

[1] The original text of this paper, prepared by the Division of National Mapping, Department of National Development, appeared as document E/CONF.52/L.90.

To collect aboriginal names and words with meanings for new place names;

To investigate and determine, as far as possible, the locality and/or the boundaries of any area covered by a place name;

To exercise and perform such other powers and duties as are conferred or imposed on it by or under the Act;

To furnish a report to each meeting of the committee on the actions taken by the board since the last preceding meeting of the committee.

Guiding principles

The board has adopted a set of principles for its guidance in the matter of new or altered names, as follows:

In the case of names of aboriginal derivation or association, the meaning should be appropriate.

Preference should be given to names having some local significance.

Preference should be given to names having some historical background: names of explorers, early settlers, notable Australians, events.

Preference should be given to an English word descriptive of the place; such a word must, however, be apt and not readily applicable elsewhere.

Consideration should be given to the euphony of the word, whether aboriginal or Anglo-Saxon, and to the confusion which may arise from duplication or similarity with existing names.

Except in special cases, the adoption of names of living persons should be avoided.

NEW SOUTH WALES

Designation

Geographical Names Board of New South Wales.

Address

The Secretary, Geographical Names Board, Department of Lands, Box 39, GPO, Sydney, NSW.

Members

The Surveyor General (Chairman), the Chairman of the State Planning Authority, the Principal Librarian of the Public Library of New South Wales, the Director of the Department of Decentralization and Development together with three appointed members from the Local Government and the Shires Association of NSW, the Royal Historical Society, the Geographical Society of New South Wales and one nominated by the Minister for Lands.

Powers and functions

To assign names to places;

To approve that a recorded name of a place shall be its geographical name;

To alter a recorded or a geographical name;

To determine whether the use of a recorded or a geographical name shall be discontinued;

To adopt rules of orthography, nomenclature and pronunciation with respect to geographical names;

To investigate and determine: the form, spelling, meaning, pronunciation, origin and history of any geographical name, and the application of any geographical name with regard to position, extent or otherwise;

To compile and maintain a vocabulary of aboriginal words used or suitable for use in geographical names and to record their meaning and tribal origin;

To compile and maintain a dictionary of geographical names with a record of their form, spelling, meaning, pronunciation, origin and history;

To publish a gazetteer of geographical names;

To inquire into and make recommendations on any matters relating to the names of places referred to it by the Minister for Lands.

Guiding principles

A broad outline of some of the principles which would influence the determination of place names may be summarized as follows:

Avoidance of duplication;

Retention of euphonious names;

Preference for names of aboriginal origin or names with a historical background;

Preference for retention of long-established place names, except where necessary to avoid ambiguity or duplication;

Avoidance of naming places after living persons;

Perpetuating names of eminent persons now deceased, such as early explorers, settlers, naturalists;

Avoidance of attempts to restore the original form of place names changed or corrupted by long-established local usage and adoption of the spelling sanctioned by general usage;

Avoidance of use of place names considered offensive or likely to give offence;

Use of the cardinal points of the compass as a prefix or suffix to an existing name is not favoured.

VICTORIA

Designation

Place Names Committee of Victoria.

Address

The Secretary, Place Names Committee, Department of Crown Lands and Survey, State Public Offices, Melbourne, Victoria.

Members

The Surveyor General (Chairman), the Chief Draftsman of the Department of Crown Lands and Survey, the Surveyor and Chief Draftsman of the Office of Titles, the Chairman of the Town and Country Planning Board and two members appointed by the Governor-in-Council, one from the Municipal Association of Victoria and one from the Royal Historical Society of Victoria.

Powers and functions

To adopt rules governing the naming of places and spelling of place names;

To examine cases of disputed spelling of place names, and determine the spelling to be used on official maps and plans and in official records;

To investigate and determine the first discovery of geographic features;

To consider and determine proposed alterations in place names;

To assign names to places;

To alter place names by substituting for them other names or by altering or correcting their spelling;

To have place names omitted from official maps, plans and records;

To compile and maintain a register of place names;

To make inquiries into and recommendations on matters relating to the naming of places referred to it by the Minister;

To exercise other powers and duties conferred on it and perform other duties imposed on it by or under the Survey Co-ordination Act of 1958.

Guiding principles

For mapping purposes, the use of the apostrophe is discontinued, irrespective of whether the name applies to a locality or feature;

For relatively minor features such as hills, streams, swamps, gullies, etc., the possessive "s" is discontinued, care being exercised to avoid the mis-spelling of surnames ending in "s";

For inhabited localities and very well known features, the possessive case, without apostrophe, is retained; it is considered that the names of such localities and features should be allowed to preserve the same "sound to the ear" as they have, both locally and throughout the state, over a very long period of time;

Where localities are situated on or adjacent to minor features of the same name, the feature name retains the possessive "s";

Where the name of a locality or feature gazetted as such under the Land Act has been superseded or the spelling changed by virtue of common usage, the new form will be investigated by the committee, which will recommend adoption or otherwise of the changed form;

Repetitive aboriginal names such as Diddah Diddah Creek, Bet Bet, Jika Jika, being part of our national heritage and lending distinctive character to our nomenclature, are preserved in their existing form without abbreviation, mutilation or change;

At the discretion of the committee, other two-worded names are condensed whenever possible to one word;

In dealing with inconsistencies of spelling in names applying to features, the general rule is to adopt the spelling appearing on the first survey showing the feature in question; experience has shown that, in the absence of conclusive evidence on the early surveys, reference to the names of the first settlers in the locality may provide the correct spelling;

Where a feature is known by alternative names, or is named differently on various maps and plans, and where no firm authority is available to confirm a particular choice, the procedure adopted is to reject any name that is already too numerous, in favour of one less likely to be duplicated;

Where "North", "South", "West" or "East" is included in the name of a locality, the proper name precedes the directional qualification;

In future naming of large branches of main streams, the use of "Right", "Left", "East" or "West Branch" etc. are to be avoided in favour of distinct separate names;

Before giving its approval for the assignment of a new place name, whether applying to an inhabited locality or feature, the committee determines: that no duplication with an existing name is created; that careful discrimination is exercised to avoid the introduction of names void of significance and inappropriate to the permanent nomenclature of the state.

TASMANIA

Designation

Nomenclature Board of Tasmania.

Address

The Secretary, Nomenclature Board of Tasmania, Department of Lands and Survey, Box 44A, GPO, Hobart, Tasmania.

Members

The Surveyor General (Chairman), the Mapping Officer of the Department of Lands and Survey, the Mapping Officer of the Forestry Commission, the Town and Country Planning Commissioner, six other members appointed by the Governor, of whom one shall be from the Mines Department and another from the Hydro-Electric Commission.

Powers and functions

The Board is given statutory power to enforce its decisions. The functions of the Board are:

To adopt rules of orthography and nomenclature in respect of place names in the state;

To examine cases of doubtful spelling of place names in the state, and determine the spelling to be adopted on official maps;

To investigate and determine the priority of the discovery of any geographic feature;

To consider and determine any proposed alteration in a place name;

To assign a name to any place in the state;

To alter the name of any place by substituting another name or by correcting the spelling of the name thereof;

To omit from official maps and records the name of any place;

To compile and maintain a register of place names;

To make inquiries and recommendations on such matters relating to the naming of places in the state as may be referred to it by the Minister;

To exercise and perform such other powers and duties as are conferred or imposed on it by or under the Act.

Guiding principles

The board has not laid down any hard and fast rules for guidance in its work; rather, it tends to judge each case on its merits. But in general it can be said to:

Give preference to original names where it considers it can reasonably do so;

Avoid duplication of names as far as possible;

Avoid the use of names of living persons except in exceptional circumstances;

Encourage the use of appropriate descriptive names;

Also encourage the use of euphonious aboriginal names when their meaning can be appropriately related to the feature under consideration;

Avoid acting in such a way as to lay itself open to charges of being autocratic in the use of its powers.

This last point is quite important, as it is desirable that any nomenclature board should retain the confidence of the public even when it feels it must make a contrary decision. This can be achieved only if individuals are encouraged to feel that any views they may put forward will be given every consideration.

SOUTH AUSTRALIA

Designation

Nomenclature Committee of South Australia.

Address

The Secretary, Nomenclature Committee, Department of Lands, Box 293A, GPO, Adelaide, SA.

Members

The Surveyor General (Chairman), the Deputy Surveyor General, the Chief Draftsman of the Department of Lands and the Curator of Anthropology, Museum Department.

Powers and functions

The Nomenclature Committee functions in an advisory capacity to the Minister of Lands. The Minister in turn advises the Governor, who is empowered by proclamation:

To constitute and define the boundaries of new counties, hundreds, and towns, and distinguish each by a name;

To alter the boundaries, or name of any county, hundred, or town;

To distinguish by a name or alter the name of any place, whether a county, hundred, or town, or any other place whatsoever.

Guiding principles

Generally, the policy of the Committee is to oppose the adoption of superfluous sub-division names; to accept local nomenclature for rural post offices and establishments; to oppose the introduction of trade names in South Australian nomenclature, and to recommend the adoption of names with due regard to avoidance of duplication, both within and outside the State, and having regard to historical and geographical significance.

WESTERN AUSTRALIA

Designation

Nomenclature Advisory Committee of Western Australia.

Address

The Secretary, Nomenclature Advisory Committee, Department of Lands and Surveys, Perth, WA.

Members

The Surveyor General (Chairman); the Superintendent, Mapping Branch, of the Department of Lands and Surveys; the State Archivist; and representatives of the following: Education Department, Postmaster-General's Department, Main Roads Department, Local Government Association and the Town Planning Department.

Powers and functions

The committee acts in an advisory capacity to the Minister for Lands and, having the Surveyor General as Chairman, is in a position to be of direct help in any matters of nomenclature in which the government departments may be concerned and which may be referred to it. It has no statutory powers, however, and beyond that the scope of its activities is limited to whatever use other authorities or private citizens choose to make of it.

Guiding principles

To secure as far as possible suitable aboriginal names for use in naming new features;

To correct duplications of names of land features in the state;

To discountenance as far as possible the naming of streets, etc., after still active members of municipalities and road boards, or persons still living in the locality;

To honour, wherever possible, the names of discoverers or first settlers in any locality under discussion; also ex-servicemen who lost their lives in action;

To avoid hyphenated or double names for either localities or streets;

To decide upon the spelling of names where two or more forms have been used in the past. This especially applies to indigenous names.

NORTHERN TERRITORY OF AUSTRALIA

Designation

Place Names Committee for the Northern Territory.

Address

The Secretary, Place Names Committee, Lands and Survey Branch, Northern Territory Administration, Darwin, NT.

Members

The Assistant Administrator (Chairman), the Surveyor General for the Northern Territory and two members of the Town Planning Board.

Powers and functions

The committee makes reports to the Administrator containing recommendations in relation to the naming of public places or the altering of the names of public places. The Administrator may:

Approve, either without alteration or subject to such alteration as he thinks fit, any recommendation contained in the report;

Reject any recommendation contained in the report; or

Return the report to the Committee for further consideration and the submission of another report.

Guiding principles

When the priority of a name has been established by publication, particularly when such publication has occurred in any standard or authoritative work, that name should if possible be retained;

When names have been changed or corrected, if not too firmly established by local usage or otherwise, the original forms should be restored;

As a rule the first published name should be retained but, where a choice is offered between two or more names for the same place or locality, all sanctioned by local usage, that which is most appropriate and euphonious should be adopted;

The possessive form should be avoided whenever this can be done without destroying the euphony of the name or changing its descriptive application; where the possessive form is retained, the apostrophe should be dropped;

Names consisting of more than one word may be connected by hyphens or combined in one word as may be advisable;

The use of alternative names should be discontinued where possible;

Geographical names in a foreign language should be rendered in the original form except where there are English equivalents already fixed by usage;

Places or features may be named after any living person.

TERRITORY OF PAPUA AND NEW GUINEA

Designation

Place Names Committee of the Territory of Papua and New Guinea.

Address

The Secretary, Place Names Committee, Department of Lands, Surveys and Mines, Konedobu, Papua.

Members

The Surveyor General (Chairman), the principal anthropologist and one other from the Department of District Administration, one from the Department of Education, one from the Department of Posts and Telegraphs and two other members.

Powers and functions

To adopt rules of orthography and nomenclature and to standardize pronunciation in respect of place names in the Territory;

To investigate and determine the priority of the discovery of any geographical feature;

Subject to the Ordinance, to consider and determine any proposed alteration in a place name;

To assign a name to any place in the Territory;

To alter the name of any place in the Territory by substituting another name, or by correcting the spelling of the name thereof;

To omit from official maps and records the name of any place;

To compile and maintain a gazetteer;

To make inquiries and recommendations on such matters relating to the naming of places in the Territory as may be referred to it by the Administrator;

To prepare and publish an index of names of places in the Territory with a record of their origin and history;

To investigate and determine, as far as possible, the locality and the boundaries of any area covered by a place name;

To exercise and perform such other powers and duties as are conferred or imposed on it by or under the Ordinance or any other law in force in the Territory or a part of the Territory.

Guiding principles

To consider all proposed names with regard to suitability and speling, and make recommendations to the Administrator.

AUSTRALIAN ANTARCTIC TERRITORY

Designation

Antarctic Names Committee of Australia.

Address

The Secretary, Antarctic Names Committee of Australia, Antarctic Division, Department of External Affairs, 568 St. Kilda Road, Melbourne SC3, Victoria.

Members

Chairman (appointed by the Minister for External Affairs), Director of Antarctic Division, Director of National Mapping, Hydrographer, RAN, Head of Southern Section, Department of External Affairs, Geographical Officer, Antarctic Division (Secretary) and two other members appointed by the Minister for External Affairs.

Powers and functions

To advise the Minister for External Affairs on Antarctic place names.

Guiding principles

As a general principle, the committee has endeavoured permanently to record the names of those of all countries who have contributed to the exploration of the Australian Antarctic Territory and to avoid repetition of names within Antarctica as a whole.

When allocating place names for features in a given region, the Committee endeavours to follow the principle of recognizing the names proposed by expeditions of whatever nationality which have demonstrated clear priority of exploration in that region.

Annex II

NATIONAL MAPPING COUNCIL—RECOMMENDED PROCEDURES FOR RECORDING OF NOMENCLATURE ON A NATIONAL BASIS

This paper has been prepared in accordance with resolution No. 300 of April 1966.

The several states and the Commonwealth, which are responsible for nomenclature occurring within their respective spheres, may each be expected to prepare and publish a name gazetteer of its own region. A national gazetteer may be formed by combining the various regional gazetteers. It is desirable, therefore, that there be uniformity of content and format, and possibly of size and binding throughout the series.

The large number of entries involved may make it necessary to publish the national gazetteer, and probably also those of at least several of the states, in a number of volumes. As the regional gazetteers must precede the national one, it is desirable for the regional gazetteer to be accepted as constituting a part of the national record until such time as it may be combined and collated therein as a composite alphabetical record.

Random listing is economical in space and possibly is most convenient for subsequent processing. Listing on separate cards permits progressive alphabetical collation to obviate duplication. However, such cards are prone to misplacement or undisclosed loss. The advantages of each method may be retained by random listing for the purpose of card punching and progressive sorting of the punched cards into alphabetical order as the work proceeds.

Electronic processing with punched cards is considered essential. The punched card input is preferred to punched tape because of its greater versatility in sorting and handling. From the punched card file, the cards may be machine sorted into alphabetical order and a document copy produced by line printer for subsequent duplication in small numbers by contact printing, or in large numbers by lithographic printing.

File maintenance by magnetic tape, upon which the current alphabetical master file of the gazetteer has been recorded from an input of punched card records, would be an economical aid. Special extractions may be obtained thereform and recorded on a special magnetic tape from which the document copy may be obtained by line printer, leaving the original master file undisturbed. The master tape may be up-dated periodically by incorporating new names gleaned from a supplementary alphabetized record.

The deterrent to extravagant extraction lies in its cost. For example, the special extraction of a nine-character field (for example, geographical co-ordinates) from a file of 100,000 cards may cost about $A240. The return of the cards to their original alphabetical order may cost a further $A1,060. The use of the magnetic tape will obviate the need for the latter restoration action and will lessen costs in other directions.

The 80-column punch card is considered essential. Its full range may be utilized and subdivided to provide the desired data fields. Certain items which may not be considered essential to all authorities may be segregated at the end of the line on the punched card. This may prove generally advantageous for ease of omission as desired.

Data essential to all authorities should comprise name, designation code, latitude and longitude, and locational reference or sheet number; grid reference and state or territory should be provided for use as required. The inclusion of such data in the sequence and with field widths and inter-field spacing should be as follows:

Item	*Field*	*Space*
Name	33	1
Designation	4	2
Latitude	5	2
Longitude	6	2
Locational reference or sheet number	8	2
Zone number	1	1
Grid reference	6	2
State or territory	3	
Type key	1	
Listing control	1	
TOTAL	68	12

It is desirable for the field titles to appear at the top of each printed page in the published gazetteer. Explanations relative to the respective data fields are given below.

Name

The national nomenclature record should contain all geographic names occurring within the region as gleaned from all known and available sources. It should include approved names, variant names and names which may not have been approved (suitably identified as such if thought desirable) and which would be subject to review by the appropriate nomenclature committee in due course.

The width of field adequate for the longest name that may be encountered cannot be predicted with certainty. The 33-character width that has been provided should prove sufficient for the approved or most acceptable name.

A variant name should be followed by a cross-reference to the standard name and hence may exceed the field width provided. However, the omission of all locational information other than the state from the record will permit the notation to extend to a 73-character width, which should be adequate for the longest notation. An entry of this nature departs from the normal processing routine and would necessitate the inclusion of a type key column in the punched card to inform the computer of the particular type of entry involved.

Consistency in treatment and in alphabetization is essential. The practices listed below are in common use and are recommended for acceptance as standards by all associated authorities.

A name shall be shown in the form approved by the nomenclature authority or, in the absence of such approval, as appearing on the source material, including diacritical signs and possessive case when applicable. However, as such matters present difficulties in electronic processing, and as they are considered inimical to good map presentation and are generally avoided by mapping authorities overseas, it is desirable for such signs and for the possessive case to be eliminated at source.

A variant name or spelling shall be listed in its own alphabetical sequence, and shall be cross-referenced to the standard or most acceptable name by use of the phrase "See . . .", and the record shall not include any locational information other than the state or territory.

A name shall include its specific and other elements when applicable (for example, Roper River).

A name that includes specific and other elements, except the name of a populated place, shall be alphabetized by specific part (for example, *D*arling River). When in fact the other element precedes the specific part of the name, the parts shall be separated in the record by a comma (for example, *C*arpentaria, Gulf of).

The name of a populated place which includes specific and other elements shall be alphabetized in its approved form (for example, *T*he Entrance, *M*ount Magnet).

Names which occur more than once shall be listed in ascending order of latitude, that is, the most northerly name first.

A name shall be recorded unabbreviated in all its elements, except when otherwise approved by the nomenclature authority.

Designation

A four-letter (or shorter) code is recommended to indicate the type of feature to which the name refers. The Commonwealth is committed under SEATO (South East Asia Treaty Organization) agreements to use the Seastag No. 2213 code, and its adoption by all associated authorities is therefore desirable. Supplementary designations will be required to provide for certain mapped features and topographic terms which are peculiar to Australian mapping, or which have not otherwise been provided or. Appendix I contains a composite list of recommended code symbols for designation of topographical features for use in official gazetteers.

Geographical co-ordinates

Latitude and longitude define position in nature in a form readily understood and universally acceptable. The following principles are recommended for general adoption:

Position shall be defined to the nearest minute as scaled from any suitable source material;

The feature shall be defined and not its mapped name;

An area feature such as a desert, and a running feature such as a river or range, shall be defined by a convenient central point;

The geographical co-ordinates shall be listed in the sequence latitude first followed by longitude;

With a view to conserving space, the letter "S" for latitude and the letter "E" for longitude and the symbols for degrees and minutes shall appear in the field headings to each published page and not against the values in the body of the tabulation; a one-character space shall separate the degrees from the minutes in each case and a two-character space shall separate the respective fields.

Locational reference

A reference to the source material upon which the name occurs may be considered desirable by some authorities. However, as numerous maps and other name source material comprise the complete reference material, its individual tabulation in a gazetteer could prove very cumbersome and space-consuming, and probably out of proportion to its value to the user. An alternative would be to group the reference material into series of types. However, as a particular name may appear on a number of different items, some order of preference would have to be established by the recording authority.

Name reference material lacks finality. New editions supersede old ones, new mapping supersedes other mapping. Hence the entry would require continual revision in the nomenclature record to be currently appropriate. Its utility in a complete national or regional gazetteer is considerably diminished when its use is dependent upon the availability of the referenced material at the time of need. However, in the case of a gazetteer of a particular map series, the shee number, which is a particular case of the locational reference, will be essential.

A field width of eight columns will be necessary to provide for this data. Sheet numbers of the 1:50,000 series will occupy this spread, which should be more than adequate for the other national map series or other reference material.

Grid reference

This locational aid can be used only when the name reference material is gridded. In fact, it would normally be derived from that material. In the gazetteer of a single map series (gridded), the grid reference would be a much more convenient and speedy aid to positional identification than geographical co-ordinates. However, it loses much of its value when maps of different grid spacing, possibly maps of different grid systems, and non-gridded name reference material are all included in the same nomenclature record. Again, a grid reference is tied to a particular map projection for identification of position on a particular edition of the referenced map. Neither projection nor map may be considered as perfect or final. Each is subject to change.

The national and regional gazetteers would be of the assorted name-source variety, and the incomplete and disjointed grid reference data that would appear in the publication may not be considered by all authorities to be of sufficient value to the user to justify their inclusion. However, provision should be made for them on the punch card for use when recording series mapping, and for general use by those authorities who may require it. A field width of eight columns, which would include the zone number and a six-digit reduced reference, should be adequate for the purpose.

State or territory

This information is clearly desirable in a gazetteer that extends beyond the confines of any one state. A 3-column field is necessary to provide for normal abbreviations, such as QLD, VIC, SA, WA, NT, TAS, NG, PAP, NSW.

A type key and document listing control are necessary on the punch card as machinery items, and not for the printed record. The former is for selection of the type of entry or record required. The latter is used to control the operation of the document listing machine, such as directing it to skip a line.

