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

Tokyo, 15–27 October 1973

Vol. II. Technical papers

UNITED NATIONS

Department of Economic and Social Affairs

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

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UNITED NATIONS
New York, 1976

NOTE

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FOREWORD

The official records of the Seventh United Nations Regional Cartographic Conference for Asia and the Far East, held in Tokyo, Japan, from 15 to 27 October 1973, are issued, as were those of the previous conferences in two volumes: volume I, *Report of the Conference*;[1] and the present publication, volume II, *Technical papers*, which contains the texts of the technical background 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 designation 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.

The official records of the previous United Nations Regional Cartographic Conferences for Asia and the Far East have been published as E/CONF.18/6 (Sales No. 55.I.29) and E/CONF.18/7 (Sales No: 56.I.23) for the First Conference; E/CONF.25/3 (Sales No. 59.I.9) and E/CONF.25/4 (Sales No. 61.I.8) for the Second Conference; E/CONF.36/2 (Sales No. 62.I.14) and E/CONF.36/3 (Sales No. 64.I.17) for the Third Conference; E/CONF.50/4 (Sales No. 65.I.16) and E/CONF.50/5 (Sales No. 66.I.3) for the Fourth Conference: E/CONF.52/4 (Sales No. E.68.I.2) and E/CONF.52/5 (Sales No. E.68.I.14) for the Fifth Conference; E/CONF.57/2 (Sales No. E.71.I.15) and E/CONF.57/3 (Sales No. E.72.I.20) for the Sixth Conference.

[1] *Seventh United Nations Regional Cartographic Conference for Asia and the Far East*, Vol. I, *Report of the Conference* (United Nations publication, Sales No. E.74.I.7).

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TECHNICAL PAPERS
PRESENTED TO THE CONFERENCE

AGENDA ITEM 6

Country reports and progress made in cartography, by countries, in matters that formed the basis of the resolutions of the last Conference

CARTOGRAPHIC ACTIVITIES IN AUSTRALIA, 1970–1973*

Paper presented by Australia

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 federal and state agencies, the chief contributors being: Department of Minerals and Energy; Department of the Army; Department of the Navy; Commonwealth Scientific and Industrial Research Organisation (CSIRO); Department of Services and Property; state Departments of Lands; state Departments of Mines and Forests.

Co-ordination of geodetic surveys and topographic mapping is effected through the National Mapping Council, on which federal and state mapping agencies are represented.

Agencies from which additional information may be obtained are listed in the annex to this paper.

GEODETIC SURVEY

The extent of the geodetic survey of Australia as at the end of 1972 is shown in figures 1 and 2. During the period from 1 January 1970 to 31 December 1972, the major achievements were:

(*a*) Completion of the precision survey of two long baselines, reported in "Two Australian baselines for the Pageos world triangulation", technical report 11, Division of National Mapping;

(*b*) Determination of the geoid in Australia in relation to the Australian geodetic datum, reported in "The geoid in Australia—1971", technical report 13, Division of National Mapping;

(*c*) Adjustment of the Australian levelling survey resulting in the establishment of the Australian height datum, reported in "The adjustment of the Australian levelling survey 1970–1971", technical report 12, Division of National Mapping;

(*d*) Adjustment of some 1,400 additional levelling sections containing over 45,000 bench-marks in terms of the Australian height datum;

(*e*) Adjustment of trigonometrical heights of about 10,000 horizontal control stations in terms of the Australian height datum;

(*f*) Establishment of 340 Aerodist stations and measurement of 1,860 lines in Australia and Papua New Guinea.

AERIAL PHOTOGRAPHY

Australia

Aerial photography in Australia is usually undertaken by federal and state authorities for their own mapping purposes. Most state photography is at medium scale and large-scale photography is flown for special projects. Many states are now flying large-scale colour photography, and the federal authorities are producing 1:25,000 scale colour photography for the Bureau of Mineral Resources, Geology and Geophysics. Current aerial photography coverage of Australia is shown in figure 3.

In 1972, 500 km of the east coast were photographed with infra-red at low tide and over 1,500 km of the north-west coast were photographed at high tide. Surveys of this nature provide information for the delineation of the low-water and high-water marks for mapping purposes.

New Guinea

Aerial photography of the New Guinea mainland is about 90 per cent complete (see figures 4 and 5). Progress in the mountainous areas is continuously hindered by clouds.

TOPOGRAPHIC MAP COVERAGE

Federal programme of 1:250,000 mapping

The existing series of mapping on the scale 1:250,000, which was completed in 1968, is being maintained on a partial revision basis, with revision being effected as the necessity arises for reprinting to preserve adequate stocks for public sale. This policy will be pursued until the new full specification series is progressively produced from fully field completed compilations of the series at 1:100,000 scale.

With the production emphasis on the current 1:100,000 programme, no new map in this series has yet been published, although production will commence late in 1973. The specifications are complete, and this series will generally conform to the presentation of the published series at 1:100,000 scale, with suitable variations to accommodate the change in scale.

*The original text of this paper, prepared by the Division of National Mapping, Department of Minerals and Energy, Canberra, appeared as document E/CONF.62/L.35 and Add.1

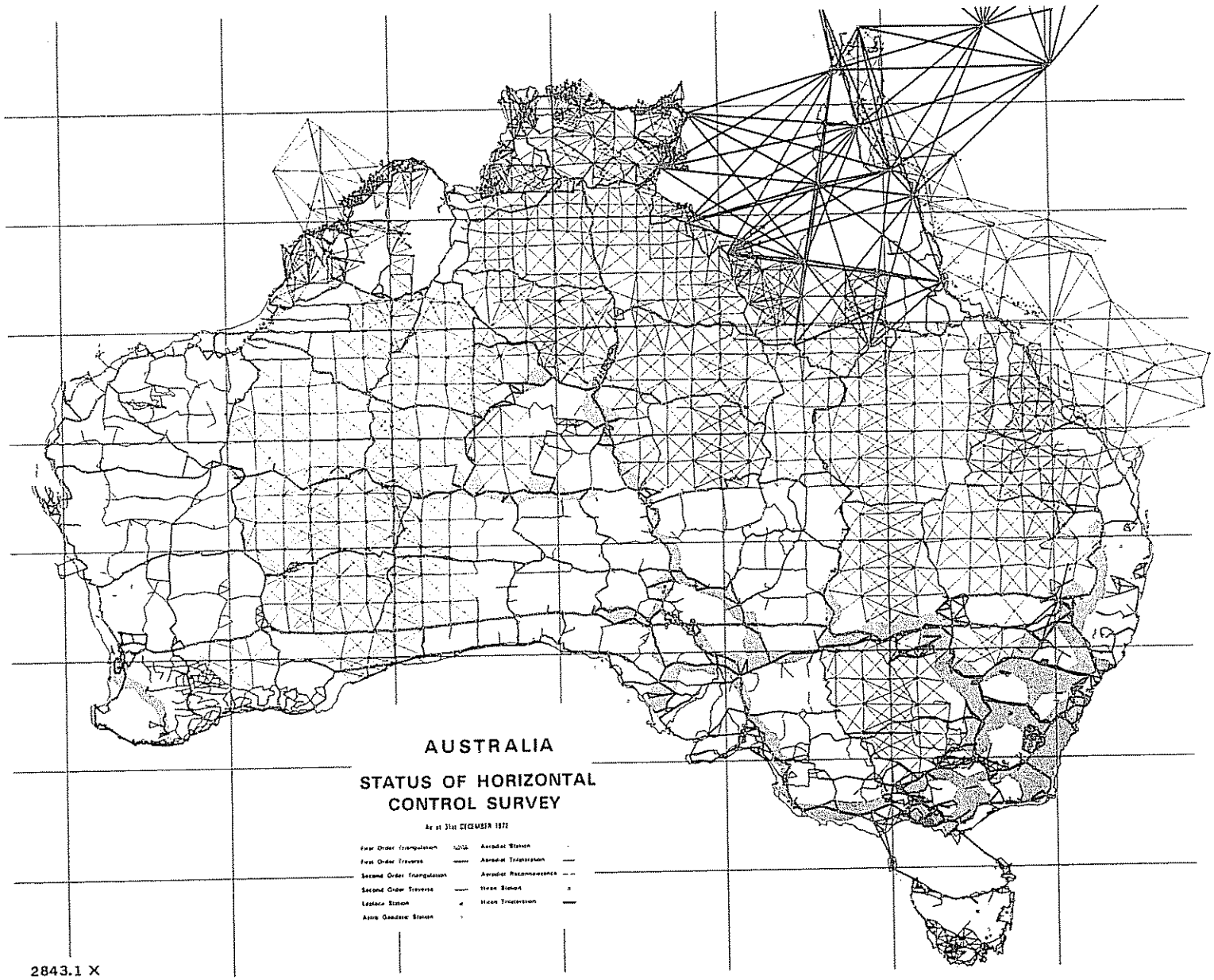


Figure 1. Australia: status of horizontal control survey as at 31 December 1972

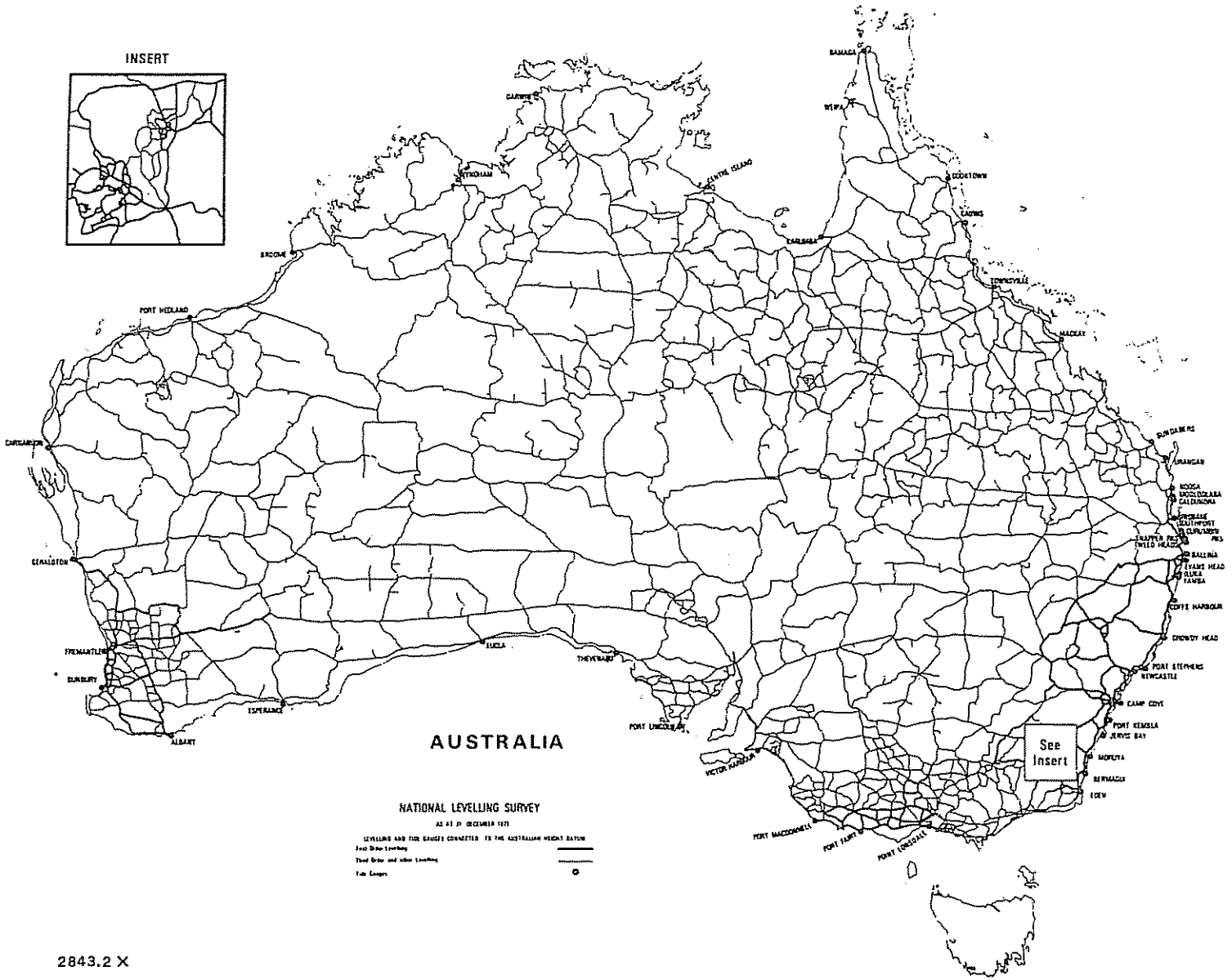


Figure 2. Australia: national levelling survey as at 31 December 1972

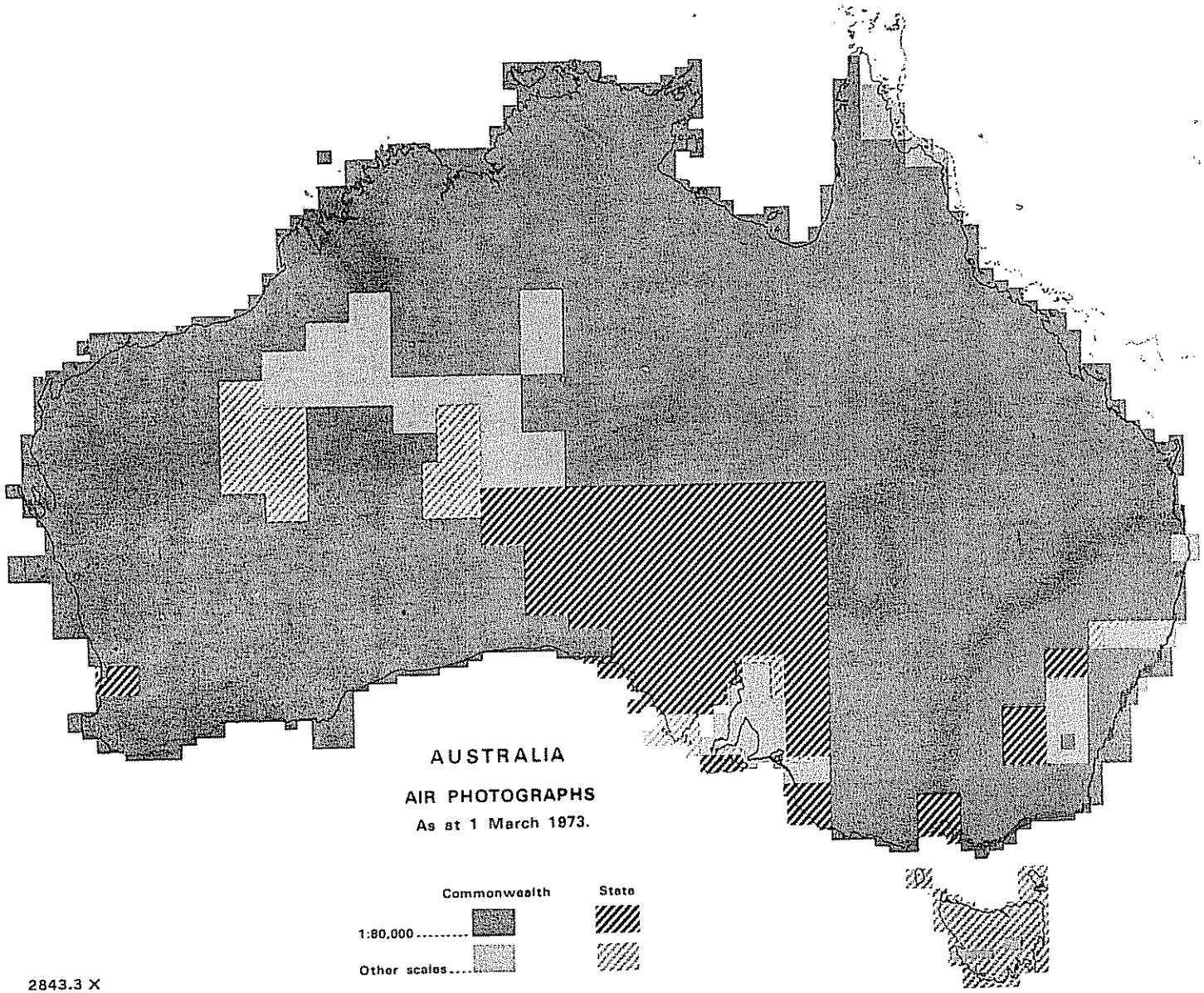


Figure 3. Australia: aerial photography as at 1 March 1973

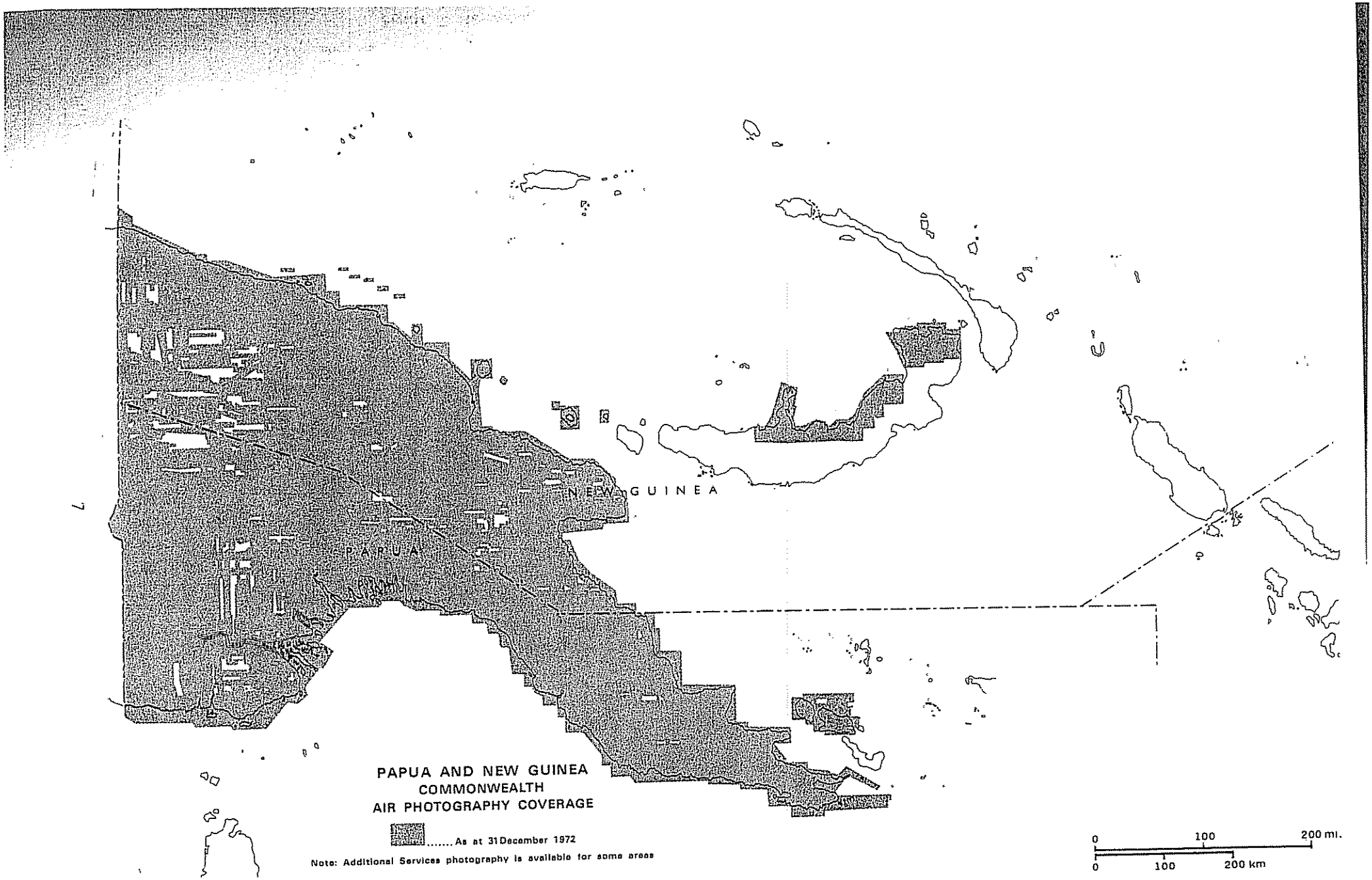
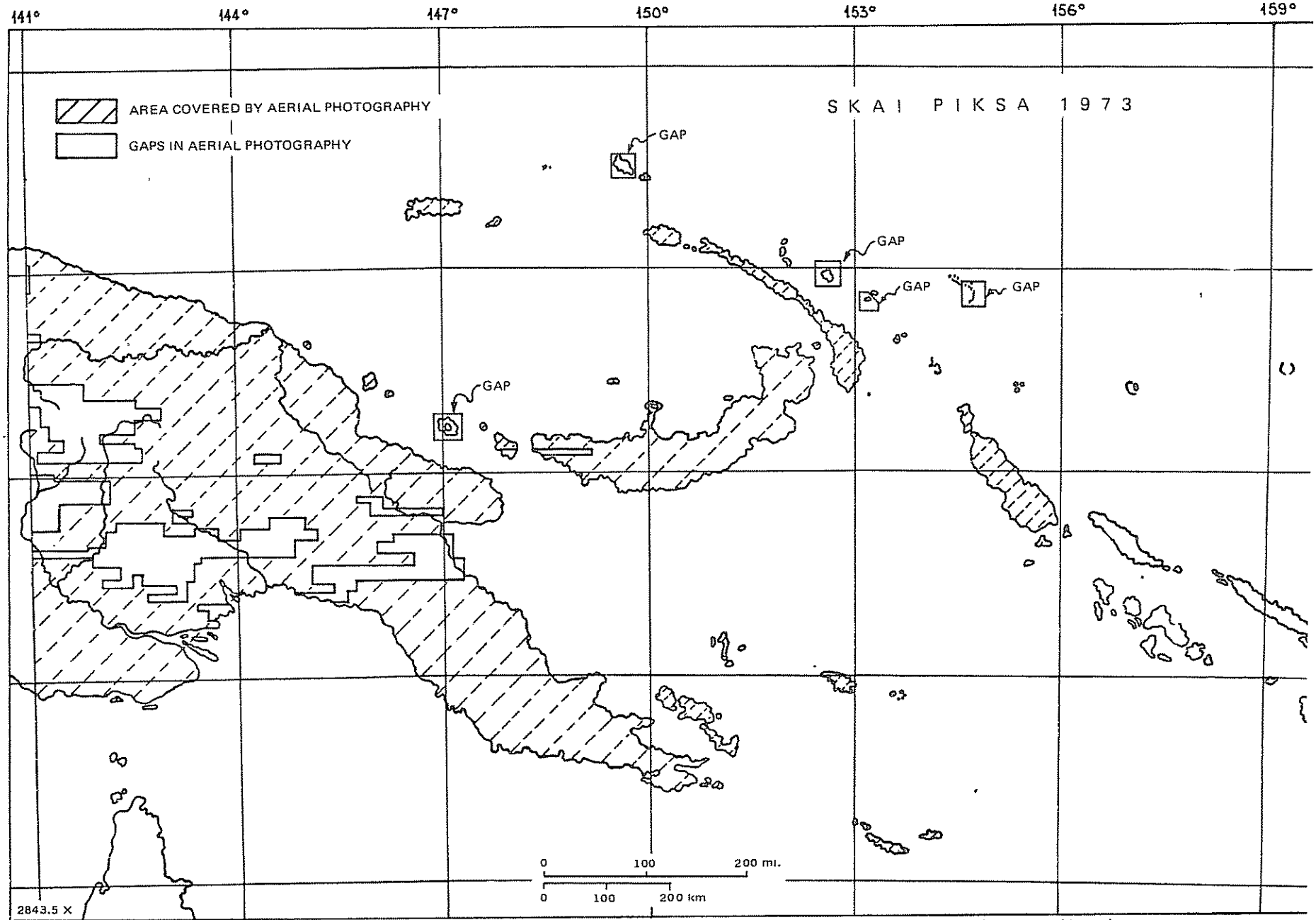


Figure 4. Australia: aerial photography coverage of Papua New Guinea as at 31 December 1972



Task: 26,000 line miles, approximately 200,000 square miles.

Obtained: 89 per cent, all classifications; "X" class, 60 per cent, less than 2 per cent cloud cover; "Y" class, 19 per cent, more than 2 per cent and less than 15 per cent cloud cover; "Z" class, 10 per cent, more than 15 per cent cloud cover.

Aircraft: Canberra (modified). One aircraft was used from 1 April to 1 July; two from 2 July to 14 September; one from 7 September to 14 September. Successful sorties constituted 70 per cent of effort.

Photography data: A Wild RC10 camera with a super-wide-angle lens cone (f = 88 mm) was used. Flight line interval was 9.5 statute miles; flight altitude (AMSL), 30,000 ft (9,144 m) for terrain elevations up to 6,000 ft (1,829 m) and 36,000 ft (10,973 m) for terrain elevation greater than 6,000 ft (1,829 m); flight direction, generally east-west. Scales were 1:83,000–1:104,000 within each altitude band; smallest scale used, about 1:125,000. Forward overlap was 80 per cent between exposure; side overlap, 15–40 per cent.

Federal programme of 1:100,000 mapping

The basic data acquisition for the series of mapping on the scale 1:100,000 is well advanced with super-wide-angle aerial photography coverage at 93 per cent of total requirement, and field surveys being about 80 per cent completed.

It is intended to publish only 50 per cent of the national coverage at 1:100,000 scale, with the balance in the inland areas being compiled at 1:100,000, but published at 1:250,000 scale.

About 350 maps have been published at 1:100,000 scale, and compilation work is in hand for about 900 sheets.

Considerable progress has been made with the use of orthophoto mapping with separate contour overlays at 1:100,000 scale. These bases and overlays provide ready interim coverage of inland areas, and for subsequent processing into conventional line-map compilation material.

In addition to the national mapping programme, the Department of the Army publishes topographic maps of selected areas of Australia on the scales 1:50,000, 1:25,000 and 1:10,000.

Progress of topographic mapping at 1:100,000 scale, of the line map series and the orthophoto map series, is shown in figures 6 and 7, respectively, with figure 8 showing the progress of 1:50,000 and larger scale mapping.

Mapping activities of the Australian states

Each Australian state has its own mapping authority to produce general topographic map coverage of its territory and to undertake mapping required for specific administrative and developmental projects. The work is carried out within the Lands and Survey Departments under the control of each state Surveyor General.

Federal and state mapping agencies, through the National Mapping Council of Australia, meet annually to co-ordinate and correlate surveys and mapping on a national basis and to determine approved methods and standards of accuracy for the national geodetic and levelling surveys and topographic activities. All states actively participate in the national 1:100,000 scale map-

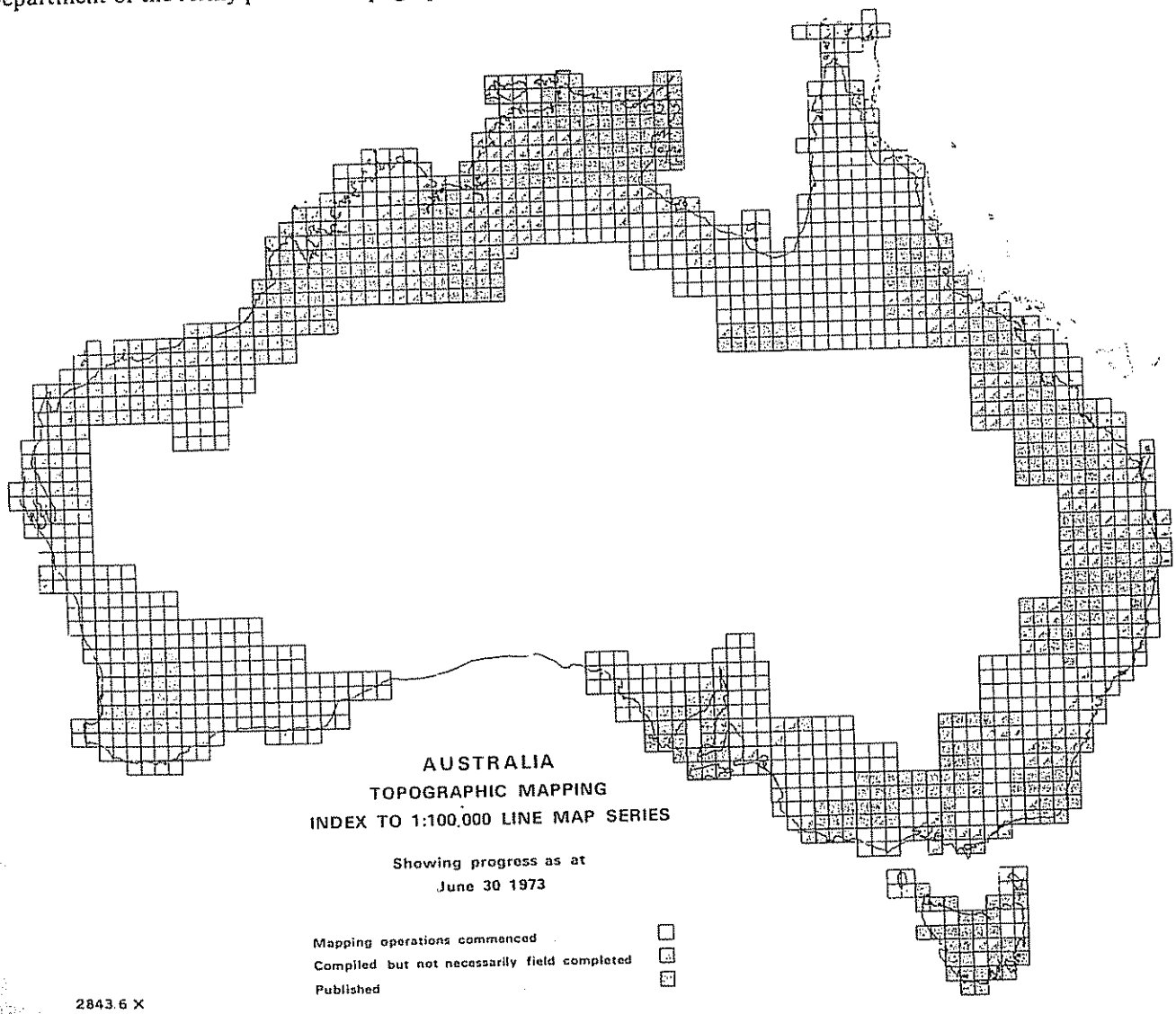


Figure 6. Australia: topographic mapping index to 1:100,000 line map series

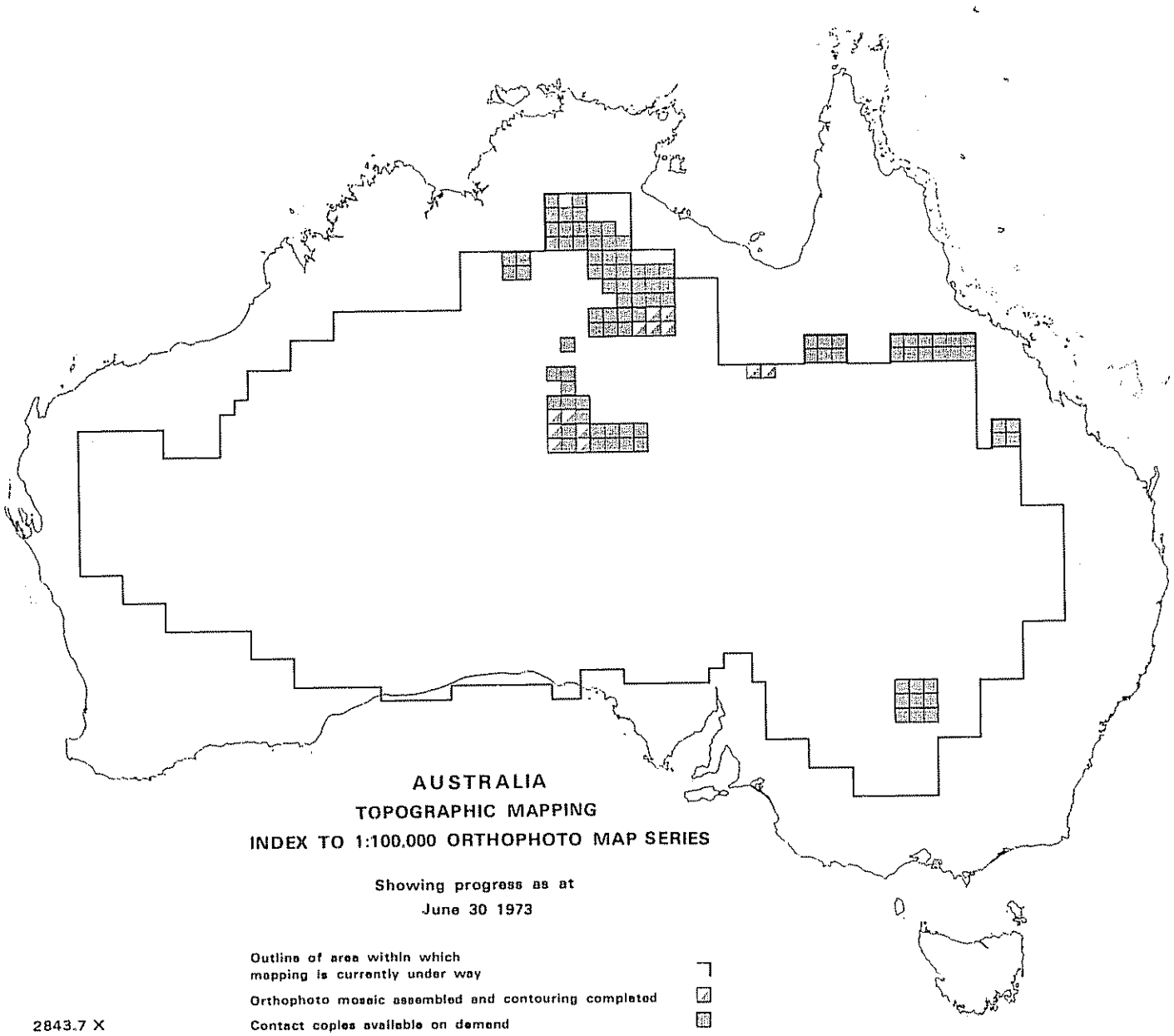


Figure 7. Australia: topographic mapping index to 1:100,000 orthophoto map series

ping programme, with Tasmania bearing responsibility for the complete coverage of that state at 1:100,000 scale.

With the general adoption of the Australian map grid for topographic mapping resources, state mapping agencies have now generally adopted scales of 1:100,000, 1:50,000 and 1:25,000, and this grid, for topographic mapping and cadastral mapping in rural areas. In some cases, the cadastral pattern is overprinted on the topographic base. The total conversion of existing mapping at "inch" scales will be a long-term programme.

A specification for mapping at 1:50,000 or 1:25,000 scale is being finalized by the National Mapping Council, for general adoption throughout Australia.

Other scales between 1:1,250 and 1:10,000 are being used for administrative and general-purpose mapping of urban areas. These maps are generally, but not wholly, in terms of the Australian map grid. Other grids, based on local meridians and having narrow zones, but still retaining other features of the Australian map grid, are being used in some instances as a basis for survey integration in highly developed areas.

Most state mapping authorities, in addition to the Commonwealth mapping agencies, now have orthophoto mapping facilities with a wide variety of equipment, as shown in the table given below. State mapping authorities are generally using these equipments to produce orthophoto maps with cadastral overlays and contours on scales varying from 1:2,000 to 1:4,000. These mapping products have been well received, and it is the intention progressively to pursue coverage of this nature over all urban areas.

Geological and geophysical surveys

Geological mapping

Geological mapping on the scale 1:250,000 has been carried out by the Federal Bureau of Mineral Resources and the state geological surveys over the areas of the

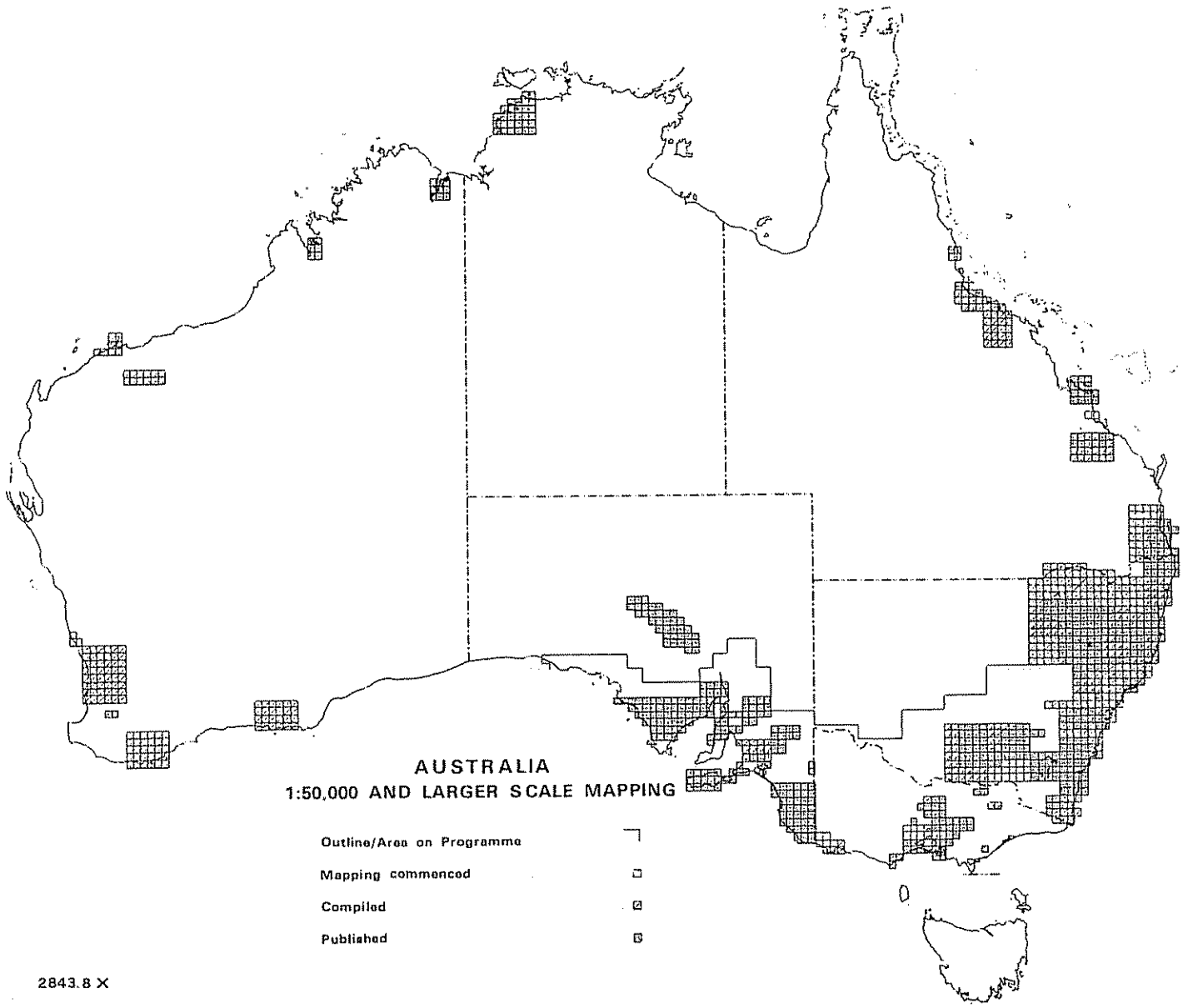


Figure 8. Australia: mapping at 1:50,000 and larger scales

Australian continent and Papua New Guinea shown in figure 9.

Aerial photographs are used to prepare photogeological maps before the field-work. These photographs are also used for location and initial plotting of geological observations in the field. The final map is compiled on controlled planimetric base maps.

Encouraging results have been obtained from the use of colour photography in some geological environments.

Magnetic surveys

Three first-order stations were occupied to finish the First-order Survey Epoch 1970.0, and a complete set of isomagnetic maps was drawn. Third-order observations were made at over 2,000 stations covering two thirds of mainland Australia. Charts for the survey areas and a comprehensive chart for eastern Australia were drawn. Some follow-up observations (at 350 stations) were made in eastern Australia in connexion with the absolute aeromagnetic map of Australia.

Reconnaissance magnetic surveys have been made in Australia and Papua New Guinea over the areas shown in figure 10. Much of the work has been done by the Bureau of Mineral Resources, using contractors where appropriate.

Over the land masses and coastal areas, aircraft are flown between 150 and 600 m above ground level and at a line spacing from 1.5 to 3 km. Navigation is mainly by aerial photography, but a Doppler system is currently in use. The strength of the earth's magnetic field and navigational data are continuously recorded in analogue and digital form.

The results of the magnetic surveys are reduced, plotted and contoured by computers and presented as magnetic profiles and contours on controlled planimetric base maps.

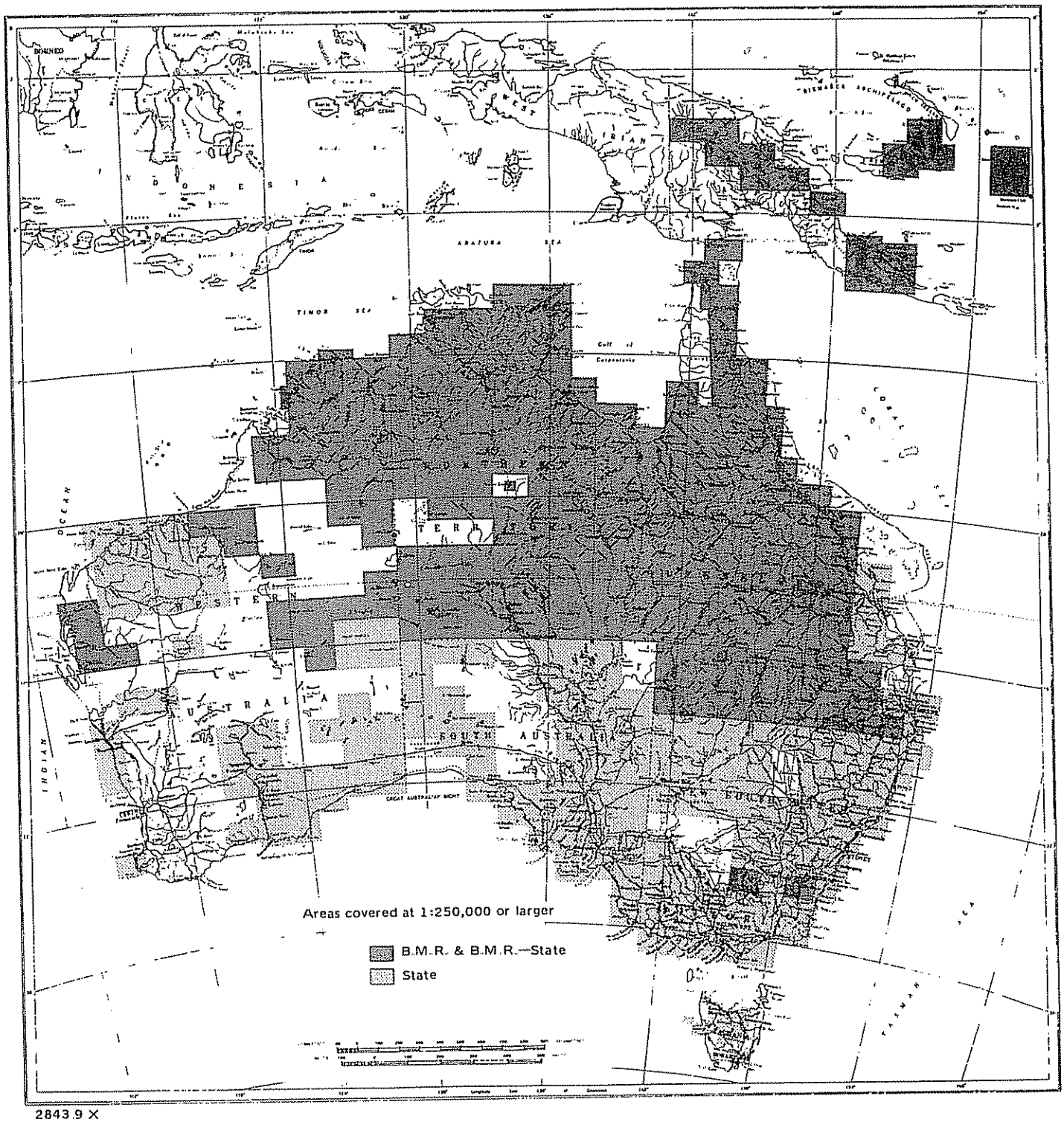


Figure 9 Australia: geological surveys as at 1 March 1973

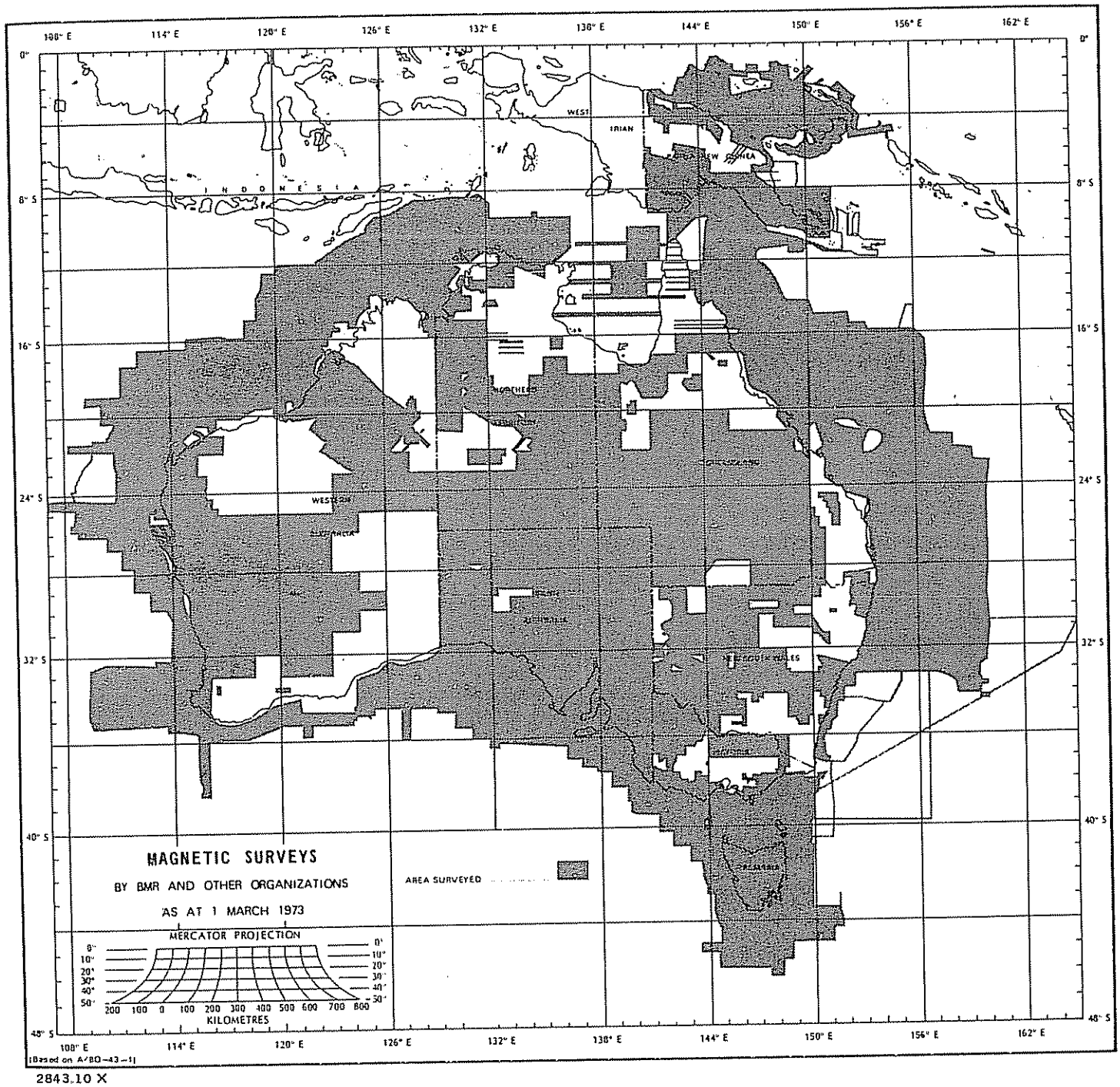


Figure 10. Australia: magnetic surveys as at 1 March 1973

Details of activity in orthophoto mapping

Organization	*Equipment*	*Output*	*Remarks*
Division of National Mapping	3 Wild B8 stereomats and computer-processed contouring from digital terrain models	*For rugged terrain:* 1:100,000 scale OPM × 20-m contours	Copies usually available as dye-line prints from half-tone negative. At first, photo map and contours are made available, and, subsequently, planimetric and stream details are accentuated in white
	2 Zeiss (Jena) topocarts, direct contouring on these stereoplotters	*For medium terrain:* 1:100,000 scale OPM × 20-m contours	
	1 Zeiss (Oberkochen) rectifier, separate contouring on conventional equipment	*For flat terrain:* 1:100,000 scale OPM × 20-m contours	
Royal Australian Survey Corps	2 Gigas Zeiss (GZI) planimat/orthoprojectors	1:25,000 OPM in colour and in black and white	Photo scale 1:68,000 with larger scale photography for contouring
	1 AP/C—OPC	OPM is lithoprinted	Work is experimental at this stage
New South Wales, Department of Lands	2 Zeiss (Jena) topocarts 7 Wild B8 stereoplotters	*Primary programme:* 1:4,000 scale OPM × 2-m contours from conventional stereoplotters	Photo scale 1:16,000
		1:2,000 scale OPM × 1-m contours from conventional stereoplotters	Photo scale 1:8,000
		1:10,000 scale OPM × 1-m stereoplotters as special project	Photo scale 1:32,000 for OPM and 1:8,000 for contouring Copies normally available as dye-line prints from half-tone negatives
Western Australia, Department of Lands	1 Gigas Zeiss (GZI) orthoprojector	*Primary programme:* 1:5,000 OPM of metropolitan area with 5-m contour, interval derived from drop-line charts, 2-m contours by manual plot	Photo scale 1:16,000
		1:25,000 scale OPM × 10-m contours by drop line	Photo scale 1:86,000 superwide
		1:10,000 scale OPM × 10-m drop-line interval	Photo scale 1:30,000 wide-angle
		1:2,000 scale, 1-m contours	Photo scale 1:3,750
Victoria, Department of Lands	1 Matra SFOM 9300 Wild A6, B8 plotters	1:10,000 scale OPM with 10-m and 20-m contours	Primary programme
		1:5,000 scale OPM with 2-m and 5-m contours, from conventional plotters	Experimental only
		1:20,000 scale OPM	Special project
South Australia, Department of Lands	1 Gigas Zeiss (GZI)	1:2,500 scale OPM contoured	Experimental printing on art paper
		1:10,000 scale OPM contoured	Colours used are black/white and sepia/blue/white
Department of Services and Property	1 Gigas Zeiss (GZI) 1 planimat	1:2,500 scale OPM contoured 1:10,000 scale OPM	Experimental only

Gravity surveys

Regional gravity surveys have been carried out in Australia and Papua New Guinea over the areas shown in figure 11. Most of this work has been done by the Bureau of Mineral Resources, much of it under contract.

Over land areas, helicopters are used for transport between ground stations where gravity and barometric elevation are read mainly on an approximate 11-km grid. Aerial photographs are used for positioning. Elevation control is surveyed on ground traverses about 80 km apart. Gravity control is obtained from a national network of stations on a 250-km grid.