Field titles should appear at the top of each published page.

It is desirable that the fly-leaf or title page to a map gazetteer should show the date of publication and that special provision be made thereon for the recording of supplementary and amending notices, which themselves should be dated and numbered for identification and ready reference.

The introduction to the map gazetteer should include such explanation of the contents as would facilitate its use. As the various gazetteers may differ as to data contained, and in the nature and extent of their source, it is not practicable to prescribe a common standard for the preamble. However, it should include the standard designation code listed alphabetically by designations and also by code letters, the key to the map locational reference and indexes to the sheets of the map series involved.

A minimum coverage in the introductory remarks should be along the following lines:

"This gazetteer includes names of places and of features in . . . gleaned from all available maps and other name source material.

"The first column shows the approved name. A variant name is cross-referenced to the approved name from which the locational details may be gleaned.

"The designation of the type of feature to which the name refers has been abbreviated to a code of four letters or fewer for convenience of processing and listing. Separate code lists are appended, one alphabetized by designation and the other by code letters.

"The latitude and longitude of the named feature have been scaled from the source material to the nearest minute. They are included for map locational purposes only and are not intended to convey positional accuracy. An area or a running feature has been defined by some convenient central point.

"The map or other source material upon which the name appears has been shown under the heading of "locational reference". It has been given by map-sheet number or by numerical code, details of which are appended together with map indexes to the main map series involved.

"The zone number and grid reference have been shown in cases where the locational map is gridded. It should be read in conjunction with the map scale if grid spacing is significant to the user, but is specifically provided for map locational purposes only and not as an accurate measure of position."

Appendix I

SUGGESTED CODE FOR DESIGNATIONS OF TOPOGRAPHICAL FEATURES FOR USE IN OFFICIAL GAZETTEERS

Code	*Designation*
ABAT	Abattoirs
AF	Airfield
	Airport
ANCH	Anchorage
AQDT	Aqueduct
ARCH	Archipelago
BANK	Bank
	Sandbank
BAPL	Baths
BAR	Barracks
	Customs barracks
BAY	Bay
BCH	Beach
BCON	Beacon
BCST	Broadcasting station
BGHT	Bight
BLDG	Agricultural establishment
	Asylum
	Barn
	Chalet
	Coal depot
	Guard house
	Hotel
	House
	Hut
	Inn
	Institute
	Museum
	Observatory
	Rest house
	Sanatorium
	Shelter
	Tavern
	Tower
	Town Hall
	Warehouse
BORE	Bore
BRDG	Bridge
	Culvert
BRKW	Breakwater
BRYD	Brickworks
	Brickyard
BTRY	Battery
CAPE	Cape
CAS	Castle
CAVE	Cave
CEM	Cemetery
CHAN	Channel
CHCH	Abbey
	Bell tower
	Chapel
	Church
	Convent
CHSM	Chasm
CLAY	Clayhole
	Claypan
CLIF	Bluff
	Cliff
CNAL	Canal
	Ditch
	Waterway
CNTY	County
COMM	Commune
COVE	Cove
	Inlet
CP	Camp
CPST	Campsite
CRRD	Crossroads
DAM	Dam
DEEP	Trough (marine)
DEPR	Depression
DESM	Deserted monastery
DESV	Deserted village
DI	District
DIKE	Dike
DOCK	Basin
	Wet-dock
DRN	Drain
DSRT	Desert
DUNE	Dunes
ENTR	Entrance
ESTY	Estuary
FARM	Farm
	Dairy farm
FLD	Enclosure
	Field
	Meadow

(*Continued on next page.*)

Appendix I (*continued*)

Code	Designation
	Pasture
	Uncultivated land
FORD	Ford
FORT	Fort
	Redoubt
FRST	Forest
	Woods
FTRY	Brewery
	Factory
	Plant
	Steel works
	Tannery
	Works
FY	Ferry
GATE	Gate (city exit)
GL	Grassland
GLCR	Glacier
GLLY	Gully
GRDN	Garden
	Vineyards
GULF	Gulf
HBR	Harbour
	Haven
	Roadstead
HDG	Hedge
HILL	Butte
	Hill
HMSD	Homestead
HOSP	Hospital
HWY	Highway
INTL	Intermittent lake
IS	Cay
	Island
	Island group
ISTH	Isthmus
	Neck
JUNC	Junction
	Road circle
KILN	Coke ovens
	Tile works
LAGN	Lagoon
LAKE	Billabong
	Lake
LBED	Lake bed
LGRD	Landing ground
LH	Lighthouse
LNDG	Landing place
LOCK	Lock
LSTA	Lifeguard station
LT	Light
MILL	Mill
	Sawmill
MINE	Mine
MON	Monastery
MONU	Benchmark
	Cairn
	Column
	Marker
	Monument
MRKT	Market
MSSN	Mission
	Mission station
MT	Mountain
MTS	Mountains
	Mountain range
OS	Out-station
PARK	Park
PASS	Pass
	Passage
PEAK	Mountain peak
PGDA	Pagoda
PIER	Pier
PIT	Pit
	Sandpit
PL	Plateau
	Tableland
PLAN	Plantation
PLN	Downs
	Tableland
	Plain
	Prairie
PLNA	Place name
PO	Post office
POND	Fishpond
	Pond
	Stagnant pool
POOL	Pool
POPL	City
	Town
	Village
PORT	Port
PRO	Province
PROM	Promontory
PRSH	Parish
PRSN	Prison
PT	Head
	Headland
	Point
QUAR	Quarry
RAV	Gorge
	Ravine
RCH	Reach
RDGE	Ridge
REEF	Reef
REGN	Region
RES	Reservoir
RESV	Reserve
RH	Gnamma hole
	Rockhole
RLY	Railroad
	Railway
RNGE	Rifle range
ROAD	Avenue
	By-pass
	Expressway
	Lane
	Road
	Roadway
ROCK	Rock
RSNL	Arsenal
RSTA	Railway station
	Siding
	Stop
RTRK	Auto track
	Cycle racing track
	Race track
RUIN	Ruin
SCHL	College
	School
SEA	Sea
SFST	Sparse forest
SHFT	Mining shaft
SHOL	Shoal
SHR	Cross
	Shrine
SIGS	Coastal telegraph
SLP	Hillside
	Slope
SLQ	Slate quarry
SLTM	Salt marsh
SM	River mouth
SND	Sound
SOAK	Native well
	Soak
SPAN	Salt pan
SPIT	Sandspit
SPRG	Pool spring
	Spring
SPUR	Spur
ST	Street
STA	Canal station
	Police station
STAT	State
STDM	Stadium
STOK	Stock route
STR	Strait
STRM	Brook
	Creek
	River
	Stream
	Watercourse
SUB	Suburb
SWP	Marsh
	Salt marsh
	Swamp
TANK	Tank
TERR	Territory
TMPL	Temple
TO	Telegraph office
	Telephone office
TUNN	Tunnel
TVST	Television station
VAL	Valley
VDUC	Viaduct
WEIR	Weir
WELL	Well
WOOD	Brushwood
	Copse
	Cutting (hedge)
	Scrub
	Thicket
WRFL	Cascade
	Cataract
	Waterfall
WTR	Water tower
WTRH	Waterhole
YD	Yard

Note. The singular includes the plural unless otherwise indicated.

Standard and variant names	Feature code	Latitude S. (degrees)	(minutes)	Longitude E. (degrees)	(minutes)	Location reference	Zone	Map reference	State
Moora Creek (see Five-Mile Creek)									VIC 2
Moorang Creek (see Crabhole Creek)									VIC 2
Moorarbool Reservoir	RES	38	24	152	39	VIC 500	7	654321	VIC 1
Moorarbool River	STRM	36	23	145	30	VIC 500	7	654321	VIC 1
Moorabool West	DI	34	53	145	28	VIC 500	7	925459	VIC 1
Moorookyle	POPL	36	53	145	35	VIC 500	6	202399	VIC 1
Morgan Creek	STRM	35	12	146	35	VIC 500	6	653245	VIC 1
Morgan Creek	STRM	36	24	144	16	VIC 500	6	500473	VIC 1
Morgan Gully (see Barkers Creek)									VIC 2
Morgan Hill (see Mount Buckle)									VIC 2
Morning Star Creek	STRM	34	23	145	32	VIC 500	7	214640	VIC 1
Morning Star Mine	MINE	36	45	146	32	VIC 500	7	230665	VIC 1
Morning Star Spur	SPUR	36	23	145	59	VIC 500	7	090355	VIC 1
Morrison	POPL	36	57	145	38	VIC 500	6	218339	VIC 1
Morses Creek	STRM	36	27	147	28	VIC 500	7	977513	VIC 1
Mortchup	POPL	35	12	152	37	VIC 500	6	160358	VIC 1
Mortjup (see Mortchup)									VIC 2
Mortons Hill	HILL	35	48	145	51	VIC 500	8	183382	VIC 1

Annex III

CURRENT GAZETTEER ACTION

The Division of National Mapping has printed a gazetteer of place names on the back of its 1:6,000,000 map of Australia and its 1:2,534,400 map of New Guinea.

A gazetteer will be prepared and published separately for the 1:2,500,000 map of Australia.

As each map of the new 1:1,000,000 series is compiled, a gazetteer will be prepared for the individual map sheet and a composite gazetteer will be printed for the whole series.

Similar action will be taken in respect of the new 1:100,000 series.

The State of Victoria has commenced production of a state gazetteer.

It is most likely that the National Mapping Council will ultimately sponsor an Australian national gazetteer which will include all geographical names that appear on published maps.

The Antarctic Division of the Department of External Affairs has produced a Gazetteer of the Australian Antarctic Territory.

AGENDA ITEM 16*

Hydrography and oceanography

HYDROGRAPHIC SERVICE, ROYAL AUSTRALIAN NAVY

Paper presented by Australia[1]

INTRODUCTION

The Hydrographic Service, Royal Australian Navy, was founded on 1 October 1920, when the Admiralty intimated that it was unable to accept further responsibility for hydrographic surveys in Australian waters.

Almost from the beginning of settlement in Australia, surveys of its lengthy coastline had been undertaken by ships of the Royal Navy, and the resultant charts were published by the Hydrographic Office of the Admiralty. Up to 1825, these surveys were entirely exploratory; but, by that date, a series of Admiralty charts based on the work of Commanders Matthew Flinders and Phillip Parker King, RN, had been published to give initial coverage for the entire Australian coastline.

Subsequently, during the next 100 years, as the need arose, particular portions of the coastline were surveyed in more detail. The more notable surveying voyages of the early period were undertaken by Commanders Wickham and Stokes in HMS *Beagle*, Captain F. P. Blackwood, RN, in HMS *Fly*, Captain Owen Stanley, RN, in HMS *Rattlesnake* and by Captain H. M. Denham, RN, in HMS *Herald*.

During the period 1860–1880, a most distinct advance was made in Australian charting, when each of the Australian colonies agreed to share the costs of the surveys with the Admiralty for the purpose of issuing a new series of Admiralty charts. These charts remained in active use for almost 100 years. In some cases, they have not yet been withdrawn and remain in use today.

From 1880 until the outbreak of the First World War, the Royal Navy, partly at Australia's expense, maintained at least two surveying ships in Australian waters, working mainly in the Great Barrier Reef, in Western Australia and Tasmania and in the south-west Pacific islands. Even after the war, surveying in Australia was resumed by the Royal Navy in 1919 and continued until 1926, while the RAN Hydrographic Service was finding its sea-legs.

HMAS *Geranium*, the first Royal Australian Navy surveying ship placed in commission, was employed at first, from 1920, on harbour surveys connected with defence; but with the advent of another surveying ship, HMAS *Moresby*, under the command of an experienced surveyor, Captain J. A. Edgell, RN (later Vice-Admiral Sir John Edgell, Hydrographer of the Navy), more ambitious surveys were commenced in the Great Barrier Reef, and in the Darwin and Clarence Strait area, Northern Territory. The *Geranium* was paid off in 1927, followed by the *Moresby* in 1930. In 1934, the latter vessel again resumed work and continued surveying alone until 1939.

With the commencement of the Second World War in the south-west Pacific, hydrographic information regarding the Solomons, New Guinea and North Australia fell far short of operational requirements. Not only had large areas remained unsurveyed, but the state of charts and sailing directions covering the remaining areas left much to be desired.

As the war in the Pacific progressed, the increasing hydrographic requirements of the allied navies meant a large increase in the RAN Hydrographic Service. In 1945, the surveying vessels consisted of two sloops, one frigate, five corvettes, three tenders, two lighthouse tenders and three harbour defence motor-launches. In all, this was a considerable increase from the solitary sloop engaged on surveying duties before the war, with the result that substantial progress was made in surveying northern Australian and New Guinea waters. Not all the surveys, however, were of permanent value, as some were undertaken for the specific wartime purpose of the moment.

In 1946, the future of the RAN Hydrographic Service was considered by the Australian Federal Cabinet. It was planned for the Navy to continue hydrographic surveys with three surveying ships and three tenders, so that in a period of twenty-five years modern surveys would become available and make possible the issue of a new series of modern Australian charts. At the same time, an agreement was signed between the British Admiralty and the Australian Commonwealth Naval Board, making, in effect, the Hydrographic Office, Sydney, the charting authority for Australian waters and certain islands within the limits of Australia's sphere of influence.

Unfortunately, three years later, the Royal Australian Navy found that manning and other difficulties made it essential to reduce the surveying ships' complements; but harbour surveys were continued from the ships immobilized in Sydney. One frigate, HMAS *Lachlan*, was transferred to the Royal New Zealand Navy. For three years, no progress was made in the national survey; but in 1952, the surveying programme was again resumed with HMAS *Warrego* and *Barcoo*. At times *Barcoo* was paid off and, in 1958, HMAS *Paluma* was converted for survey

* The following papers relating to the present agenda item are reproduced above, under the agenda items indicated: "Cartographic activities in Japan (hydrography)", presented by Japan (agenda item 6); "Status of hydrographic surveys and oceanographic research in Indonesia", presented by Indonesia (agenda item 6); "Photogrammetric research work on the Gulf Stream", presented by the United States of America (agenda item 8).

[1] The original text of this paper, prepared by G. C. Ingleton, Hydrographic Office, Sydney, and Captain D. W. Haslam, Hydrographer, Royal Australian Navy, appeared as document E/CONF. 52/L.36.

work. HMAS *Moresby* was commissioned in 1964 when *Barcoo* and *Warrego* were finally paid off.

In view of these circumstances, the twenty-five year programme planned in 1946, with three tenders, has been somewhat delayed, but progress has been made. The coastal waters over the continental shelf from Spencer Gulf in South Australia to Palm Passage in Queensland have been covered by modern surveys. The north and east coasts of Tasmania have almost been completely surveyed. Within the Great Barrier Reef and Torres Strait large areas have been covered by adequate surveys and these areas are being surveyed in the next five years by HMAS *Paluma*, concentrating principally on establishing shipping routes for deep-draught shipping.

Between Torres Strait and King Sound in Western Australia, most of the shipping routes have been surveyed, as well as the more important harbours and approaches. Between King Sound and Exmouth Gulf some large detached areas have been surveyed, and the principal shipping routes through this vast unsurveyed area will be surveyed within the next five years.

Thus, by 1970, the main shipping routes through the more complicated waters of Australia will have been completed, leaving yet to be done the coastline between North-West Cape and Kangaroo Island. In addition, special surveys will be required for developmental and other purposes, and certain regions must, of course, be resurveyed from time to time.

In New Guinea, progress is also being made with hydrographic surveys and, during the next five years, surveys are scheduled of the main shipping routes in New Guinea.

The diagram at the end of this paper shows areas completed by modern Royal Australian Navy surveys, and areas to be undertaken in the next five years, as laid down by a meeting of interested authorities, held in Canberra in 1965, and known as "Hydroscheme 1965". As in most other countries, the responsibility for surveys within the established harbour limits rests with the local or state harbour authorities, who have various vessels and surveyors engaged in the continuous task of surveying the busy port areas. Information from these sources is made available to the RAN Hydrographic Service for inclusion in Australian charts, and excellent co-operation exists to ensure that these port charts are maintained up to date. In addition, much useful information has been received as a result of commercial seismic and other mineral exploration expeditions, which have usually employed electronically controlled echo-sounder tracks in their surveys.

Surveying ships

During the current year, 1966, only two surveying ships are in active employment in the RAN Hydrographic Service, the *Moresby* and the *Paluma*.

HMAS *Moresby* is the first ship in the Royal Australian Navy to be specially designed for hydrographic surveying duties. All previous vessels employed by the RAN Hydrographic Service commenced their life as warships in general service and were subsequently converted for surveying duties.

The *Moresby* was built by the State Dockyard, Newcastle, New South Wales, and launched on 7 September 1963. The vessel was commissioned into naval service on 8 March 1964 and undertook its first survey work in the approaches to Hobart, Tasmania, between April and June of the same year.

The *Moresby*'s statistics are shown below.

Displacement: 2,500 tons.

Length over-all: 314 ft, with 42 ft beam.

Propulsion machinery: Diesel electric.

Complement: 130 officers and men (including 5 surveyors).

Speed: 18 knots. (Range: 10,000 miles.)

Equipment: Two ship's echo-sounders, type 771; one EDO echo-sounder, type 185, with precision depth recorder (PDR); one Lambda two-range Decca fixing aid; one Hi-Fix two-range fixing aid; high-accuracy radar, type 979; three 34 ft surveying motor-boats, fitted with echo-sounder, type 772; one Westland Scout helicopter, capable of a maximum all-up weight of 5,000 lb and a speed of 115 knots.

The running cost of each surveying day's work achieved is approximately $A4,000.

Experience with Lambda in the *Moresby* suggests that, in North Australian waters, the ship can be fixed to a maximum range of 200 miles from the shore station by day, and of 100 miles by night. HI-FIX has been used satisfactorily to a distance of 60 to 80 miles both in Torres Strait, Tasmania, and north-west Australia. With these aids, the ships can survey regardless of visibility and much further offshore than is possible with horizontal sextant angles between series of marked positions ashore or of floating beacons at sea. The new geodetic control available in Australia and use of tellurometers greatly increase the time available each year for sounding, whilst the possibility of using electronic fixing at even greater distances offshore, possibly using satellites and computers, is being investigated.

The *Moresby*'s echo-sounders, type 771, record depths up to 900 fathoms, while the EDO with the PDR can record depths up to 6,000, should such an ocean depth exist.

The Scout helicopter enables a Lambda or HI-FIX slave station to be erected in a day. Rough-country vehicles —"desert rats"—will be used when this is not available. Each slave station takes about half a day to calibrate and in an ideal case, where previous ground control is available, the *Moresby* has started sounding within four days of arriving in the area.

The newer surveying motor-boats have been fitted with bunks, galley, etc. to enable them to work independently of the ship for short periods on detached duties, especially the inshore sounding and inner waters.

HMAS *Moresby* is also equipped for a limited oceanographic role with a small laboratory and an oceanographic winch, and equipment includes bottom samplers, gear for water sampling and bathythermographs. Other equipment could be installed, but with so much hydrographic work to be done, it is not intended to use the ship for more than routine oceanographic observations.

HMAS *Paluma* was formerly the *Motor Store Lighter* No. 252, but, after a short trial period on survey work, the vessel was formally commissioned and re-named in May 1958 as a surveying ship. "Paluma" means "thunder" in the aboriginal dialect and the name was previously carried by a celebrated unit of the Queensland Navy, which was also employed on surveys in the Great Barrier Reef in the 1890s.

The *Paluma*'s statistics are shown below.

Displacement: 208 tons.

Length over-all: $124\frac{1}{2}$ ft with 24 ft beam.

Propulsion machinery: Two Ruston Hornsby Diesel.

Speed: 9 knots. (Range: 17,000 miles.)

Complement: 28 officers and men (including 3 surveyors).

Equipment: One ship's echo-sounder, type 771; one Hi-Fix two-range fixing aid; one Radar, type 975.

In addition, a 34 ft surveying motor-boat accompanies the *Paluma* for boat-sounding work, and is fitted with echo-sounder, type 772.

The running cost of each surveying day's work achieved is approximately $A1,000.

In spite of its small size, slow speed and inability to hoist the accompanying surveying motor-boat, the *Paluma* has accomplished a good deal of useful work, and has recently been much improved with new radar and other equipment.

Oceanographic data

At present, the Royal Australian Navy has not an oceanographic vessel designed as such, but, since 1960, two frigates, HMAS *Gascoyne* and *Diamantina* have been employed partially on oceanographic work. Each vessel has made some five or six cruises each year varying from ten to thirty-five days each with scientific teams supplied by the Royal Australian Navy Experimental Laboratory, or the Commonwealth Scientific and Industrial Research Organization (CSIRO), Division of Fisheries and Oceanography, Cronulla or various Australian universities.

Both ships took part in the International Indian Ocean Expedition, although the *Gascoyne* has normally worked in the Tasman and Coral Sea areas.

Results of these oceanographic cruises have mostly been published by CSIRO.

Within the Hydrographic Office, an Australian Oceanographic Data Centre has been established to assist in the promulgation of these scientific results and for the accumulation and dissemination of oceanographic data.

Hydrographic Office

The Hydrographic Office was moved from the Royal Australian Navy Dockyard, Garden Island, in April 1964, to the eighth floor of the IBM Building, Kent Street, Sydney. This provides excellent conditions for chart production and enables the many people requiring access to the office to enjoy it without the restrictions involved in dockyard security.

Subsequently, probably in the mid 1970s, it is intended to move the Hydrographic Office to Canberra, to a new building being designed as a mapping centre to house the mapping agencies of the Army, Navy and the Division of National Mapping. It is considered that the close association of these mapping authorities can be better achieved if they are situated in one building, with easy access to such common services as air photography, triangulation data, co-ordinatographs, cameras and printing facilities, etc., and that the production of Australian charts will be further expedited.