The results of the gravity surveys are reduced by the use of computers. Those over the land and the off-shore results over the Bonaparte Gulf and the Timor Sea have

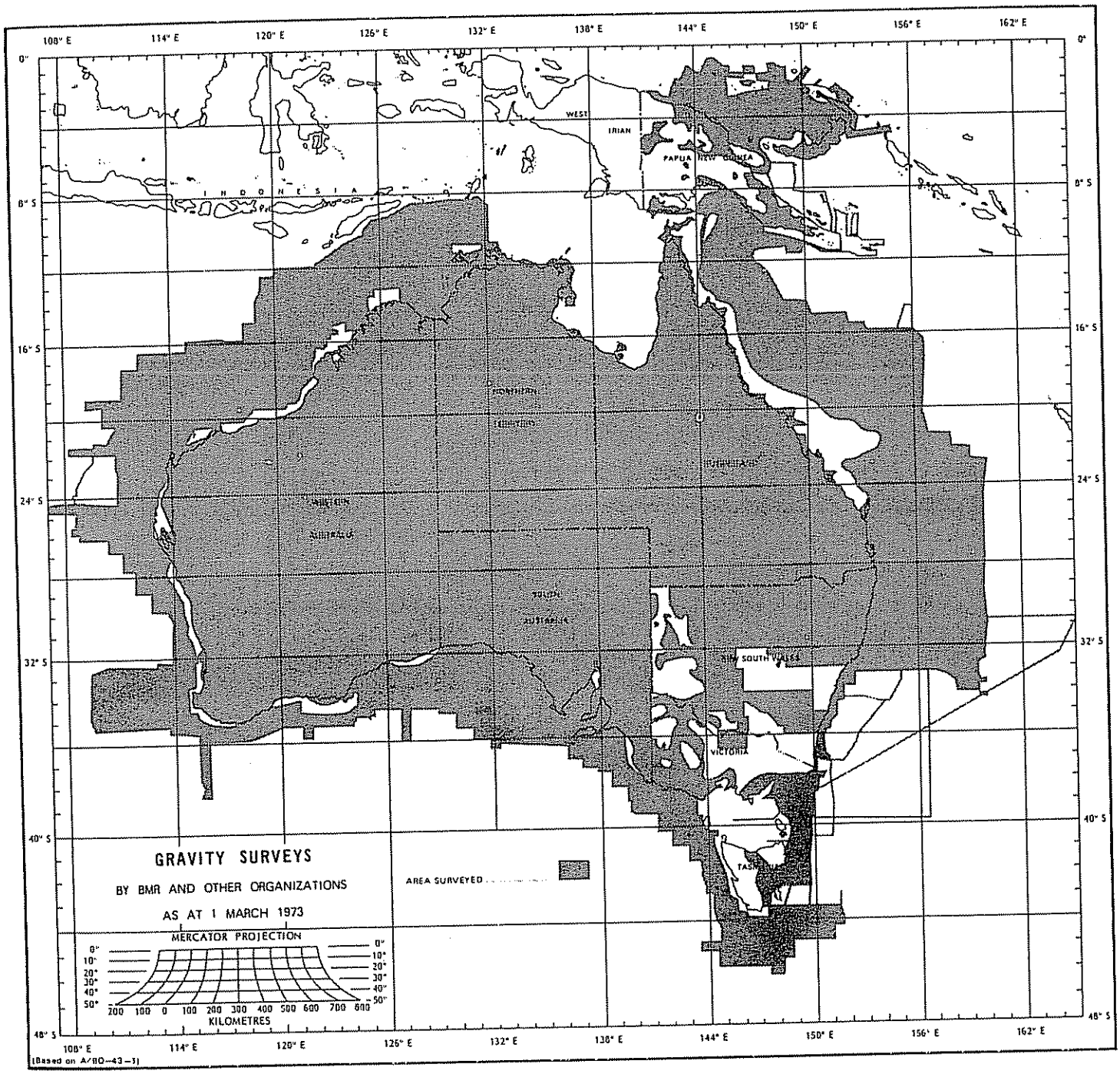


Figure 11. Australia: gravity surveys as at 1 March 1973

been published as gravity contour maps on the scale 1:500,000; the land areas have been shown on controlled planimetric base maps. The remaining off-shore work will be published as contoured maps on the scale 1:1,000,000. Computer plotting and contouring of gravity data are currently being used.

Oceanographic surveys

Reconnaissance geological mapping of the Australian continental margin to 500 m was begun by the Federal Bureau of Mineral Resources in 1967. Ships' tracks form a grid of about 20-km spacing. Maps will be produced on the scale 1:1,000,000, showing distribution of the sediment and rock types. To date, four cruises have been completed—one on the north-western Australian shelf, one in the Arafura Sea, one in eastern Australian waters south of the Barrier Reef and one in Tasmanian waters and the Bass Strait.

Multisensor marine geophysical surveys have been carried out by the Bureau of Mineral Resources since 1965. Bathymetric, seismic, gravity and magnetic measurements have been made along parallel traverses more or less normal to the coast. In the Bonaparte Gulf, in the Timor Sea and on the north-western continental shelf, the traverses were 16 km apart. In the Bismarck Sea, the Gulf of Papua and the eastern and southern continental margins, they were 32 km apart; and in the western continental margin, about 50 km apart. They extend from the 20-m to the 4,000-m isobath. The areas surveyed are included in figure 11, which illustrates areas covered by gravity surveys. Navigation is aided by the use of satellite Doppler and sonar Doppler equipment. Data were recorded in digital form on a magnetic tape.

Gravity contour maps, and gravity, magnetic and seismic profiles on the scale 1:500,000, covering parts of the Bonaparte Gulf, the Timor Sea and the north-western shelf, have been published. For the remainder, it is intended to publish contour maps of bathymetric, gravity and magnetic data at 1:1,000,000 scale, and bathymetric, gravity, magnetic and seismic profiles at 1:250,000 scale.

It is intended to continue the marine geophysical survey of the remaining areas in the Arafura Sea, Gulf of Carpentaria and Barrier Reef within the next three or four years.

Radiometric surveys

Radiometric surveys have been carried out by the Bureau of Mineral Resources over the areas shown in figure 12.

The level of radio-activity is recorded by instruments in aircraft flown between 100 and 150 m above ground level and at a line spacing from 160 to 300 m. Since 1970, gamma-ray spectrometers have been used. These surveys are usually made in conjunction with a magnetic survey.

The results of these surveys are presented as radiometric profiles, contours and point source anomalies, on controlled planimetric base maps.

BATHYMETRIC SURVEYS

In 1971, the Division of National Mapping commenced a programme to produce bathymetric maps of the continental shelf at 1:250,000 scale. The objective of the series is to portray the continental shelf in as much detail as possible, consistent with this scale, by contours at 20-m intervals to a depth of 300 m, by layer tints and by spot heights selected to show change of grade. The maps are produced in two colours, black and blue.

Sheet size is the same for the national topographic series on the scale 1:250,000; and the sheet lines are an extension of this series to cover the continental shelf. Symbols and line weights from the national topographic series have been adopted for the land area so that repromats from that series can be used without alteration.

Surveys have been carried out by contract and additional information has been included, where appropriate, from existing hydrographic surveys of the Royal Australian Navy (RAN).

HYDROGRAPHIC SURVEYS AND NAUTICAL CHARTING

In Australia, the responsibility for hydrographic surveys of coastal waters rests with the Royal Australian Navy. Harbours and port sites are surveyed by the appropriate state, harbour or commercial organization. All navigational charts for Australia are published by RAN.

Hydrographic surveys

The current programme for hydrographic surveys has been dictated by the need to provide safe tracks for deep-draught vessels on newly developed routes. The surveys conducted by RAN since 1970 are shown in figure 13. The future programme envisages continuance of the survey of the main coastal routes.

New ships

HMAS Flinders, a new survey ship, was commissioned in 1973. It will be used mainly for surveys in north-eastern Australian and Papua New Guinea waters. Tenders have been called for an oceanographic vessel, which is expected to be completed in 1976.

Chart production

During the period 1970–1972, the following new charts and new editions were published:

Year	*New charts*	*New editions and large corrections*
1970	22	1
1971	24	4
1972	36	1

Metrication of charts

Considerable progress has been made in the conversion of existing charts from fathoms to metric units and almost all harbour charts are now in metric form. All new charts are being published in metres.

International co-operation

Chart coverage of Australian waters is maintained by co-operative arrangements with the British Admiralty. In general, new charts are produced by Australia and arrangements exist for the reproduction of each other's charts.

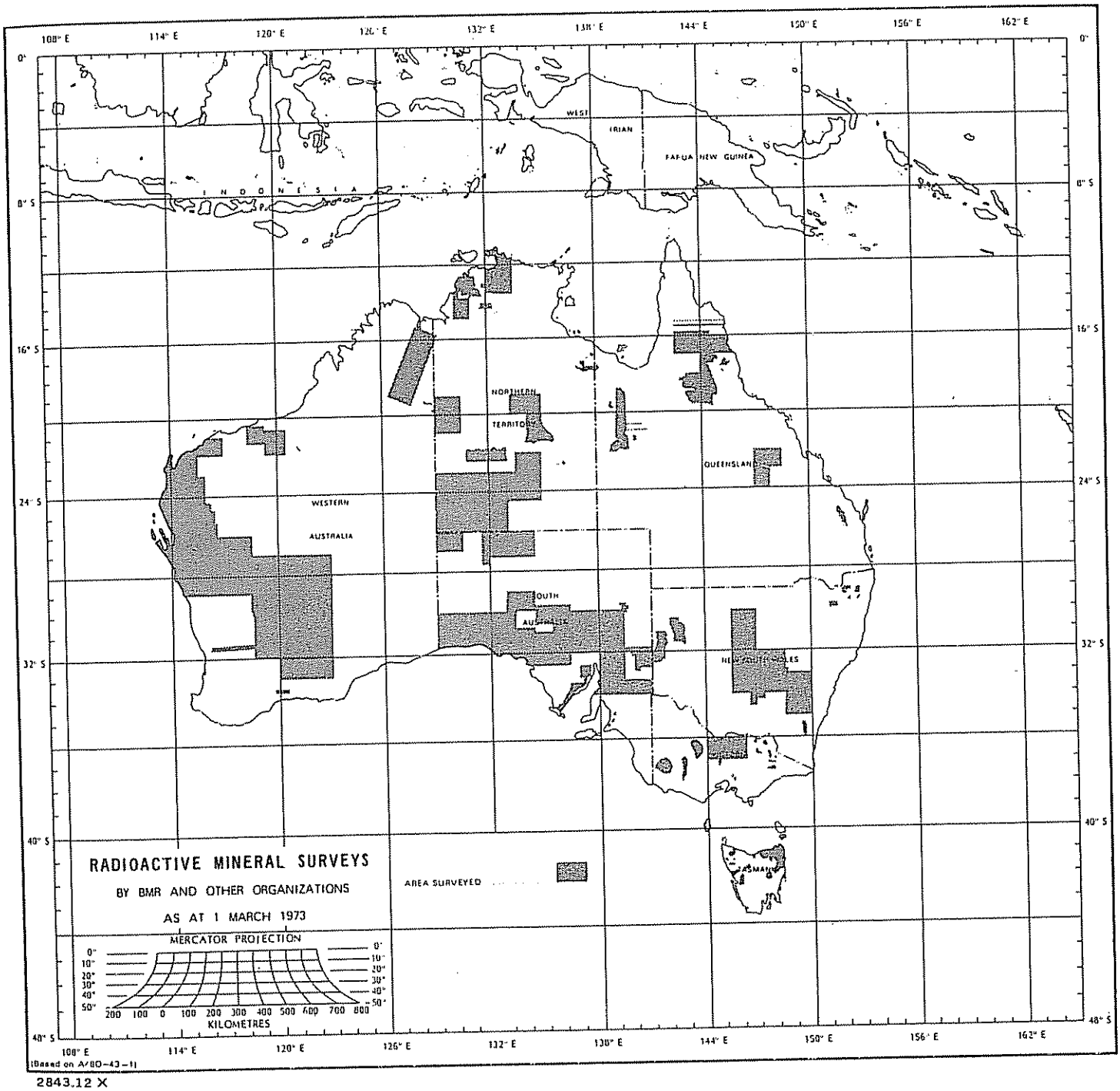


Figure 12. Australia: radio-active mineral surveys as at 1 March 1973

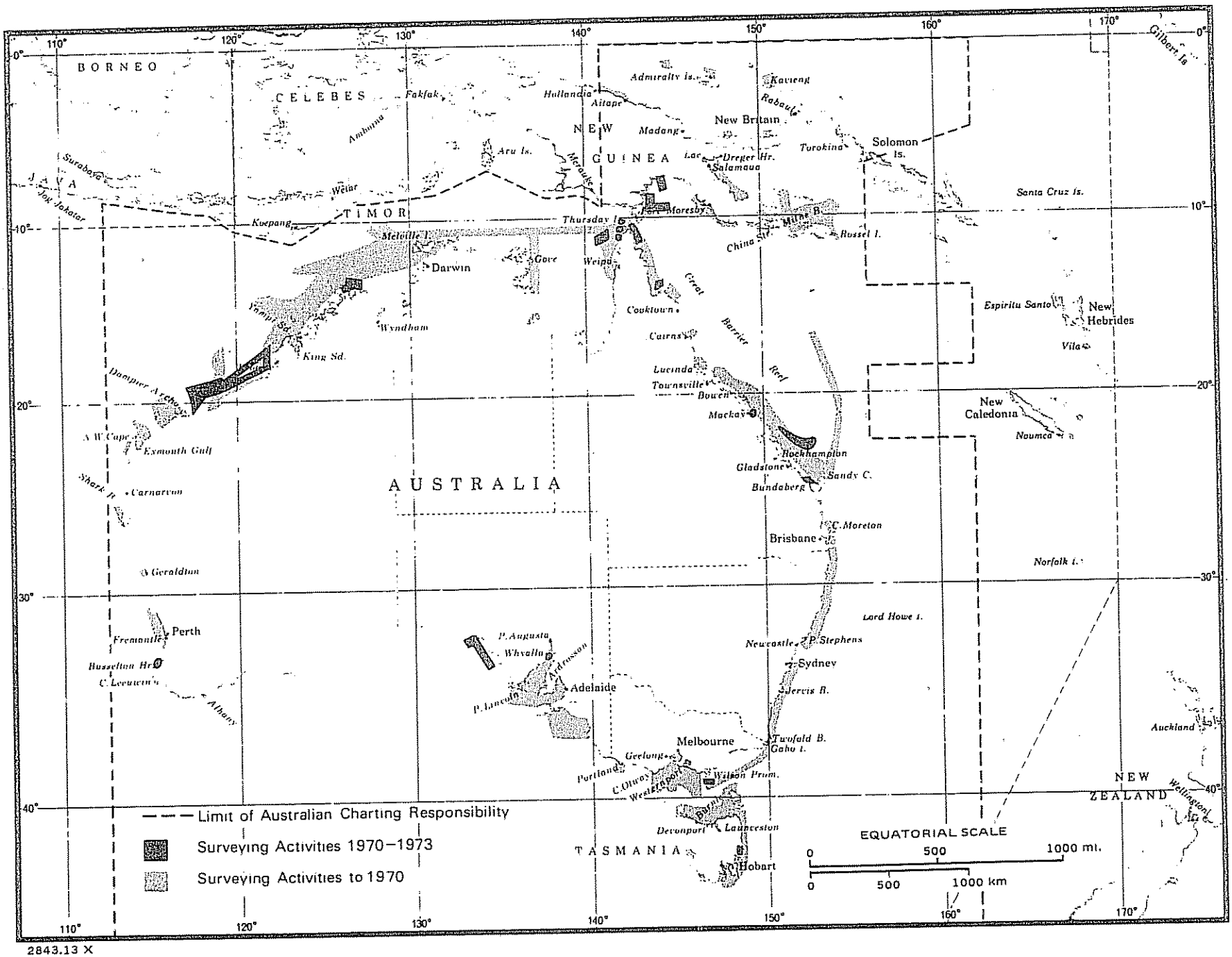


Figure 13. Australia: limits of Australian charting responsibility

The first Australian-produced charts of the 1:3,500,000 international series under the auspices of the International Hydrographic Organization have been published.

Training

The Hydrographic School continues to train junior officers and surveying recorders. In the period 1970–1972, ten foreign surveying recorders and ten foreign officers were accepted for courses at the school.

National and regional thematic atlases

Atlas of Australian Resources

A further nine sheets have been produced in the second series of the Atlas of Australian Resources, which is being published by the Department of Minerals and Energy. These sheets deal with landforms, rainfall, temperatures, land use, croplands, grasslands, the mineral industry, ports and shipping, and immigration. The final nine sheets of this 30-sheet series (sheet size 725 × 750 mm) are currently in production.

Atlas of Resources of New South Wales

The Atlas of Resources of New South Wales, produced by the State Department of Decentralisation and Development at Sydney, is being prepared as a loose-leaf desk atlas. Measuring 440 × 550 mm, it will contain about 20 map-sheets at 1:3,000,000 and at smaller scales. Eight sheets have so far been published and a similar number are in preparation.

Burdekin-Townsville region resource series

The Burdekin-Townsville region resources series deals with eight topics, each comprising one or two map-sheets and an explanatory booklet, concerning the resources of a Queensland region of 160,000 km^2. Five topics of the series—land forms, geology and minerals, climate, soils and vegetation—have been completed.

Other thematic maps

Land classification

Further work by CSIRO and state government agencies has resulted in the production of a number of maps classifying lands into units based on such environmental features as geomorphology, soils and vegetation. These surveys range from broad-scale ones, resulting in maps at 1:1,000,000 scale, to more detailed ones, with maps at 1:250,000 scale which are suitable as aids in rural property management. Recent mapping activity has been concentrated in the pastoral zone, especially in Queensland, New South Wales, Victoria and Western Australia. Various ancillary maps (covering geomorphology, climate, soils, vegetation, pastures, land use and the like) are usually included in the publications.

Vegetation

In addition to maps produced in connexion with land-classification surveys, a number of vegetation maps have been produced or are in preparation by private and official bodies as single maps or, as in Western Australia, as part of a state-wide vegetation survey.

Information for the entire continent is being summarized in a map being prepared at 1:6,000,000 scale for the Atlas of Australian Resources. The primary objective is to show the structure of the natural vegetation. A draft compilation has been completed.

Forestry

In addition to further production by the state forest services of relatively detailed maps of reserved forests, an important mapping programme is being undertaken by state and federal organizations in connexion with FORWOOD, a national forestry conference to be held in April 1974. From original compilations at 1:1,000,000 scale, maps of forest types and tenure are being prepared at 1:2,500,000 scale. A single-sheet continental map at 1:5,000,000 scale, showing forest types, will also be produced.

Climate

The Commonwealth Bureau of Meteorology has published 10 surveys in its series of regional climatic surveys in the period under review. The Bureau publishes a range of summary maps of climate and of meteorological elements for each state and for the whole of Australia, as well as the normal range of daily weather maps and synoptic charts. In the report period, it also contributed a considerable amount of new mapping to the Atlas of Australian Resources.

Water resources

Four maps of Australia at 1:5,000,000 scale have been prepared on behalf of the Australian Water Resources Council, to summarize knowledge of ground-water resources. It is expected that these maps will be published late in 1973, upon completion of the accompanying report. State maps have already been published for Queensland and South Australia.

In New South Wales, the Water Conservation and Irrigation Commission has published a report entitled *Water Resources of N.S.W.* Volume 2 of this report is an atlas containing 40 maps and diagrams dealing with various aspects of precipitation, evaporation, discharge, ground water and water supply.

Earth resources technology

An Australian Committee on Earth Resources and Science (ACERTS) has been set up and has arranged for the assessment of Earth Resources Technology Satellite (ERTS) imagery. The Division of National Mapping has been responsible for the distribution of the imagery to some 57 Australian investigators participating in the project.

The known coverage of Australia with less than 20 per cent cloud cover at the time of tape-recorder failure is shown in figure 14.

Supporting test projects over special areas have been arranged using side-looking airborne-radar (SLAR) imagery and high-level multispectral photography.

Technical assistance to other countries

During the period 1970–1973, more than 50 trainees have been provided with international training courses

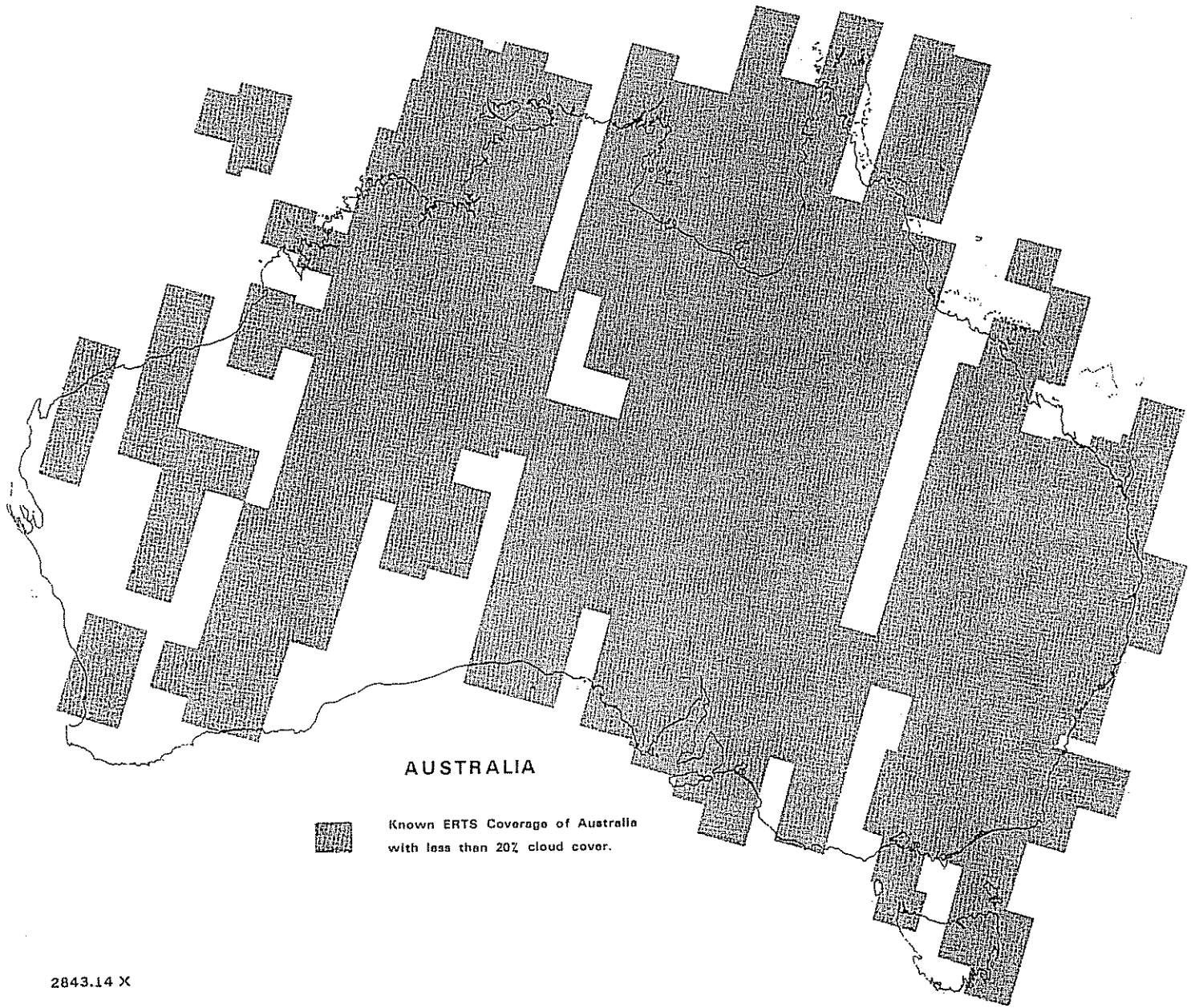


Figure 14. Australia: known coverage by Earth Resources Technology Satellite

in photogrammetry, and several technicians have been trained in photo-litho processes.

A number of geodetic instruments have been given to Indonesia, as well as the services of an Australian surveyor for instruction purposes.

As part of a defence aid project, and as a result of a request from Indonesia, the Royal Australian Survey Corps has been engaged on a 1:50,000 scale co-operative mapping programme in that country. Operations were commenced in West Kalimantan in 1970 and in Sumatra in 1971. The mapping of Sumatra is approximately 50 per cent completed.

A study team is currently undertaking a feasibility study of a Fijian request that Australia provide survey staff for local property surveys. Training in aerial triangulation is proposed for a Fijian trainee on the basis that observations be computer-processed by the Division of National Mapping.

Annex

Agencies from which additional cartographic information may be obtained

Inquiries concerning the geodetic survey, aerial photography, topographic map coverage, bathymetric surveys, Earth Resources Technology Satellite (ERTS) and technical assistance to other countries should be directed to:

The Director, Division of National Mapping, Department of Minerals and Energy, P O Box 667, *Canberra City*, ACT 2601

Inquiries relating to geological mapping and geophysical surveys should be sent to:

The Director, Bureau of Mineral Resources Geology and Geophysics, P.O Box 378, *Canberra City*, ACT 2601.

Inquiries about hydrographic surveys and nautical charting should be directed to:

RAN Chart Agency, Garden Island, *Sydney*, N S W 2000.

Inquiries concerning national and regional thematic atlases and other thematic maps should be sent to:

Officer in Charge, Geographic Section, Department of Minerals and Energy, P O Box 5, *Canberra City*, ACT 2601.

CARTOGRAPHIC ACTIVITIES IN CANADA*

Paper presented by Canada

This report summarizes cartographic activities in Canada during the past three years. Responsibility for activities in geodesy, topographic mapping, aeronautical charting and map production for the federal Government is assigned to the Surveys and Mapping Branch of the Department of Energy, Mines and Resources, while activities in hydrography and oceanography are undertaken by the Marine Sciences Branch of the Department of Environment. The demand for surveying and mapping services of provincial survey organizations has been increasing, and steps are being taken to provide them with the resources needed to meet these needs.

GEODETIC SURVEY OPERATIONS

Horizontal control

The fundamental horizontal control framework has been extended and currently consists of about 5,600 stations in 25,700 miles of survey. Of these, 284 are Laplace stations and 841 are primary deflection points.

The most southerly areas of the country have been covered with first-order networks, whereas the mid-Canada region has been provided with a grid of framework nets to support lower order surveys. The northern areas are covered with SHORAN trilateration, of which the average side length is about 200 miles. A breakdown of existing triangulation loops by first-order traverse was begun in 1973.

The programme of strengthening the existing networks has been continued in preparation for readjustment of the framework surveys of Canada. All of the fundamental framework nets have been evaluated and compared with recently established specifications to indicate specific needs for additional scale and azimuth control. During the past three years, scale control has been added to many older triangulation networks. Fifteen old Laplace stations have been reobserved and 18 new Laplace stations have been added to the existing networks.

Since 1970, Aerodist has been used to establish an additional 114 first-order and 31 second-order stations in the more remote parts of Canada to provide control for topographic mapping on the scale 1:50,000 for an area of approximately 335,000 square miles. An additional 5,500 line miles of second-order traversing covering approximately 150,000 square miles in the northern territories of Canada have been completed to support topographic mapping and resource development surveys in that area

The North American Satellite Triangulation Project, a joint undertaking of Canada and the United States of America, which was begun in 1964, has been completed. There are eight stations in Canada with connexions made to Alaska, Greenland and Bermuda.

Early in 1973, plans were formulated for the establishment of a network of approximately 100 Doppler satellite stations in Canada, a programme which is expected to be completed within three years. These points, which are spaced at from 300 to 500 km, along with the satellite triangulation and fundamental geodetic triangulation networks, will be used in the readjustment of the North American fundamental geodetic framework. Meetings of representatives of Canada, Mexico and the United States have been held to provide for co-operation and co-ordination on this important project.

Vertical control

In the three-year period, 1971–1973, the Geodetic Survey completed 4,300 miles of new first-order levels, relevelled 220 miles and established 5,100 new bench-marks. The country-wide network currently includes 59,500 miles of first-order levels, 16,700 miles of second-order levels and 37,400 bench-marks.

The Trans-Canada level line, begun in 1966, was completed in 1971 and has a total length of 4,000 miles.

*The original text of this paper appeared as document E/CONF.62/L.101.

The basic relevelling for the re-evaluation of the International Great Lakes Datum has been completed. That project was carried out using the parallel-plate method and metric rods to an allowable discrepancy between forward and backward levelling of 3 mm $\sqrt{k}$.

The programme to establish deep bench-marks in areas of instability has continued. To date, 316 of these marks have been installed at depths of up to 204 feet.

The programme of establishing basic grids of vertical control in municipalities is continuing. Projects in nine cities and municipalities have been completed, bringing the total to 43.

Special vertical control lines were established to aid in the study of expected subsidence at two large hydroelectric generating station earth-filled dams. First-order level lines have been extended into some areas of northern Canada to support resource development projects.

Computations, research and development

The gyro-theodolite investigation has continued and the Wild GAK-1 has been equipped with automatic read-out and print-out. With stringent operating procedures, the system is capable of producing azimuths with a standard deviation of about 1 second.

Investigation of the Mekometer—a precise distance-measuring device—has been initiated. It is expected that the Mekometer can be used to establish base-lines at suitable locations throughout the country to produce a local standard of comparison for electronic distance-measuring equipment.

Computer programme GALS, used for the adjustment of horizontal control survey data, has been revised for use with a recently developed method of adjustment by sections. Very large blocks of survey data can now be adjusted to yield results that are not significantly different from the results achieved using more expensive simultaneous solution methods.

A computer-based national positional control survey data file is currently under development by the Geodetic Survey. The file will provide control survey data in the fields of geodesy, surveying and mapping to government agencies, industry and the general public. A pilot project has been completed.

Several prototype Doppler satellite receivers produced by the Canadian Marconi Company were field-tested in the summer of 1973. Preliminary indications are that the results are equivalent to those obtained from comparable equipment and that the receivers remain serviceable under field conditions.

Topographic and General-Purpose Mapping

Work on the International Map of the World on the Millionth Scale (IMW) is continuing; 28 maps of the more southerly areas have been published and three more are in production. Support of the 1:250,000 series has been mainly directed to revision, while in the 1:125,000 series, 95 maps have been published and 46 others are in production. A wide range of general-purpose maps and other special series, such as electoral district, bilingual district and national park maps, has been maintained.

There have been heavy demands for the production of new maps, at 1:50,000 scale, especially in the more northerly areas, in support of the development of natural resources. At the same time, a modest programme of revision and remapping of the more densely populated areas of the country has been continued. Over 5,000 maps of the 1:50,000 scale series have now been produced, covering approximately 50 per cent of the land area of Canada.

Photo maps on the scale 1:50,000, with the use of orthophoto instruments and rectifiers, have been produced in support of the resource development studies in many areas where standard line maps are not available. There has also been a demand for photo maps as a supplement to standard line maps for resource and environmental studies.

Approximately 700 maps on the scale 1:25,000 are available for the more densely populated areas. These maps are updated on an eight-year cycle.

Research and development

Block adjustment of independent models has been in operational use for more than a year with the Stuttgart University Programme Package for Aerial Triangulation with Independent Models (PAT-M), which has proved to be a very effective and economical programme for the adjustment of large photogrammetric blocks with perimeter horizontal control. Furthermore, development of a programme similar to PAT-M has recently been completed. While less flexible, in its first version, it has proven to be just as effective.

Research is in progress to determine means of improving the accuracy of vertical control derived by Airborne Profile Recorder (APR). A simultaneous adjustment of APR and photogrammetric data is being developed by Stuttgart University. In addition, an improved version of APR, which has been developed by the National Research Council, is being evaluated.

A photogrammetric digitizing system is being developed for the digitization of topographic map data from stereo models. As a part of this project, a simple and versatile digitizer, which has been merged with a video terminal, has been developed. It can be connected to any single- or multiple-axis measuring system and is capable of operating on-line to a computer or off-line to a recording device, such as a teleprinter or magnetic tape recorder. It is expected that commercial manufacture of this unit under a licence from the Canadian Government will commence in the near future.

Development of an automated cartography system has continued, and the first topographic map in the national topographic system 1:50,000 series (Mount Mye—105 K/6) was produced in 1972. Since then, production and development have shared the system, with the development aspect being directed to refining techniques and increasing the versatility of the system to include revision and small-scale mapping.

Aeronautical Charts

The conversion of the 1:1,000,000 scale series of visual flight charts to a new format, which gives coverage of Canada in 19 charts, has been completed; and maintenance work continues on the 1:500,000 scale series of visual flight charts.

The Aeronautical Charts Division continues to maintain the wide range of plotting, radio navigation, instrument approach, radar surveillance and controller charts, and associated publications needed to support air traffic activities in Canada.

National Atlas

The fourth edition of the National Atlas of Canada was completed in 1973 in loose-leaf form, and a bound version is to be produced in 1974. The fifth edition is in the planning stage. The National Atlas programme is an ongoing commitment to document the physical environment and growth of the country in graphic form with the goal of completing a new edition every 10 years.

Hydrography

The Canadian Hydrographic Service has an inventory of just over 1,000 navigational charts of Canadian waters; this inventory is being increased by about 15 new charts each year. The Service is wholly responsible for producing three small-scale (1:3,500,000) international charts covering the eastern seaboard, the first of which (INT 109) was published in 1972 and the remaining two of which are in advanced stages of preparation. The Service has a sincere commitment to the project for the General Bathymetric Chart of the Oceans (GEBCO), maintaining a responsibility for 17 of the 1:1,000,000 plotting sheets covering the western north Atlantic and the Canadian polar region. In addition to the implementation of a metric conversion programme for all Canadian charts, the Service is now preparing all new publications, including charts, in a bilingual (French-English) format.

The programme of special charting, focused on the exploitation of the resources of the continental shelf, has been accelerated to the point that the Service is now able to publish geomorphological, geophysical and surficial geology maps in many of the off-shore areas of the three oceans surrounding Canada. The Service is also making significant progress in the development of an automated cartographic system that will eventually be interfaced with the digital data systems output for field surveys.

Oceanography

The Marine Sciences Directorate is the responsibility centre for the provision of assistance and expertise on those ocean matters of interest and benefit to the Canadian economy in resource development and environmental programmes. Assistance is provided by research studies on oceanography, namely, growth and decay of ice, dynamics of coastal and ocean circulation, real-time forecasts of sea and swell conditions, real-time and non-real-time tidal and water-level information, measurement; collection, archiving and retrieval of environmental data; and publication of various oceanographic papers and products for the fishing and off-shore exploration industries.

Research studies and surveys in geophysical, geological and chemical oceanography are carried out from the Bedford Institute of Oceanography, Dartmouth, Nova Scotia; and in the Pacific region, from Victoria, British Columbia. Canadian international aspects of ocean affairs are undertaken at Ottawa, with assistance from the regions for the role of Canada in the Intergovernmental Oceanographic Commission (IOC), the International Council for the Exploration of the Sea (ICES) and many other international marine organizations and fisheries commissions.

These activities include co-operation and collaboration with other scientists and laboratories throughout the world, the international exchange of data, development of the Integrated Global Ocean Station System (IGOSS) and of pollution and environmental monitoring.

SURVEY AND MAPPING OF CYPRUS IN THE PAST THREE YEARS*

Paper presented by Cyprus

Geographical and historical background

Cyprus is an island in the north-eastern Mediterranean Sea. It is situated between latitudes 34°33′ and 35°42′ north and between longitudes 32°16′ and 34°35′ east. It is some 40 miles from the Turkish coast to the north, 60 miles from the Syrian coast to the east, 250 miles from the Egyptian coast and about 300 miles from the Greek islands to the west.

The area of Cyprus is reported to be 3,572 square miles, while the length of its coastline is about 486 miles. Its maximum length from east to west direction is about 140 miles, while its breadth in a north-south direction is about 60 miles. It comprises two mountain ranges running in an east-west direction, with flat fertile land between the ranges. It is the third largest island in the Mediterranean, being smaller than Sicily and Sardinia, but larger than Corsica and Crete. The population of Cyprus, as estimated from recent statistics, is about 655,000; its rate of growth is 1 per cent.

By virtue of its geographical position, Cyprus enjoys the best of the Mediterranean type of climate. The mean annual temperature in the coastal districts is about 67° F; in the lowlands, about 70° F; and in the highlands, about 56° F. The average minimum temperature on the highlands during the coldest months is about 35° F; and in the lowlands, about 42° F. The average maximum temperature during the hottest months in the highlands is 78° F; and in the lowlands, 97° F. The average monthly rainfall during the wettest months is 9 inches in the highlands, 4 inches in the coastal areas and 3 inches on the lowlands. However, the average rainfall during 1972–1973 has been exceptionally low.

Responsibility for mapping in Cyprus and equipment available

The Department of Lands and Surveys, under the Ministry of the Interior, is charged with the responsibility for all cadastral and topographic surveys on the island, whether for government or public use. Although cadastral surveys (now mainly revision surveys) are still carried out using the traditional chain and tape, new

*The original text of this paper, prepared by A. Christofi, Senior Land Survey Officer, Department of Lands and Survey, Ministry of the Interior, Cyprus, appeared as document E/CONF.62/L.71.

topographic surveys are carried out by photogrammetric methods. Up to the end of 1968, such mapping was given out to contract. In January 1969, however, the Department established a small photogrammetric unit; and it has since been compiling its own maps by stereoplotting. The photographic and map coverages of the island are described in the following section. A list of the instruments currently available, excluding such field equipment as theodolites and levels, is given below:

(*a*) Two precision plotting instruments complete with plotting tables and accessories;

(*b*) Four large mirror stereoscopes;

(*c*) Six pocket stereoscopes;

(*d*) One parallax bar;

(*e*) One conventional contact printer;

(*f*) Two sets of electromagnetic distance-measuring equipment;

(*g*) Two electric computing-machines;

(*h*) One horizontal darkroom process camera, cartographic type;

(*i*) One automatic flat-bed offset litho-proving press.

Triangulation of Cyprus

Cyprus is one of the best triangulated countries in the area. It was first triangulated by Kitchener, as a prerequisite of mapping on the scale of 1 inch to 1 mile, in the period 1878–1882. It was retriangulated on the recommendation of Captain Lyons in 1912, as a prerequisite of large-scale cadastral mapping; and it was trilaterated in 1961, as a prerequisite of topographic mapping on the Universal Transverse Mercator (UTM) projection. The reputed scale error of the triangulation of Cyprus is better than one part in 100,000. The primary triangulation, which has been connected to that of Syria and Turkey, comprises 46 stations, all permanently monumented with concrete pillars. This triangulation was broken down to a minor triangulation which comprises some 520 stations, all of which are symmetrically distributed within the primary framework, in a mesh of interlaced polygons. A further breakdown provides an even denser network of horizontal control and is termed the fourth-order triangulation, which comprises some 6,000 stations throughout the island. These stations, which are, on average, 1 mile apart, have been used as terminal points for fixing by traversing methods, control for the cadastral survey in the urban areas; and in some districts of the rural areas, for land registration purposes. Because of the density of the triangulation in Cyprus, almost all the control necessary for topographic mapping by photogrammetric methods is fixed by ground methods.

Levelling operations

Levelling operations in Cyprus did not begin on a national basis until 1966. These operations were considered necessary for consistency in the large-scale topographic mapping which was in progress for government development projects. The primary levelling of Cyprus, which was completed in 1967, comprises four loops with a total length of approximately 450 miles. The instruments used were Zeiss N12 self-aligning levels fitted with parallel plate micrometers and invar staves. The standard of the observations and the precautions taken during levelling operations gave an accuracy after least-squares adjustment of better than $0.015\sqrt{M}$. The probable error of an adjusted observation was found to be $\pm 0.004\sqrt{M}$ ft, where M is the distance in miles. It is therefore considered to be of geodetic standard. The primary levelling was broken down to secondary and tertiary circuits, in order to facilitate the provision of vertical control for large- and medium-scale photogrammetric mapping. Mean sea level in Cyprus has been determined by a tide-gauge recorder. It was related to a datum bench-mark on which the primary levelling was based. The tide-gauge recorder was established in Famagusta harbour, and observations were taken for 117 weeks. It was then moved and established in Paphos harbour for another 90 weeks. The difference between the two datum bench-marks as obtained by the tide-gauge and by primary levelling is 0.25 ft, while the distance between them is about 120 miles.

PHOTOGRAPHIC COVERAGE

Cyprus has been photographed from the air several times during the past 30 years. Photography was undertaken mainly for topographic mapping, map revision or for such operations as compilation of a pasture survey and land-use maps. The purpose for each cover is given below in the chronological order taken.

The first cover was taken in 1941, at various contact scales of approximately 1:6,000–1:20,000. Format size was 8.5 × 7 inches and the focal length of the camera lens was 14 inches. It was flown by the Royal Air Force of the United Kingdom (for Cyprus was a British Colony at the time), and it was extensively used for multiplex heighting and contouring of the 1:50,000 scale topographic maps under preparation by the British Army at that time. The mapping is described below in more detail. This photography is now obsolete and is used only as a statistical record.

The second cover was taken in 1949, on a contact scale of approximately 1:10,000. Format size was 9 × 9 inches, and the focal length of the camera lens was 12 inches. It was again flown by the Royal Air Force, and the purpose was the revision of the 1:50,000 scale maps referred to above, as well as to provide a post-war tool for geological, forest, water and agricultural studies. It is currently used only by the Geological Survey Department.

The third cover was taken in 1955, on a contact scale of approximately 1:35,000. Format size was 9 × 9 inches. and the focal length of the camera lens was 6 inches. As in the two previous covers, it was flown by the Royal Air Force, and the purpose was the compilation of a pasture survey map for the Department of Agriculture. This map is described in more detail in the section on thematic maps.

The fourth cover was taken in 1957, at a contact scale of approximately 1:25,000. Format size was 9 × 9 inches, and the focal length of the camera lens was 6 inches. This photography was flown by Fairey Surveys Ltd. (United Kingdom), on a contract basis. It was to be used for new mapping of Cyprus at 1:25,000 scale; and, for certain areas only, at 1:10,000 scale. The photography is still in use in most government departments.

The fifth cover, also flown by Fairey Surveys, was taken in 1963, at a contact scale of approximately 1:10,000. Format size was 9 × 9 inches, and the focal length of the camera lens was 6 inches. This cover was to

be used in all fields of planning for the Government's first five-year economic development projects. It was, and still is, extensively used for large-scale topographic maps on the scale 1:5,000 for the Department of Water Development. These maps are described below in more detail.

The sixth and seventh covers were taken in March and July 1968, respectively, both on the contact scale 1:15,000. Format size was 9 × 9 inches, and the focal length of the camera lens was, for both covers, 6 inches. They were flown by the Royal Air Force of the United Kingdom, at the request of the Government of Cyprus. The photography was extensively used for the compilation of a land-use map, required by the water-planning project undertaken by the United Nations Development Programme (UNDP) (see section on thematic maps). Neither of the above-mentioned covers was used for photogrammetric mapping.

The eighth and ninth covers were taken in August-September 1970, on the contact scales 1:50,000 and 1:15,000, respectively. Format size was 9 × 9 inches, and the focal length of the camera lens for both covers was 6 inches. They were again flown by the Royal Air Force. The eighth cover was for the purpose of compiling a new topographic map of Cyprus at 1:50,000 scale to be produced by the British Army; and the ninth cover was to be used in the compilation of a set of new town maps of Cyprus, at 1:25,000 scale, for the Department of Town Planning and Housing. The 1:15,000 scale photography is currently used also for the systematic topographic mapping of the island at 1:5,000 scale for general use.

About one fourth of the area of the island in the south was flown in June 1973 on the scale 1:15,000, by Hunting Surveys Ltd., contracted by the United Kingdom Directorate of Overseas Surveys (DOS) with the sanction of the Government of Cyprus. This was part of an agreement between the Governments of Cyprus and the United Kingdom for the joint mapping of the above-mentioned area on the scale 1:5,000 for a large water-engineering project. A number of preselected trigonometrical points have been premarked and control for mapping will be provided by aerotriangulation methods. It is hoped that the Government of the United Kingdom, through DOS, will extend this form of aid until the mapping of Cyprus on the same scale has been completed.

Cadastral map coverage

Built-up areas

All the towns and villages in Cyprus are covered by large-scale cadastral plans at 1:500, 1:1,000 or 1:1,250 scale. The survey of some areas dates as far back as the early 1900s, and the plans show property boundaries and buildings. It is unfortunate that these maps were not kept up to date by a continuous revision process. Some of them are hopelessly out of date; but they are still used as the basis for registration of title to land, for valuation and for taxation purposes. The survey was carried out by chain.

Rural areas

The survey of the rural areas is on two scales: 1:2,500 for the districts of Famagusta and Kyrenia, and the suburbs of Nicosia; and 1:5,000 for the remainder of the island. The plans at 1:2,500 scale have been surveyed by chain and those at 1:5,000 by a combination of tacheometric and plane-table methods. As in the case of the built-up areas, the plans show property boundaries (no relief), and they also are badly out of date. Revisions are shown on them only at the instance of landowners. With the exception of certain areas in the Famagusta district, all other surveys are based on trigonometrical control. The cadastral survey was begun in 1904 and was completed in 1928. Figure 15 shows the cadastral plan coverage of Cyprus.

Topographic map coverage

The first topographic map of Cyprus was that produced by Kitchener, the Director of Surveys at the time, over the period 1878–1883. It was published on the scale of 1 inch to 1 mile, and its purpose was to serve as a general administration map for the island. The map was compiled by plane-table methods and was based on Kitchener's trigonometrical survey. Relief was shown by hill shading. It was printed in 1883 and never reprinted. The island was covered by 15 sheets. The map fell out of date and consequently out of use.

By mechanographic reduction and generalization of the cadastral plans referred to above, a map on the scale of 2 inches to 1 mile was developed. The map showed no relief and was therefore of limited value for development planning. The island is covered by 59 sheets, and each sheet covers an area of 8 × 12 square miles. The sheet lines coincide with the cadastral sheet-line system of the survey of Cyprus. The series has fallen out of date and is currently used mainly as an index to the large-scale plans.

Further successive photographic reduction and generalization gave rise to three more scales of maps: the ½ inch to 1 mile general-use map; the ¼ inch to 1 mile administration map; and the ⅛ inch to 1 mile motor map of Cyprus. These are all coloured editions, and the last two show relief by a combination of contours and altitude tints. These editions have recently been combined into one, at the scale of the administration map, and have been revised. The new edition was produced in colour with insets of the main towns printed at the back in grey. The map is offered in both flat and folded forms and is very popular for visitors and tourists. It is also offered in English, Greek and Turkish editions.

At the beginning of the Second World War, the need was greatly felt for a topographic map on the scale 1:50,000 with contours at a 100-ft vertical interval for defence purposes. Photography flown in 1941 was used mainly for contouring purposes. The basic compilation material for this series was the map at 2 inches to 1 mile, described above. The map was successively revised, until it was superseded by another series on the same scale in 1964. That series is on the UTM projection and is on the metric system, with contours at a 20-m vertical interval. Although an excellent map cartographically, it was found to be inconsistent and inaccurate, for it was merely a copy of the previous one in many respects, with a change in projection and grid. A new series, described below, has been produced and is in circulation.

In 1957, it was decided to remap the island on the scale 1:25,000 with contours at a 25-ft vertical interval; and, for some areas, on the scale 1:10,000. The mapping was to be done by photogrammetric methods and completed by field-checking, using new photography flown for the purpose. The mapping was discontinued in 1960, with only one fourth of the island completed at 1:25,000 scale

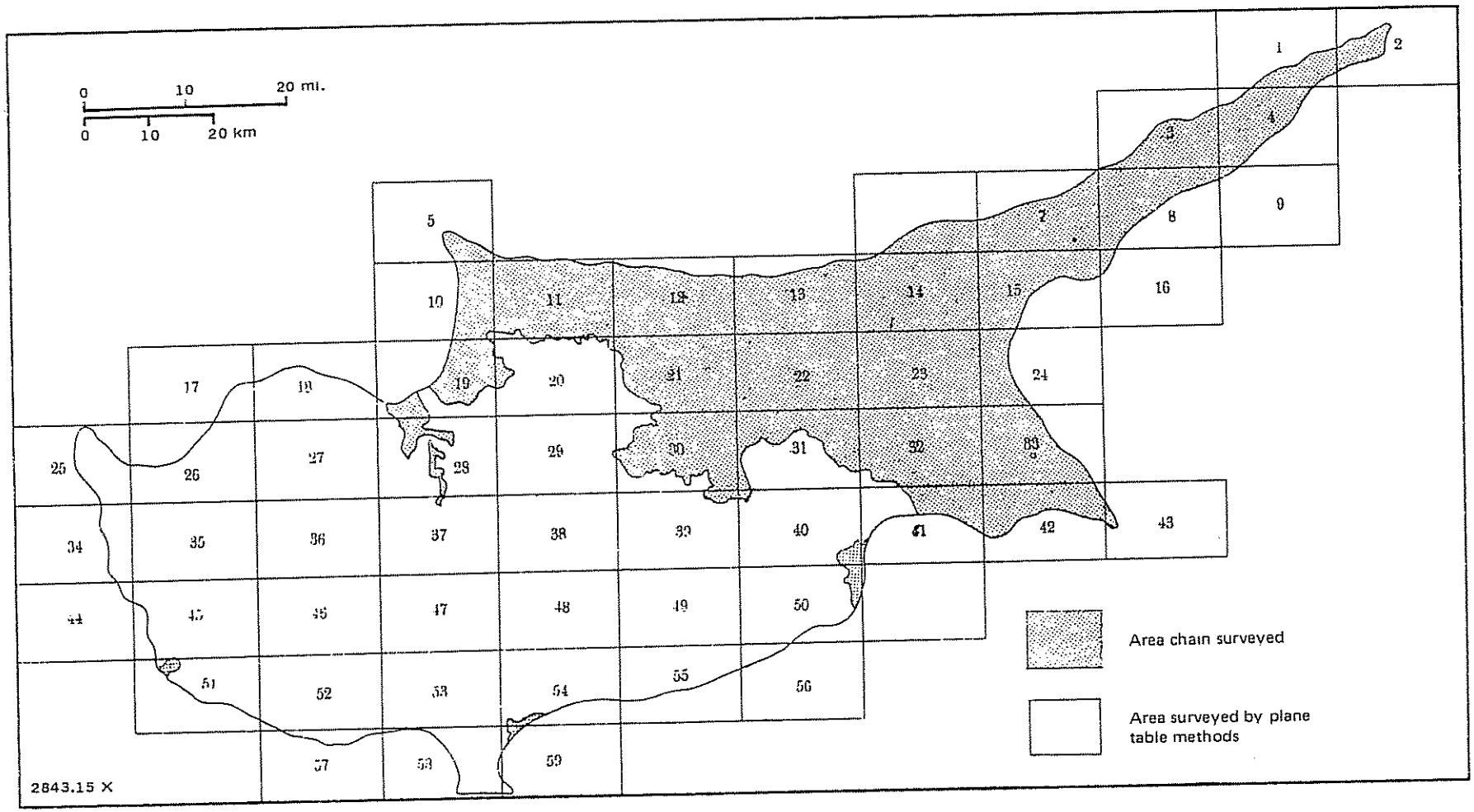


Figure 15. Cyprus: cadastral plan coverage

and a few sheets at 1:10,000 scale. The areas mapped at both these scales are shown in figure 16.

With the first five-year development programme after Cyprus became independent, there was a great demand for large-scale topographic maps for development projects throughout the island. It was therefore decided to fly new photography on the contact scale 1:10,000 and to contract a photogrammetric firm to undertake the mapping. Ground control was provided by the Department of Lands and Surveys, and the mapping was entrusted to Fairey Surveys Ltd. (United Kingdom). Mapping commenced in the middle of 1964; and by the end of 1968, approximately 300 square miles had been mapped up to the machine-plot stage, on the scale 1:5,000 with contours at a 4-ft vertical interval. After the establishment of a photogrammetric unit in the Department, the mapping was continued on the same scale, but with a contour interval of 2 m instead of 4 ft. All control is provided by the Department of Lands and Surveys, and the sheets are completed by ground-checking and are scribed for reproduction in colour. A total area of about 370 square miles has been mapped on the Department's stereoplotters (see figure 17). Sixty square miles (20 sheets) have been scribed, and at least 10 sheets have been printed in five colours.

In addition to the various types and scales of maps described above, the Department maintains a series of street-name maps on the scales 1:5,000 and 1:7,500 for all the main towns of Cyprus. These maps are compiled by photogrammetric methods, in co-operation with the Director of Military Surveys of the British Army, who does the bulk of the work, and with the local authorities in connexion with street names, etc. A new set of street-name maps is currently under preparation by Fairey Surveys Ltd., which has been contracted by the Directorate of Military Surveys of the United Kingdom, Ministry of Defence, in co-operation with the Government of Cyprus.

From the 1:15,000 scale photography flown in 1970, the Government contracted Fairey Surveys Ltd. to undertake the compilation and production of a set of maps at 1:25,000 scale, with contours at a 10-m vertical interval, covering the area of the seven main towns of Cyprus with their suburbs. The request came from the Department of Town Planning and Housing, which is engaged in the preparation of a study in town and country planning for the island. Ground control, field completion and the supply of names were undertaken by the Department of Lands and Surveys. The maps were successfully completed and put into circulation early in 1972. The reproduction material of this series is being used for the compilation of the new set of street-name maps mentioned above.

From the photography at 1:50,000 scale flown in 1970, the Directorate of Military Surveys of the British Army contracted Fairey Surveys Ltd. for the compilation and production of a new series of topographic maps of Cyprus on the scale 1:50,000. The Department of Lands and Surveys undertook the field completion, the supply of names and the classification of vegetation and roads for this series. The map series was successfully completed and was handed over to the Government of Cyprus by the Government of the United Kingdom in May 1973. The Government of Cyprus is grateful to the Government of the United Kingdom for its continued contribution towards the mapping of Cyprus.

THEMATIC MAP COVERAGE

The following maps were based on the administration map at one-quarter inch to the mile, described above in the section on topographic map coverage:

(a) *Forest map*. This map was prepared by the Forest Department of Cyprus and was printed in 1964. It is overprinted in green to show major and minor state forests and other forest information;

(b) *Geological and hydrogeological maps*. For these maps, the basic material of the administration map was slightly enlarged to 1:250,000 scale. Both maps were prepared by the Geological Survey Department of Cyprus; they were printed in 1963 and 1970, respectively;

(c) *Population distribution map*. The basic material of the administration map was appropriately modified to show the population distribution of the 1970 census of the island. The map was prepared by the Department of Lands and Surveys and was printed in 1964;

(d) *Average annual precipitation map of Cyprus*. The basic material for this map, which shows precipitation for the period 1941–1970, was the administration map slightly enlarged to 1:250,000 scale. It was prepared by the Meteorological Service of Cyprus and was printed by the Department of Lands and Surveys in 1972;

(e) *General soil map of Cyprus*. For this map, the material of the administration map was enlarged to 1:200,000 scale. It was prepared by the Section of Soils and Plant Nutrition of the Department of Agriculture, of the Ministry of Agriculture and Natural Resources; it was printed in 1970.

The Department of Lands and Surveys also prepared other maps based on the administration map and at the same scale, covering prospecting permits, mining leases and licences, mines and quarries, quarry licences, oil exploration licences and game reserve areas.