The present staff of the Hydrographic Office consists of:

1 Captain—Hydrographer, RAN;

1 Commander—Deputy hydrographer, RAN;

1 Lieutenant commander—Assistant hydrographer and superintendent, charts;

1 Lieutenant—Naval assistant in charge of equipment and Hydrographic School (with 2 surveying recorders);

1 Retired lieutenant commander—Notices to Mariners (with 2 assistants);

1 Retired lieutenant commander—For planning and archives;

1 Retired lieutenant commander—Australian Oceanographic Data Centre;

2 Drafting officers—Records section;

1 Chief cartographer—In charge of drawing office;

1 Senior drafting officer—Deputy chief cartographer;

1 Senior drafting officer—Verification of documents;

1 Senior drafting officer, 6 drafting officers—Compilation section;

1 Senior drafting officer, 4 drafting officers—Fair drawing section;

2 Drafting officers—Photographic section;

1 Senior drafting officer, 1 drafting officer—Lettering section;

1 Drafting officer—Employed at the Army Mapping Centre, Bendigo, for liaison in connexion with printing and compilation of topography;

1 Clerk, 1 female typist—Secretariat.

1 Lithographic printer has recently joined the staff.

The Hydrographic Office in Sydney is the repository of hydrographic information for Australia and preserves the original surveys and other hydrographic and oceanographic data, as well as archival copies of published Australian and Admiralty charts. In this office are planned the charts and the hydrographic instructions for the surveying ships for the essential data, upon which these charts are constructed. The compilation of the charts is undertaken in the office and the production processes up to the stage of supplying reproduction material from which the plates can be made. The making of the chart plates and the printing is undertaken by the Royal Australian Survey Corps, at its establishment in Bendigo, Victoria, by some private firms in Sydney and by the newly recruited lithographic printer.

The Hydrographic Office also promulgates weekly Notices to Mariners and other data, and answers many hydrographic problems forwarded by the various marine, shipping and harbour authorities in Australia. In addition, Australia has assumed responsibility for an extensive area surrounding this continent, for the compilation of plotting sheets for the General Bathymetric Charts of the Ocean, to be published by the International Hydrographic Bureau.

Attached to the Hydrographic Office, but in a separate building close by, are the Royal Australian Navy Chart Depot and the Royal Australian Navy Chart Agency, both of which hold considerable stocks of Australian and Admiralty charts and publications for the Royal Australian Navy fleet purposes, as well as for sale to the general public. The charts are kept up to date by chart correctors, and otherwise maintained according to special requirements. This section has eighteen civilian employees.

Australian chart planning

In 1963, a charting arrangement was made between the Admiralty and the Australian Commonwealth Naval Board, to replace gradually the existing Admiralty charts of the Australian charting area, by Australian charts, which the Admiralty, in turn, would reproduce in facsimile and issue, or put on sale with its Admiralty chart agents.

The main purpose of this agreement was to circumvent duplication. During the past twenty years, the Australian charting programme has been making good progress, and from these charts the Admiralty had been correcting its own coverage of Australian waters, until a considerable amount of duplication has come about.

This problem had been foreseen in 1946. But at that time the Admiralty were reluctant to allow the replacement of Admiralty charts by Australian charts. However, as the standard of Australian charts reached an equivalent standard with that of the Admiralty, and as the problem of maintaining world-wide coverage of Admiralty charts became considerably more difficult, the sensible decision to remove chart duplication was made. Nevertheless, it will be many years before the Admiralty charts of Australian waters are replaced entirely by Australian charts.

By September 1966, the Admiralty had withdrawn thirteen of its charts in favour of facsimiles of equivalent Australian charts. At present, there are 209 Admiralty charts in the Australian charting area, and 133 Australian charts in present use. Eventually, the Australian charting area (limits shown in diagram on page 492) will be covered by approximately 450 Australian charts.

Chart production

Initially, the Hydrographic Office produced the chart original copy by hand-drawing techniques on mediums such as Bristol-board, enamel zincs and various opaque plastic sheets, and a fine standard of penmanship was achieved by the draftsmen. Reproduction by photo-lithography followed using, generally, a two-thirds reduction on wet-plate glass negatives for stability in scales. The charts would be printed from albumen-coated zinc or aluminium plates by offset printing presses, usually in four colours.

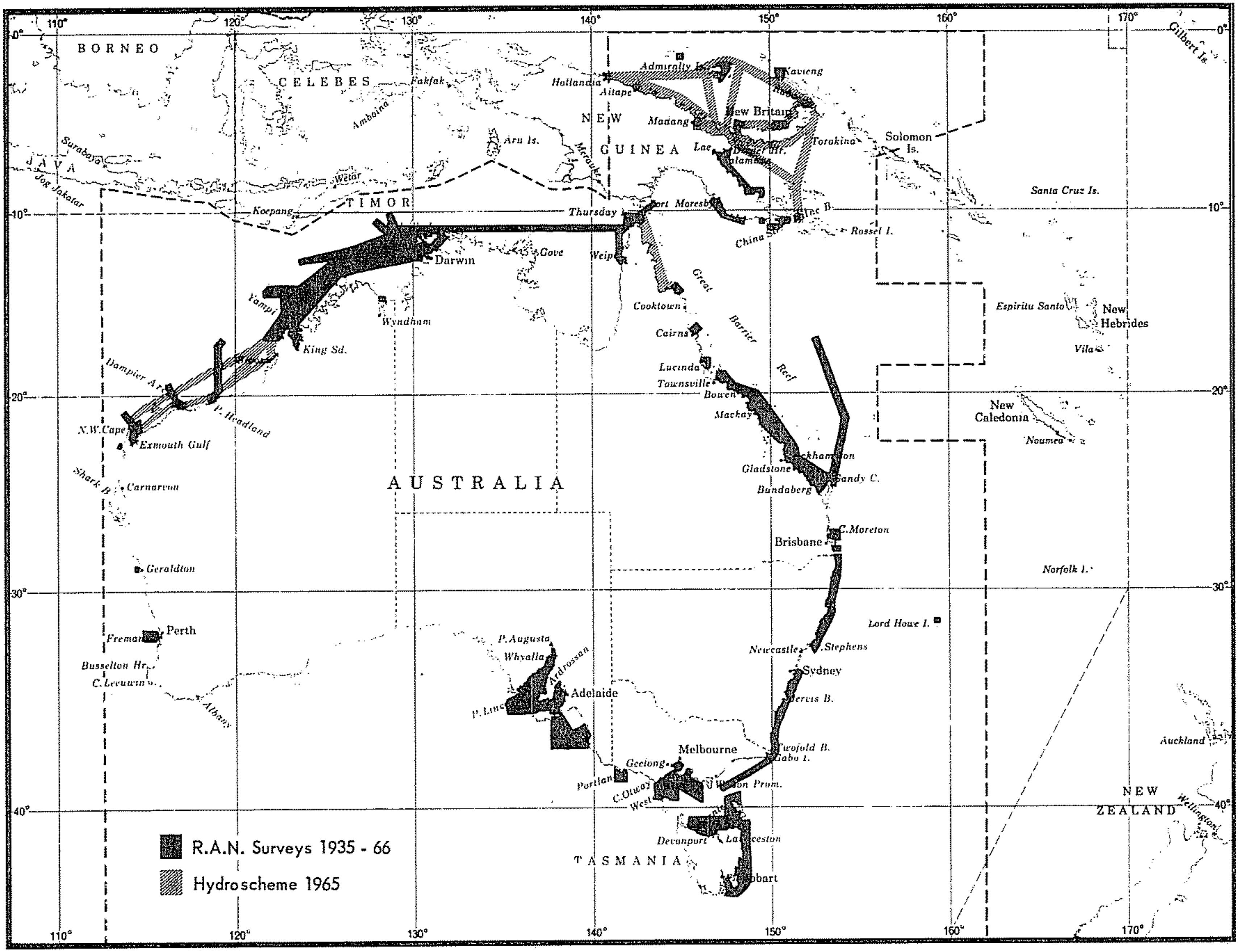
Since 1958, this traditional method has been abandoned in favour of the scribing process on a stable plastic material. As navigational charts are subject to constant revision and correction, the material used must have stability, permanency and first-class reproduction qualities. In addition, it must be able to withstand repeated correction. In the Hydrographic Office, the materials used are Stabilene scribe coat, Chronoflex mat (for positives), Cronar (for negatives) and Kodak dry stripper for lettering. Positives are used throughout the process until the final colour proving, when negative reproduction material (repromat) is supplied to the printer to make each plate (black, blue and magenta) either on pre-sensitized plates or, in some cases, on albumen-coated zinc plates.

The charts are first compiled by the compilation section of the Drawing Office at the same scale as the published chart, and in a simplified style, conforming, however, with the style and lay-out of the final appearance of the chart. The draftsman carefully selects his information from a mass of relevant data at his disposal for the chart, and his compilation conforms to standards laid down, which are similar to those on Admiralty charts. Prints of the compilation are then circulated for checking and approval, both within the office and, where applicable, by outside bodies, such as state lands departments, state and port authorities; even commercial firms which are particularly interested.

The compilation in its final form is then taken in hand for fair drawing and preparation of repromat, by the appropriate section of the Drawing Office. All line work is scribed as continuous lines and opaqued out as necessary. Coral, rocks, cliffs etc., are scribed free-hand. Lettering, soundings and symbols are prepared and stuck-up in accordance with style and agreement in lay-out with the compilation. After a print of the fair drawing is circulated and checked, colour overlays are prepared for the blue and magenta plates, and for the various screens (or tints), which are to be put down on the final black plate. These screens for the land, mud, mangroves etc. are the same as those used by the Admiralty, and greatly assist the Australian charts to conform in style with the Admiralty chart. The lettering is composed of standard faces used by typesetters, with a range of styles selected to give uniformity between charts.

Conclusion

The RAN Hydrographic Service is a small unit with a great responsibility. Australia's coastline and navigable waters are very extensive, and the task of producing modern surveys by the small number of eight surveyors in two surveying ships is a difficult and long undertaking. Similarly, the production and maintenance of approximately 450 Australian charts is also a formidable task for the small staff of the Hydrographic Office. If the proposals envisaged in 1946, for a larger surveying service, could be implemented today, much would be done in speeding up the programme of modernizing Australia's charting requirements.



Australia: RAN surveys, 1935–1966, and hydroscheme, 1965

PUBLICATION OF BATHYMETRIC CHARTS

Paper presented by Japan[1]

It is proposed that each maritime State be encouraged to publish bathymetric charts of its adjacent seas.

EXPLANATORY NOTE

Every maritime State possesses oceanic soundings of its adjacent seas and is utilizing them in its navigational charts. It should be noted, however, that navigational charts do not show fully the features of the ocean bed.

Meanwhile, bathymetric charts as general maps for the sea have become indispensable owing to the advancement in various fields of the study of oceans. Consequently, if each country publishes bathymetric charts of its adjacent seas using bathymetric data in hand, those charts would be widely applicable not only for scientific work but also for such services as prediction of earthquakes, tsunami warning, submarine cable laying operation, exploitation of sea bed resources etc.

In Japan, two bathymetric charts covering the area bounded both by parallels of 18° N and 48° N and by meridians 120° E and 150° E, were newly published in 1966. In succession, the other two charts, covering the eastern adjoining area extending to as far as the meridian of 180°, are to be published in 1967.

A brief description of these bathymetric charts follows.

DATA ADOPTED

The bathymetric data adopted for these charts includes all the sounding records obtained by Japanese ships up to 1965, as well as those provided from various sources abroad.

First, the bathymetric data were plotted on plotting sheets at 1:500,000 for the waters within about 180 miles of Japan and, outside that area, at 1:1,000,000. These plotting sheets were then photographically reduced to the scale of 1:3,000,000. These materials, partly simplified, were used as original manuscripts for compilation of the bathymetric charts.

PROJECTION

Mercator's projection was adopted for preparation of the plotting sheets mentioned above, so that they might serve as a basis for navigational charts as well as for plotting sheets of the fourth edition of GEBCO sheets being prepared under the auspices of the International Hydrographic Bureau. The bathymetric charts were also compiled on Mercator's projection with the standard latitude of 35° N, because their publication was hastened in order to be in time for exhibition service of the Eleventh Pacific Science Congress held in Tokyo.

Mercator's projection is suitable for navigational charts; but it is unsatisfactory for construction of such topographic maps as bathymetric charts, since actual topography cannot be properly expressed with that projection. Therefore, in future, it would be advisable to employ an equal-area projection instead.

SCALE

To include the aforementioned coverage in a single sheet of standard size, the scale of such a sheet should be smaller than 1:5,000,000. On such a small-scale chart, detailed drawing of topography may not be possible. On the other hand, if the scale of 1:1,000,000 is adopted, it would be required to cover the said area with about thirty different sheets, which could cause inconvenience to the user in obtaining a general view of the whole area. Therefore a medium scale of 1:3,000,000 has been adopted so that only four sheets are required to cover the area in question to form a series.

DEPTH CONTOURS AND COLOURS

There are various methods used to express the ocean bottom's configuration. On this series, expression by depth contours is employed, and isobaths of 200 m, 500 m and every 500 m thereafter are indicated. Accordingly, relief less than a few hundred metres is not explicitly shown. Further, some omissions of depth contours are made where the ocean bottom is so steep that delineation of all contours is impossible because the thickness of a depth contour line is 0.1 mm. In order that depth contour lines may be sharply printed on charts, a scribing method is employed to delineate them on the manuscript.

For hydrographic tints, cobalt blue is used to give the charts a light impression. The colour is divided into seven grades (0–1,000 m, 1,000–2,000 m, 2,000–3,000 m, 3,000–4,000 m, 4,000–5,000 m, 5,000–7,000 m and over 7,000 m) by screening so that the outline of topography may easily be seen.

DEPTH FIGURES

The number of depth figures is reduced as far as possible, since these charts are intended to show the depth of water by isobaths, unlike the ordinary navigational charts where depths are indicated by depth figures themselves. Depth figures are marked only on main tops and bottoms of uneven portions of the ocean bottom. In areas where depth contours are congested, depth figures are shown off position, with respective indication lines tying the figures and their proper positions.

PROPER GEOGRAPHICAL NAMES

Proper geographical names of ocean bottom features are inserted only on main features. These names are adopted from the report of the GEBCO sub-committee on proper geographical names of ocean bed features under the chairmanship of the Chief Hydrographer of Japan, prior to the official approval of the GEBCO Committee, IAPO, to which the report was submitted. These names are all accompanied by their English translations, while the names of islands, capes and other places on land are in Japanese only.

The characters and letters of these geographical names, as well as depth figures and other notes, are photo-composed on a film and then pasted on the manuscript.

PAPER AND INK

Although it has expansion and contraction to some degree, a thinner nautical chart paper is preferably used for this series of bathymetric charts, so that the charts may easily be folded, while it is not necessary to measure and plot correct terrestrial positions on them.

The ink used is a resin type which does not become discoloured.

[1] The original text of this paper appeared as document E/CONF. 52/L.91.

PROBLEMS OF PRECISION HYDROGRAPHIC SURVEYING

Paper presented by Japan[1]

Since the last conference, new hydrographic survey methods have been extensively employed in surveying harbours and passages in this country. In the present paper, we explain some findings and problems emerging from our experience in carrying out these surveys. The locus navigation methods described below are being used to enable survey boats to navigate correctly on predetermined surveying lines.

Straight line method

Using a transit set on land with its telescope directed along the line which will be the track of the survey boat, an observer contacts the boat by radio transmitter and gives the surveyor aboard instructions so that the boat may be kept on the vertical line of the cross-hair in the finder of the telescope while it conducts observations on the predetermined line. The deviation allowed in this method is within 2 m of the selected line.

Circular arc method

When using autotape in this method, the survey boat should move in an arc so as not to deviate from the assumed distance from a know position, the radius of the arc being set on the equipment in advance. The deviation allowed is within 3 m of the predetermined survey line.

When using a sextant, the survey boat should move so as to keep the subtended angle constant between two known marks. The allowable deviation is 5 m.

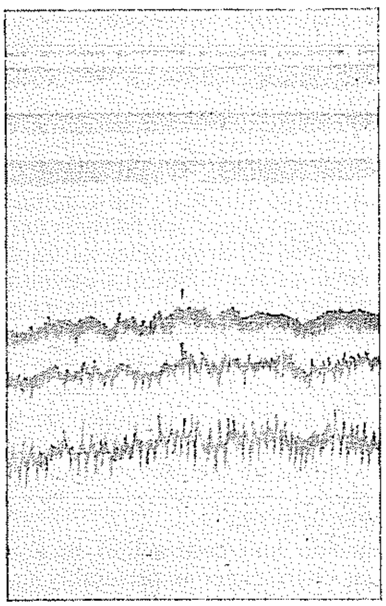
Correct ship's position (within the deviation allowed) is then easily determined by observing at regular intervals (1 to 2 minutes) a position line preferably at right angles to the predetermined survey line, maintained by autotape or sextant.

Recent harbour surveys have disclosed a number of submarine obstructions which could probably not be discovered by conventional surveying methods. On the echograms, they appear as spot images as if they were detached from the bottom of the sea. These isolated images were noted and confirmed by divers as being obstructions. It has been found that those images, formerly considered as being due to fish, weeds or electric noise at the time of echo-sounding, are actually submarine obstructions in many cases. Some of the records of these are shown in the first four figures below.

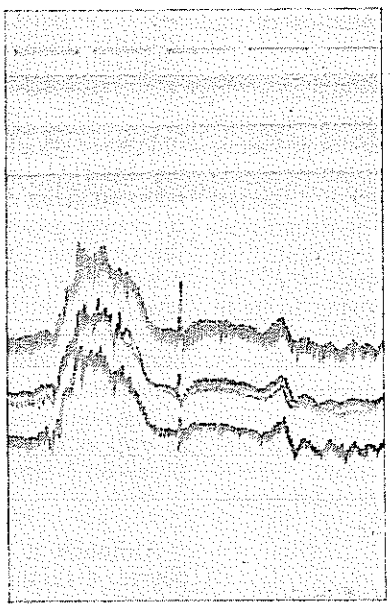
On 4 February 1966, when a commercial airliner crashed into Tokyo Wan (bay), the Japanese Hydrographic Office at once organized a surveying party consisting of five survey ships and boats, and dispatched them to carry out an echo-sweeping survey over the search area. As a result, they discovered most of the wreckage scattered on the sea bed. The echograms in the last four figures indicate the existence of the wreckage.

Thus it is obvious that echo-sweeping surveys not only contribute to the safety of navigation, but may also be effectively utilized in searching for underwater wreckage and obstructions.

Japan: Echograms



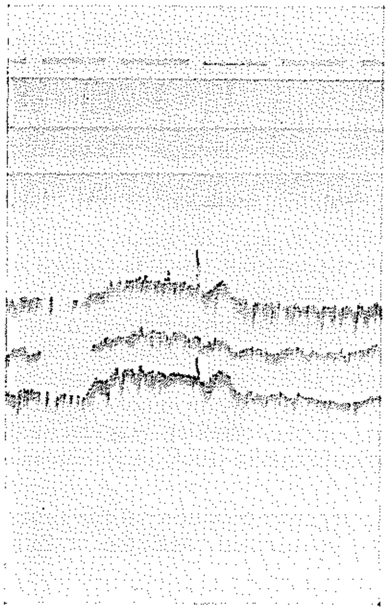
1. Timber



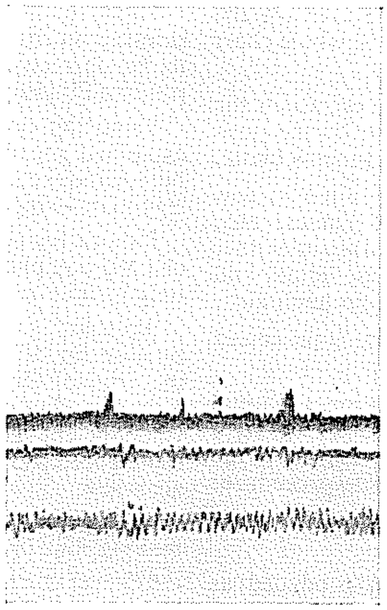
2. Tetrapod

3. Sand-pipe

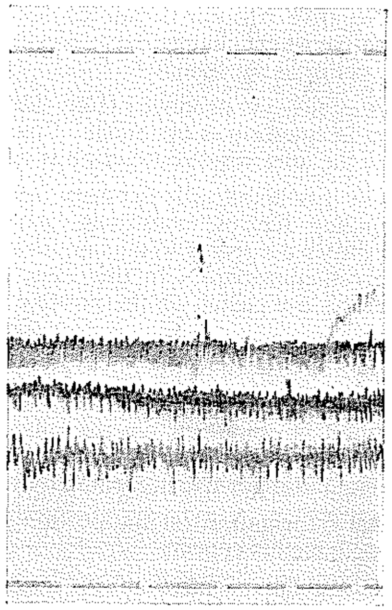
[1] The original text of this paper appeared as document E/CONF.52/L.92.



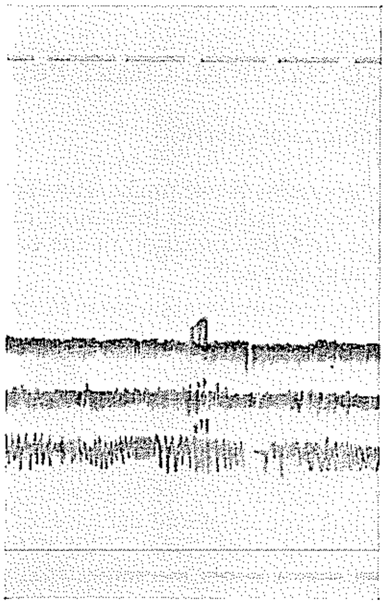
4. *Motorcar*



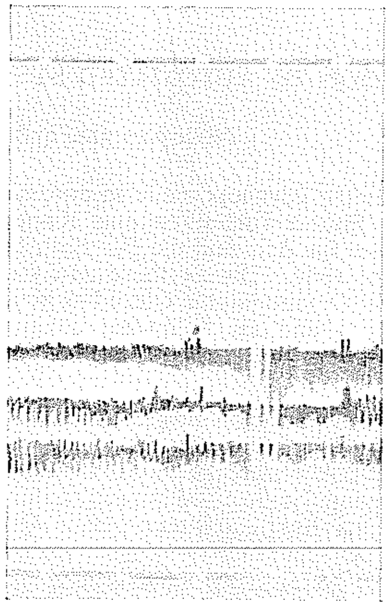
5. *Aircraft engines*



6. *Aircraft tail*



7. *Aircraft wheels*



8. *Aircraft body*

USE OF ORIGINAL FILM POSITIVES FOR UPDATING CHARTS

Paper presented by Japan[1]

In order to deal with the rapid increase in the volume of chart corrections necessitated by recent progress in harbour construction, the Japanese Hydrographic Office has been using, since 1958, original positive films of charts to replace the conventional method of maintaining original zinc plates.