Other thematic maps, based on various materials, include:

(a) *Soil series map*. The basic material for this series comes from reductions of various scales of maps produced by the Department of Lands and Surveys. The map has been prepared by the Soil Section of the Department of Agriculture, from aerial photographs and ground inspection at 1:25,000 scale, but only a few sheets have been published to date;

(b) *Pasture survey*. The basic material and the scale for this series were taken from the 1941 topographic map at 1:50,000 scale with a 100-ft vertical interval. Pasture detail was obtained from aerial photography flown in 1955. It was prepared for the Department of Agriculture by Hunting Technical Services Ltd. (United Kingdom) in 1956. The series is now obsolete due to the great changes in land use;

(c) *Land-use survey*. This series was based on the 1964 topographic series at 1:50,000 scale, on a UTM projection with a 20-m contour interval, enlarged to 1:25,000 scale. Land-use information was obtained from aerial photography flown in 1968. It was prepared by Hunting Technical Services Ltd. in 1968-1969 for the UNDP water-planning project in Cyprus and was used for study of water resources and water conservation on the island.

FUTURE MAP COVERAGE PROGRAMME

It is planned to continue photogrammetric mapping at 1:50,000 scale with 2-m contours as described above in

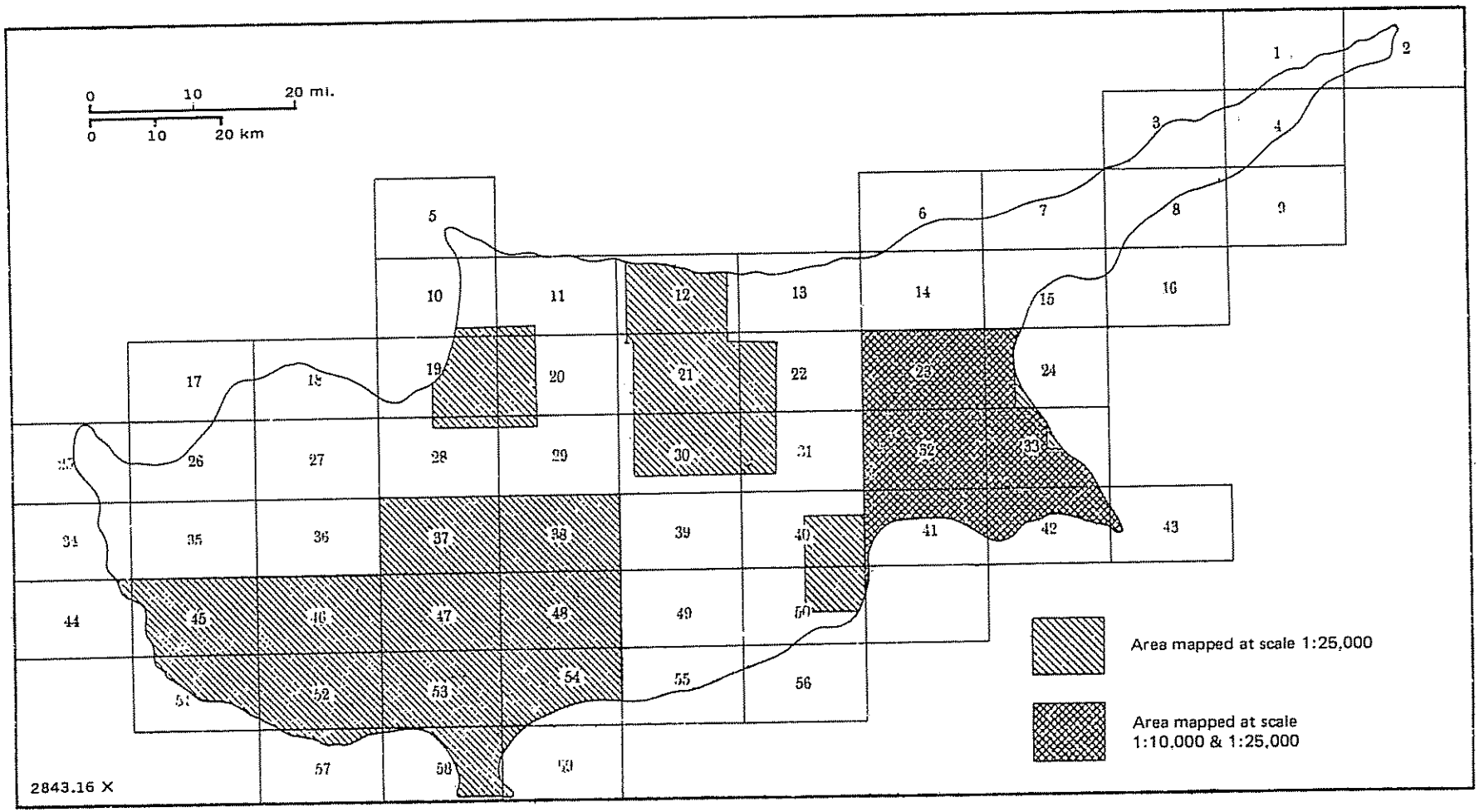


Figure 16. Cyprus: mapping diagram

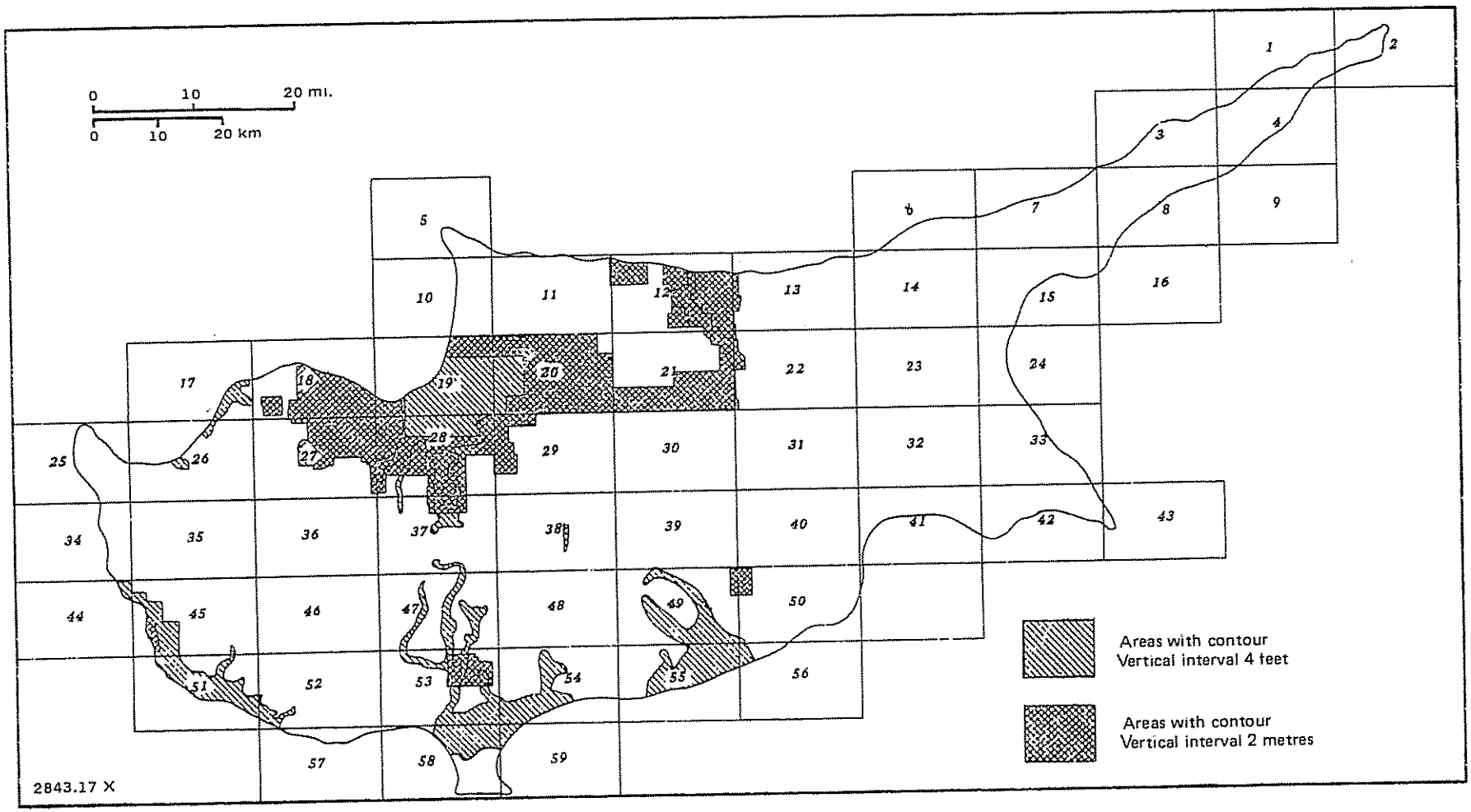


Figure 17. Cyprus: areas mapped at 1:5,000 scale

the section on topographic mapping. This mapping will cover the entire island and will become the national topographic series of maps for general use. With current arrangements, and the anticipated assistance from the Government of the United Kingdom, the mapping will be completed over a period of five or six years.

The new topographic map of Cyprus at 1:50,000 scale will be reduced photographically to provide the base for a new general topographic map of the island at 1:100,000 scale. A further reduction to 1:250,000 scale will provide the basis for new administration and road maps of Cyprus, which will replace those currently in use.

CARTOGRAPHIC ACTIVITIES IN FINLAND*

Paper presented by Finland

At the Sixth United Nations Regional Cartographic Conference for Asia and the Far East, held at Tehran in 1970, a detailed report was presented on the activities in Finland concerning the field of geodesy, photogrammetry and cartography.[1] Supplementary information is given below.

The basic map of Finland at 1:20,000 scale, which is the largest scale topographic map covering the entire country, will be completed in the near future. This map will be available with or without property boundaries. The original of the map at 1:10,000 scale containing cadastral information is constantly kept up to date. Other information is going to be revised, on average, at 10-year intervals. The edition with property boundaries has proved to be in great demand.

As the basic map covers the entire country it is possible to produce special maps of different types on the basis of this material. As one of the novelties may be mentioned a special edition in the road map series, which, in addition to the usual information, shows the arable lands and represents the relief through contour lines. Based on the same idea of themes, two new maps of Finland at 1:1,000,000 scale were also produced. One of them is closely related to the International Map of the World on the Millionth Scale (IMW). The sheets of the IMW concerning Finnish territory are under preparation.

Since 1971, the Government of Finland has been sponsoring the topographic mapping of the Serengeti area in the United Republic of Tanzania, as a part of the bilateral development co-operation between Finland and the East African countries. As an example of smaller projects, mention might be made of the aid Finland has given in establishing the training centre for photogrammetry and photo-interpretation at Ile-Ife, Nigeria. The development of co-operation in the field of surveying and mapping is still being expanded.

In Finland, new real estates are being formed through land survey operations. These operations are carried out also for other purposes concerning real estates, as, for instance, land consolidations and delineation of property boundaries (boundary surveys).

Two different registers are used to record real estates. In rural areas and other areas with scattered dwellings, a land register is used; while in the most densely populated urban areas, a register of building sites is used. There is a trend towards fusion of these two registers in the near future. At the same time, the manual operation system currently employed for these registers is going to be replaced by automatic data-processing.

The total number of real estates in Finland is currently approximately 1.6 million. The annual increase is approximately 30,000.

The main responsibility for general mapping, land surveys and registration of real estates in Finland is carried by the National Board of Survey. Assistance in control surveys is given by the Geodetic Institute and in topographic surveys, by the Army Map Service. The cities maintain the register of building sites on their own areas.

*The original text of this paper appeared as document E/CONF.62/L.111.

[1] "Cartographic activities in Finland", *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II. *Technical Papers* (United Nations publication, Sales No. E.72.I.20), pp. 80–82.

PROGRESS OF SURVEY WORK IN THE FEDERAL REPUBLIC OF GERMANY*

Paper presented by the Federal Republic of Germany

LAND SURVEYING

In the Federal Republic of Germany, the network of horizontal fixed points of the first order has been further concentrated and analysed by distance-measuring as to its homogeneity, especially in its older parts. The networks of the second, third and fourth orders also have been either renewed or concentrated where they no longer satisfy modern expectations, or such projects are in progress or are being planned. The surveying procedures used for this task depend upon electro-optical distance-measuring and angle-measuring instruments. The signalization of the points has been facilitated through the use of aluminium towers, which were set up in the building-block manner and required at most one day for construction of a measuring and aiming height of up to 60 m. The readjustment of the reflectors on the towers is also done automatically from the observation stations. This remote control saves time and personnel.

In supplementing the terrestrial procedures, an attempt has been made to make use of aerotriangulation for the point concentration of the fourth order. Through

*The original text of this paper appeared as document E/CONF.62/L.104.

several overflights, as well as signalization of the connecting points and sufficient concentration of the basic networks of the first, second and third orders, an initial study is being made to determine which parameters have the greatest influence on the precision of the plotting.

In recent years, the continuation of the topographic maps on the scale of 1:25,000 and at smaller scales has caused considerable difficulty in the Federal Republic of Germany. The sheets could not be continued rapidly enough, or the corrective cycle of a map series could not be as intensified as the transformation of the landscape demanded. The result was that not only the individual map-sheets, but the map series became increasingly out of date. In order to alleviate that situation, the most modern methods of photogrammetry, especially orthophotography, were made available for the continuation. The use of these methods has brought surprising results. First, it was possible to continue the maps independent of each other and to give preference to the map on the scale 1:50,000, which is in most urgent need of correction. It has been demonstrated not only that the production of orthophotos through the optimum combination of instruments (three planimats plus one orthoprojector) could be adapted to the required work with a minimum of personnel, but that on the basis of the orthophotos made available, both the field-work and the cartographic work could be considerably reduced. This fact can be explained from the high interpretation quota and the rectified pictorial offering of the orthophoto.

Apart from continuation, orthophotos are used for the production of aerial-photo maps on a large scale. In those areas in which no basic map of 1:5,000 had previously been available, these aerial-photo maps serve to close the gaps. As soon as this basis is built up, the aerial-photo maps are to be further developed into conventional line maps.

In addition to orthophotography, analogous aerial photoplotting has greatly increased in the production of the basic German map on the scale 1:5,000, where the outline plan could be built up photomechanically from the large-scale land-registry maps. In doing so, an attempt is made to shape the result of the analogous plotting in such a way that it can be used directly, without cartographic revision, as a map original and thus for reproduction. In this way, because the cartographic work is by and large eliminated, it is possible rapidly to increase the production of such basic maps from fivefold to tenfold with a corresponding increase in photogrammetric equipment.

When using the photogrammetric technique, forested areas make the production of basic maps more difficult. Good results can be achieved only when the photogrammetric potential is augmented by the terrestrial potential. Both photographic techniques should be seamlessly meshed together, from both the numerical and the analogous sides. Attempts are being made to realize a topographic survey using automatically registering tachymeters and to achieve its result by automatic interpolation.

The preliminary work for the setting-up of co-ordinate and outline data indexes, which subsequently are to be the foundation for the production and continuation of land-registry plans and land-registry maps, is currently being planned. The skeleton models should be finished in 1974, and one of the numerous conditions for the establishment of cartographic databanks would be fulfilled.

Land-registry surveying

Land-registry surveying in the Federal Republic of Germany also is characterized by automation and data flow. Decisive progress has been made in measuring automation, as well as in calculating and plotting automation. The use of automatically registering tachymeters has been expanded. Efficient conversion programmes make possible the representation, sifting and correcting of the survey data. New calculating and plotting programmes permit the easy elimination of onset, data and system errors, as well as smooth teamwork between the surveying and registering institutions, on the one hand, and the computer centres, on the other.

The setting-up of a real-estate data bank, which is subsequently to be integrated into the land-registry data bank, is in full progress. A preliminary plan has been drawn up as a basis for this work. In approximately five years, the programming for this data bank is planned to have advanced to such a stage that it can be put into operation.

Block adjustment, which derives from photogrammetry, has opened new perspectives for the application of photogrammetry in land-registry surveying. Thus, to an increasing degree; land-registry surveying is being done, under certain conditions, photogrammetrically. Above all, it is being done where the difficulties of the terrain, the extent of the land-registry surveying or other circumstances give clear superiority to the photogrammetric procedure over the terrestrial method. The measured model co-ordinates are registered on tape by means of Ecomat. The course of further calculation is analogous to that used in terrestrial land-registry surveying.

Concerning preparation for the aerial photography, the signalization requires appropriate organization, primarily with respect to the span measurement check. The signalization of auxiliary points is facilitated by distributing devices. There are plans for further intensifying the use of photogrammetry in land-registry surveying, especially for large projects, such as the subdivision of land for building sites and for road construction.

Engineering survey

Engineering surveys have been greatly encouraged in recent years by the construction of pipelines, dams, retainer basins and water-supply networks, as well as energy facilities and roads. In addition to terrestrial procedures, photogrammetric methods will also be employed, autonomously or in conjunction with the former method. In this field also, the use of measuring and plotting automation has rapidly increased.

WORK OF THE INSTITUT GEOGRAPHIQUE NATIONAL, 1970–1973*

Paper presented by France

During the period 1970–1973, work was carried out by the Institut géographique national (IGN) in French territories and in a number of countries in Asia and the Far East

FRENCH TERRITORIES

New Caledonia

New Caledonia consists of a main island and four lesser islands, the total land area being 19,000 km². A third-order geodetic network had been established previously; and maps on the scales 1:50,000 and 1:100,000 are available, covering the whole of the territory.

Aerial photography carried out in the period 1970–1973 on behalf of the Topographical Service comprises:

(*a*) Aerial photography at 1:20,000 over 1,766 km² (RC8, 152), aircraft altitude 3,000;

(*b*) Photography at 1:15,000 over 882 km² (RC8 camera; focal length, 152 mm), aircraft altitude 2,250;

(*c*) Photography at 1:7,500 over 507 km² (RC8 camera; focal length, 152 mm), aircraft altitude 1,125.

The operation at 1:7,500 scale was carried out in preparation for work on the Noumea Peninsula, which will include a survey at 1:2,000 scale over an area of 168 km². Colour photography at 1:10,000 scale was also carried out with the RC8 camera over 4,744 km². Flight altitude was 1,500.

All the photography was carried out with an Aero-Commander.

Field operations preparatory to the 1:2,000 survey made it necessary to provide fourth-order and fifth-order ground control on the Noumea Peninsula. The observations covered 394 points.

In addition, stereoscopic ground-control work for the 1:20,000 coverage was carried out from the air, yielding the control points necessary for the 1:7,500 plotting of the photographs.

An area of 33 km² has been plotted at 1:2,000 and an area of 135 km² at 1:5,000, with a view to the preparation of a 1:2,000 edition

A total of 112 sheets was published in 1973, at 1:2,000 scale (65 per cent of the area), while 81 sheets have yet to be published. These maps at 1:2,000 scale were prepared in four colours according to the Universal Transversal Mercutor (UTM) projection and feature a 100-m grid and 5-m contour intervals.

New Hebrides

The New Hebrides archipelago is composed of 37 islands, covering a total area of 14,760 km².

The geodetic survey comprises a second-order network and a triangulation system established for the stereoscopic ground control of the archipelago before 1970.

Fifteen 1:50,000 maps have been published so far, and 14 more are ready for publication. These maps feature UTM projection and 20-m contour intervals, and are in four colours with shading.

Four maps on the scale 1:100,000 have been published with 40-m contour intervals in four colours with shading. Plans provide for 11 new sheets to be published in 1974, thus completing the cartographic coverage of the archipelago.

The two existing 1:500,000 sheets are being revised and will be issued in 1974.

French Polynesia

French Polynesia comprises the Society Islands (nine islands, including Tahiti, with a total area of 1,048 km²), and the Tuamotu archipelago (12 islands with a total area of 360 km²). The Society Islands have cartographic coverage at 1:40,000 scale and first- and second-order geodetic networks.

Work carried out between 1970 and 1973 includes:

(*a*) Photography at 1:30,000 scale over 650 km² using an RC8 camera, f = 152, at 4,500 flight altitude by Aero-Commander;

(*b*) A map at 1:2,000 scale of the Papeete-airfield, which is designed for civil aircraft;

(*c*) Cartographic coverage on the scale 1:10,000 of certain islands in the Tuamotu archipelago, using a 20-m contour interval;

(*d*) Three 1:2,000,000 sheets of Oceania, which have already been published; and three others in the course of preparation (Lambert intersecting conic projections, with distorted scale at the seventh and twentieth parallels);

(*e*) A 1:7,500,000 sheet entitled "Sydney-Tahiti" and a long-range navigation chart (Mercator projection) having the scale 1:680,446 at 25° south, in two colours with reference points indicated.

OTHER COUNTRIES OF ASIA AND THE FAR EAST

Aerial photography has been carried out over the following areas:

(*a*) Coverage of 194,268 km² on the scale 1:75,000 (RC10 camera; focal length, 89 mm; altitude, 6,700 m);

(*b*) Coverage of 75 km² at 1:5,000 scale (RC8 camera; focal length, 152 mm; altitude, 760 m);

(*c*) Coverage of 1,042 km² and 482 km² (colour photographs) at 1:10,000 scale (RC8 camera; focal length, 152 mm; altitude, 1,520 m);

(*d*) Coverage of 69,718 km² and 4,716 km² (colour photographs) at 1:30,000 scale (RC8 camera; focal length, 152 mm; altitude, 4,560 m).

In the first case, photography was carried out from a Mystère 20 aircraft, and in the last three cases, from a B17 aircraft.

An Aero-Commander equipped with an on-board scanner was used in a special aircraft mission to conduct thermographic surveys by remote sensing over areas totalling 50 km².

*The original text of this paper, prepared by the Institut géographique national (France), submitted in French, appeared as document E/CONF.62/L.116

Publications

On the basis of the IGN *Carte des Continents*, four sheets covering the Asian Highway have been published in five colours, with overprinting in three colours.

A geological map of Nepal on the scale 1:506,880 is being prepared. No publication date has yet been set.

Photogrammetric surveys of architectural sites

In addition to the above-mentioned cartographic work, it is of interest to mention the photogrammetic surveys of architectural sites carried out in 1972 and 1973 by IGN at the request of the United Nations Educational, Scientific and Cultural Organization (UNESCO), with a substantial contribution from the French Ministry of Foreign Affairs.

One of the surveys involves the temple of Borobudur, on the island of Java, in Indonesia. This temple is a pyramid of tiered terraces which has a base 120 m square and reaches a height of 50 m in its central part. Since the temple was to be completely restored, an over-all survey at 1:50,000 scale was the first essential step. The survey was carried out on the basis of photographs taken with a Zeiss-Jena UMK with 100-mm focal length, used on the ground and from a helicopter. Vertical aerial photographs were essential for the drafting of the over-all plan for the structure, and horizontal aerial photographs were also taken for use in the restoration of the upper parts of the temple. The restoration is nearing completion.

A new series of photographs will shortly be taken with a view to completing stereometric coverage of all the walls of the terraces on the scale 1:20,000, so that they can be restored.

The second survey involves the palace of Haniman Dhoka at Kathmandu, Nepal. This survey, too, is part of a restoration plan. Photographs taken with a Carl Zeiss TMK-t camera have been used for photo plans of the façades and for three-dimensional plotting on the scale 1:50,000. This work will be completed in the near future.

TRAINING OF CARTOGRAPHERS AT BUDAPEST UNIVERSITY*

Paper presented by Hungary

The Department of Cartography of Budapest University was established in 1953, and the training of cartographers began in 1955. The Department also undertakes the teaching of cartographic studies in related disciplines, such as geology and geography.

To date, 72 students have obtained a degree in cartography and 10 students have obtained a doctoral degree. Thirty diploma works and theses have dealt with general and methodological problems, 14 with physical geographical cartography and 38 with thematic cartography (of this group, 6 concerned economic subjects; 14, geographical cartography; 5, foreign tourist traffic; and 13, other subjects in the field of thematic cartography). Instruction is given by five staff members and two invited teachers.

Admission to the Department is by entrance examination. The number of candidates permits a selection, as there is sufficient interest in cartography, owing to the good employment possibilities, the attraction of the profession and other reasons.

The actual schedule of lessons is:

Schedule of lessons
(*Hours*)

Subject	*Semester* V	VI	VII	VIII	IX	X	*Total*
Cartographic mathematics	2[a] + 2[b]	—	—	—	—	—	2 + 2
Geodesy	2 + 2	2 + 2	2 + 2	—	—	—	6 + 6
Map projections	—	2 + 2	2 + 2	—	—	—	4 + 4
General cartography	1 + 2	2 + 1	—	2 + 2	2 + 2	—	7 + 7
Thematic cartography	—	—	2 + 1	2 + 2	2 + 2	—	6 + 5
History of maps	—	—	—	—	—	2 + 0	2 + 0
Cartographic technology	0 + 1	0 + 1	0 + 2	3 + 1	0 + 4	—	2 + 9
Technical laboratory	—	—	—	—	—	0 + 8	0 + 8
TOTAL	5 + 7	6 + 6	6 + 7	7 + 5	4 + 8	2 + 8	30 + 41
	12	12	13	12	12	10	71

[a] Weekly theory.
[b] Weekly practice.

The schedule of examinations is as follows:

(*a*) Practical studies are graded at the end of each semester;

(*b*) The examination in cartographic mathematics is given by the end of semester V;

(*c*) The university examinations in geodesy and map projections are given by the end of semester VII;

(*d*) The examination in cartographic technology is given by the end of semester VIII;

*The original text of this paper, prepared by Lajos Stegena, Department of Cartography, Budapest University, appeared as document E/CONF.62/L.96.

(*e*) The university examination in general cartography is given by the end of semester IX;

(*f*) The university examination in thematic cartography is given by the end of semester IX.

(*g*) The examination in the history of maps is given by the end of semester X;

(*h*) The state examination is given after semester X.

Outdoor professional exercises comprise four weeks of field-work after semester VI and three weeks of workshop practice after semester VIII.

Educational objectives and programmes of individual subjects

The programmes and objectives of the various cartographic projects are described below:

(a) *Cartographic mathematics*. This course provides the mathematical foundations of the special subjects. The programme includes analytical geometry, computers and calculators, mathematical statistics and their utilization in cartography;

(b) *Geodesy*. The student becomes sufficiently acquainted with geodetical instruments and methods to enable him to interpret the available geodetic data and to undertake individual field and laboratory works for cartographic purposes. Subjects include geodetic instruments (the classical instruments of geodesy, radio-frequency instruments, satellites); surveying (plane surveying, topographic and hydrographic survey); photogrammetry and photographic interpretation; elements of higher geodesy (form of the earth, national grid); and astronomical and terrestrial fixing of points. Future geodetic exercises demanding a higher degree of instrumentation are envisaged to be effected in the Photogrammetry Department of Budapest Technical University;

(c) *Map projections*. This subject encompasses more profound study of the fundamental principles, compositions, distortions and analysis of the current projections; general projective geometry, geographical projections and their analysis and drawing, and mechanical calculation of projections;

(d) *General cartography*. This course comprises thorough study of the general elements of cartography and of map compilation and map editing. The programme includes general criteria of the map, planimetric details, relief representation, lettering, framework and marginal information, cartographic generalization, illumination of the map, map compilation, map editing, preparation for printing, reproduction, publishing and distribution of maps, editorial principles of atlases, of reference and educational maps; mechanical data-processing and data-storing in cartography, copying and drawing mechanisms, mechanical establishment of complex parameters, objective generalization;

(e) *Thematic cartography*. In this course, the general principles and the principles of compilation and editing of thematic (special) maps are acquired. Topics covered include methodology of representation in thematic maps, preparation for cartographic representation of statistical and other data assets, and of parameters; principles of compilation and methodology of representation in thematic maps in natural sciences, general principles of compilation and methodology of representation of thematic maps in the social sciences, compilation and editing of thematic atlases;

(f) *History of maps*. This course acquaints the student with the development of modern cartography and with the utilization of old maps. Studies include the general history of maps and the history of Hungarian cartography;

(g) *Cartographic technology*. Practical methods of map-making are mastered to a degree which enables the student to perform some processes alone and to have a sufficiently profound grasp of others. Studies include map-drawing and lettering, phototechnics and map reproduction;

(h) *Technical laboratory*. Preparation of the diploma work is undertaken in this course. Areas covered include study of the technical literature, collection of materials, computation, construction of projections, compilation of maps, phototechnical and typographical works of the diploma work.

One of the main areas in the training of cartographers must be thematic cartography. In addition to this subject, the cartographer must obtain a thorough grounding in the elements of the major map-making disciplines—economic geography, political economics, geology, geophysics, meteorology, oceanography, foreign tourist traffic and pedology—so that he will be able to understand the language of the related disciplines.

Owing to the specialization of maps, another important field of development of cartography is the automation and mathematization of map-making. Therefore, in the training of cartographers, more stress should be laid on the teaching of subjects in the field of mathematics: theory of probability; mathematical statistics; mechanical mathematics; and automation.

The Department of Cartography of Budapest University would welcome students from Japan and other countries of the Far East.

SPECIAL GEOCARTOGRAPHIC WORKS IN HUNGARY, 1970–1973*

Paper presented by Hungary

International cartographic conferences and exhibitions

Since 1962, the National Office of Lands and Mapping of Hungary has been organizing regular annual conferences connected with exhibitions concerning individual fields of cartography. These conferences and exhibitions have dealt with particular fields of cartography which are of international scientific interest.

*The original text of this paper, prepared by the National Office of Lands and Mapping, Budapest, appeared as document E/CONF 62/L 123.

Hungary: cartographic conferences and exhibitions, 1970–1973

International Cartographic Conference		Number of lectures delivered	Number of participating countries	Number of exhibits
Year	Subject			
1970	Transportation maps	19	33	300
1971	National atlases and complex economic maps	22	59	280
1972	Historical maps and atlases	26	21	207
1973	New trends in cartography automation, remote sensing	30	17	Sample map-sheets, instruments, equipment, etc.

Catalogues of the above-mentioned exhibitions and texts of the lectures delivered are displayed in the technical exhibition of this Conference. With respect to the quantity of maps comprised and the number of participating countries, these catalogues can be considered bibliographical surveys of the cartography of a given field. The National Office of Lands and Mapping is prepared to send upon request, a limited number of copies of the proceedings and catalogues of the conferences and exhibitions.

Maps serving interests of the general public

In addition to publications providing general information and materials for foreign tourist traffic (general geographical atlases, and tourist and city maps), two specific series produced in the past three years by the National Office have attracted attention.

One series comprises the postcard map and the postcard map-block. Several million copies of these postcards, which show, in an artistic drawing, monuments and other sights adjusted to a map base, have been published. They are also published with text in other languages, for exportation.

The other series is that of poster maps. These maps are executed with strong lines, bright colours and conspicuous graphical representation, similar to the design of posters. By cartographic methods, they provide information about particular events related to domestic and foreign economics and politics. Hungary is the first country to publish informational material in this form on a regular basis. Each year from 20 to 25 poster maps are published; 60 per cent of these maps deal with subjects related to foreign affairs and 40 per cent concern economic and political events in Hungary.

Thematic mapping

Since 1970, work has been progressing on a series of regional atlases, comprising six volumes, covering the whole of Hungary on the scale 1:500,000. This work is near completion. By the middle of 1974, all volumes will be published simultaneously.

One other thematic mapping undertaking of major importance is the engineering-geological mapping on the scale 1:10,000, which was begun in 1969 and covers several regions of the country. In the course of the surveys concerning each region, nine different types of maps will be compiled: geological map; geomorphological map; hydrological map; hydrochemical map; soil map; run-off map; map for shallow foundations; map for deep foundations; map for engineering projects.

The survey has been begun in the largest recreational area of the country, on the shore of Lake Balaton, on the Tihany Peninsula. The relevant map-sheet is displayed in the exhibition. To date, the mapping of the whole northern shore of Lake Balaton has been completed. The text of the legend is given in both Hungarian and English.

Land-use Map of Europe

For the period 1972–1976, on the initiative of Hungary, the Work Land Use Survey Commission of the International Geographical Union adopted as one of its main projects the Land-use Map of Europe, to be prepared on the scale 1:2,500,000. The 130 × 180 cm base map is ready; in blue print it has been assembled by 12 sheets of the World Map on the scale 1:2,500,000, covering the continent of Europe (extending eastwards as far as Moscow).

The Geocartographic Research Department of the Institute of Surveying and Mapping at Budapest developed the colour legend, which is based on the land use classification system of the Food and Agriculture Organization of the United Nations (FAO); but to provide more information and higher versatility, it introduces subdivisions into the major FAO grouping. The legend consists of 27 symbols and a total of 32 land-use types; it is displayed in the technical exhibition. The project is supported by the active participation of specialists from 19 European countries.

CARTOGRAPHIC ACTIVITIES IN INDONESIA 1971–1973*

Paper presented by Indonesia

Organizations

The Badan Kordinasi Survey dan Pemetaan Nasional (BAKOSURTANAL) was established in 1969 to function with planning, budgeting and control of the surveys of natural resources and the systematic mapping of Indonesia. The agency was given responsibility for the following activities:

(*a*) Preparation of a national topographic base map series at 1:50,000 scale and compilation of a national map series at scales ranging from 1:100,000 to 1:1,000,000;

(*b*) Compilation and publication of national atlases;

*The original text of this paper, prepared by the Badan Kordinasi Survey dan Pemetaan Nasional (National Co-ordination Board for Surveys and Mapping), Indonesia, appeared as document E/CONF.62/L.102.

(*c*) Establishment and maintenance of national fundamental control networks (horizontal and vertical) and national gravity base stations;

(*d*) Basic hydrographic surveys and bathymetric charting;

(*e*) National geographical surveys;

(*f*) Management of the natural resources and environmental information system;

(*g*) Establishment and maintenance of national land and sea boundaries, including the delineation of continental-shelf boundaries;

(*h*) Information management of maps, aerial photos and other imageries;

(*i*) Preparation of aeronautical charts.

Not much has been achieved in the relatively short period since its establishment, but preparation must be made to raise its capacity in anticipation of increasing activities in surveys and mapping with the beginning of the Second Five-Year National Development Plan in April 1974. National research programmes involving long-term growth perspectives (25–30 years) have been formulated by the newly appointed Minister of State for Research, with stress on inventory, assessment and preservation of natural and human resources, and on ecology, as this is the basis for sound planning, policy-making and management as concerns resources in Indonesia.

To implement the national programmes outlined by BAKOSURTANAL the following capacities have been utilized: the Army Topographic Service for topographic mapping and geodetic surveys; the Naval Hydrographic Service for hydrographic and oceanographic surveys and for bathymetric charting. Both agencies, as part of the Department of Defence, are co-ordinated by the Armed Forces Surveys and Mapping. In addition to their special missions for defence, both agencies also render services to various government projects supporting the national development plan.

Other agencies involved in cartographic activities include: the Directorate General of Agrarian Affairs of the Department of Interior for cadastral and land-use mapping; the Soil Institute of the Department of Agriculture for soil research and mapping; the Directorate of Geology (known as the Geological Survey of Indonesia) for geological mapping and geophysical surveys; the Department of Public Works and Energy for large-scale mapping in conjunction with river-basin development projects, irrigation, highway construction, urban planning and development, etc.

Many foreign surveys and mapping firms are taking part in various development projects, either as contractors or in joint ventures with state or private enterprises, in the field of aerial surveys and mapping, especially in mineral and oil explorations, as well as in public works projects.

GEODETIC ACTIVITIES

During the period covered by this report, the geodetic operations described below and illustrated in figure 18[1] were conducted.

Trilateration

An Aerodist net consisting of 149 stations and 482 lines, covering an area of approximately 200,000 km², was established in the eastern part of Sumatera,[2] which connects the existing first-order triangulation network of the western part of Sumatera with that of Bangka-Riau network. In addition, a geodetic link was established by Aerodist survey between the west coast of Malaysia and the east coast of North Sumatera. The accuracy of the main Aerodist stations is of the second order, while that of minor Aerodist stations is of the third order.

A Tellurometer traverse measured in Central Sumatera is made up of eight stations with a total length of 430 km. The angles were measured with Wild T-3 and the sides with Tellurometer MRA-2. This traverse of first-order accuracy serves to strengthen the existing triangulation network of Central Sumatera. To check the old measurement of the Bangka-Riau trangulation network, a Tellurometer traverse was measured running from the fundamental point of this system, i.e., station P1-Gunung Menumbing on the island of Bangka to station P4-Gunung Jantan on the island of Karimun Besar. This traverse of nine stations has a total length of 470 km.

The above-mentioned Aerodist network and Tellurometer traverse are to provide ground control for the topographic mapping of Sumatera at 1:50,000 scale, carried out with technical assistance from Australia.

Triangulation

No triangulation station of first-order standard was observed during the report period. However, to close the triangulation system in the northern part of Sumatera, a Laplace station was observed at station C of the base net Cot Seupung in Aceh Province. With this fix, the provisionally computed Aceh triangulation could be adjusted, and the entire Sumatera triangulation system could be reviewed and rigorously adjusted. The Sumatera triangulation, which is an extension of the Jawa[3] triangulation system founded on a datum point at Gunung Genuk in Central Jawa established in 1873, was adjusted on a piecemeal method, as this adjustment had only a topographic and not a scientific purpose. For consistency and compatibility with other Laplace stations in the system, a reobservation of the above-mentioned datum point was conducted in 1972; but it failed to obtain results due to weather conditions. A plan is being made to renew the observation in 1974.

Satellite triangulation network

Since the Indonesian geometric network consists of separate geodetic systems that are difficult to unify by means of conventional optical measurements, a proposal has been submitted to the Government to consider the utilization of Geoceivers for Doppler satellite observation. A geodetic satellite programme in Indonesia has been prepared with the following objectives:

(*a*) The national geodetic satellite network should serve to strengthen the previously established geodetic control networks;

[1] Certain unnumbered maps have been placed in the pocket at the end of the volume. References in the text refer to the listing of these figures in the table of contents. Figures 18–21 are in this pocket.

[2] Formerly known as Sumatra.

[3] Formerly known as Java.

(*b*) It should provide for strong geodetic relationships between the separate Indonesian geodetic systems and an earth-centred co-ordinated system;

(*c*) It should be used to establish a national (unified) geodetic datum; therefore, it should provide for strong geodetic relationships to neighbouring geodetic systems, such as those of Australia and South-East Asia, and to the world-wide satellite geodetic system.

With these objectives in mind, the idea of a satellite network based on BC-4 camera observations consisting of 10 stations, as presented at the Sixth United Nations Regional Cartographic Conference for Asia and the Far East,[4] has been reviewed. It consists of 34 Doppler stations, which will be called the zeroth-order stations. In this field of development, Indonesia is aware that co-operation is mandatory to gear the envisioned plan, but it anticipates that co-operating countries should render their assistance on the basis of mutual need.

Gravity surveys

Both the Geological Survey of Indonesia and the State Oil Company (Pertamina) conducted intensive gravity surveys throughout the archipelago in conjunction with geophysical explorations. It has been reported that new Bouguer anomaly maps of Jawa, Madura and Bali have been published by the Survey. Due to the nature of gravity surveys performed by oil firms, not much information could be retrieved. Gravity measurement for geodetic purposes has not yet been initiated.

Levelling

A second-order levelling was carried out in South Sumatera for an agricultural project. The total length of the net is approximately 500 km; it was measured with a Wild N3 instrument. Second- and third-order levellings have been observed in Jawa for various river-basin development projects, irrigations and other public works. Barometric heighting in relation to topographic mapping of Sumatera on the scale 1:50,000 was executed using helicopters as transportation means.

A first-order precise levelling network initiated in 1925 partially covers the island of Jawa; the operation had to be stopped because of the economic depression in the 1930s and little attention has since been given to it. A great many of the bench-marks were lost or damaged, for various reasons.

There are numerous local-level nets, most of them linked to sea level through tide-gauge observations, but there is no uniformity. Nearly all the original tide-gauges have disappeared, as have the original readings. Consequently, the relationships between various local systems are not very accurately known. Very often, the only link consists of a relatively inexact trigonometrical measurement between triangulation stations. Even within the local systems, accuracy of observations varies strongly. In view of the importance of having a homogeneous height system, a proposal has been submitted to the Government to resume this unfinished work in Jawa, as well as to initiate a high-precision levelling survey in Sumatera.

[4] "An idea of a national fundamental network as a densification to the world-wide satellite triangulation system", *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.72.I.20), pp. 156–157.

MAP PRODUCTION AND REVISION

Topographic maps

Thirty new topographic map sheets of West Kalimantan at 1:50,000 scale have been produced. The sheet size is 15′ × 15′ and, for the first time, is presented in the Universal Transverse Mercator (UTM) grid system. Eight new topographic map-sheets covering the city of Jakarta at 1:25,000 scale have been produced. Figure 19 shows the areas of new topographic mapping in the period 1970-1973.

Fifteen topographic map-sheets of Jawa and South Sulawesi at 1:50,000 scale have been revised during the period under review.

International Map of the World on the Millionth Scale (IMW)

The compilation of the IMW series has had to be put aside for the time being since funds and forces must be directed towards the compilation of new topographic map series of West Kalimantan and South Sumatera.

EARTH RESOURCES STUDY AND NATIONAL ATLAS

The earth resources inventory and the regional studies utilizing aerial photos have been widely accepted and experimented by several government agencies (see figure 20). Remote sensing by multispectral camera also has been initiated by BAKOSURTANAL. For this purpose, at the beginning of 1973, the island of Bali was chosen as a pilot project with technical assistance from the United States Agency for International Development. Commencing with a short course in remote-sensing techniques conducted by experts from the United States of America, several government agencies in the fields of land, water, mineral and marine resources took part in the pilot project by conducting a ground-truth data survey in order to find keys for interpretation of multispectral imageries. This pilot project is continuing.

When the pilot project has been successfully concluded and implemented, it is planned to produce new national atlases of earth resources.

The interpretation of Earth Resources Technology Satellite (ERTS) imageries and the compilation of photo maps from those imageries on the scales of 1:1,000,000 and 1:250,000 also have been initiated but the results have not yet been reported. Indonesia is taking part in the project of the United States National Aeronautical and Space Administration (NASA) on the use of ERTS imageries for earth resources studies.

The presentation of thematic maps in digitized form is under study by BAKOSURTANAL.

HYDROGRAPHIC CHARTING AND OCEANOGRAPHIC SURVEYS

During the period under review, the Naval Hydrographic Service, in co-operation with the Directorate of Harbours and Dredging of the Department of Sea Communication, carried out the following operations:

(*a*) Hydrographic surveying in the Belawan channel to measure the depths of and the sedimentation in the channel for dredging purposes (1971);

(*b*) Hydro-oceanographic survey in the Batanghari River by the survey vessel RI *Burudjulasad* to measure the depths at the outer bar of Jambi harbour, Muarasabak harbour and the transit near Sungei Kelemak (1971);

(*c*) Hydro-oceanographic survey in the Musi River by the survey vessel RI *Burdjamhal* to measure the depths at the outer bar of the Musi River for dredging purposes (1971).

In co-operation with the State Enterprise of Mining, hydrographic surveys in the Kijang Strait and in Pomalaa, and a hydro-oceanographic survey in the Cilacap channel were conducted for dredging purposes (1971-1972).

In co-operation with the Port Administrator of Surabaya, the following activities were reported:

(*a*) Hydro-oceanographic survey in the western channel of Jamuang (Surabaya) by KM *Samudera* to measure the depths of and the sedimentation in the channel caused by the Bengawan Solo River (1971);

(*b*) Hydro-oceanographic survey in Meneng harbour (Banyuwangi) to prepare a special chart of the newly constructed Meneng harbour (1972).

Reported also are activities conducted in 1972 under survey contracts with several private firms, including among others:

(*a*) Hydrographic surveying in the channel of Balikpapan for timber transportation;

(*b*) Hydro-oceanographic survey in Anyer Lor (West Jawa);

(*c*) Hydro-oceanographic survey in Tanjung Pasir to measure the depths and the influence of monsoons along the coastal waters.

Joint survey by Indonesia, Malaysia, Singapore and Japan

The joint survey being conducted by Indonesia, Malaysia, Singapore and Japan known as the "Malacca Strait II Hydro-oceanographic Survey", is a continuation of the Malacca Strait I survey conducted in 1970. It has the same objectives as the previous survey: to measure the depths of several areas and to increase the safety of navigation in the Strait. Indonesian vessels that took part in this operation were RI *Burudjulasad*, RI *Jalanidhi* and RI *Aries*; and that of Malaysia was KD *Perantau*.

Charts corrected according to survey results in 1971-1972 and one new chart produced in 1972 have been reported as follows:

(a) *Chart No. 19*: the eastern coast of Sumatera and the mouths of the Belawan and Deli rivers at 1:25,000 scale;

(b) *Chart No. 48*: the eastern coast of Sumatera, Jambi River with detailed charts of Jambi harbour, Muarasabak harbour and the transit near Sungei Kelemak, which was also corrected according to Indonesian Notes to Mariners up to No. 28 (1971), at 1:50,000 scale;

(c) *Chart No. 44B*: the southern coast of Bintan (Kijang, Dendang and Kelong Straits) on the scales 1:7,500, 1:20,000 and 1:50,000;

(d) *Chart No. 290*: a new chart of Meneng harbour (Banyuwangi) at 1:10,000 scale;

(e) *Chart No. 319*: the southern coast of Sulawesi and northern part of Teluk Bone at 1:200,000 scale, with anchorage plan at Sungei Wotu at 1:25,000, as well as plans of Teluk Usu at 1:50,000, Teluk Pausu at 1:25,000 and Teluk Labuandata at 1:20,000;

(f) *Chart No. 152*: the southern coast of Sulawesi, Teluk Bone and Teluk Mekongga at 1:100,000 scale.

Common Datum Project Indonesia-Malaysia

Owing to the differences in fundamental points and reference surfaces used in the charting systems of Indonesia and Malaysia, difficulties arise in position-fixing, as well as in delineation of continental-shelf boundaries in the Strait of Malacca. Consequently, the Governments of Indonesia and Malaysia mutually agreed upon the fixing of one point of origin and upon the adoption of a common reference surface for mapping operations in the Strait of Malacca. The Director of Naval Hydrographic Service of Indonesia and the Director of National Mapping of Malaysia are responsible for the implementation of this joint effort, known as the "Common Datum Project Indonesia-Malaysia".

The selected fundamental point is the Malaysian island, Pulau Pisang, and the selected azimuth is the direction from this station to the first-order triangulation station of Indonesia, P4-Gunung Jantan. Astronomical observations of first-order accuracy using DKM-3A were observed by both parties, the Indonesian-Malaysian joint technical team, during the period from March to April 1972: the latitude by circummeridian method, the longitude by almucantar transit and the azimuth by star hour angle. Additional first-order astronomical observations were performed at P4-Gunung Jantan; furthermore, the distance from Pulau Pisang to Gunung Jantan was observed with Tellurometer, first, to close the Bangka-Riau network; and, secondly, to serve as an additional control to the fundamental point at Pulau Pisang. The Tellurometer results, however, were not quite satisfactory owing to the noise reflected by being too close to sea-surface measurement. As a common reference surface for computation of geodetic positions, the International Ellipsoid of 1924 was used. Even though the final result was accepted by the joint technical team in May 1973, it still requires verification by both Governments.

Through the linking of the Indonesian station at Gunung Jantan with the fundamental point at Pulau Pisang, the Indonesian triangulation system would, in fact, become one system with that of Malaysia when the transformation computation takes place.

Geographical Names

Effective January 1973, the Governments of Indonesia and Malaysia agreed upon the simplification of the spellings of the Indonesian and Malaysian languages. Consequently, former Indonesian spellings must be changed into a common Indonesian-Malaysian system, e.g., *tj* becomes *c*, *dj* becomes *j*, *j* becomes *y*, *ch* becomes *kh*, *nj* becomes *ny*. This change also affects all geographical names, some of which are given below:

Former spelling	*Current spelling*
*Tj*irebon	*C*irebon
*Dj*akarta	*J*akarta
*Dj*a*j*apura	*J*a*y*apura
Ban*j*uwangi	Ban*y*uwangi

Mention should be made also of some geographical names that have been changed:

Former name	*Current name*
Kutaraja (in Aceh)	Banda Aceh
Makassar (city)	Ujung Pandang
Irian Barat (former West New Guinea)	Iran Jaya
Sukarnopura (former Hollandia)	Jayapura

Furthermore, some Indonesian islands named according to the Dutch language have been given Indonesian names. It is expected that these names will be printed in all new atlases or maps produced by any country. Some of the changes made are:

Former name	*Current name*
Indonesian Borneo	Kalimantan
Celebes	Sulawesi
Lesser Sunda Isles	Nusa Tenggara
West Irian or West New Guinea	Irian Jaya
Molukken or Moluccas	Maluku
Sumatra	Sumatera
Java	Jawa

Training and education

To cope with the increasing activities in surveys and mapping in the decade to come and with future development, the manpower needed for research, science and technology, as well as the manpower required for the lower echelons, is a subject for concern. In this respect, it is worth while to mention that a School for Photogrammetric and Cartographic Operators, with technical assistance rendered by the Government of the Netherlands, is to commence in 1974. Preparation for the opening of this institution is under way. This school will be attached to the Bandung Institute of Technology; and its objective is to fulfil the need for operators in government agencies within the subsequent five years. The annual output expected is 20 photogrammetric operators and 20 cartographic technicians.

A school for interpretation of imageries will be the next priority, as this technique is now widely accepted as a tool for resources inventory and study; and abundant materials are currently available, both for aerial photos and for remote-sensing imageries, including those of ERTS-A. Indonesia advocates any technical assistance that might help to build up the national capabilities in this field. A short training programme was conducted some time ago by experts from the United States of America; however, a permanent training school in remote sensing is worth considering in connexion with future developments.

Courses in geodesy and photogrammetry are being offered by two universities, Bandung Institute of Technology at Bandung and Gajah Mada University at Jogyakarta. Courses at Bandung Institute constitute a four-year programme leading to an engineering degree in land surveying, photogrammetry and hydrographic surveying, and an additional two-year programme leading to a science degree in geodesy. Courses at Gajah Mada University are still based on the old system of a five-year programme leading to an engineering degree in geodesy.

Courses in geography are being offered at several universities, but only that of Gajah Mada University is considered the feeder institute of the country.

IRANIAN NATIONAL REPORT*

Paper presented by Iran

Up to July 1973, two organizations, the National Geographic Organization and the National Cartographic Centre, were responsible for surveying and mapping activities throughout Iran.

The National Geographic Organization was responsible for preparing geodetic data and for the production of small- and medium-scale maps to cover the entire country. At first, the National Geographic Organization was a geographic department within the military staff. Subsequently, as a result of the development of the department, it became known as the National Geographic Organization.

The National Cartographic Centre was established in 1953 for the purpose of preparing maps required by the planning organization. It was thus responsible for preparing maps required for such development projects as dams and irrigation works, communications, power transmission and transport of water-supplies.

In July 1973, the National Geographic Organization and the National Cartographic Centre were merged. These two organizations then became known as the National Geographic Organization.

Cartographic activities in Iran

Geodesy

Triangulation and traverses

The main basis is a chain of triangulation 60 km wide linking the border of Iran and Turkey in the north-west with the border of Iran and Pakistan in the south-east, and extending over a distance of 2,000 km. The chain follows the central mountain ranges and all angular measurements were made using one-tenth second theodolites.

Five base lines, suitably disposed along the chain, were measured by Geodimeter. The chain has been computed and adjusted on to Laplace position fixes on the international spheroid. The chain is connected to a number of SHORAN stations which have been used for control of aerial photographic cover.

The national geodetic chain is a triangulation and traverse network in the southern area which covers some

*The original text of this paper appeared as document E/CONF.62/L.103

250,000 km². Figure 22 shows the geodetic net index in Iran.[1]

Current operations include an extension to the northern part of the country by a system of Tellurometer traverses.

Levelling

The levelling network is based on tide-gauge observations at stations located in the south. The network, which is evenly distributed over the entire country, required some 100,000 km of levelling of the second, third and fourth orders.

A system of carrying heights to the higher ground from the lower lying lines of levels by trigonometrical observations has now been adopted.

Geomagnetic and gravity measurements

For geomagnetic measurements, a modern, fully equipped observatory has been established, with capability for both absolute and variation measurement. The equipment includes a Schmidt magnetic theodolite, an Askania earth inductor, an Askania variograph, a pulsation magnetograph and an H-magnetograph.

Gravity measurements were first taken in 1960, using an Askania gravity meter; since 1967, however, a La-Coste and Romberg instrument has been employed. To date, some 5,000 first- and second-order bases have been established. Measurements commenced in the north-western province of Azarbaijan and are being extended to cover the whole country. The gravity survey of Iran is shown in figure 23.

The adjustment of results is being carried out according to the least squares of Gauss-Vogler.

Photogrammetry

Aerial photography

The whole of Iran was first covered by aerial photography during the period 1955-1957. The photo scale was approximately 1:50,000, and the main purpose was for the production of two general series of maps at 1:50,000 and 1:250,000 scales.

A second programme of new complete coverage, which was begun in 1965, was completed in 1972. The photo scale is approximately 1:20,000, and it is intended for land reform mapping purposes and other uses.

Aerial photography and map coverage are shown in figures 24–28.

Terrestrial photography

Increasing use is being successfully made of terrestrial photogrammetry in the preparation of large-scale maps for dam sites, archaeological studies, etc.

Provision of photogrammetric control

The necessary control for orientation of stereograms for photogrammetric restitution is provided either through field surveys or through a combination of field control and aerotriangulation adjusted in strips or blocks. Both methods of aeropolygon extension and independent models for strip-and-block adjustment to ground control are used.

[1] Figures 22–28 and 30 are in pocket at end of volume

Survey methods usually employed for providing control consist mainly of triangulation or Tellurometer traversing, or a combination of both.

Cartography

Drawing

The majority of maps are fair drawn for reproduction using scribing methods. Some free-hand pen-and-ink drawing is practised for work of a short-term nature.