The original positive film is produced from the photographic negative of the original chart and is identical with it in size so that a plate may be obtained by "contract print" of the film.

Since the adoption of this method, considerable efficiency has been gained both in chart correction and revision, while at the same time the accuracy has been improved.

The method is briefly explained below.

A negative is made from the original film, of a size slightly wider than the portion of the chart for which a chartlet is to be issued.

[1] The original text of this paper appeared as document E/CONF. 52/L.93.

Negative opaque is painted to cover the area on the negative where changes have occurred, that is, where chart correction is necessary.

A positive is produced from the negative on which the area in question is opaqued. Consequently, on the positive, the area where correction is necessary appears blank.

On this blank, all necessary information, such as new sounding figures, coastlines, geographical names, etc., are drawn according to the smooth sheet of survey and other sources concerned. In this case, all figures, letters and symbols are pasted on the positive by stick-up method.

Using this as a manuscript, a printing plate is processed and chartlets are printed by offset printing.

To make a partial correction, the conventional manual method is employed on zinc plate. However, where a chartlet has been issued, the correction is made on the original film positive according to the following procedure:

All information on the portion for which a chartlet is to be issued is erased;

Using the negative of the positive film produced as explained above, the corrected portion only is printed on to another zinc plate whose size is identical with the plate of the chart in question;

Using this new zinc plate, the image is printed by offset printing on the original film positive on which the portion to be corrected is left blank; thus, a renewed original positive film is completed.

From the corrected original positive film produced as explained above, a zinc plate is processed according to the Neo-Vandyke method. Charts are then printed from this zinc plate using the offset printing method.

Labour for updating charts is reduced, since, to make a charlet, compilation and cartographic work is carried out only for the portion where changes have occurred.

Accuracy is raised. Since the unchanged portion on the manuscript of the chartlet is printed by contact print of the original film, the degree of expansion and contraction is far less than would occur using the conventional method whereby the manuscript of the chartlet was manually reproduced from the original chart in stock, thus increasing accuracy.

In updating plates, the negative produced at the time of making the chartlet can be utilized, and the resultant plate is quite accurate.

A sharp line can be maintained on the film at the time of correction, and repeated corrections to an identical portion are feasible.

APPLICATION OF AUTOMATED SYSTEMS TO NAUTICAL CHART PRODUCTION

Paper presented by the United States of America[1]

This report describes the advances made in automatic cartography since the Fourth United Nations Regional Cartographic Conference for Asia and the Far East, held in Manila in December 1964. During those two years, the United States Naval Oceanographic Office has greatly expanded its capabilities and the following computer programmes have been added to the automatic digital co-ordinatograph system.

1. Construction of map and chart projections: oblique Mercator; polar gnomonic; oblique gnomonic; Lambert zenithal equal area; polar stereographic; meridional stereographic; equi-rectangular; rectified skewed; Lambert cylindrical equal area; Lambert equal area polar; Albers equal area.

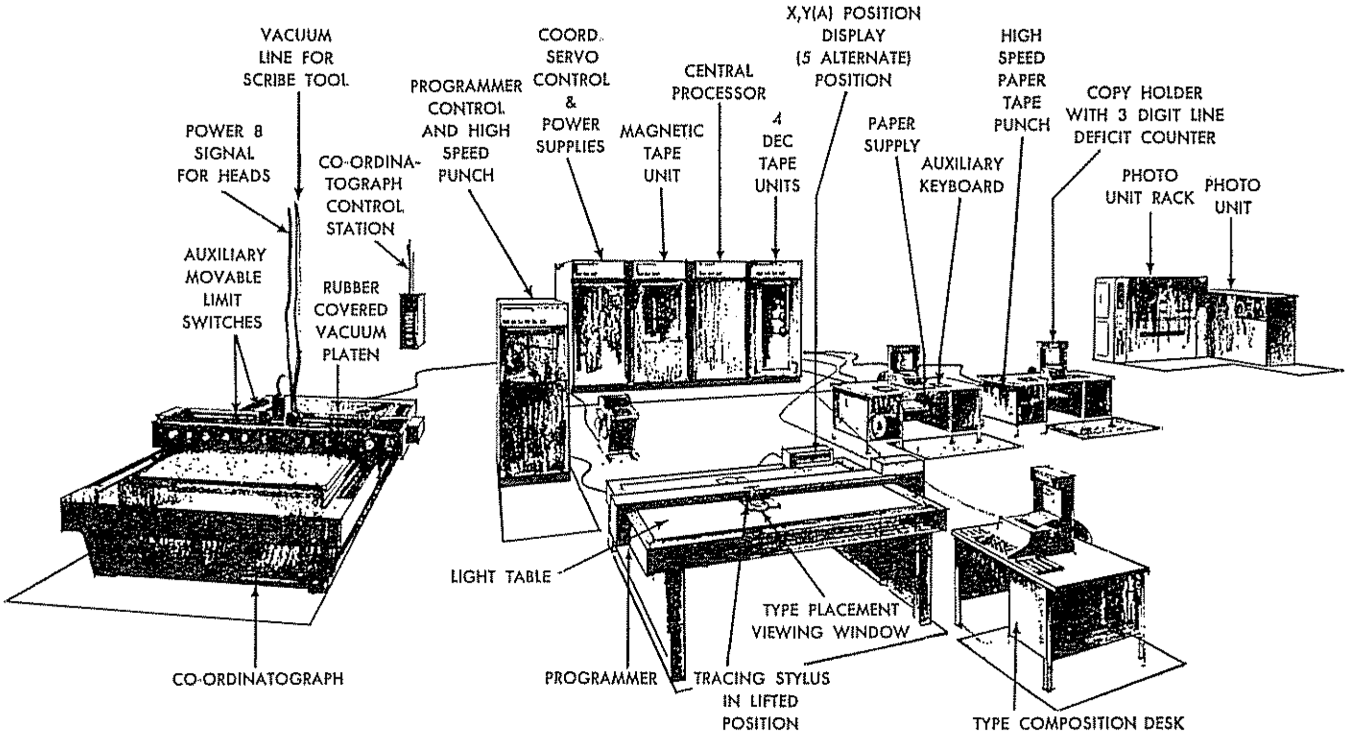
2. Special computer programmes to construct automatically: magnetic variation curves; various types of grid reference systems to overprint on charts constructed on the Mercator projection, including the Universal Transverse Mercator (UTM); underwater cable routes and shiptrack routes.

Also during this period the Oceanographic Office took another big step forward in automated cartography by purchasing the new E-103 automatic cartographic plotter system (see figure below), which is scheduled to be operational in the latter part of 1967. This system consists of the following basic units: an on-line computer, a programmer—used for automatic type placement of names and digitizing of cartographic source data, a photo-composition unit, and the co-ordinatograph. The on-line computer will make it possible to operate all the different components of the system at one time. It will also serve as the director unit in receiving and processing cartographic data as well as control the operation of the co-ordinatograph and the instrument heads.

The programmer is a large horizontal reader and serves a dual purpose: automatic type placement of names and notes, and digitizing of various cartographic source material, that is, shoreline, bathymetry, topography etc. When used for type placement, a chart compilation manuscript is placed on the programmer, and the accurate position of each name in X, Y co-ordinates is then recorded on a control tape by the cartographer. After selecting various type styles and sizes, this information is recorded on a punched paper tape. This paper tape is subsequently used by the photocomposition unit to prepare automatically a 70 mm film strip bearing name images in sequence as they were compiled. The control tape and film strips are then used to operate the photo-projector head on the co-ordinatograph to produce the final plotted names overlay on sensitized film. In using the programmer as a digitizer, it will be possible to establish, maintain, store and update a library of chart information on magnetic tape. Thus, it will become possible readily to retrieve and process cartographic data resulting in the production of a chart or map within a very short period of time and at different scales and projection systems.

The photocomposition unit of the new E-103 automatic cartographic system will not be restricted to name placement, as mentioned above, but will also be utilized to prepare the text page reproducible negatives for the Oceanographic Office Publication I-N (Catalogue of Nautical Charts and Publications) and various aeronautical information published in textual form. To accomplish this task, the programmer is not involved; all work will be

[1] The original text of this paper, prepared by R. Bolton, N. Banks and A. Basile, United States Naval Oceanographic Office, appeared as document E/CONF.52/L.97.



United States of America: E-103 automatic cartographic plotter system

prepared on the photocomposition keyboard unit which utilizes punched paper tape as output. This tape is used by the photocomposition unit processor automatically to produce the text information negatives in final format. It will also be possible to use the photocomposition unit to prepare textual material and other similar types of publications, such as procedure manuals, projection tables and other tabular materials or information needed by cartographers and chart-users.

The new E-103 cartographic system will also have the capability to provide other office components with automatic cartographic services on a time-sharing basis. Furthermore, the computer programmes already developed for the present E-51 digital co-ordinatograph can be utilized by this new system without change. In addition, data to be processed can be stored or "packed" on the magnetic tape so that maximum utilization of the tape will be obtained. For example, the present E-51 co-ordinatograph utilized an average of five magnetic tapes on a two-shift basis where the E-103 system would use only one tape containing the same data.

In processing digitized cartographic source data, economy will be gained through the utilization of a generalization programme. The Oceanographic Office has seen a need for such a programme and on a contract basis has designed and is presently testing this programme. The programme will have the capability of processing the required number of data points to accurate graphics, according to scale and tolerance.

In addition to a generalization programme, the Oceanographic Office is presently developing an automatic bathymetric contouring programme. This will make it possible to generate fathom curves, at any given interval, from available hydrographic sounding data by mathematical interpolation between known sounding positions.

The combination of these two cartographic processing systems (E-51 and E-103) still does not give us the capability automatically to produce a complete chart or map in its entirety. To accomplish this goal, future plans at the Oceanographic Office call for ADP and equipment development as described below.

Procedure, method and techniques

A cartographic data storage system will be established where data are stored on magnetic tape in digitized and coded form, e.g. shoreline, topography, hydrography, navigational aids and wrecks. In addition, names, symbols, special characteristics and other chart type images will be stored in a memory bank and retrieved by computer location number in accordance with a specific characteristic. The name can be annotated in any desired type, style and size.

The data are to be stored in a random-access memory system, which will enable the cartographer to retrieve data for a complete chart within fractions of a minute, and then record it on magnetic tape for processing on a co-ordinate plotter or CRT visual display system. This system will also include editing capabilities by using on-line editing procedures and equipment. This unit will consist of a CRT display console to retrieve stored data and present it visually in graphic form for editing purposes prior to final production. This system will enable us to edit from magnetic tapes rather than from proof copies. A world index of available digitized data, essential for the immediate retrieval of information, will be established and kept up to date.

Rapid and completely automatic methods of digitizing source material may be accomplished in the future, using film positives of master charts on a continuous roll and identifying each master with a number. The roll would travel across the surface of the scanner and stop at the chart desired. Almost instantly, the complete chart would be digitized by a photo-electric cell or CRT recoverer technique. For charts that cover two master bases, each master would be digitized and the resulting data would be compiled together by the computer. The charts are naturally the key to this method of digitizing. In reality, they comprise the stored data and eliminate the need for a large memory computer system. This state-of-the-art will be utilized solely for the production of special types of charts that are not used for navigation.

It is estimated that, with this method of digitizing, we shall be capable of producing charts with accuracies ranging from 0.005" to 0.01". In addition, the master base can easily and more economically be up-dated.

Equipment

CRT or visual display systems will play a large part in editing the chart—almost instantly after the request has been received. The cartographer will delete or add information. Also, by employing a visual display system, a chart may be reproduced directly from the display presented. This would be of great value in preparing indices, tables, diagrams and interim or special purpose charts. The co-ordinate plotter will be so designed to permit the plotting of lines, names and notes without the interchanging of instrument heads; therefore numerous different types of charts could be processed within a matter of hours. Implementation of such an automatic cartographic equipment system will require the procurement of certain peripheral equipment, such as high-speed tape units, automatic scanners, co-ordinate plotters, etc. Automatic cartographic recorders will be used for scanning a manuscript (in colour) to isolate and digitize various types of data.

Type of products

The automatic cartographic equipment and techniques described above will place few limitations on the types of charts and products that can be produced, e.g. different types of graphics (profiles and indices), tables, listings, tabulations and overprints of various types of data on existing charts. Also it will be possible to adapt products and data to shipboard visual display and navigational systems. The ultimate objective is to standardize the computer, data-handling methods and procedures of all government mapping and charting agencies, to permit exchange of information for immediate processing. This most important feature will provide the capabilities to transmit data for field use and *vice versa*.

In the distant future, it is anticipated that cartographers will be capable of providing accurate and detailed charts of any type within a matter of hours, assuming the source has been made available in suitable format. This will be made possible by employing ADP equipment, where the cartographer operates a console unit and uses a coded manual, indicating storage locations of various cartographic data. The console will be used to enter the coded data into the ADP equipment, which will retrieve the information desired and show it on a visual display screen in colour or in black and white. This display should be readily photographed and produced by electrostatic printing methods. Because the data is electronically organized when displayed, it will be possible to transmit the chart to the user or users in any part of the world, *via* satellite or radio transmission.

Although this paper presents only those advances in automatic cartography made at the United States Naval Oceanographic Office, similar advances have also been made by the Army, Air Force and ESSA. While at the present time the various systems must be compatible, the ultimate goal is to standardize the computers, data-handling methods and procedures of all United States government mapping and charting agencies.

STUDY OF COLOUR AERIAL CARTOGRAPHIC MAPPING PHOTOGRAPHY FOR HYDROGRAPHY

Paper presented by the United States of America[1]

Introduction

The purpose of the project which is the subject of this paper was to evaluate the use of colour cartographic mapping photography for supplementing existing or compiling new hydrographic data. The area selected for study was Wake Island.

One of the functions of the United States Naval Oceanographic Office is to compile and revise nautical charts from aerial photography by photogrammetric techniques and procedures. It is at once apparent that the continual natural and man-made changes of surface and sub-surface features rapidly make charts obsolete. The photogrammetric methods of revising and compiling surface features are well known. This study will therefore exploit the feasibility of using colour aerial photography by photogrammetric stereo-instruments methods to provide sub-surface data rapidly, accurately and economically.

[1] The original text of this paper, prepared by the United States Naval Oceanographic Office, appeared as document E/CONF. 52/L.107.

Description

The camera used for the test was a CA-14 (T-11) No. 52-120 with magazine No. 21. This camera has a wide-angle metrogon lens (No. XF2265), a 9×9 inch format, and a calibrated focal length of 152.51 mm. All exposures were made with an F 11 aperture and at a shutter speed of 1/75 second by Heavy Photographic Squadron Sixty-One on 14 September 1964 at 5,000 ft true altitude. The type of filter used is not known.

The photography evaluated consisted of one roll of Eastman Kodak MS Ektachrome. Exposures 03 through 05 were selected for testing purposes. The selected colour transparencies were cut from the roll and used directly in the instrument between plates of clear optical glass. Contact black and white plates (dianegatives) were also made from the colour transparencies for test purposes.

The Zeiss stereoplanigraph was used for the read-out. This instrument is a first-order stereo-instrument that enables establishment of point read-out to an accuracy of 1:6,000 of the flight altitude. Thus, for this test the maximum accuracy obtainable will be ±0.83 ft.

Hydrographic data (Boat Sheet No. 305738) obtained during United States Navy survey of Wake Island in 1946 were used for sounding (positions and depths) and shoreline base data.

Investigation

Both the original colour transparencies and colour prints were evaluated for over-all photo-interpretation value.

Underwater elevations established by the stereoplanigraph (from cut colour transparencies and dianegatives) were evaluated for accuracy by direct comparison with sounding data.

The source boat sheet was checked for scale accuracy and enlarged to scale 1:5,000. Shoreline and sounding positions were then transferred to a base manuscript to provide the horizontal scale and points for which elevations were to be established. The "cut" colour transparencies for stereo models 3 and 4 were oriented in the stereoplanigraph to the control data. Elevations were then read out for the sounding positions and accuracy determined by direct comparison with the soundings. This procedure was repeated for all test models.

Results

In the general appraisal of the various types of film, colour has unquestionably definite advantage for nautical charting use. Colour film records all colour gradations in nature in separable colours, shades, and hues, whereas panchromatic photography records colour in about 200 distinguishable shades of grey. The whole picture looks so much more natural that even the trained photo-interpreter will find it easier to work with. The individual images of both natural features and man-made objects recorded on the colour film showed fine detail and high image quality. For nautical application, navigational aids, channel buoys, the out-boat channel, bottom characteristics, etc., are easily and accurately identified.

The accurate positioning of surface and sub-surface detail can be obtained by using stereo-plotting instruments. The stereo-operator sees more, interprets more readily and thus makes a chart compilation compatible with the quality of the photography and the control data.

The addition of sounding data by stereo-instrument read-out will help complete the nautical chart information. The tabulation below shows sub-surface readings established by the stereoplanigraph from waters ranging from 0 to 18 ft. The summary of points concludes a mean square error of 1.30 ft, with 75 per cent of the points with ± 1 ft and 95 per cent of the points within ± 2 ft.

Colour transparency—stereo read-out results

Models 3 and 4	*No. of points read:* 127
92 points	were within ± 1 ft
25 points	were within ± 2 ft
10 points	were within ± 3 ft
0 points	were within greater than 4 but less than 5 ft
Models 4 and 5	*No. of points read:* 220
166 points	were within ± 1 ft
46 points	were within ± 2 ft
6 points	were within ± 3 ft
2 points	were within ± 4 ft
Summary models 3 through 5 using 347 points	
258 points	were within ± 1 ft
71 points	were within ± 2 ft
16 points	were within ± 3 ft
2 points	were within ± 4 ft

Attention is called to the fact that, with 6-inch focal length photography at 5,000 ft, the maximum accuracy obtainable with the stereoplanigraph is approximately ± 1 ft. Thus, by lowering the flight altitude, a greater accuracy can be expected. Moreover, the read-out was limited to those points where sounding data existed. This restricted the operator's selection of good "contrast" points and thus reduced accuracy. For a production item, sounding can be established to the shoreline.

As the CA-14 (T-11) does not have a true colour-corrected lens, there is generally a strong shift to the blue and uneven illumination all over the focal plane. To use colour photography as a method for improving nautical charting, we must first consider the importance of using a colour-corrected lens with the proper filters. A Wild RC-8 or its equivalent with an AL (380 millimicrons) or A2 (420 millimicrons) filter is best suited to achieve the highest quality colour photography.

The use of "cut" colour transparencies should not be considered to be an operational procedure. The film is easily scratched and difficult to orient on the stage plate, as it is held flat by two clear optical glass plates. For the second test, the use of dianegatives defeated the purpose for which the colour film was obtained. The plates are very grainy, and areas that are solid grey become impossible to read accurately. It is therefore recommended that the only method to consider for production should be that of using colour diapositives.

The value of this study was reduced by the lack of colour aerial coverage over deep water. An attempt was made to establish elevations in deep water along the edge of the coral. Unfortunately, these are at the extreme edge of the usable photography, and no soundings exist for comparison purposes. It is concluded that the read-out limits will depend upon water clarity and bottom contrast, and may vary regionally from 5 to 60 ft. There is a belief that new camera filters now being developed by the United States Coast and Geodetic Survey will increase the ability to penetrate waters and thus enhance depth determinations by stereo methods.

In those areas where the photography is 75 to 100 per cent water, existing sounding data or a reference plane either on or below the surface of the water must be used as a vertical datum. It is suggested that objects such as oil drums dropped from a proceeding flight might serve as a vertical datum plane. In any case, this is an area that becomes extremely important, and there remain other suggestions that should be investigated for a logical solution for the vertical datum.

Conclusions

It is concluded that, depending upon water clarity and bottom contrast, excellent results may be expected in stereo determination of depths ranging from shoreline to 40 or 60 ft. Moreover, the results of this study indicate that colour film will give a great deal more surface and sub-surface information about foreshore and offshore shallow areas than heretofore possible. It is of particular interest that those areas are the most difficult for the hydrographer to reach.

RECOMMENDATIONS

It is recommended that, to obtain the highest quality and maximum results with the colour photography, certain controls should be practised, namely:

The aerial camera should have a colour-corrected lens and proper filters for use with time-tables and exposure charts;

Flight schedules should be restricted, both as to month and time of day to ensure maximum water penetration and elimination of the sun's reflection;

When possible, colour photography should be exposed at low water to increase accuracy;

Colour film and colour plate processing should be rigidly controlled for quality;

Minor light adjustments should be made on the C-8 to compensate for the "colour" plates.

PARTICIPATION IN THE CO-OPERATIVE STUDY OF THE KUROSHIO (CSK)

Paper presented by China[1]

The Co-operative Study of the Kuroshio current and its adjacent region (CSK) is sponsored by the United Nations Educational, Scientific and Cultural Organization and nine countries have taken part in this study. To carry out this co-operative project, a selection of scientific personnel was made from various institutions and the research vessel is provided by the Chinese Navy.

Three cruises have been carried out: the first one took place in September–October 1965, the second in March–April 1966 and the third in September–October 1966. A fourth cruise is planned for March 1967.

The area of investigation for China is the surrounding waters of Taiwan and the farthest station is about 200 miles from the coast. The items of study for every cruise include hydrographic and meteorological observations, current measurements, water collecting and analysis, plankton sampling and bottom sample collecting. The CSK project has obtained interesting results, and all the data have been processed and sent to the Kuroshio Data Centre in Tokyo within three months after every cruise.

[1] The original text of this paper appeared as document E/CONF.52/L.117.

CREATION OF HYDROGRAPHIC SERVICES IN NEWLY INDEPENDENT COUNTRIES

Paper presented by the International Hydrographic Bureau[1]

FOREWORD

A number of countries which have recently become independent are faced with the responsibility, in the case of maritime States, of ensuring safe navigation within their territorial waters and of supplying their ships with the nautical documents necessary for navigation. Such a responsibility poses problems which can be effectively solved only by the creation of national hydrographic services.

For reasons of economy, however, the creation at the outset of a complete hydrographic service modelled on the larger hydrographic offices of the world is out of the question. But without undue expense it will be possible to consider the setting up of an embryo service sufficient to satisfy the most urgent basic needs, and one out of which a true hydrographic office could later develop should this be found necessary. The International Hydrographic Bureau (IHB) has drawn up the present memorandum for the purpose of guiding those new countries in the accomplishment of that task.

We shall indicate, in order of priority, the fields in which such a service should exercise its activities.

Naturally, the point of departure and the internal possibilities differ from country to country and, in consequence, each country wishing to establish a hydrographic service might find it to its advantage to take a detailed statement of its present situation and requirements to the IHB, which would then proffer advice and help.

NAUTICAL INFORMATION

The essential task of any hydrographic office it to inform the navigators of the whole world of the conditions of navigation in territorial waters, so as to ensure the highest possible degree of navigational safety.

For the accomplishment of that task, new countries do not as a rule start from scratch. Another country has usually carried out the installation of lights and beacons along the coasts and in ports, established surveys of coastal waters and published plans, charts and adequate nautical documents. The continuation of this work, its keeping up to date and its improvement if necessary constitute the essential task of the new country's hydrographic service.

It is therefore imperative to create first of all the indispensable service of nautical information, which should include a section on notices to mariners and a section on nautical documentation.

Notices to mariners

A maritime bureau, generally situated in the principal port, will centralize the data received by the harbour master from mariners concerning the following observations carried out by the captains of the various vessels: buoys or land-marks, lights that are extinguished, soundings different from those shown on the charts in use or new soundings, currents and, in general, any observation reported by mariners to harbour masters' offices concerning navigation in the area.

It is important that there should be an organization for drafting and diffusing notices which would transmit all

[1] The original text of this paper appeared as document E/CONF.52/L.131.

nautical information to mariners as rapidly as possible. For that purpose, the notice should first be properly corrected, and then checked and circulated. Depending upon the urgency, and according to the means available, it could be broadcast by a national radio station, following international procedure. Information as to this procedure may be found in the lists of radio signals published in the language most often used. Generally speaking, the notice would be communicated by rapid means to the hydrographic office of the country whose charts and documents are used by the mariners of the new country, this office being responsible for circulation and correction. The corrections would nevertheless be made without delay to the stock of charts and documents in the possession of the new country (see below).

Nautical documentation

Mariners of the new country have in general already used the nautical documentation established by another country. It would be advisable, therefore, before envisaging the production of new original nautical documentation, to constitute, to keep up to date and to maintain stocks of nautical documents designed to satisfy national needs. The first requirement, therefore, is to estimate those needs. Next, it is recommended that agreements be concluded with the hydrographic office of the country whose documents are used in order to obtain those stocks, part of which could be distributed to the local sales agents. This nautical documentation consists chiefly of the following: nautical charts; sailing directions; lists of lights; lists of radio signals; tide tables.

All these documents may be selected from among those concerning the coasts of the new country listed in the catalogues issued by the hydrographic office of the country whose charts and documents are used. Documents concerning other regions of the globe frequented by mariners of the new country could be added as required. All these documents should be kept up to date locally.

HYDROGRAPHIC SURVEYS

In the Public Works Office of the new country there is generally a section dealing with port works and which already possesses boats (pilot boats, tenders etc.). This office could be responsible for keeping the port charts up to date. The embryo survey service could be developed as part of this existing service.

Navigational activities in territorial waters and unstable bottom conditions near the coast or at the entries to ports may make it necessary to carry out frequent hydrographic work in order to keep the relevant nautical documents up to date. In that case, it might be in the interests of the new country to organize a national service for carrying out regular hydrographic surveys. The acquisition of a survey ship with the necessary equipment and a qualified staff would then have to be considered. The staff would have to consist of persons who had followed specialized courses in other countries and expert guidance would have to be provided under the United Nations assistance programme.

If the question of equipping a hydrographic ship to work on a full-time basis is to be envisaged, we recommend that the country concerned should contact IHB.

CARTOGRAPHY

The marine charting of a country that has recently attained independence has usually been done before and all that is needed is to keep it up to date, particularly with regard to bottom changes liable to occur in certain regions, or to improve it where necessary. In the latter case, the new country may envisage the production of original charts. If it does not possess a ship or boat equipped with specialized personnel and material, it can have the work carried out under contract by private firms or the national organizations of another country.

The new country may wish to consider constituting nautical documentation in its own language. If so, the bureau recommends the conclusion of a bilateral agreement with the country concerned for either the reproduction or the translation of the documents. Facsimile reproductions of the charts could be made, the legends being incorporated in the national language. For this purpose, it would be necessary to consider the setting up of a cartographic drawing office with qualified staff. In some new countries a cartographic office may already exist; it may formerly have been a branch of the geographic service of another country or a part of the local ordnance or cadastral office. In that case, it might be of advantage to consider co-operation with those existing bodies. The same applies in the case of printing work, for which the help of either a local or a foreign firm could be sought.

In any event, the processing of original surveys for cartography requires specialized staff and a specialized technique. The new country would therefore have to envisage the training abroad of qualified cartographers and hydrographers. The Bureau is in a position to provide all information on this subject.

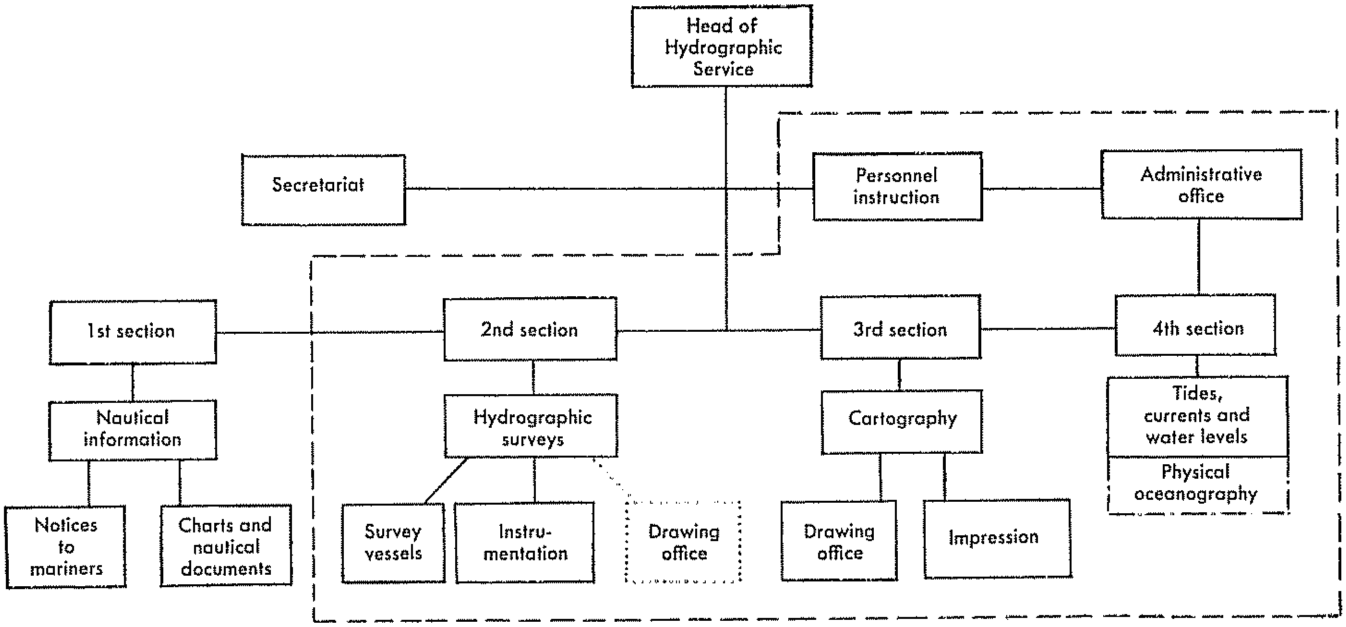
TIDES, CURRENTS AND WATER LEVELS

Lastly, the documents to be supplied to mariners concerning tides and water levels (for river navigation) are important information material.

Tide predictions generally exist for a number of local stations and are published in the tide tables issued by the larger hydrographic offices. In this connexion, the function of a new hydrographic service would primarily consist in ensuring the continuity of tide and water level observations by maintaining the operation of tide gauges where such exist, or installing them if need be at points where tide or water level data seem necessary. The reduction and calculation of the predictions from the tide records could be done by arrangement with a hydrographic office possessing a tidal prediction service. Water level predictions can be made only after long studies of data taken from a number of recording stations. The main task, therefore, is to install recording equipment at an appropriate number of points.

In large hydrographic offices, a physical oceanography section, the creation of which might be envisaged by the new country as a matter of second priority, is usually attached to the tidal section.

Manning table



The part enclosed within the broken line represents the sections of the Hydrographic Service whose development is not urgent.

The drawing office, shown by a dotted line in the survey section, should disappear when the cartography section is created.

Physical oceanography, shown by a broken dotted line in the tides, currents and water levels section, will later be incorporated in the latter section.

GENERAL BATHYMETRIC CHART OF THE OCEANS (GEBCO)

Paper presented by the Federal Republic of Germany[1]

The systematic exploration of the sea must be based on chart material meeting all scientific standards.

The necessity of creating a bathymetric chart of the world was recognized in the nineteenth century. In 1899, the seventh International Geographical Congress in Berlin resolved to produce the "General Bathymetric Chart of the Oceans (GEBCO)". After the Berlin congress, a committee was convened consisting of Prince Albert I of Monaco, and Messrs. von Richthofen, O. Krümmel, Makaroff, Hugh Robert Mill, John Murray, Fridtjof Nansen, O. Petterson, Supan and Thoulet, who in April 1903 in Wiesbaden fixed the rules for the size and layout of GEBCO.

GEBCO represents the earth in sixteen sheets on Mercator projection, at 1:10,000,000 scale (referred to the equator), and in eight polar sheets on gnomonic projection, at 1:3,100,000 scale (referred to 72°). Each of the eight sheets of series A covers an area of 90° in longitude and 46°20′ in latitude; each of the eight sheets of series B, an area of 90° in longitude and 25°20′ in latitude; each of the eight polar sheets of series C, an area of 90° in longitude and 18° in latitude. The size is about 100 × 65 cm.

Prince Albert I of Monaco, a scientist of world-wide reputation in the field of oceanography, undertook to have GEBCO prepared and produced at his own expense in his laboratory. At the eighth International Geographical Congress, held in 1904 in New York, Prince Albert presented the first GEBCO edition, which contained all soundings known by July 1903—about 18,400—and which had been completed within eight months. Most of the soundings had been taken from British Admiralty charts, supplemented by soundings of cable and research ships.

A second edition was started in July 1910 in Monaco and published between 1912 and 1927. It now contained 29,000 soundings; the depth contours were drafted by G. Schott, of Germany. After the death of Prince Albert in 1922 nothing was done in respect of GEBCO until 1929.

The great value of GEBCO for oceanography, hydrography, geography, geology and other sciences had been recognized and new support was sought for the project, which had considerably expanded owing to the invention of the echo-sounder and the resulting greater number of soundings. The International Hydrographic Conferences of 1929 and 1932 in Monaco therefore called upon the International Hydrographic Bureau (IHB) in Monaco to undertake the correction and publication of GEBCO. Preparations for the third GEBCO edition started in 1932 and were completed in 1955. Of the twenty-four sheets, eighteen were newly edited, while six (four north polar and two south polar sheets) remained unchanged. As many as 370,000 soundings had been plotted on 1,001 fair sheets at 1:1,000,000 scale; of these, 54,518 were incorporated in the GEBCO sheets. Each sheet of the third edition was provided with explanations in the form of general information about the sheet in question and notes on the origin of the soundings and charts used.

The sixth International Hydrographic Conference, held in 1952 in Monaco, felt that a fourth edition of GEBCO was necessary in view of the immense increase in soundings.

[1] The original text of this paper, prepared by H. R. Ermel, German Hydrographic Institute, Hamburg, appeared as document E/CONF.52/L.133.

Since this task could not be carried out with the small staff available at IHB in Monaco, it was decided at the seventh International Hydrographic Conference, held in 1957 in Monaco, to decentralize the preparation of GEBCO and to have the material collected through the voluntary assistance of the hydrographic offices of the member countries of IHB. The Monaco resolution of May 1957 was supported at the eleventh General Assembly of the International Union of Geodesy and Geophysics (IUGG), held in September 1957 in Toronto, and at the meeting of the Scientific Committee on Oceanic Research (SCOR), held in September 1959 in New York. At the General Assembly of the IUGG, the International Association of Physical Oceanography (IAPO) formed a GEBCO committee under the chairmanship of Mr. Böhnecke, former president of the German Hydrographic Institute, consisting of Messrs. Atherton (United Kingdom); Bezrukov (USSR); Collins (United Kingdom); Ermel (Federal Republic of Germany); Fagerholm (Sweden); Fraser (United Kingdom); Gougenheim (France); Heezen (United States of America); Herdman (United Kingdom); Menard (United States of America); Suda (Japan); Viglieri (of IHB, Monaco). During two working sessions, in March 1959 in Monaco and in April 1960 in Paris, the rules for the layout of GEBCO and for the production of the basic material in the form of plotting sheets at 1:1,000,000 scale were established.

The eighth International Hydrographic Conference, held in 1962 in Monaco, once again dealt with GEBCO in detail. It called upon the States members of IHB to give greater voluntary assistance in producing the basic material for GEBCO in the form of plotting sheets at 1:1,000,000. It appointed IHB as the co-ordinator of the production of GEBCO in co-operation with the States members and the international organizations interested in oceanography. It allocated for the following five years a total of 250,000 gold francs to be spent on drafting and printing the new edition of GEBCO.

The IHB office in Monaco has become the collecting centre for all data, which as far as possible are corrected according to the "Tables of the velocity of sound in pure water and sea water" by D. J. Matthews.

The hydrographic office of the USSR and the French Institut géographique national (IGN) in Paris decided to undertake the printing of the whole GEBCO at their own expense, provided selected depth numbers, depth contours and coastlines were made available to them at the scale 1:1,000,000.

During a discussion between representatives of IHB, IGN and the Service hydrographique de la marine in October 1964, in Paris, it was agreed that IGN was to receive no remuneration for this service but should be entitled to sell GEBCO. The Institut géographique national seemed peculiarly qualified for the task: it had already issued sheets A I and A'I; the language used in GEBCO is French; and the map of the world at 1:10,000,000 issued by IGN can be used for representing land areas.

The GEBCO programme now consists of the following three parts: production of plotting sheets at 1:1,000,000 by the voluntarily co-operating hydrographic offices; evaluation of the plotting sheets for GEBCO by IGN in co-operation with the Service hydrographique de la marine; production of originals and printing of GEBCO by IGN.

General rules were laid down for the production of GEBCO. The originals of plotting sheets at 1:1,000,000 are to be drawn on transparent stable material and are to contain all data available from former GEBCO editions, from hydrographic offices, from national and international oceanographic institutions and from public and private organizations.

Size and numbering of the plotting sheets are derived from the British chart No. 5330, "The World. Index of Plotting Areas". In all, 603 different plotting sheets have therefore to be produced.

All plotting sheets are drawn on Mercator projection to the scale of 1:1,000,000. They have a constant latitudinal extension of 6° while the extension in longitude increases from 10° to 25° when advancing to the north. They also have different mean latitudes. Extensions in longitude and mean latitude may be seen from the table below.

Extensions in longitude and mean latitude

Range	*Longitudinal extension*	*Mean latitude*
0°–30°	10°	33°
30°–48°	12°	46°
48°–60°	15°	57°
60°–66°	20°	65°
66°–72°	25°	70°
72°–78°	25°	76°

The arrangement of the sheets as well as the competence of the single hydrographic offices for the production of the plotting sheets have been established.

On the plotting sheets, depths may be given in metres or fathoms, depending on the system used by the respective hydrographic office. But only one unit may be inserted: either metres or fathoms. The agency in charge decides independently which data to insert. The centre of a depth number generally represents the position of the depth. In areas with numerous depth numbers, a dot with attached depth number may indicate the location of the sounding. All depth numbers are corrected according to Matthews's tables.

In order that the origin of a depth number and thus its accuracy and reliability may be traced, an overlay is added to each plotting sheet showing when and by whom the respective sounding has been taken.

The Institut géographique national is presently working on GEBCO sheets B I and B IV on the basis of the plotting sheets furnished by the German Hydrographic Institute. These GEBCO sheets are to come out as new editions in the spring of 1967. Material for producing further sheets is available.

MODERN PROBLEMS OF CHART PRODUCTION

Paper presented by the Federal Republic of Germany[1]

DEFINITION OF "CHART"

When dealing with modern problems of chart production, we must first define the term "chart". A chart is defined as a map issued by a national hydrographic office covering a certain sea area or the adjacent coast as far as the latter is of importance to shipping as a navigational aid. A chart contains all information necessary for navigation, such as channel depths, mud flats, sands, reefs and rocks, wrecks, land-marks, fixed or floating sea-marks, lights and radio beacons, magnetic data. As these data are continuously changing, only the latest chart editions are authoritative or those currently corrected in accordance with the appropriate *Notices to Mariners*. In view of nautical requirements, only angle-preserving chart drafts are used.

In contrast to the official topographical maps, there are no uniform rules for the size and scale of charts.

Depending on scale and contents, charts are subdivided as follows: 1:1,000,000 and smaller charts for selecting routes; charts for plotting courses and fixing ship's position; charts for approaching coast and navigating along the coastline (1:225,000–1:40,000); special charts for individual parts of the coast, narrow channels, bights and ports (larger than 1:40,000); plans for port entrances and ports (large scale).

HISTORY OF HYDROGRAPHIC CHARTING

In view of the ancient history of navigation itself, it is surprising how late useful charts were developed. The first charts known to us which really deserve that name are the Italian compass charts of the Mediterranean dating from the early fourteenth century. In addition, descriptive pilot charts known as *portolani* were being used.

In the age of discoveries, with the growing extension of navigation, Spain and Portugal started to cover large oceanic areas with charts. They had taken over from the Arabs, the first astronomical navigators, the astronomical method of fixing geographical latitudes, which was now taken as the basis for constructing charts.

For the northern peoples, no less seaworthy than those of the Mediterranean, the descriptions by fifteenth-century pilots of the coastline as viewed from the sea are the oldest aids to navigation preserved. In the sixteenth century, charts appeared for the first time, providing the outline of the coast with views of the coast in upright projection and depth numbers as well. Up to the eighteenth century, the Dutch were the leading marine cartographers. Their atlas, *Spieghel der Zeevaardt*, issued in 1584, was used by mariners of all nations.

All ancient European charts were based on the "plotting chart" projection, a cylindrical projection dating back to Marinus of Tyre in about the year 100 AD. But its use led to considerable mistakes in the plotting of courses, particularly on long voyages. A great reform took place in 1569 in Mercator's map of the world based on the projection named after him. The essential features of this projection are the latitudes which increase towards the poles in a way similar to the longitudes on any cylindrical projection. A whole century passed, however, before the Mercator projection, which had been specifically designed *ad usum navigantium*, was generally accepted for charts. Only since 1700 has it become a conventional means for constructing charts.

Marine cartography was formerly exercised by private persons only. It is true that in 1503 an "Indian House" existed in Seville which issued an official classified chart for Indiamen and that the States-General of Holland in 1663 entrusted an official cartographer with the perusal and correction of charts. But hydrographic offices in the navy departments of all seafaring nations were not set up until the early to middle of the eighteenth century. These offices began to have systematic nautical surveys conducted by warships, initially in their home waters, and published charts. This was mainly done by the United Kingdom which, since 1760, has been establishing a world-wide system of surveys and charts.

World hydrographic charting

Country	*Year of foundation*	*No. of sheets*	*Catalogue*	*Areas covered*
Argentina	1879	130	1950	Argentine coast
Australia	1920	117	1962	Australian coast and New Guinea
Belgium	1860	3	—	Belgian coast
Brazil	1876	165	1962	Brazilian coast
Canada	1883	700	1963	Canadian coast and Great Lakes
Chile	1874	170	1962	Chilean coast
Denmark	1784	164	1962	Danish coast and Greenland
Dominican Republic	1948	2	—	Dominican coast
East Germany	1946	181	1962	Mediterranean
Federal Republic of Germany	1861	930	1963	The world
Finland	1851	100	1963	Finnish coast
France	1720	2585	1960	The world
Greece	1920	77	1962	Greek coast
Iceland	1918	32	1960	Icelandic coast
India	1668	19	—	Indian coast
Indonesia	1945	270	1954	Indonesian coast and waters
Italy	1872	322	1964	Mediterranean coasts and Somalia
Japan	1871	1353	1963	Pacific and Indian oceans and adjacent seas
Netherlands	1874	80	1960	Neth. coast and colonial territories, including former Neth. New Guinea
New Zealand	1949	41	1964	New Zealand coast
Norway	1874	210	1963	Norwegian coast and Spitzbergen
Poland	1920	18	1957	Polish coast
Portugal	1849	184	1964	Portuguese coast and colonial territories

[1] The original text of this paper, prepared by H. R. Ermel, German Hydrographic Institute, Hamburg, appeared as document E/CONF. 52/L.134.

World hydrographic charting (*continued*)

Country	Year of foundation	No. of sheets	Catalogue	Areas covered
Republic of Korea	1949	300	1961	Korean coast
South Africa	1955	19	—	South African coast
Spain	1800	370	1962	Spanish coast and colonial territories
Sweden	1872	107	1964	Gulfs of Bothnia and Finland, Baltic Sea
Thailand	1851	37	1958	Thailand coast
Turkey	1909	18	1964	Turkish coast
Union of Soviet Socialist Republics	1827	700	1940	USSR coast and adjacent areas
United Kingdom	1795	3295	1964	The world
United States of America	1816	4050	1964	The world
Uruguay	1915	20	1956	Uruguayan coast
Yugoslavia	1922	79	1962	Adriatic and Ionian Seas

As may be seen from the above summary, the United States has the most chart work, with over 4,000 individual sheets covering the whole world. It is interesting in this context that a single agency is not in charge of the whole United States chart work but that the work is divided among the Coast and Geodetic Survey, which is responsible for all charts of the home coasts, and the Naval Oceanographic Office, which deals with all other sea areas.

The United Kingdom, with about 3,300 different charts, carries on a world-wide chart work whose venerable tradition goes back to 1795; France, too, with about 2,600 charts, has a comprehensive chart work; the fourth place is taken by Japan with about 1,350 charts, followed by German chart work with 930 charts.