For suitable projects, direct scribing on the plotting instruments is occasionally employed.

Lettering and numbers are added to the maps by usual letterpress methods, and stencilling or free-hand lettering is used occasionally for short-term project work.

Strip-masking methods are frequently used for colour separation.

Printing

Scribed sheets are printed down on to zinc or aluminium plates, and multicoloured final map-sheets are produced on offset printing machines.

Map production

General series

It is planned to cover the country with two map series at 1:50,000 and 1:250,000 scales. To cover the entire country, 2,650 sheets at 1:50,000 scale, each covering an area 15′ × 15′, are required. Up to July 1973, 1,235 sheets have been printed in seven or eight colours, of which 936 sheets have been completed during the past three years.

At 1:250,000 scale, 136 sheets, each covering an area of 1° × 1½°, are required to cover the country. Up to July 1973, 108 sheets have been printed in seven or eight colours. An index to topographic mapping at 1:250,000 scale is shown below.

Project mapping

A wide variety of different scales and types of mapping is undertaken as demanded by all forms of development projects. Scales vary from 1:200 to 1:10,000, and the maps are used for study, planning and execution of hydroelectric and irrigation schemes, transmission line networks, urban development, mineral exploration, pipelines, highways, etc.

Cadastral mapping

As a basis for cadastral mapping, aerial photography on the scale 1:6,500 or 1:7,500 is first undertaken. Each photograph is enlarged and rectified to 1:2,500 scale based on ground control.

The rectified enlargements are then taken to the area to be settled or resettled. In consultation with local elders and owners, the boundaries of each property are determined, marked on the enlargements, numbered and entered in the register. From this information, maps are produced, which, in addition to the cadastral information, include all main topographic details.

The maps are annotated with the information collected on the photo enlargements and property areas measured. Title deeds are then issued to each owner.

An extensive, regulated programme is planned to produce a complete series of cadastral maps from the aforementioned work, with 1:20,000 scale photography.

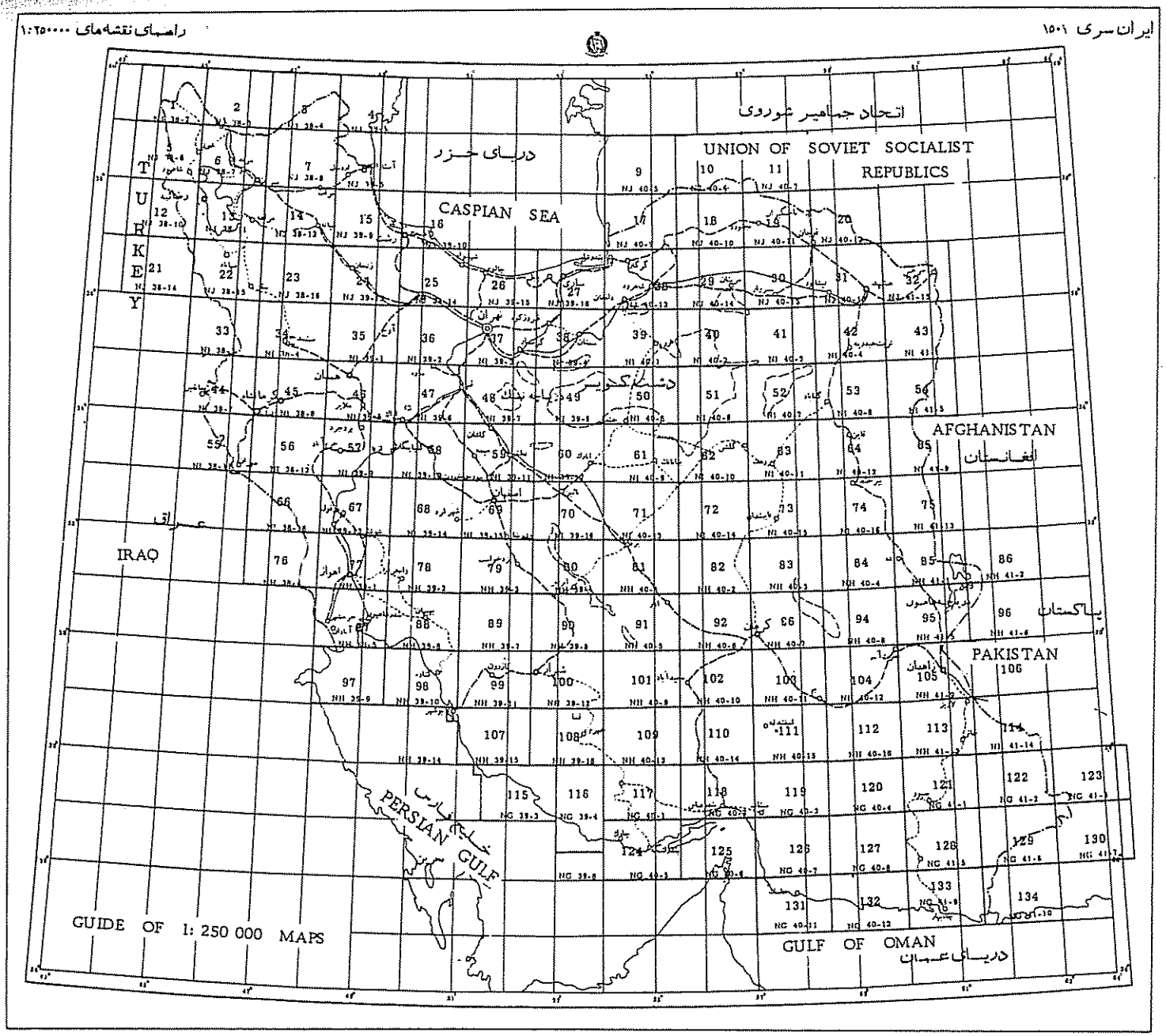


Figure 29. Iran: index to topographic mapping at 1:250,000 scale

Photo-interpretation

Apart from the normal process of photo-interpretation as required for general mapping, the existing aerial photography is used for a number of other purposes, notably photogeology and forest inventory.

Numerous photogeological studies have been concentrated along the Caspian littoral. This work has been undertaken by the Engineering Department of the Ministry of Natural Resources, using photographs on the scales 1:50,000, 1:10,000 and 1:5,000 for inventory, classification and tree-height measurements.

The information thus obtained is being used for re-afforestation, preservation and development of allied industry.

Geological mapping

The production of geological maps in Iran is the responsibility of the Geological Survey Institute. The National Iranian Oil Company makes a significant contribution to this work in the areas in which it is active.

Geological maps are being produced at 1:500,000 scale and, subsequently, at 1:100,000 scale. An area of approximately one third of Iran has been covered with geological maps of varying scales and quality. An extensive programme of extending geological coverage and upgrading existing mapping where necessary, to meet the ever-increasing needs of the country, is now planned.

The progress in geological map production as of March 1973 is shown in figure 30.

Classification of aerial photography and collection of geographical information

Revision of existing geographical information through interpretation of aerial photographs has been the main objective during the past three years. Photographs have been classified and existing maps brought up to date by means of extensive ground surveys, aerial observations carried out from reconnaissance aeroplanes or helicopters, travels *via* motor vehicles and even trips on horseback to the various parts of the country.

Along with the above-mentioned activity, all information necessary for bringing the existing village and country files up to date are collected systematically and stored for proper utilization. Maps and records are revised regularly, and corrected information is disseminated among governmental agencies, as well as the general public.

Standardization of geographical names

A recent scheme for standardization of names and proper recording of the local usages has been introduced and is successfully operational in the south-eastern part of Iran. A phonetic archive has also been initiated in which all names will gradually be recorded for future needs.

In addition to these efforts, which are primarily concerned with names of individual villages, monographs are compiled at various levels covering counties and districts. These monographs are prepared and checked by senior university students and are intended to supply the necessary material for the new geographical dictionary of Iran.

Role of Literacy or "Knowledge" Corps

The tremendous role played by Iranian youth, who, under an ingenious scheme, spend the major part of their compulsory military service in combating illiteracy in Iranian villages, is well known.

The National Geographic Organization has exploited the unique opportunity offered by the military Education Corps in the fulfilment of its various geographical objectives. Each year, no fewer than 15,000 of the young men who comprise the main body of the Literacy or "Knowledge" Corps are dispatched to remote villages throughout the country. They are by nature educated, energetic, progressive in outlook and ready to co-operate with all government agencies.

The National Geographic Organization supplies them with a special questionnaire form as shown in figure 32. In time, the conscripts fill in and mail the completed form to the Organization headquarters, where the information supplied is checked and transferred to cards for systematic treatment. The process goes on from year to year and results in numerous questionnaires for each village. The system not only supplies up-to-date information, but provides a good system for cross-checking of names and related data. Some 20,000 villages have been thus surveyed and the information gathered has been utilized very effectively

Romanization of geographical names

The system developed by the National Geographic Organization for the romanization of place names and adopted by the United Nations Conference on the Standardization of Geographical Names[2] under resolution 13 is widely used throughout Iran. Government agencies, as well as private publishers and cartographers, make use of this system in their publications.

[2] *United Nations Conference on the Standardization of Geographical Names*, vol I, *Report of the Conference* (United Nations publication, Sales No. E.68.I.9), p. 13

NAME OF VILLAGE
اسامی آبادیها

SHEET NAME
نام شیت آبـــادان

SHEET NO.
شماره شیت NH-39-5

MINISTRY OF WAR
وزارت جنگ

NATIONAL GEOGRAPHIC ORGANIZATION
سازمان جغرافیایی کشور

GEOGRAPHIC INFORMATION DIRECTORATE
مدیریت عملی اطلاعات جغرافیایی

PROVINCE
استان خوزستان شماره برگ ۱

CITY شهرستان

DISTRICT بخش

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۱	آبـــادان	ĀBĀDĀN	۴۸° ۱۷′ ۳۰″	۳۰° ۲۰′ ۱۵″	۳	آبـادان ـ مـرکزی
۲	آبشـــار	ĀBSHĀR	۴۸° ۴۲′ ۱۰″	۳۰° ۳۶′ ۰″	۴	اهـواز ـ حـومـه
۳	اُبُسخـــر	OBOSKHER	۴۸° ۲۱′ ۴۰″	۳۰° ۵۸′ ۱۰″	۵	اهـواز ـ حـومـه
۴	ابو شُلـوک	ABŪ SHOLŪK	۴۸° ۳۰′ ۱۰″	۳۰° ۴۳′ ۴۰″	۴	خرمشهر ـ شادگان
۵	ابو عَظیم	ABŪ ʻAẒĪM	۴۹° ۰۴′ ۱۰″	۳۰° ۵۷′ ۰″	۱۴	آبادان ـ قصبه
۶	بَنَدر شاهپور	BANDAR-E SHĀHPŪR	۴۹° ۰۴′ ۳۰″	۳۰° ۲۵′ ۵۵″	۴	مـاه شـهر ـ حومه
۷	بَنَدر ماهشَهر	BANDAR-E MĀHSHAHR	۴۹° ۱۱′ ۴۵″	۳۰° ۴۰′ ۴۹″	۶	مـاه شـهر ـ حومه
۸	بـــوزی	BŪZĪ	۴۸° ۴۳′ ۱۰″	۳۰° ۳۹′ ۳۰″	۴	مـاه شـهر ـ هندیجان
۹	بُویـرده	BOVEYRDEH	۴۹° ۲۰′ ۴۰″	۳۰° ۵۶′ ۴۰″	۲۰	رامهرمز ـ رامشیـر
۱۰	بیت یاسین	BEYṬ-E YĀSĪN	۴۸° ۱۷′ ۴۰″	۳۰° ۲۱′ ۱۵″	۳	آبـادان ـ حومه
۱۱	تِخیط	TEKHEYṬ	۴۹° ۰۵′ ۵۰″	۳۰° ۴۲′ ۴۰″	۱۴	ماه شهر ـ حومه
۱۲	تُلتُلیه	TOLTOLEYYEH	۴۹° ۲۰′ ۲۰″	۳۰° ۵۰′ ۳۰″	۱۵	خرمشهر ـ شادگان
۱۳	تـــوپچی	TŪPCHĪ	۴۸° ۳۸′ ۲۰″	۳۰° ۴۱′ ۵۰″	۳	خرمشهر ـ شادگان
۱۴	تـــومـار	TŪMĀR	۴۸° ۰۳′ ۱۰″	۳۰° ۲۸′ ۲۰″	۳	خرمشهر ـ حـومه
۱۵	ثُلث	SOLS	۴۹° ۰۲′ ۴۰″	۳۰° ۴۳′ ۴۰″	۱۳	مـاه شـهر ـ حومه
۱۶	جابری	JĀBERĪ	۴۸° ۳۹′ ۵۰″	۳۰° ۴۸′ ۵۰″	۸	خرمشهر ـ شادگان
۱۷	جَـدید	JADĪD	۴۸° ۴۶′ ۲۰″	۳۰° ۳۸′ ۱۰″	۳	خرمشهر ـ شادگان
۱۸	جَعفَـری	JAʻFARĪ	۴۸° ۴۳′ ۲۰″	۳۰° ۴۷′ ۰″	۹	خرمشهر ـ شادگان
۱۹	چَـم مَهاوی	CHAM-E MAHĀVĪ	۴۸° ۴۳′ ۰۵″	۳۰° ۴۶′ ۰۰″	۱۴	رامهرمز ـ رامشیـر
۲۰	حَـدبه	ḤADBEH	۴۸° ۴۳′ ۵۰″	۳۰° ۳۸′ ۳۰″	۴	خرمشهر ـ شادگان
۲۱	حَـدید	ḤADĪD	۴۹° ۱۷′ ۰۰″	۳۰° ۴۸′ ۱۰″	۱۵	رامهرمز ـ حـومه

2843.31 X

Figure 31. Iran: geographical information sheet

NATIONAL GEOGRAPHIC ORGANIZATION
GEOGRAPHIC INFORMATION DIRECTORATE

VILLAGE INFORMATION SHEET

VILLAGE NAME VILLAGE NAME WITH SYLLABLES AND SEPARATE ALPHABET

PROVINCE GOVERNORY CITY TOWN VILLAGE

OTHER NAMES (PAST AND PRESENT) VILLAGE NAME VILLAGE NAME WITH SYLLABLES

1:VILLAGE NAME 2:VILLAGE NAME IN FULL SEPARATE LETTERS

NATURAL POSITION:

FOOTHILL ☐ PLAIN ☐ FOREST ☐ SEASIDE ☐ RIVERSIDE ☐ ☐ ☐

CLIMATE:

COLD ☐ HOT ☐ DRY ☐ WET ☐ ☐ ☐ ☐ ☐

POTABLE WATER:

PIPE LAYING (PROCESSED WATER) ☐ PIPE-LAYING ☐ SPRING ☐ CANAL ☐

RIVER ☐ WELL ☐

ROADS CROSSING THE VILLAGE:

RAILWAY ☐ HARD SURFACE ☐ FOOT ROAD ☐ DIRT ROAD ☐☐☐

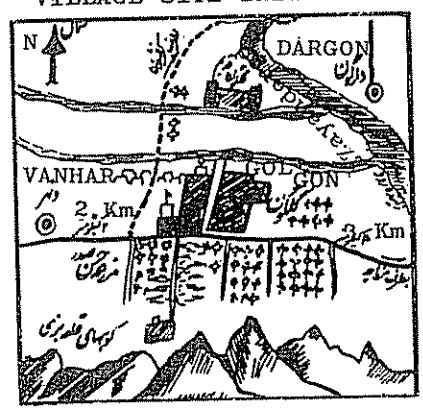
DISTANCE FROM THE CENTRE OF COUNTY (km)

DISTANCE FROM MAIN ROAD (km)

DISTANCE TO THE NEAREST VILLAGE (km)

KIND OF GAME, WILD ANIMALS OR FISH AVAILABLE IN THE NEIGHBOURHOOD OF THE VILLAGE

VILLAGE SITE SKETCH



FOREST AND WOODS BESIDE THE VILLAGE:

NAME APPROXIMATE AREA KIND OF TREES FOREST PRODUCTS

PREVALENT WIND:

KIND OF WIND WIND NAME WIND SEASON WIND TIME WIND EFFECT

2843.32 X

Figure 32. Iran: village information sheet

NATIONAL REPORT OF ISRAEL FOR THE PERIOD 1970-1973*

Paper presented by Israel

Surveying and mapping activities in Israel are practised on different levels at various establishments, the major one of which is the Survey of Israel, a governmental agency of departmental rank within the Ministry of Labour.

While the Survey of Israel is responsible for national geodetic and cartographic tasks, a number of private practitioners are engaged in surveying activities for engineering and land-registration purposes.

Academic training in geodesy and cartography is given at Technion-Israel Institute of Technology, Haifa; and at Tel-Aviv University, both of which are also active in research and experimental work. This report reviews the changes and developments that have taken place in the field of surveying and mapping in Israel in the period 1970-1973.

GEODESY

The geodetic activities of the Survey of Israel have been mainly concerned with the improvement and extension of the major control network of the country. The original triangulation has been augmented by electromagnetic distance measurements, trilaterations and geodetic traverses, as well as astronomical observations.

Electronic distance-measuring equipment is being extensively used, particularly the laser Geodimeter. The major network is being recomputed and readjusted, the preliminary results showing a very considerable improvement on the 1:70,000 relative accuracy achieved within the original triangulation network.

A number of computer programmes, covering the whole range of geodetic computations, has been developed.

A new base for the field calibration of electronic distance-measuring instruments is being established, and a magnetic field observatory is in the process of being relocated and augmented by new equipment.

The precise levelling network is being strengthened by gravimetric observations along the major lines.

PHOTOGRAMMETRY

Topographic mapping, for various purposes, on scales ranging from 1:500 to 1:50,000, has continued, utilizing a wide range of plotting instruments.

The orthophotoscope was recently introduced at the Survey of Israel, and orthophotos are in the process of being introduced as an alternative to planimetric maps for engineering and cadastral purposes. They have been very well received by the users, and a rapidly increasing demand for this product is envisaged.

It is expected that the orthophoto will be gradually introduced as the background of regular map series, thus reducing the amount of cartographic work involved in the production of conventional line maps. The photogrammetric control extension is gradually being switched over to analytical methods based on the measurements with the aid of a digital monocomparator coupled with a card punch and processed in the electronic computer. Preliminary results show that accuracies close to 1 micron are feasible within the realm of measurement, which is, of course, a considerable improvement on control extension accuracies achievable through aerial triangulation or the independent model method.

The digital monocomparator may well be instrumental in advancing photogrammetric methods in the field of cadastral surveys, which thus far has not met with success.

CARTOGRAPHY AND REPRODUCTION

Whereas commercial firms have continued to publish various thematic maps and atlases, the activities of the Survey of Israel have been mainly, though by no means exclusively, in the field of topographic mapping.

Stress was laid on large scales for economic and planning purposes, on the one hand, and on small scales, on the other. In addition to extensions to the Hebrew edition of the 1:100,000 series, an overprint in English of selected names is in preparation. A new series on the scale 1:250,000, in four sheets, has been published, as well as a new 1:750,000 map. A general-purpose map of the country, at 1:500,000 scale with four inserts of main cities, is about to be printed and made available.

Several new town plans were added to the existing 1:10,000 and 1:12,500 series. Some of the existing town plans were revised and the style changed to bring them in line with the most recent editions. A variable-scale town plan is currently in experimental preparation. The policy of presenting a town map on one sheet, which is desirable from the point of view of the user's convenience, can only be preserved if either the scale is reduced or the map is presented at a variable scale. Considering that the density of built-up areas usually decreases more or less radially from the centre, the experiment concerns the production of a map of Jerusalem based on a parabolic projection.

A novelty was the aerial photograph of the Old City of Jerusalem at 1:2,000 scale, printed in sepia and supplied with or without an overlay of names. Naturally, updating of existing maps has been one of the major tasks of the Survey of Israel.

Thematic maps published by private firms fall mainly under the headings of town and road maps for tourists, for which there is a great demand. The former maps are mostly of the pictorial variety, some being perspective views or differential scale maps. The latter are small-scale maps all based on material supplied by the Survey of Israel and produced by such firms as Carta Ltd. (Jerusalem), by the Cartographic Institute of the Technion-Israel Institute of Technology (Haifa), and by others.

Thematic maps printed by the Survey of Israel include four new maps at 1:250,000 scale in two sheets: a detailed map of soil types in Israel; a new road map; a map of the administrative divisions; and a historical map of the Holy Land during the period of the Crusades. The geomorphology of the Elat region and a series of navigation charts of the Mediterranean coastal waters of Israel

*The original text of this paper appeared as document E/CONF. 62/L.53.

250,000 km². Figure 22 shows the geodetic net index in Iran.[1]

Current operations include an extension to the northern part of the country by a system of Tellurometer traverses.

Levelling

The levelling network is based on tide-gauge observations at stations located in the south. The network, which is evenly distributed over the entire country, required some 100,000 km of levelling of the second, third and fourth orders.

A system of carrying heights to the higher ground from the lower lying lines of levels by trigonometrical observations has now been adopted.

Geomagnetic and gravity measurements

For geomagnetic measurements, a modern, fully equipped observatory has been established, with capability for both absolute and variation measurement. The equipment includes a Schmidt magnetic theodolite, an Askania earth inductor, an Askania variograph, a pulsation magnetograph and an H-magnetograph.

Gravity measurements were first taken in 1960, using an Askania gravity meter; since 1967, however, a La-Coste and Romberg instrument has been employed. To date, some 5,000 first- and second-order bases have been established. Measurements commenced in the north-western province of Azarbaijan and are being extended to cover the whole country. The gravity survey of Iran is shown in figure 23.

The adjustment of results is being carried out according to the least squares of Gauss-Vogler.

Photogrammetry

Aerial photography

The whole of Iran was first covered by aerial photography during the period 1955-1957. The photo scale was approximately 1:50,000, and the main purpose was for the production of two general series of maps at 1:50,000 and 1:250,000 scales.

A second programme of new complete coverage, which was begun in 1965, was completed in 1972. The photo scale is approximately 1:20,000, and it is intended for land reform mapping purposes and other uses.

Aerial photography and map coverage are shown in figures 24–28.

Terrestrial photography

Increasing use is being successfully made of terrestrial photogrammetry in the preparation of large-scale maps for dam sites, archaeological studies, etc.

Provision of photogrammetric control

The necessary control for orientation of stereograms for photogrammetric restitution is provided either through field surveys or through a combination of field control and aerotriangulation adjusted in strips or blocks. Both methods of aeropolygon extension and independent models for strip-and-block adjustment to ground control are used.

[1] Figures 22–28 and 30 are in pocket at end of volume

Survey methods usually employed for providing control consist mainly of triangulation or Tellurometer traversing, or a combination of both.

Cartography

Drawing

The majority of maps are fair drawn for reproduction using scribing methods. Some free-hand pen-and-ink drawing is practised for work of a short-term nature.

For suitable projects, direct scribing on the plotting instruments is occasionally employed.

Lettering and numbers are added to the maps by usual letterpress methods, and stencilling or free-hand lettering is used occasionally for short-term project work.

Strip-masking methods are frequently used for colour separation.

Printing

Scribed sheets are printed down on to zinc or aluminium plates, and multicoloured final map-sheets are produced on offset printing machines.

Map production

General series

It is planned to cover the country with two map series at 1:50,000 and 1:250,000 scales. To cover the entire country, 2,650 sheets at 1:50,000 scale, each covering an area 15′ × 15′, are required. Up to July 1973, 1,235 sheets have been printed in seven or eight colours, of which 936 sheets have been completed during the past three years.

At 1:250,000 scale, 136 sheets, each covering an area of 1° × 1½°, are required to cover the country. Up to July 1973, 108 sheets have been printed in seven or eight colours. An index to topographic mapping at 1:250,000 scale is shown below.

Project mapping

A wide variety of different scales and types of mapping is undertaken as demanded by all forms of development projects. Scales vary from 1:200 to 1:10,000, and the maps are used for study, planning and execution of hydroelectric and irrigation schemes, transmission line networks, urban development, mineral exploration, pipelines, highways, etc.

Cadastral mapping

As a basis for cadastral mapping, aerial photography on the scale 1:6,500 or 1:7,500 is first undertaken. Each photograph is enlarged and rectified to 1:2,500 scale based on ground control.

The rectified enlargements are then taken to the area to be settled or resettled. In consultation with local elders and owners, the boundaries of each property are determined, marked on the enlargements, numbered and entered in the register. From this information, maps are produced, which, in addition to the cadastral information, include all main topographic details.

The maps are annotated with the information collected on the photo enlargements and property areas measured. Title deeds are then issued to each owner.

An extensive, regulated programme is planned to produce a complete series of cadastral maps from the aforementioned work, with 1:20,000 scale photography.

CARTOGRAPHIC WORKS IN JAPAN, 1970–1973*

Paper presented by Japan

Most of the cartographic works in Japan are controlled by governmental organizations. They are classified into two categories: the national fundamental survey executed by the Geographical Survey Institute (GSI) and the Hydrographic Department; and the public surveys which are carried out by other governmental or public organizations, such as the Bureau of Forests, the Economic Planning Agency, Japan National Railways, Highway Public Co-operation and local governments.

NATIONAL FUNDAMENTAL SURVEY

The national fundamental survey in Japan is mainly divided into geodetic works, topographic works, geographical works and others. The details of each work are summarized below.

Geodetic works

The fundamental geodetic work undertaken by GSI consists of the revisional survey of existing control points and the establishment of new minor control points for plane areas where large-scale mapping or cadastral surveys are planned. Revision surveys are used to detect the deformations of the earth's crust, as well as to maintain the current geodetic network. Studies on crustal deformation are very important in Japan, for they are considered to be the most effective means for predicting earthquakes.

Triangulation and base-line measurement

The first revisional survey of 330 principal first-order triangulation stations, which form the framework of the Japanese triangulation net, began in 1947 and was completed in 1967 for most of the country. The second revisional survey commenced in 1968 from the Kyushu district, the south-western part of Japan; and was in progress in the Kinki district, the middle part of Japan, in 1972. It will require 10–15 years for the current survey to cover the entire country.

In the first revisional survey, 26 base lines were established with the Geodimeter, and 81 Laplace stations were also established; whereas the old network which was completed in 1909 had only 13 base lines and no Laplace stations. In the current survey, 9 base lines and 33 Laplace stations have been established for the control of the first-order triangulation net. The average spacing of the base lines is about 150 km; about two thirds of the principal first-order triangulation stations are planned to be Laplace stations (see table 1).

As for the second- and the third-order triangulation stations, only those areas where the land was disturbed by earthquake or other reasons are being revised.

Around cultivated areas and their vicinities, minor control points are established by fourth-order triangulation and second-order traverse survey. Because of its high accuracy, the traverse survey using electronic distance-measuring instruments has recently become more useful than the triangulation method. Establishment of some minor control points is being carried out by private surveying firms under contract to GSI.