Producing the original

All classical chart work, that is, work prior to the turn of the century, had one thing in common: the originals were engraved on copper. Reprinting, too, until the nineteen-twenties, was done from copper plates, which yielded an excellent chart image. The disadvantage of this procedure was that only unicolour charts could be printed, while coloured information had to be inserted by hand.

In the nineteen-thirties and particularly during the last war, the demand for charts steadily increased. Copper plate printing had then, for economic reasons, to be set aside in favour of printing on flatbed presses. The chart image was copied from the existing copper plate to the flatbed plate, through the so-called transfer process. The outcome, however, was not fully satisfactory; a decline in quality could not be avoided and size distortions were caused by the use of damp transfer paper, which showed unfavourable effects on multicolour charts in particular.

The great development of all techniques and processes in the graphic industry during the last few decades, owing to new discoveries and advancement in all fields of plastic foil production, photography, coat engraving and, above all, contact copying, has forced all chart agencies to adjust themselves to that situation. Most of them have undergone radical changes. The requirements which have now to be met by a chart original may be summarized as follows:

Originals must be produced on transparent plastic sheets so that transfer to printing plates can take place by simple contact copying;

The material of chart originals must be stable so that exact register between the different colour plates is guaranteed for multicolour charts; it must be durable and capable of storage over many years;

Chart originals should provide for a combination of line work with area and screen tints;

Originals must be simple and regularly brought up to date.

A material corresponding to these requirements was developed many years ago. It is a polyvinyl chloride copolymer which, depending on its country of origin, is called Astralon, Astrafoil, Mylar, Codatrace, Siccoprint, etc., and is placed on the market in 0.1–0.25 mm thick foils. There are fundamentally different methods of producing chart originals: drawing (separated after colours) on paper in connexion with photographic reproduction; drawing (separated after colours) on transparent sheet; coat engraving (separated after colours) on glass or plastic foils.

Fitting technique

As variety of signatures of a repetitive character is characteristic of charts—we have about 200 different signatures for sea areas and about 120 signatures for land—it was quite natural to try to incorporate those signatures mechanically. After much experimenting, the exact pasting in of prefabricated signatures has proved an excellent and labour-saving solution.

An especially complicated aspect of chart production was formerly the type work. All types had either to be engraved on copper or, later, to be drawn, an extraordinarily time-consuming task. This was further aggravated by the lack of sufficient numbers of qualified draftsmen available for this work. A way had therefore to be found to mechanize this part of chart production. This can be done either by means of special photocomposing machines where the name is taken letter by letter from a matrix table by individual exposures, or by employing the negative matrix set to produce a film thereof.

A cartographic original is now produced in such a way that all line elements of a chart are drawn or engraved on a stable transparent sheet. In this way a "silent" chart comes into being.

The type work composed on strip film is fitted on a special transparent sheet.

The drawing and the type work originals are assembled and constitute the original for the black master printing plate.

Strip masking technique

A new method known as the strip masking technique is used for the production of colour plates for single charts. A coating solution of polyvinyl alcohol is used for this purpose. After exposure and development, this can be stripped from smooth surfaces like a thin skin. If the drawing of an area outline has been used as copying pattern, this line is unmasked after exposure and development. When stripping the hardened coat, a limit is automatically set at the unmasked line.

The originals of single colours thus produced are copied on to printing plates from which copies are printed on offset presses.

Cartographic treatment of charts

Having dealt with the influence of reproduction techniques on modernizing chart work, we shall turn to cartographic development in the same context.

The last decades have seen a rapid increase in the number of soundings resulting from the echo-sounder. The echograph, in particular, delivers all particulars of the profile run.

The profile soundings yield, in particular, reliable points for the construction of depth contours. This way of representing depths is gaining more and more importance with the increasing number of soundings for charts, as the contours with their simple and space-saving signatures can now replace a great many depth numbers often showing the same values. It is therefore no longer the rule to provide as many numbers as possible. Depth conditions are, on the contrary, represented by depth contours in connexion with a few but carefully selected depth numbers, especially in the coastal areas. The result is a clearly arranged chart which furnishes the mariner with all necessary depth data.

The introduction of new methods of producing originals, such as coat engraving, has had its effect on the representation of depth contours. The signature of the depth contour formerly indicated the type of depth contour in question.

As long as the charts were based on drawing, this signature was no problem. With the introduction of coat engraving, however, it became a problem. More recent charts are therefore provided with continuous depth contours, with repeated insertions of the metre number in question and a distinction in line thickness by stressing, for example, the 10 m contour, because the 6 m contour, formerly regarded as the nautical warning line, has lost its importance with the steadily increasing draught of ships, and has been replaced by the 10 m contour.

Many examples show how the views on chart representation have changed in the last few years on the basis of the above.

As long as chart work was carried on in isolation, each national series had its own signatures. Only after the foundation of the International Hydrographic Bureau in Monaco, in 1919, did standardization slowly begin to develop in this field. This was of great practical importance to mariners. Nothing is worse than the former differences in signatures whereby one and the same nautical object was represented by different signatures. Since 1919, eight great international hydrographic conferences have taken place, largely dealing with the standardization of chart signatures. These conferences are held every five years in Monaco with representatives of forty-one seafaring nations in attendance. The last conference was held in 1962; the next one is to take place in April 1967.

The result of these negotiations is a uniform list of signs for all charts which is now being used by most nations. There is now one sign used to depict one and the same object.

Geodetic chart fundamentals

In addition to this modernization in the technical and cartographic sectors, reference has also to be made to the standardization of the geodetic fundamentals of international charts. Until recently, differences in identical points were quite normal when changing from one chart to that of the neighbouring country. They resulted from the fact that each country had a geodetic reference system of its own, sometimes even a reference ellipsoid of its own, and also different projections. This, of course, mostly affected large-scale charts. The following corrections had to be made, therefore, when changing, for instance, from German charts to those of neighbouring countries:

	Denmark	*Sweden*	*Netherlands*
Latitude	+ 6″	+ 6″	+ 1.4″
Longitude	− 9″	− 3″	+ 0.3″

Through the central European adjustment of the network on the basis of the Hayfort international ellipsoid, these values have been eliminated, so that direct interchange between the charts of Germany, Denmark, Sweden and the Netherlands is possible. As the position of identical points in the local grids was geodetically correct, a shift of the grid by a nationally varying amount was necessary. Denmark and the Netherlands have fully changed over to what is now called the European datum.

Radio navigational aids charts

Position fixing by astronomy is no longer the only method applied at sea. Hyperbolic navigational methods have been developed in the last few decades, initially created for airborne navigation, and guaranteeing a relatively high degree of accuracy. The installation of DECCA and LORAN systems on merchant ships and fishing vessels has forced the chart agencies to keep pace with this development by providing existing charts with DECCA and LORAN hyperbolic grids.

This work has been rationalized by the exchange between the hydrographic offices of the computational material for hyperbola insertion.

A special problem so far only insufficiently resolved is that of radar charts. It is only natural to take the normal charts as a basis for such charts, as they are available on different scales. The simplest method—colour imprint of the radar screen display—cannot be used, as the chart is based on Mercator projection, whereas the radar screen display can be called an equidistant azimuthal projection; moreover, the display varies in accordance with the ship's position, aerial height, wave length, type and adjustment of the gear, atmospheric conditions, as well as sea level and condition. In order to adapt a normal chart to radar purposes, it is endeavoured to mark all objects responding to radar and to represent the land relief by contour and form lines by simultaneously accentuating the summits by contour numbers. For a greater plastic effect, the form lines facing the sea and causing a stronger radar reflection are more emphasized. It is difficult, however, to represent the land relief, as reliable material on the respective coasts is missing.

Fisheries charts

All over the world, deep-sea fishing plays an important role in the nourishment of mankind. In 1965, about 56 million tons of fish were landed throughout the world. As the different kinds of fish are not equally distributed over the oceans, and special species of fish prefer special places, depths and temperatures, the chart agencies have to consider that phenomenon, too, by producing fisheries charts of special areas.

Programme for modern chart work

The IHB in Monaco plays a most satisfactory role in co-ordinating modern chart work. A great task still to be resolved is that of charting the world uniformly, covering and representing oceans, coasts and ports to their remotest corners.

Every hydrographic office has enlarged its chart work to the extent necessary for national shipping. The chart work of individual countries has thus developed historically in accordance with national demand. It was necessary in former times to be independent in this respect.

At the present time of understanding among nations, much duplication could be avoided if there were a single international chart of a distinct area of the oceans instead of a variety of national charts. Such a chart could be produced by the nation responsible for the original survey work. This procedure is still hampered by the existence of two different systems, the metric system and the foot-fathom system of Canada, the United Kingdom and the United States of America. But there is the hope that these countries, too, will one day change over to the metric system.

The final objective, which still appears as an almost insuperable barrier, is a chart of the world where each nation would be allocated a distinct regional area, with the hydrographic office concerned responsible for surveying and chart production to uniform rules. This charting of the world would result in fewer than 5,000 charts instead of the 17,000 hitherto. The difference between these two figures is enough to show that the task is worth every effort.

To prompt discussion on this topic—hitherto treated as taboo—France will present a compromise proposal this year in Monaco. This proposal provides that the various hydrographic offices should be responsible for distinct areas as regards surveying and chart production and that they should publish charts in two versions: one with depth data in metres; the other with depth data in fathoms. This arrangement would make it easier for the Anglo-Saxon countries to agree to the proposal and perhaps to change over, all at once, to the metric system; otherwise it might be decades before the cumbersome existence of both systems was brought to an end.

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ANNEXURE 1

NMP/66/140

ANNEXURE 2

NMP/66/140

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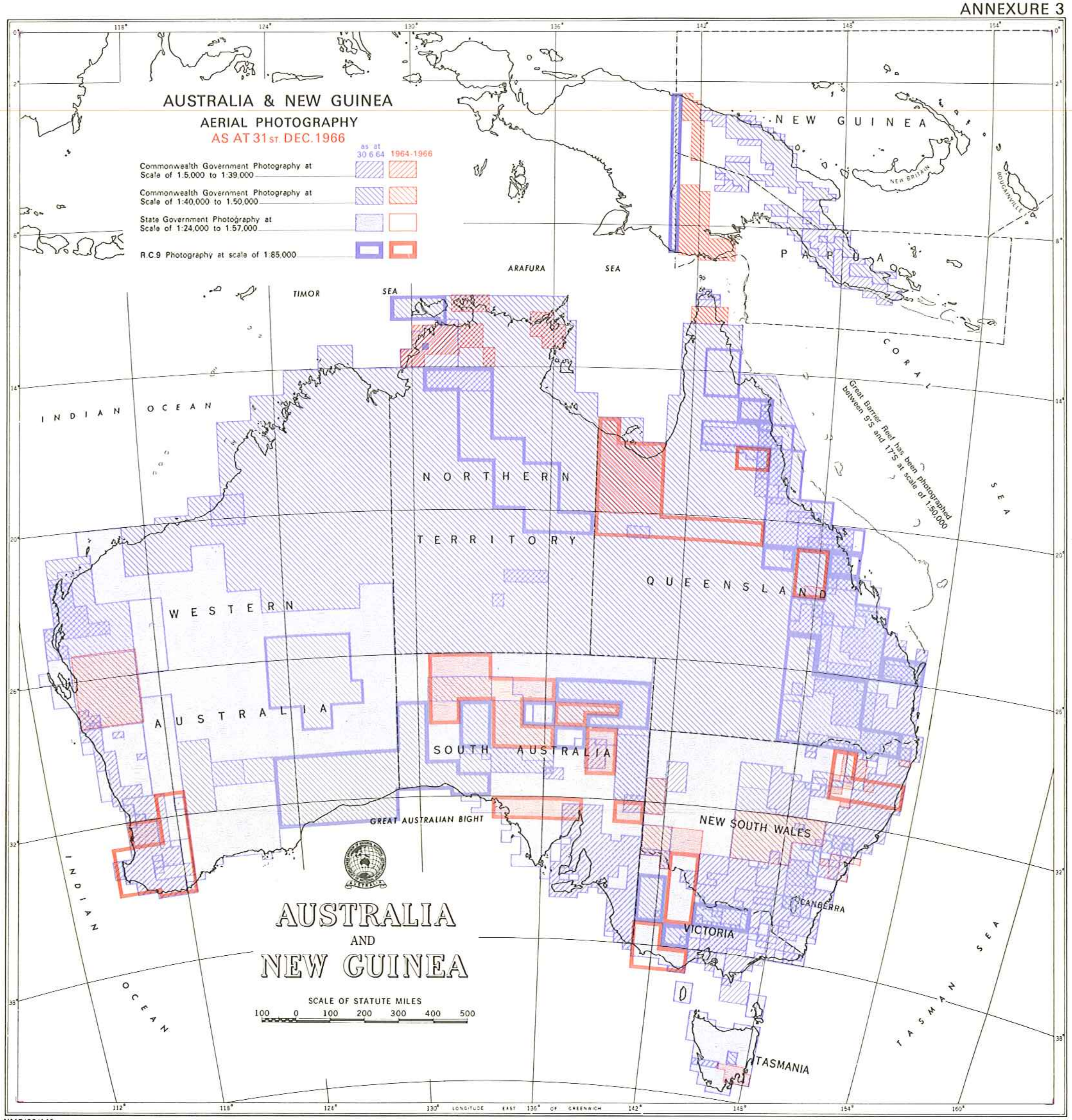
AUSTRALIA & NEW GUINEA
AERIAL PHOTOGRAPHY
AS AT 31st. DEC. 1966
as at 30 6 64
1964-1966
Commonwealth Government Photography at Scale of 1:5,000 to 1:39,000
Commonwealth Government Photography at Scale of 1:40,000 to 1:50,000
State Government Photography at Scale of 1:24,000 to 1:57,000
R.C.9 Photography at scale of 1:85,000
NEW GUINEA
NEW BRITAIN
BOUGAINVILLE
PAPUA
ARAFURA SEA
TIMOR SEA
CORAL SEA
Great Barrier Reef has been photographed between 9°S and 17°S at scale of 1:50,000
INDIAN OCEAN
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
GREAT AUSTRALIAN BIGHT
CANBERRA
VICTORIA
TASMANIA
TASMAN SEA
AUSTRALIA AND NEW GUINEA
SCALE OF STATUTE MILES
100 0 100 200 300 400 500
LONGITUDE EAST OF GREENWICH
NMP/66/140
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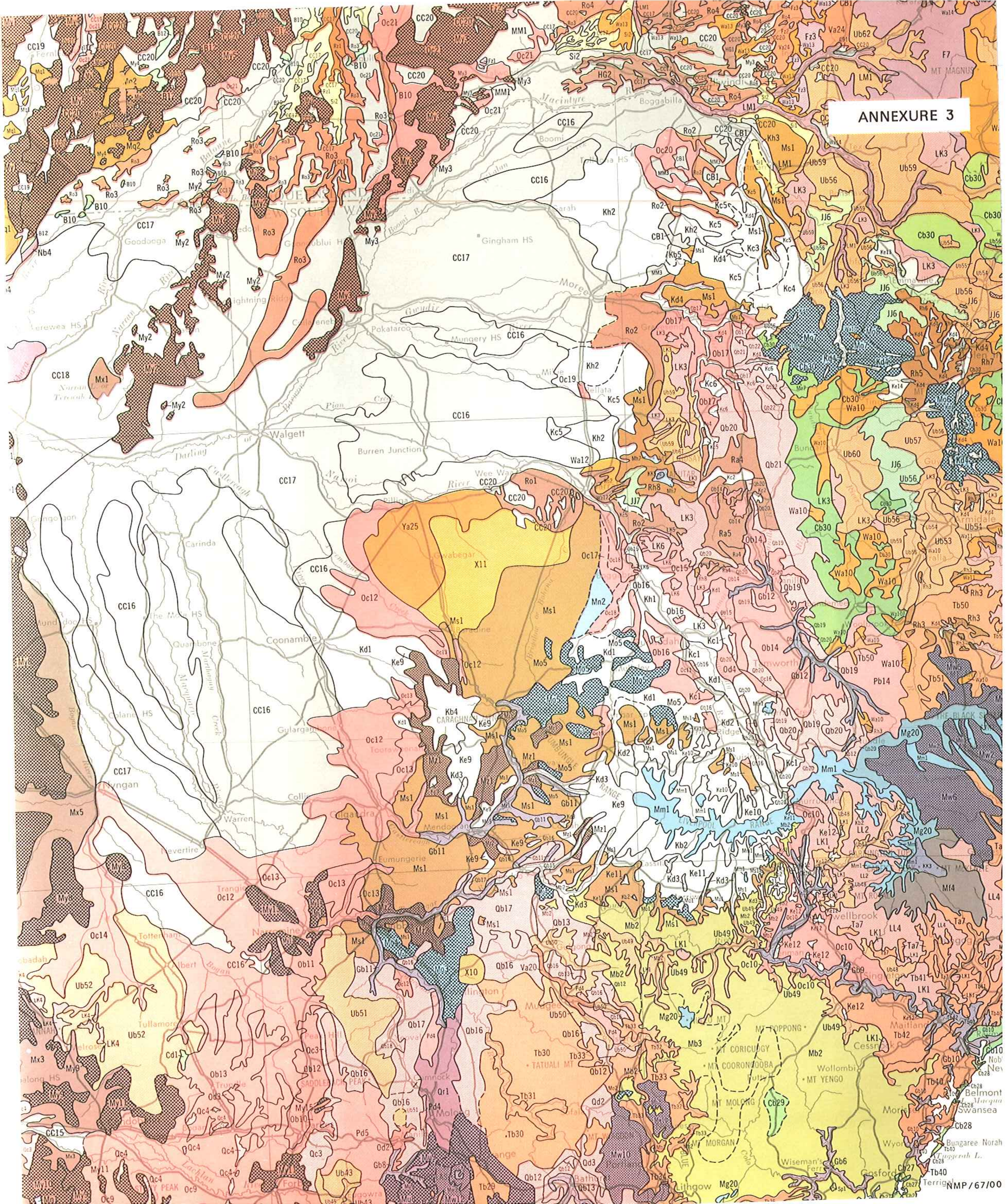
ANNEXURE 3



Moree
Walgett
Coonamble
Burren Junction
Narromine
Tamworth
Armidale
Muswellbrook
Maitland
Lithgow
Gosford
Swansea
Belmont
LIVERPOOL RANGE
MT YENGO
MT POPPONG
MT CORICUDGY
MT COORONGOOBA
MT MOLONG
Wollombi
Wiseman's Ferry
Boggabilla
Goodooga
Lightning Ridge
Gingham HS
Mungery HS
Pokataroo
Carinda
Warren
Nyngan
Trangie
Tottenham
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Gilgandra
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Mudgee
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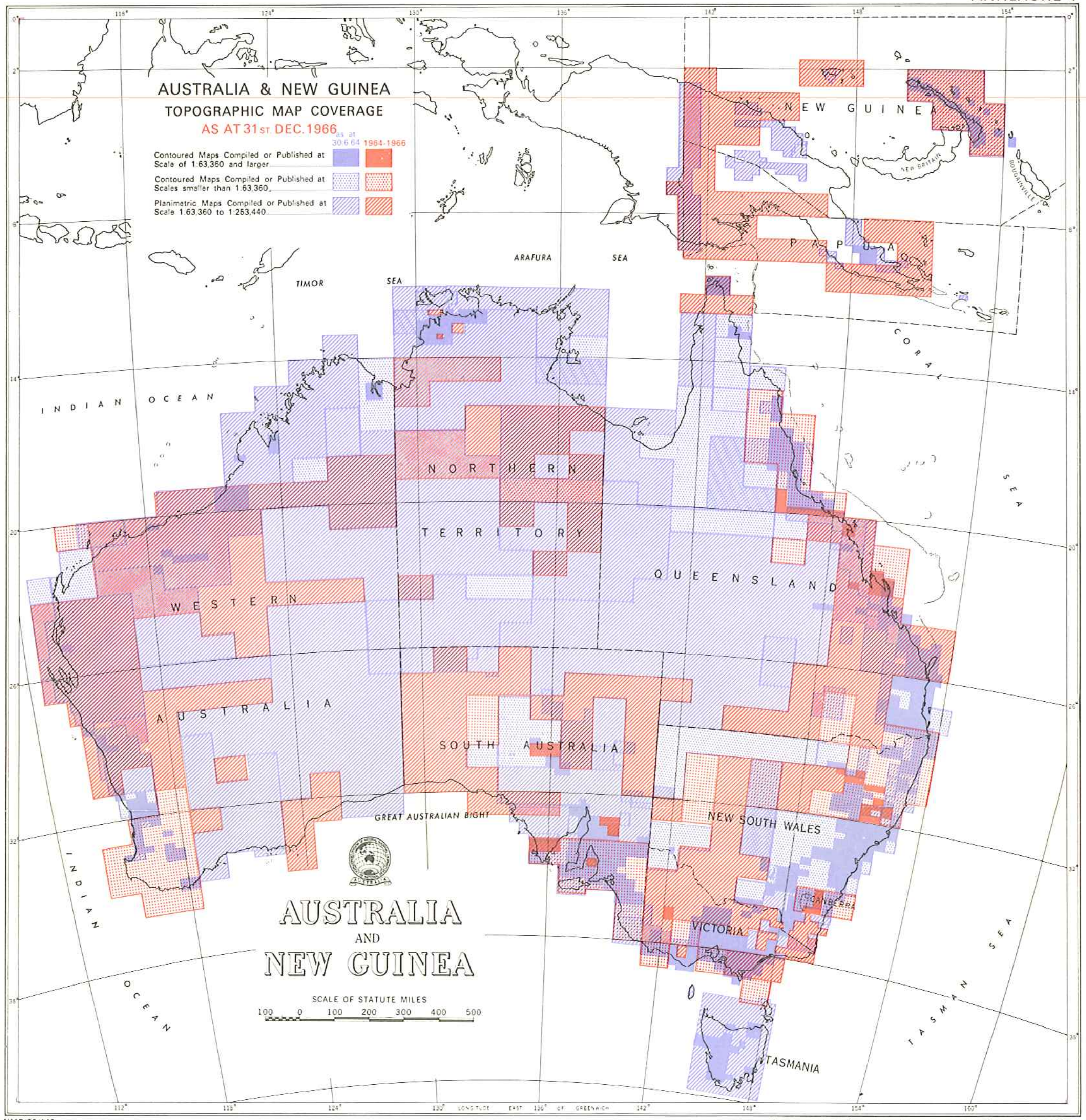
Cessnock
Wyong
Terrigal
NMP/67/00



NMP/66/140

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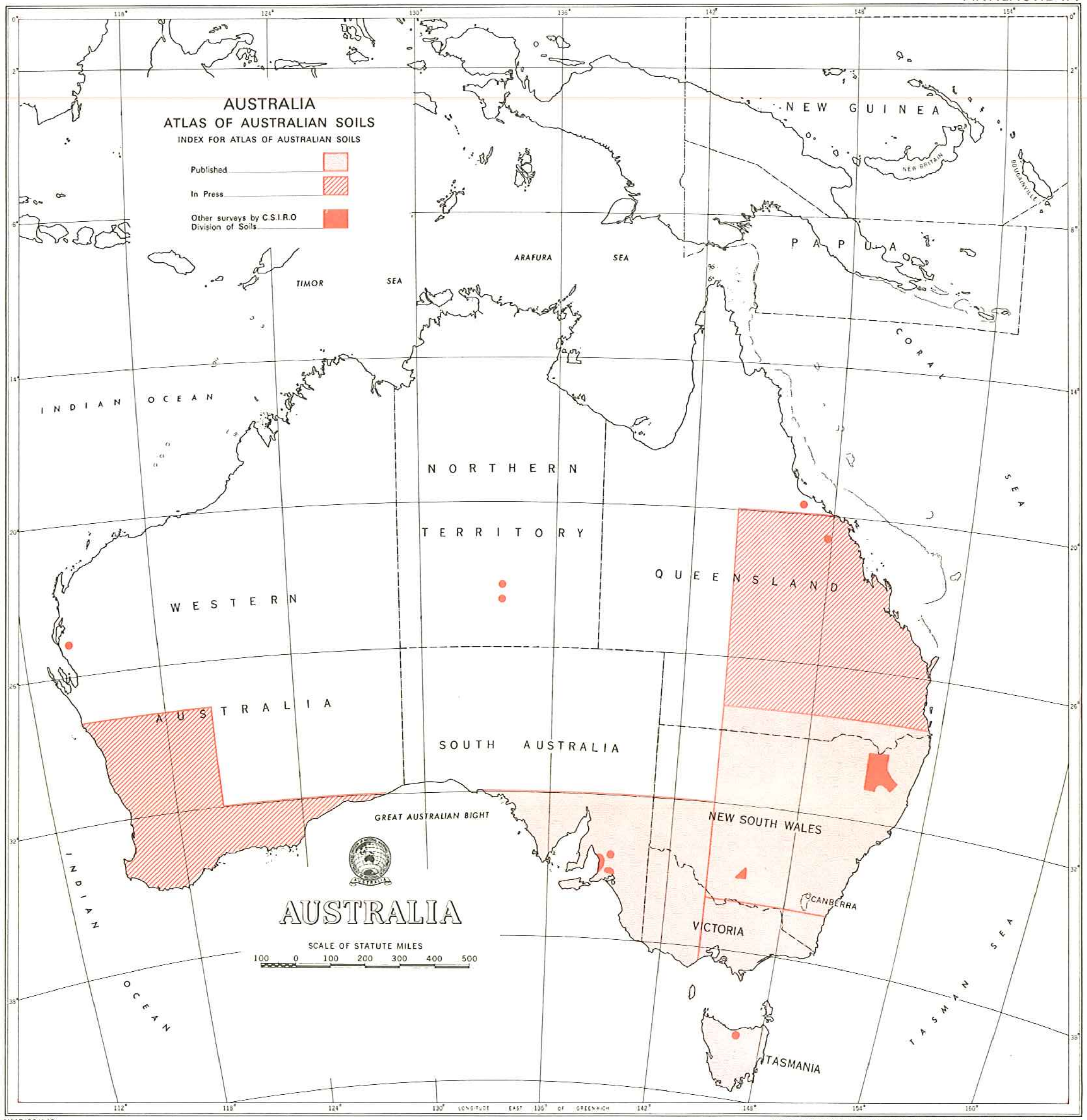

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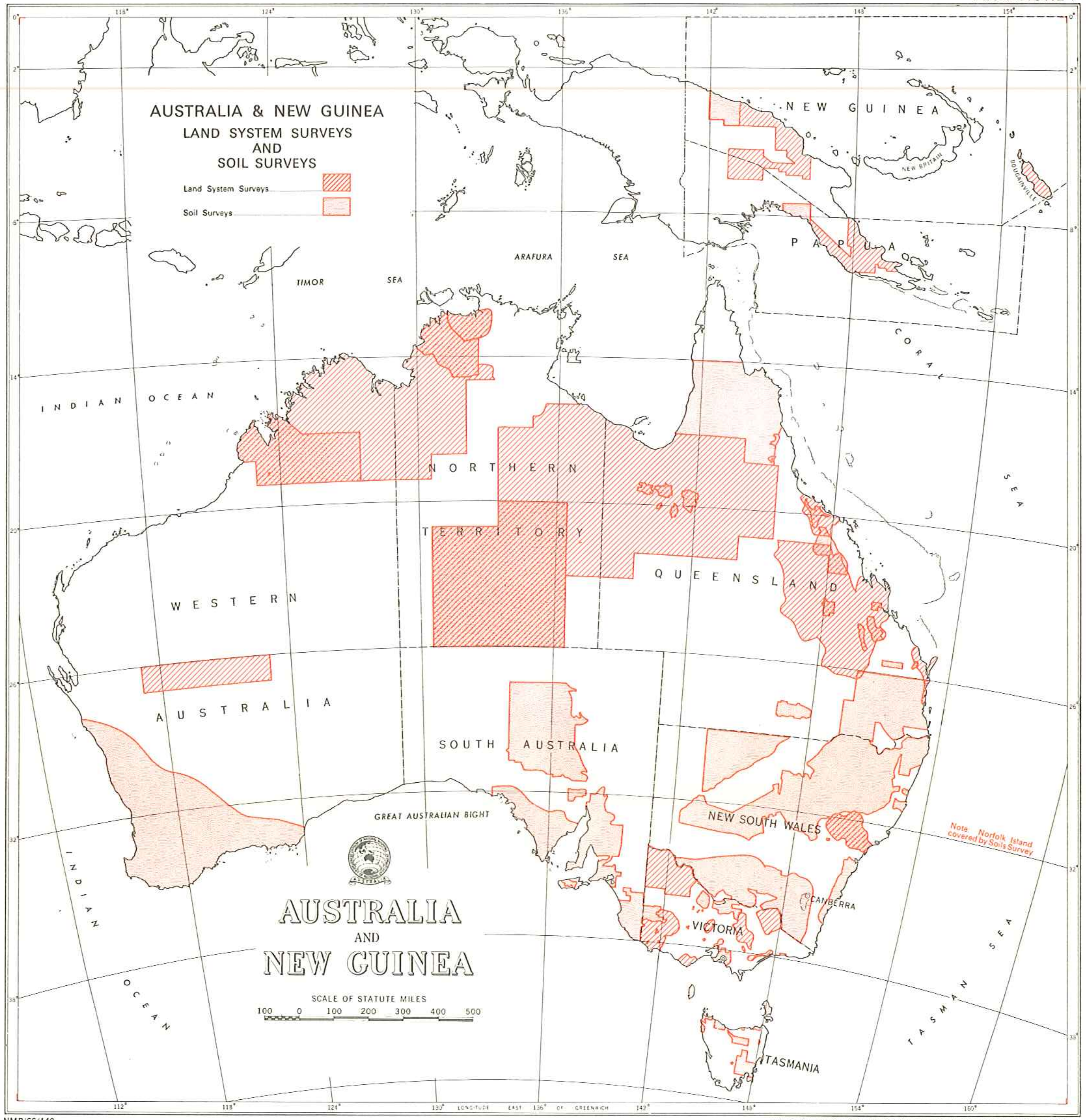
ANNEXURE 7



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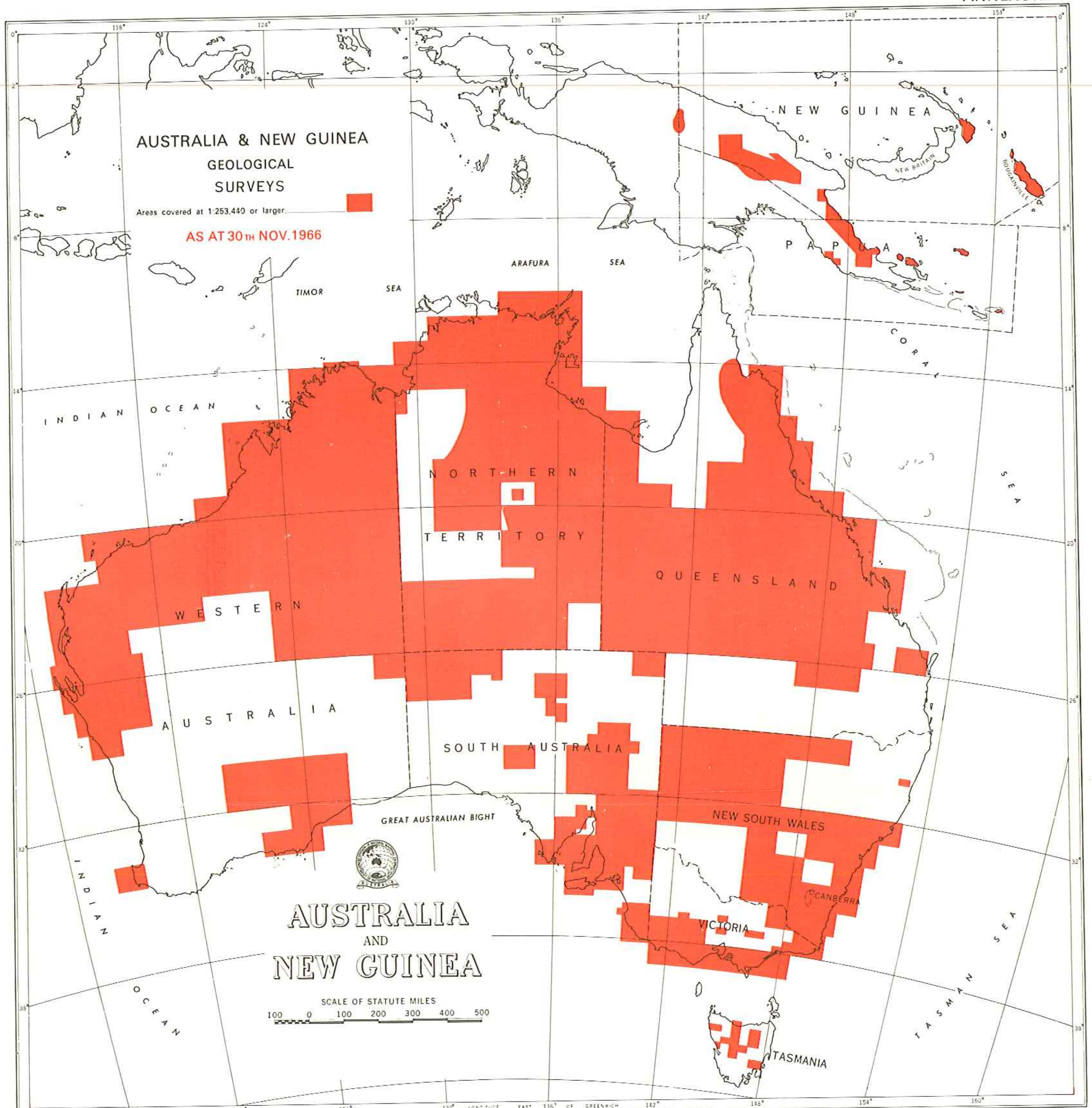
ANNEXURE 6



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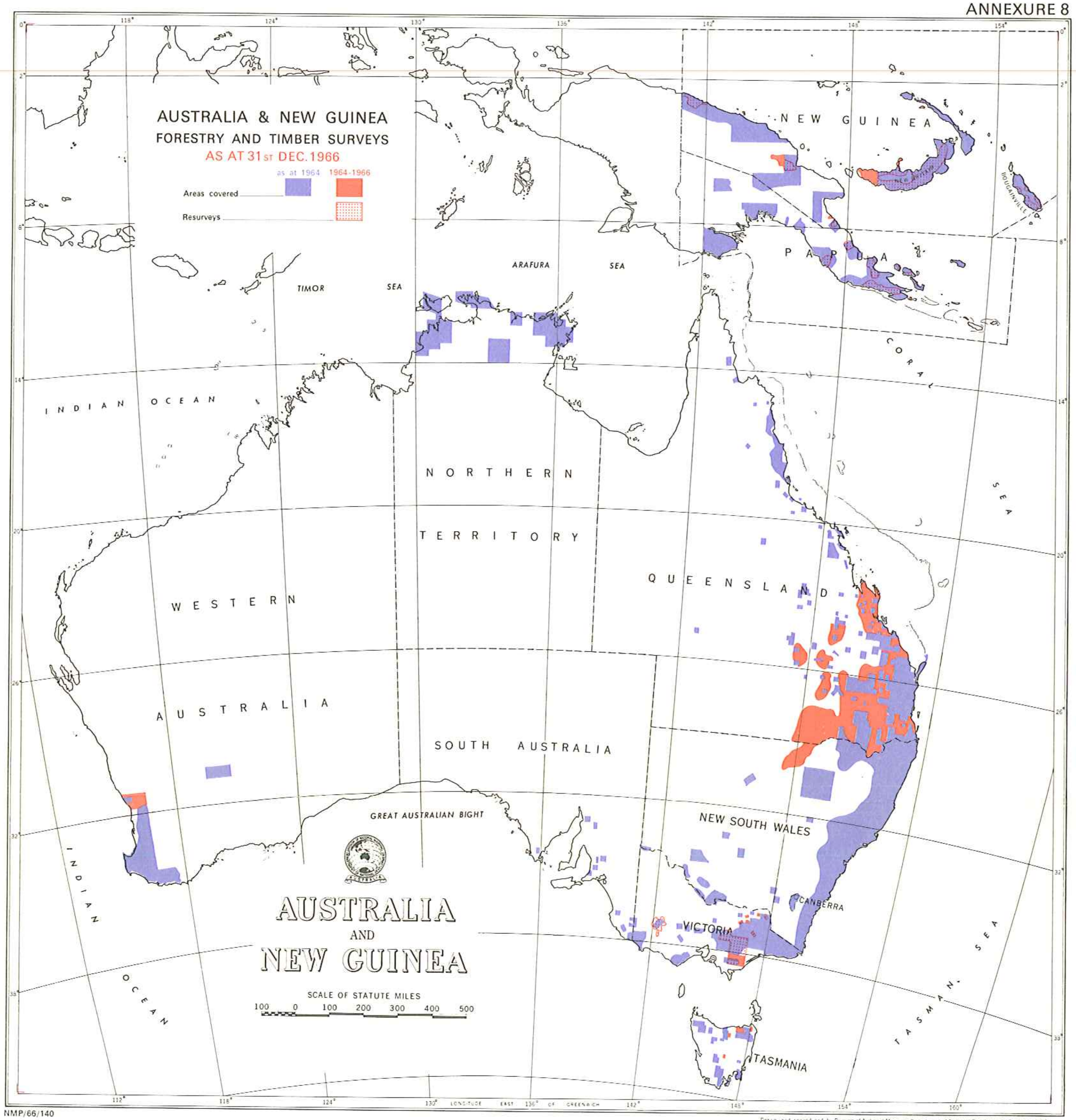

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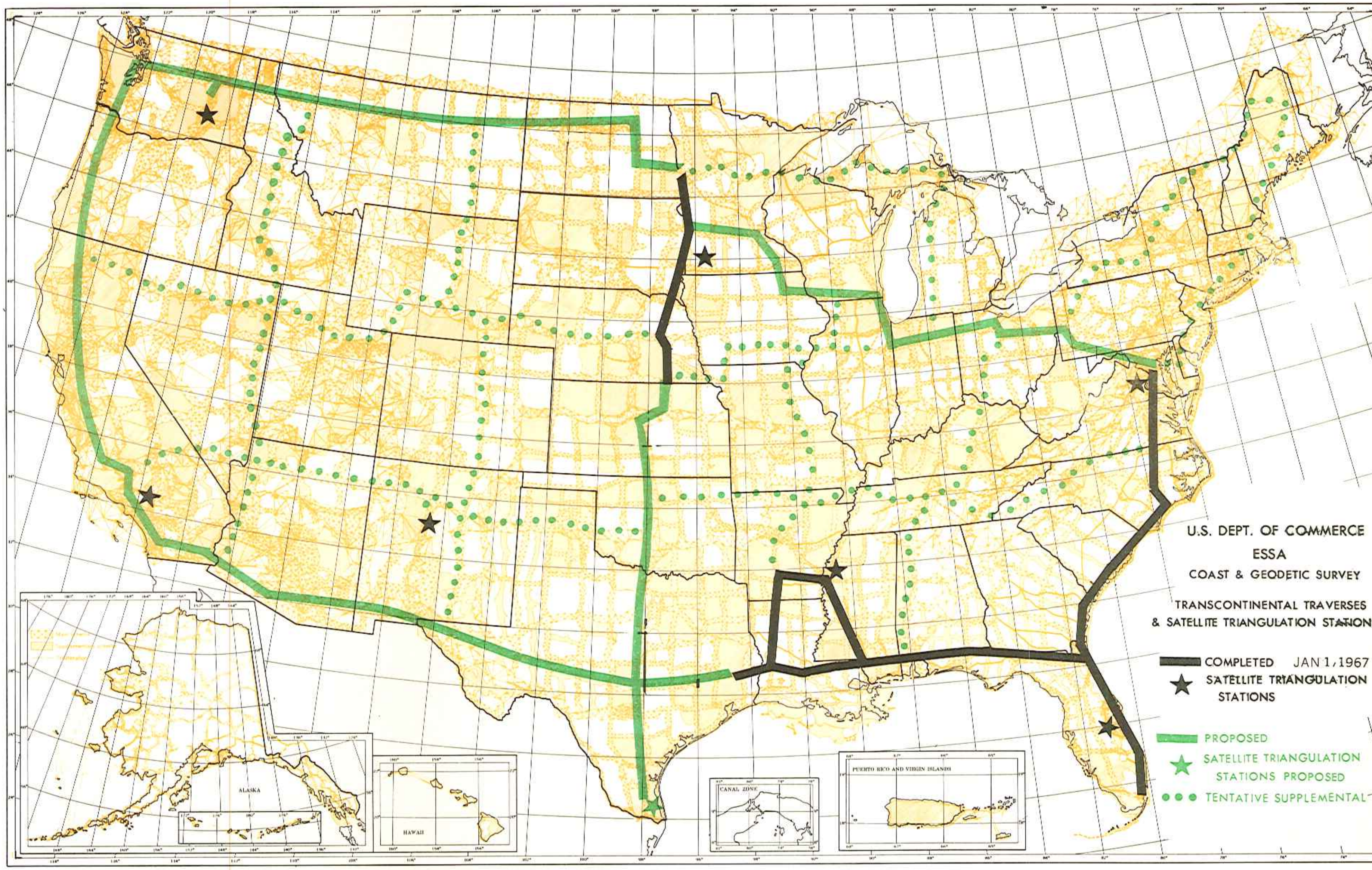
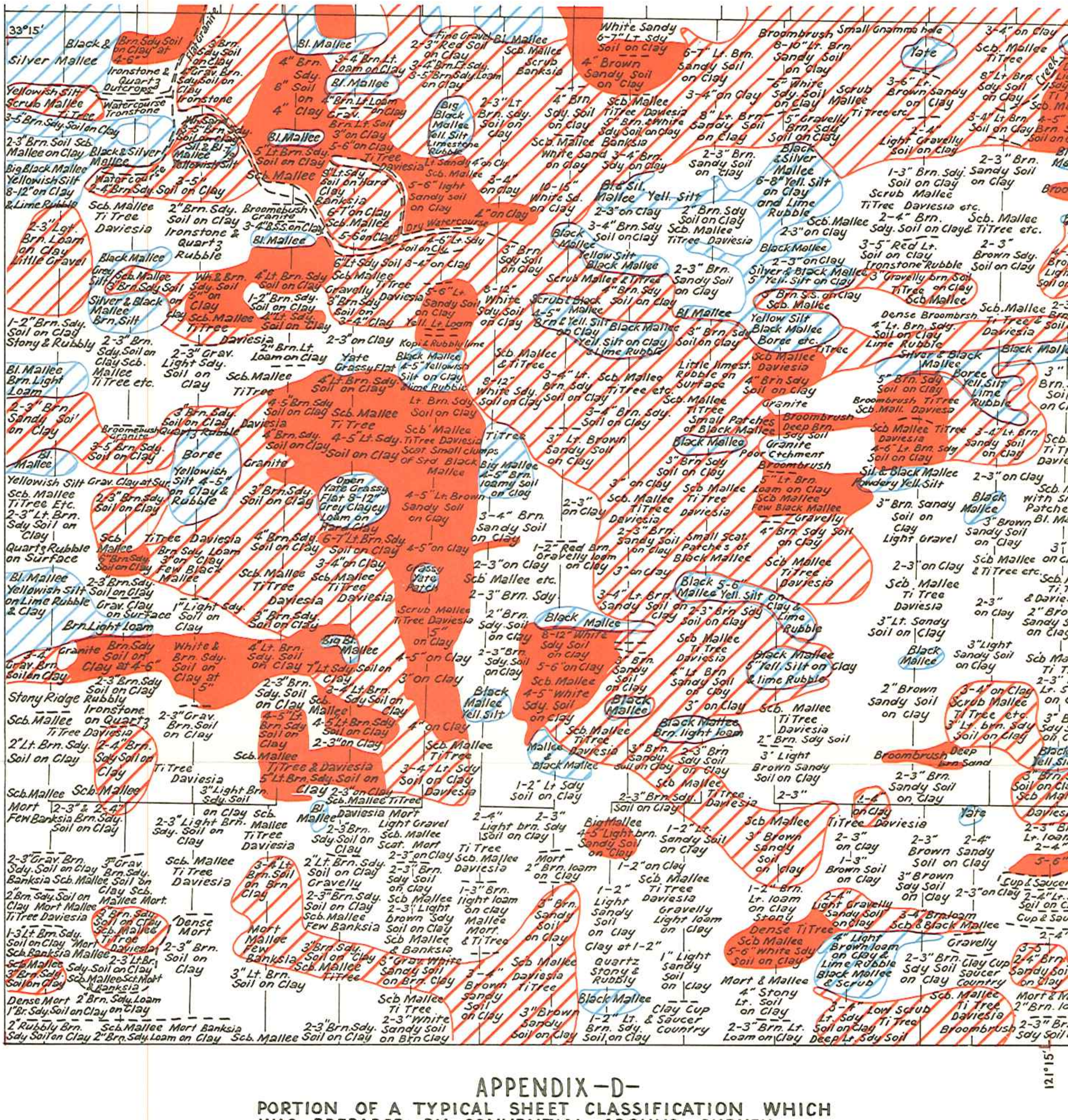

U.S. DEPT. OF COMMERCE
ESSA
COAST & GEODETIC SURVEY
TRANSCONTINENTAL TRAVERSES
& SATELLITE TRIANGULATION STATIONS
COMPLETED JAN 1, 1967
SATELLITE TRIANGULATION
STATIONS
PROPOSED
SATELLITE TRIANGULATION
STATIONS PROPOSED
TENTATIVE SUPPLEMENTAL
ALASKA
HAWAII
CANAL ZONE
PUERTO RICO AND VIRGIN ISLANDS



APPENDIX -D-

PORTION OF A TYPICAL SHEET CLASSIFICATION WHICH WAS PREPARED BY CONVENTIAL GROUND SURVEY METHODS IN THE LATE 1920'S

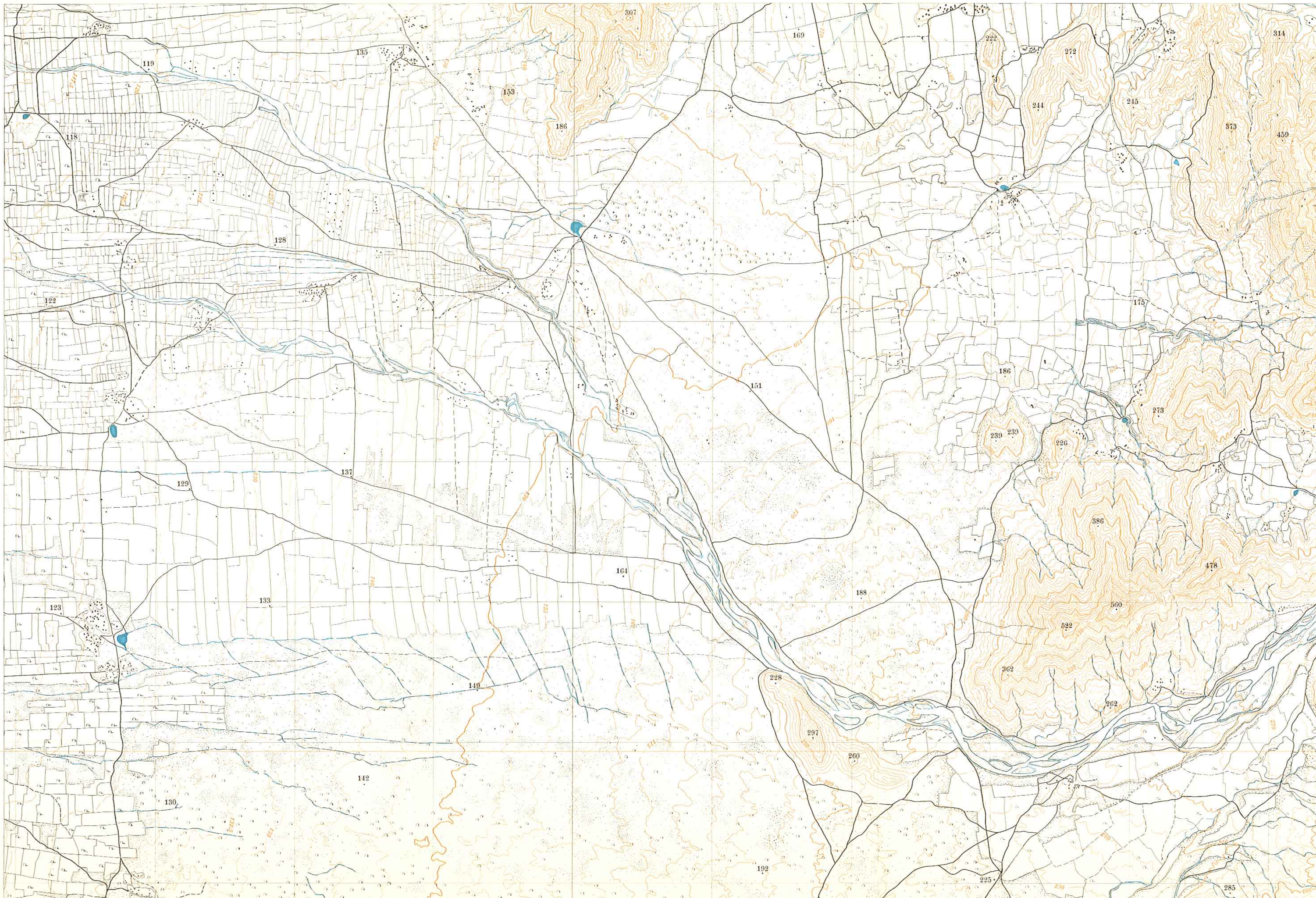
Mallee Country with shallower soils over clay
ie. under 4" or soil poorer

Mallee Country with brown and light coloured sandy soils over 4" deep on brown clay

Black Mallee, Silver Salmon and Yate flats
Yellowish silt over lime rubble on clay

Granite Rockholes, winter supply only

Uncoloured : Clay near surface and sandplains
and other 3rd. class country



307
169
314
222
272
135
119
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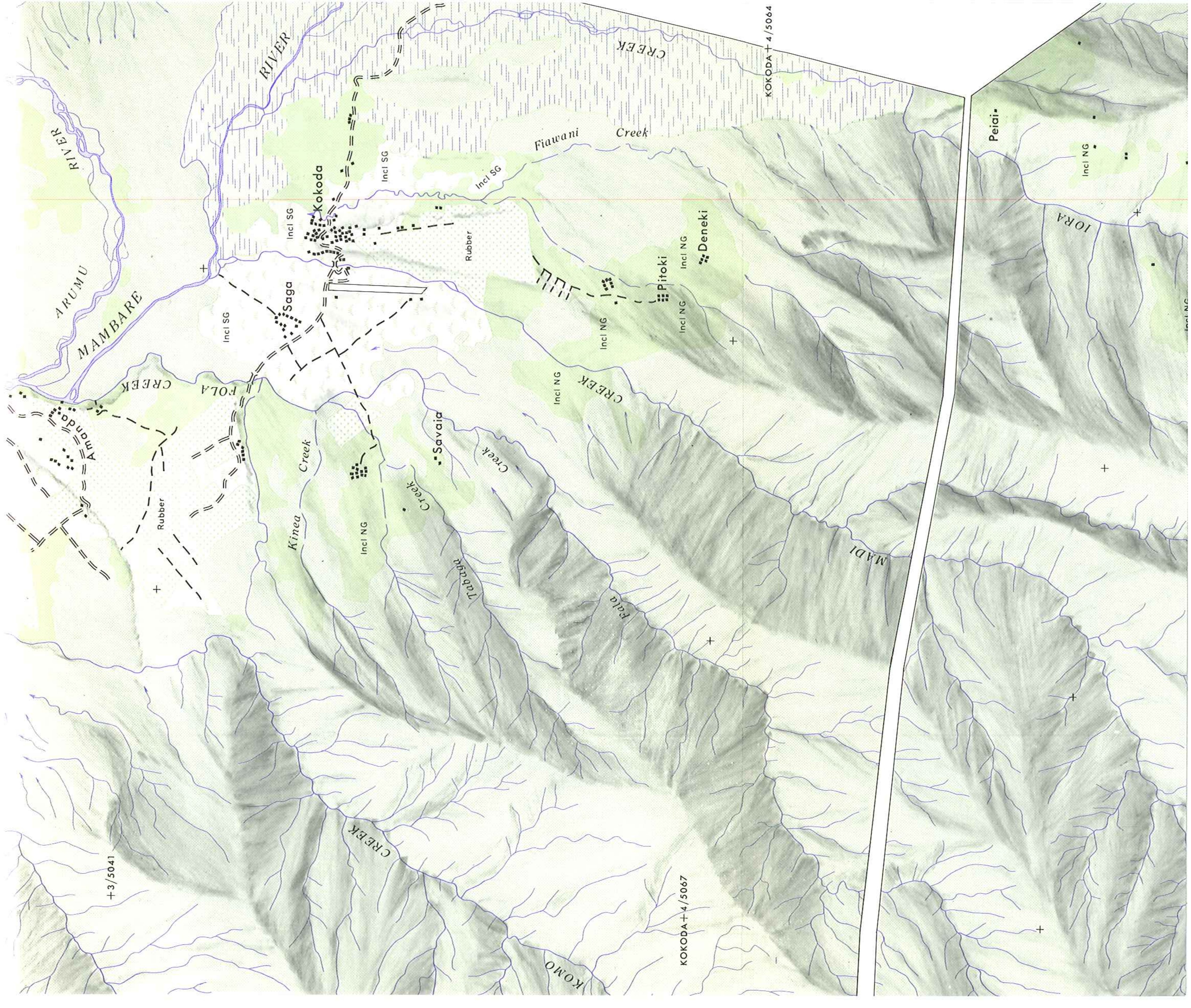
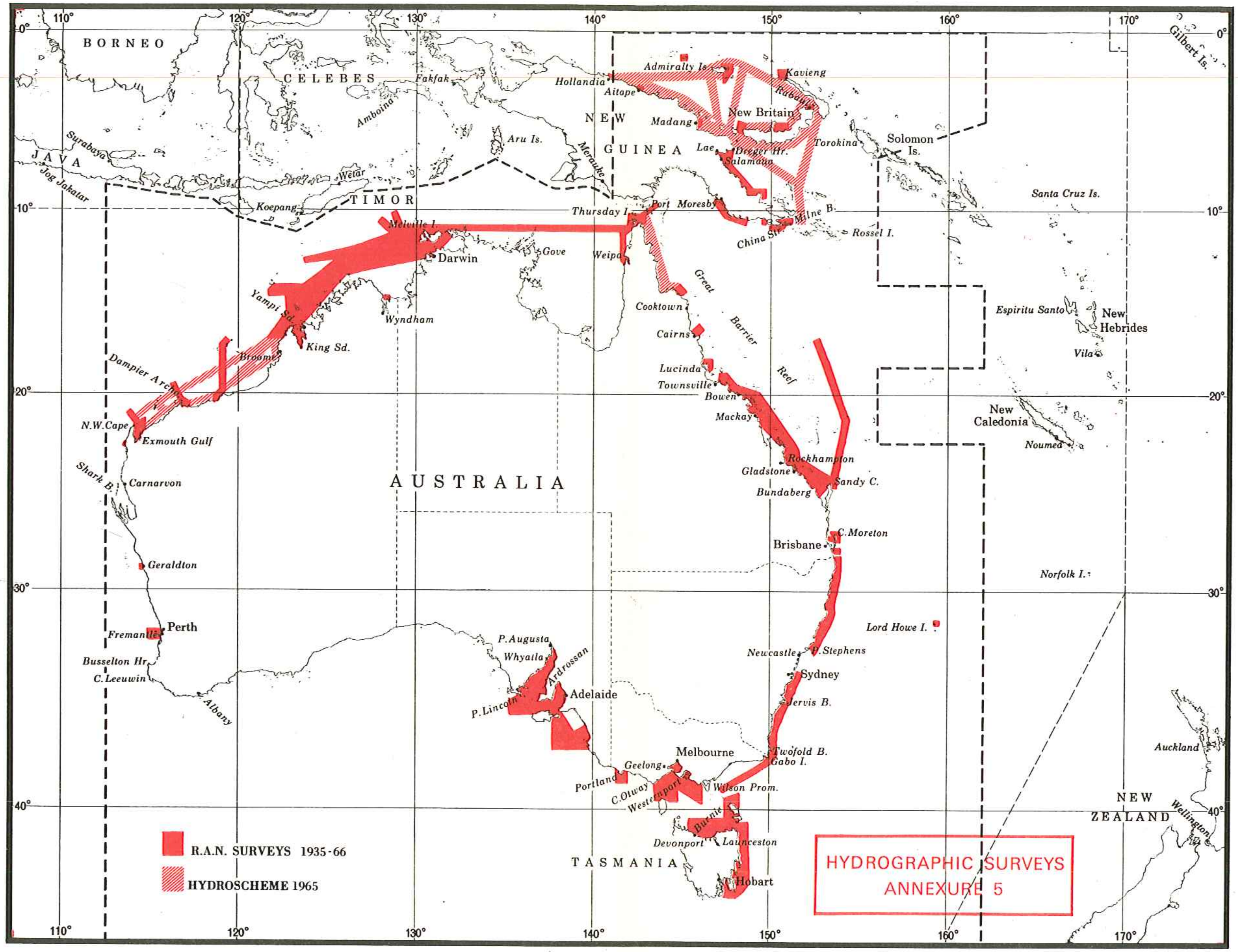
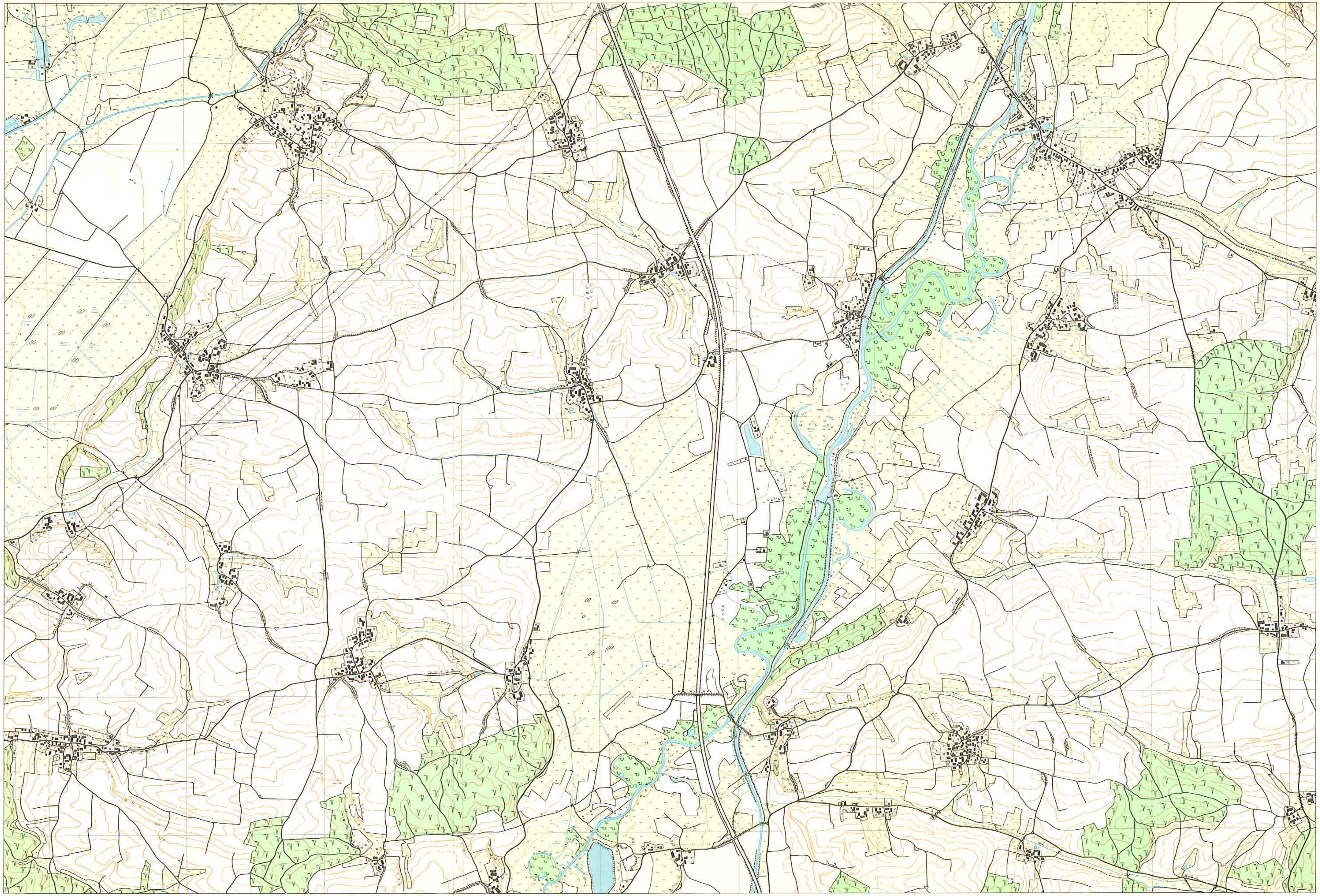


MAMBARE
RIVER
ARUMU
RIVER
CREEK
Fiawani Creek
KOKODA +4/5064
Peiai
Incl NG
IORA
Incl SG
Kokoda
Rubber
Deneki
Pitoki
Saga
FOLA CREEK
Amanda
Savaia
Kinea Creek
Creek
Pala
MADI
KOMO CREEK
+3/5041
KOKODA +4/5067


COBRAM
MT BOOMANOOMANA
COROWA
YARRAWONGA
MURRAY R
ALBURY
WODONGA
Rutherglen
Chiltern
NUMURKAH
SHEPPARTON
WANGARATTA
BEECHWORTH
HUME RESERVOIR
Tallangatta
CORRYONG
MT BURROWA
MT BENAMBRA
MT PINNIBAR
MT GIBBO
MOUNT KOS
BENALLA
HUME
HIGHWAY
Violet Town
EUROA
MT WOMBAT
MT SAMARIA
MYRTLEFORD
Bright
MT BUFFALO
MT BOGONG
Mount Beauty
MT TAWANGA
MT FEATHERTOP
MT HOTHAM
Hotham Heights
Falls Creek
Omeo
OMEO
HWY
MT TAMBO
BLACK MOUNTAIN
GREAT
DIVIDING
RANGE
Mansfield
EILDON RESERVOIR
Alexandra
Eildon
MT BULLER
Mount Buller
MT HOWITT
BARRY MTS
MT COBBLER
THE TWINS
MT PARSLOW
MT TORBRECK
CATHEDRAL RA
MT McDONALD
MT DE GUERARD
MT REYNARD
MT TAMBORITHA
MT WELLINGTON
MT SKENE
MT BIRREGUN
MT DELUSION
MT BALDHEAD
MT ELIZABETH
MT MURRINDAL
MT DAWSON
MT VICTORIA
Swifts Creek
Dargo
MITCHELL R
Buchan
Marysville
HEALESVILLE
MT JULIET
MT DONNA BUANG
LILYDALE
Warburton
Yarra Junction
Upper Yarra Res
MT MATLOCK
Woods Point
MT SELMA
Aberfeldy
Thomson
MT BAW BAW
MT ERICA
BEN CRUACHAN
Walhalla
HEYFIELD
MAFFRA
Stratford
Briagolong
BAIRNSDALE
PRINCES
HIGHWAY
Bruthen
Lakes Entrance
L King
Paynesville
Metung
Kalimna
Swan Reach
TAMBO R
SALE
LAKE WELLINGTON
EAST SALE
Longford
Seaspray
L Denison
Lake Victoria
Rosedale
TRARALGON
LATROBE VALLEY
YALLOURN
MOE
MORWELL
TRAFALGAR
Yarragon
DROUIN
WARRAGUL
Neerim South
BERWICK
Lang Lang
KORUMBURRA
LEONGATHA
Mirboo North
Boolarra
Yinnar
Toongabbie
Glengarry
Tyers
Moondarra
Erica
Noojee
Powelltown
Cockatoo
Gembrook
Merrimans C
Flynn's Creek Upper
Gormandale
Willung South
Carrajung
Won Wron
Darriman
Loch
Poowong
Ruby
Glen Forbes
Bass


AUSTRALIA
NATIONAL LEVELLING SURVEY
As at 31st December 1966
LEGEND
Precision
Third Order
Bench Marks placed
Tide Gauges
114°
120°
126°
132°
138°
144°
150°
156°
108°
12°
16°
20°
24°
28°
32°
36°
40°
Drawn by Division of National Mapping, Department of National Development, Canberra, A.C.T.


BORNEO
CELEBES
JAVA
TIMOR
NEW GUINEA
AUSTRALIA
TASMANIA
NEW ZEALAND
Surabaya
Jog Jakatar
Amboina
Fakfak
Wetar
Koepang
Aru Is.
Merauke
Hollandia
Aitape
Admiralty Is.
Kavieng
Rabaul
New Britain
Madang
Lae
Dreger Hr.
Salamaua
Torokina
Solomon Is.
Port Moresby
Milne B.
China Str.
Rossel I.
Thursday I.
Melville I.
Darwin
Gove
Weipa
Great Barrier Reef
Cooktown
Cairns
Lucinda
Townsville
Bowen
Mackay
Rockhampton
Gladstone
Sandy C.
Bundaberg
C. Moreton
Brisbane
Newcastle
P. Stephens
Sydney
Jervis B.
Twofold B.
Gabo I.
Wilson Prom.
Melbourne
Geelong
Westernport
C. Otway
Portland
Adelaide
Ardrossan
Whyalla
P. Augusta
P. Lincoln
Devonport
Burnie
Launceston
Hobart
Wyndham
Yampi Sd.
King Sd.
Broome
Dampier Arch.
N.W. Cape
Exmouth Gulf
Shark B.
Carnarvon
Geraldton
Perth
Fremantle
Busselton Hr.
C. Leeuwin
Albany
Santa Cruz Is.
Espiritu Santo
New Hebrides
Vila
New Caledonia
Noumea
Norfolk I.
Lord Howe I.
Auckland
Wellington
Gilbert Is.
110°
120°
130°
140°
150°
160°
170°
0°
10°
20°
30°
40°
R.A.N. SURVEYS 1935-66
HYDROSCHEME 1965
HYDROGRAPHIC SURVEYS
ANNEXURE 5



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