In order to calibrate and standardize electronic distance-measuring instruments, a comparison base line was established in 1965, as previously reported. In 1968, a new base line with invar wires was established near the former base line. These lines were connected by angle observations, and they became a Musashino comparison base-line net, which will provide a more detailed study for distance-measuring problems. The introduction of the laser Geodimeter in 1969 made possible the measurement of long distances which could not be measured with the type of instruments formerly used. This Geodimeter will serve for long-range distance measurements, as described below. In order to increase

Table 1. Second revisional survey

Year	Revised first-order triangulation stations	Base lines observed with Geodimeter	Precise traverse surveys for the base line of satellite triangulation: Lines	Precise traverse surveys for the base line of satellite triangulation: Total kilometers
1968			5	153
1969			16	440
1970	22	2	15	414
1971	20	3	16	439
1972	17	4	11	391

Year	Geodynamic project traverse surveys high-precision: Lines	Geodynamic project traverse surveys high-precision: Total kilometers	Laplace stations	Astronomical stations
1968				
1969				
1970			12	
1971			11	2
1972	23	690	10	6

Year	Precise earth-strain measurements (lines)	Rhombus line measurements	Satellite triangulation
1964		1	
1965		2	
1966		3	
1967		3	
1968		4	
1969		4	
1970	31	5	2 (times)
1971	27	4	1
1972	22	5	2

Year	Second- and third-order stations	Fourth-order stations including precise Geodimeter traverse stations	Second-order traverse stations
1970	0 (120) (45)	1,668	630
1971	18 (150) (25)	1,836	267
1972	30 (220)	1,798	126

*The original text of this paper, prepared by the Geographical Survey Institute, Ministry of Construction; and the Hydrographic Department, Maritime Safety Agency, Japan, appeared as document E/CONF.62/L.15.

the accuracy of the distance measurement, the meteorological conditions along the light path are being studied especially, using captive balloons. For the purpose of investigating detailed crustal movements, 31 quadrilateral base-line nets have been established since 1964.

Analysis of crustal deformation has been carried out through the comparison of the new data and those previously obtained.

In order to detect crustal deformation in specified regions, the high-precision traverse survey based on the geodynamic project was executed in the districts of the eastern part of Hokkaido, Kanto-Koshinetsu and Kyushu, by using Geodimeter VIII and Wild T3.

In order to improve earthquake prediction in the southern part of the Kanto district, the distances (25 km on average) between the 30 triangulation stations located on the peninsulas of Boso and Izu, and in the vicinity of Oshima Island and Sagami Bay, have been measured since 1969 by means of an electronic distance-measuring instrument with the light source of laser (Geodimeter VIII).

As a result of those measurements, it has been made clear that horizontal crustal movements in those areas have continued to increase during the 50 years since the great Kanto earthquake (M = 7.9) in 1923. The accumulation of the maximum shear in these areas has amounted to 3×10^{-5} during the past 50 years, and the crusts are compressed from the south-east to the north-west.

Levelling

Since 1947, all routes of the first-order levelling nets in Japan have been revised continuously. In 1968, the land area of Japan excluding the Hokkaido district, was covered by the fourth revisional survey, which had been begun in 1962; and the adjusted values of those measurements have been adopted as the current authorized heights of Japan.

The fifth revisional survey also was begun from the Kyushu district, and it is currently in progress in the Kanto district, the Hokuriku district and the Hokkaido district. The revisional survey of the first-order levelling for the third time was commenced in 1968 and completed in 1972.

In addition to the general revisional survey of the levelling net, the first-order levelling has been repeated more frequently in the area called the "special observation area" in the Earthquake Prediction Project of Japan. The southern part of the Kanto district is specified as the "observation intensified area" in the project; therefore, the repetitional survey of precision levelling along the routes of approximately 600 km has been carried out annually on the peninsulas of Boso and Miura and in their vicinities.

Recently, ground subsidence in urban areas has become one of the serious social problems in Japan. Most large cities, being built on alluvium layers along the coast, have suffered damage due to ground subsidence. In the investigation of such subsidence, precision levelling amounting to 700 km is carried out every year in the ground subsidence area through the co-operation of GSI and local governments.

Second-order levelling has been carried out in various parts of the country to establish a supplementary levelling network and to revise the existing levelling routes. Table 2 shows the working records of the first- and second-order levelling executed by GSI.

Tidal stations are maintained by several governmental organizations. Records obtained at 73 stations belonging to the Geographical Survey Institute, the Hydrographic Department and the Japan Meteorological Agency are evaluated by the Coastal Movements Data Centre in GSI, in order to study the vertical movements of the crust and the changes in the sea level.

Table 2. Levelling work, 1970–1972

	Revised first-order levelling (Kilometres)	*Established second-order levelling (Kilometres)*	*Established second-order bench-marks*	
			Kilometres	*Number of points*
1970 ...	4,219	236	106	89
1971 ...	4,740	245	149	98
1972 ...	4,546	193	193	96
TOTAL	13,505	674	448	283

Astronomical and satellite observations

The astronomical latitude and longitude are to be observed at approximately two thirds of the principal first-order triangulation stations for the purpose of establishing Laplace stations. Such observations are made with astrolabes equipped with the electronic transit detector developed by GSI. Before and after field observations, the astrolabe is calibrated at the Tokyo Astronomical Observatory. Satellite geodesy has become of practical use. The geodetic connexion of isolated islands to the mainland and also of the Japanese geodetic network to those of other parts of the world is currently, in progress. The geodetic position of the Oki Islands has been determined by this method. The Geographical Survey Institute is currently striving for the development of a new geodetic satellite which can be observed with its tracking camera and can also be used as a target of laser distance measurements.

In order to serve as a base of satellite geodesy, two long base lines between Kanozan and Kanoya are planned. Observation of the base line was begun in 1968 and is scheduled to be finished in 1973.

Gravity survey

In order to complete the Western Pacific Calibration Line, a series of pendulum observations for connecting Japan and New Zealand was executed in 1970 at Christchurch through use of the GSI pendulum apparatus.

For the domestic survey, the GSI pendulum apparatus and three sets of LaCoste and Romberg gravity meters were used for the revisional measurements at six fundamental gravity stations in 1972. These measurements are based on the project for country-wide gravity measurement, which is to be intermittently executed for periods of three years.

The first-order gravity survey is to be executed for periods of five years. In the period 1970–1972, 21 stations were newly established and 39 stations were reoccupied, with the use of three sets of LaCoste and Romberg gravity meters; 97 points of the first-order gravity stations had been established by 1972.

The second revisional measurements of the second-order gravity stations, mainly located at the levelling bench-marks, were begun in 1967; 2,645 points of the gravity stations were covered by a set of LaCoste and Romberg gravity meters; measurements of specifically high accuracy were carried out at 420 stations located in

the districts of Tokai and Kanto; measurements on the equi-gravity line were executed at 129 stations located in the Shikoku district; and measurements of densely distributed points were also executed at 867 stations located in the districts of Shikoku, Kanto and Tohoku. Approximately 12,000 second-order gravity stations were established at the bench-marks of levelling and triangulation stations during the period 1961–1972.

In connexion with the geodynamic project, five points of first-order stations and 30 points of second-order stations for gravity measurement were established in the south-western archipelago in Japan.

Sea gravity surveys were made in the Pacific Ocean and in the Japan Sea with two types of surface-ship gravity meters constructed by the Ocean Research Institute, the University of Tokyo and the Geographical Survey Institute.

Magnetic survey

The Geographical Survey Institute has regularly undertaken various kinds of magnetic surveys such as the first-order magnetic survey at the fundamental and first-order magnetic stations, the second-order magnetic survey at the second-order magnetic stations, the aerial magnetic survey and the marine magnetic survey.

The first-order magnetic survey was commenced in 1949; by March 1973, it was planned to have established 99 magnetic stations. Twenty of the first-order stations were selected as the standard and have been reoccupied every other year for a total of 209 times (44 times from 1970 to 1973). Seventy-nine points of the remaining first-order stations have been reoccupied 344 times (105 times from 1970 to 1973) at intervals of from three to five years. In order to detect the correlation between the crustal deformation of the earth and anomalous secular changes of the geomagnetic field, the period of reoccupation for measurement has been shortened since 1970.

From 1952 to 1973, the second-order magnetic survey has covered 795 points of stations with 1,670 times of the measurements for the purpose of clarifying local anomalies of the geomagnetic distribution.

By compiling the results of the first- and second-order magnetic surveys, a chart indicating the five components of the geomagnetic field reduced to the epoch of 1970.0 was completed in 1973.

In connexion with the project of the World Magnetic Survey (WMS) the aerial magnetic survey of three components covering the entire area of the country was carried out from 1961 to 1964. The measurements of the total force with proton precession magnetometers, which was begun in 1965, are planned to cover the entire area of Japan by 1975.

In order to detect the geomagnetic secular change under the sea, the development of an undersea magnetometer is in progress.

Geodesy in hydrographic work

As the basis for establishing the framework for world-wide geodetic nets, geodetic observations using artificial satellites were carried out in 1971 and 1972 at Io Jima and Minami Tori Sima, to determine the geodetic positions of these off-lying islands which play the role of triangulation points in the ocean.

Observations of occultations of stars by the moon have been conducted continuously at the three astronomical observatories of the Hydrographic Department located at Sirahama, Simosato and Kurasiki, by means of photo-electric and visual observations. Results of reduction of the observed data have been used in compilation of nautical almanacs.

As part of the earthquake prediction programme, observations of plumb-line deflection were carried out at five off-lying islands of Izu Syoto in 1971 and 1972.

The total solar eclipse was observed by the Hydrographic Department team in Mauritania on 30 June 1973.

Geomagnetism in hydrographic work

Magnetic charts for the epoch 1970.0 were published in 1973, based on magnetic surveys carried out in 1969 and 1970 at 45 land stations throughout Japan and along 30 tracks on the sea, by aircraft, within 800 nautical miles from the coast.

Geomagnetic absolute and variation observations of three elements and total magnetic force are being carried out at Simosato Hydrographic Observatory, thus forming part of the network of world magnetic observatories.

National base maps

The 1:25,000 scale mapping project is currently in progress in accordance with the Second Ten-year Plan, which began in 1964. More than 80 per cent of the entire country has already been covered by the new base maps. Most of the remaining areas are steep mountainous regions or many isolated small islands.

The revision survey has been executed at intervals of three years, five years or ten years. Progress during the past three years is shown in table 3.

Table 3. Base maps at 1:25,000 scale, 1970–1972

	1970	*1971*	*1972*
New edition	416 sheets	353 sheets	296 sheets
Revision	(29,380 km²)	(30,280 km²)	(25,990 km²)
Photographic coverage (1:40,000)	397 sheets (32,610 km²) 36,680 km²	385 sheets (31,380 km²) 39,880 km²	408 sheets (34,010 km²) 27,280 km²

National large-scale maps

The national large-scale mapping project, which began in 1960, consists of photographic coverage (every three years for urban areas, every five years for others), large-scale mapping and establishment of fourth-order control points for the flat land areas (approximately 95,000 km²). The progress of this project is shown in table 4.

Table 4. Area covered by national large-scale maps (Square kilometres)

	Scale	*1970*	*1971*	*1972*
Photographic coverage	1:10,000	731	547	426
	1:20,000	31,728	29,511	31,269
New edition	1:2,500	61	211	0
	1:5,000	5,238	4,858	4,733
Revision	1:2,500	145	477	0
	1:5,000	0	1,762	1,560
Photomap	1:5,000	1,022	471	398

The multicoloured photo maps are experimentally compiled by means of tone-line process

Compilation and revision of small-scale maps

Small-scale national base map series have been prepared and revised as described below.

Topographic maps at 1:50,000 scale

The series of topographic maps at 1:50,000 scale is being revised by using the new map series at 1:25,000 scale. During this period, 393 sheets have been compiled. A total of 880 sheets have been compiled since 1965, covering 69.8 per cent of the entire territory of Japan.

In addition, regular revisions of these sheets and of the old surveyed sheets are being made by referring to the series at 1:25,000 scale, depending upon the number of changes in the features. Approximately 150 sheets are regularly revised each year.

The compilation and drafting of the series at 1:50,000 scale are done by private firms under the supervision of GSI. Approximately 90 per cent of the sheets are contracted out to private firms, while the remaining 10 per cent of the sheets are done by GSI.

Regional maps at 1:200,000 scale

Fifty-eight sheets of the series of regional maps at 1:200,000 scale have been recompiled by revision survey. This means that almost all the sheets will have been newly revised by the end of this period. In addition, sheets covering Okinawa and the Northern Territories have been newly compiled. Furthermore, several sheets covering areas where considerable changes have taken place, such as the suburbs of large cities and zones near the national railway trunk-line or expressways, are partially revised each year.

District maps at 1:500,000 scale

Two editions of the district maps at 1:500,000 scale have been produced. One edition has layer tint, while the other edition does not. Regular revisions of each edition were done in the period 1969–1971.

Maps of Japan at 1:1,000,000 scale

Two editions of the maps of Japan at 1:1,000,000 scale have been produced. One edition is the International Map of the World on the Millionth Scale (IMW), done with layer tint; while the other edition, for domestic use, is without layer tint. Both editions were revised in 1972–1973.

Map of Japan and its surroundings at 1:3,000,000 scale

This map at 1:3,000,000 scale shows the position of Japan in relation to the surrounding countries. It was newly compiled in 1971 and is printed on the largest size map paper.

Composite topical maps

The map of Daisen at 1:50,000 scale; the urban function map of Sapporo at 1:15,000 scale; and the urban land-use map of Fukuoka at 1:25,000 scale were compiled during the period 1970–1973. Each of these sheets shows on the reverse side a small-scale regional map, maps showing changes that have occurred over past years, etc. These maps were compiled as an experimental project for the development of a new map design. On this basis, the city map of Tokyo and the map of Hakone were experimentally compiled on the scale 1:25,000 in 1973.

Cadastral surveys

The cadastral survey in Japan, as reported previously, is carried out by the Economic Planning Agency on the basis of the National Land Survey Law. The principal purpose of the Law is to clarify the natural characteristics of the country by cadastral surveys, including establishment of control points for cadastral surveys, land-classification surveys and water resources surveys. Table 5 shows the cadastral work done during the period 1970–1972.

Table 5. Cadastral surveys in Japan, 1970–1972

	1970	*1971*	*1972*	*Over-all total*
Control point survey (points)	1,028	1,051	1,099	29,653
Cadastral surveys (km²)	3,516	3,858	4,138	37,720

Public surveys

Public surveys comprise considerable cartographic works, and large numbers of maps on the scales 1:500–1:10,000 have been made for public use in Japan. These surveys have usually been carried out by private firms in compliance with requests from various public organizations (see table 6). The quantity of photogrammetric equipment in Japan is shown in table 7.

Table 6. Private firms undertaking public surveys for cartographic works in Japan

	1970	*1971*	*1972*	*Remarks*
Number of private firms	2,815 (101)[a]	3,257 (106)[a]	3,775 (127)[a]	
Number of employees	6,296	7,773	11,560	Registered surveyors
	6,146	8,696	10,324	Registered assistant surveyors
	39,122	53,562	89,295	Assistant surveyors
TOTAL	51,564	70,031	111,179	

[a] Number of firms that can perform photogrammetric work

The Forestry Agency, in co-operation with GSI has taken aerial photographs of the mountainous areas in Japan, which principally correspond with forest areas. The Forestry Agency has a project to take photographs of about 190,000 km² of Japan. The scale of the photographs is mainly 1:20,000.

The total area of photographic coverage and the types of maps produced during 1969–1972 are shown in tables 8 and 9 respectively.

Recently, various scales of photographs have tended to be used for flood forecasting, traffic control, basic investigation for water resources, quantitative analyses of landslides and evaluation of numerical data on the results of construction. Moreover, many other construc-

tion projects and investigations, such as those for undersea tunnels, building, bridges across channels, and land subsidence occurring in many cities, are carried out with precise surveys, which form a large part of the public surveys.

Table 7. Photogrammetric equipment in Japan

	1970	1971	1972
Aircraft for taking aerial photographs			
Government	1	1	1
Private	30	38	36
Cameras			
Government	6	6	6
Private	39	44	47
First-order instruments			
Government	3	3	3
Private	27	30	30
Second-order instruments			
Government	26	26	36
Private	145	179	185
Third-order instruments			
Government	25	30	33
Private	53	53	53
Comparators			
Stereo			
Government	1	1	2
Private	5	8	9
Mono			
Government	1	1	2
Private	3	3	3

Table 8. Areas photographed for public surveys, 1969–1972 (Square kilometres)

Year	Photographic scale	Forestry survey	Other public surveys
1969	1:10,000	0	10,373
	~1:20,000	25,396	20,060
	~1:30,000	0	7,523
1970	1:10,000	0	4,286
	~1:20,000	16,554	18,793
	~1:30,000	0	2,658
1971	1:10,000	0	7,798
	~1:20,000	25,668	27,982
	~1:30,000	0	12,363
1972	1:10,000	0	9,099
	~1:20,000	22,993	23,838
	~1:30,000	0	12,012

Table 9. Areas mapped for public surveys, 1969–1972 (Square kilometres)

	1969	1970	1971	1972
Forestry contour map	10,134	9,002	7,417	15,060
City-planning map	11,817	19,586	17,175	16,920
Road-planning map	1,399	1,578	5,292	5,389
Railway-planning map	2,429	1,314	7,363	10,511
River-improving map	970	937	3,504	4,050
Load-improving map	2,467	2,265	3,933	3,178
TOTAL	29,216	34,682	44,684	55,108

THEMATIC MAPS

Land-classification map

The Economic Planning Agency is co-ordinating the compilation of the land-classification map series. To date, 12 sets of the 1:50,000 scale maps, which consist of three thematic maps—landform classification, subsurface geology and soils—have been prepared with the co-operation of various government agencies. Forty-six sets of these maps have been completed since 1954. The entire series, totalling 51 sets, is scheduled to be completed in 1973.

In 1970, the Economic Planning Agency commenced the compilation of a new series at 1:50,000 scale as the basic materials for each regional project based on the New Comprehensive National Development Plan. This new series is a continuation of the above-mentioned series. All of the expenditures for the former 1:50,000 scale map series came from the national budget; however, the expenditures for the new 1:50,000 scale map series consist of a two-thirds subsidy from the national budget and a one-third subsidy from the budget of each local government concerned. The contents of the new and old map series at 1:50,000 scale differ only slightly. The new series will consist of 57 sets.

The Economic Planning Agency is also compiling the 1:200,000 scale land-classification map series for each local governmental area. As of March 1973, the map series for 36 prefectures had been completed. The map series for the remaining 11 prefectures was in work at that time, and the entire series should be completed in 1977. The map series consists of the following nine thematic maps: geomorphological land-classification map; classification map of areas for possible land use; classification map of areas for possible land use and current land-use situation; subsurface geological map and planimetric classification map; soils map; relative relief and valley density overlay; subsurface geological overlay; slope classification overlay; classification overlay of soil productivity.

Land-use maps

Fifty-two sheets of the land-use maps at 1:50,000 scale and six sheets of the maps at 1:25,000 scale were prepared by GSI in co-operation with local governments during the period 1970–1972.

In 1970, GSI changed the legend of the 1:50,000 scale land-use map to meet the urgent requirement of the national Government and local governments for a large supply of maps for establishing a proposed land-use plan.

Land-condition maps

The Geographical Survey Institute has compiled land-condition maps to clarify the land condition of various areas for the purpose of preventing natural disasters and for regional planning for land development. The maps show the pattern of land classification units, ground heights and public facilities. They are also used as fundamental materials for each regional project based on the New Comprehensive National Development Plan.

The 1:25,000 scale land-condition maps have been issued for the Tokyo-Yokohama area (revised edition, five sheets); the Sendai area (new edition, five sheets); and the other five areas (new edition, 56 sheets).

The 1:10,000 scale land-condition maps have been issued for Kita-Kyushu City (new edition, three sheets); and Kochi City (new edition, one sheet).

Topographic maps and land-condition maps of the coastal area

In 1972, GSI began to prepare topographic maps and land-condition maps of the coastal area at 1:25,000 scale in order to clarify the land and sea-bottom condition of coastal areas for the purposes of coast management, peaceful use of sea-space, regional planning of coastal-area development, fishery development, etc.

The topographic map of the coastal area shows depth contours at every metre, bottom materials, transparency of sea-water and facilities of the coast and sea-bottom. The land-condition map of the coastal area shows depth contours at every metre, geomorphological classification of the sea-bottom, bottom materials, composition materials and thickness of alluvial deposit and characteristics of bed layers. In 1972, five sheets of topographic maps and five sheets of land-condition maps for Ise Bay were compiled, and it is planned to survey 42,500 km² of territorial seas within five years.

Lake charts

During the period 1970–1973, the Geographical Survey Institute compiled 12 charts of the 1:10,000 series for seven lakes. Twenty-five lakes (1825.3 km²) have been surveyed since 1955. GSI also revised one sheet covering a part of Lake Kasumigaura.

Water-use maps

For important river systems in Japan, water-use maps at 1:50,000 scale have been prepared since 1965 by the Economic Planning Agency in co-operation with GSI. Thirty sheets have been completed for the Yodo Yamato and Kinokawa rivers in Kinki district, and seven rivers, including the Ota River in west Chugoku district. In 1972, 23 sheets were surveyed for the Kitakami River and six for others in Tohoku district.

Climatic atlas

Based on a resolution adopted by the World Meteorological Organization (WMO) in 1955 for the preparation of the World Climatic Atlas, the Japan Meteorological Agency, under a three-year project, compiled the Climatic Atlas of Japan. Volume I was completed in 1971, while volume II was completed in 1972. The principal maps in the atlas are at 1:3,000,000 scale. Volume I consists of 59 plates showing such fundamental climatic data as temperature, humidity and precipitation, among others. Volume II consists of 90 plates showing maps related to climate, e.g., the number of sunny days, number of rainy days, depth of snow cover, typhoons and phenology. The data contained in the atlas cover a period of 30 years (1931–1960). There are approximately 1,500 observation stations for temperature and approximately 1,900 observation stations for precipitation, considerably more than the number of stations found in the Climatic Atlas of Japan published in 1948.

Although not a basic requirement of WMO, small-scale maps were included in the Climatic Atlas of Japan because of the many climatic conditions peculiar only to Japan.

In 1973, the Meteorological Association of Japan (Meteorological Agency) compiled the "Maps showing the course of typhoons covering 30 years, 1941–1970", consisting of 142 pages.

Geological maps

Geological maps of Japan are mainly published by the Geological Survey of Japan (GSJ).

During the period under review, 24 sheets of geological maps of the 1:50,000 series and their explanatory texts were published by the Geological Survey of Japan, the Geological Survey of Hokkaido and the Hokkaido Development Agency. Eight sheets of the 1:200,000 series and one sheet of the 1:500,000 series also were published by GSJ.

Many geological maps of other series also have been published by GSJ:

(*a*) The 1:2,000,000 map series consisting of four sheets: Geological Map of Japan; metamorphic facies map of Japan; metallogenic map of Japan; and coal-fields of Japan;

(*b*) One sheet of the tectonic map series at 1:500,000 scale;

(*c*) One sheet of the geological map of coal-fields of Japan on the scale 1:50,000;

(*d*) Three sheets of the geological maps of oil and gas fields of Japan on the scales 1:25,000–1:50,000;

(*e*) Four sheets of the hydrogeological maps of Japan on the scales 1:25,000–1:50,000;

(*f*) Eight sheets of total-intensity aeromagnetic maps of two areas off the coast on the scales 1:200,000–1:500,000.

Vegetation maps

The Agency for Cultural Affairs is preparing 1:200,000 scale vegetation maps covering all of Japan, according to a plan initiated in 1967. Maps covering 27 prefectures had been completed by March 1973, and maps for the remaining 20 prefectures are scheduled to be completed within three or four years.

The vegetation maps at 1:200,000 scale show actual vegetation with information derived from photo-interpretation and field survey. The method of classification depended mainly upon the types of vegetation formation and the dominant species. A standard legend was established for the entire country, but some changes were necessary because of the different characteristics of each prefecture.

The Society of Forestry Environment (Forestry Experiment Station, Forestry Agency) has prepared 1:2,000,000 scale forest environment maps of Japan, consisting of a set of four sheets covering forest soils, vegetation, warmth index, precipitation and snow depth. These maps were compiled to show the forest environment of Japan by emphasizing the interrelationship of soil, vegetation and meteorological factors.

Population maps and population-related maps

The Bureau of Statistics of the Office of the Prime Minister has prepared various maps of national interest, such as population maps and maps pertaining to households, based on statistical data from the national census taken in 1970, some of which are listed below:

Table 10. Population-related maps produced

Scale	Map	Number of sheets
1:1,000,000 1:1,500,000	Population distribution by terrain type	3
	Population density by *Shi, Machi* and *Mura*	1
	Rate of population change	3
	Ratio of old-age population	1
	Percentage of population that moved after 1965	1
	Number of persons per household	1
	Ratio of households with a family nucleus	1
	Percentage of households with employees	1
	Percentage of agricultural households	1
	Number of rooms per household	1
	Number of *tatami* per household member	1
	Percentage of population owning their homes	1
	Ratio of working-age population	1

The Bureau of Statistics also published the 1:300,000 scale statistical maps on a grid-square basis for the Kanto metropolitan area and the Kinki region. The maps of the Kanto metropolitan area were divided into five categories: population (5 sheets); employment situation and occupations (5 sheets); industries (5 sheets); housing (5 sheets); and types of industries (4 sheets). These maps were based on the 1965 national census and the 1966 employment census. A map of the Kinki region showing only population distribution was compiled on the basis of the 1970 national census.

Regional mesh statistics maps of an atlas type consisting of 300 pages were compiled of the Kinki and Chukyo regions. Fifteen subjects, including population, sex ratio and average age, were covered on 20 map-sheets compiled on the scale 1:430,000.

Agricultural maps

In conjunction with the 1970 World Census of Agriculture and Forestry, the Statistics and Survey Department of the Ministry of Agriculture and Forestry prepared several map series in 1972 and 1973, as follows: seven sheets of agricultural maps of Japan at 1:1,500,000 scale; 46 separate volumes of rural community maps at 1:200,000 scale; and an atlas type of forestry maps of Japan by city and town.

The first series consists of maps showing the ratio of farm households and the ratio of persons engaged in agriculture, among others.

The second series of 46 volumes covers rural communities by prefecture. The maps portray the structure of rural communities in Japan. Three sheets show the fundamental classification of the rural communities, such as plain village, mountain village, fishing village, paddy-field village, paddy-field and cultivated-field village, cultivated-field village, or agricultural or non-agricultural village. The other five sheets show the ratio of farm households, types of persons engaged in agriculture, prices of cultivated land, ratio of persons working away from farm households, etc.

The third series contains forest maps, which are separated into five categories, including percentage of forest land, percentage of artificial forest land, volume of production and receipts of lumber.

Traffic-volume maps

The traffic-volume map of Japan, on the scale 1:1,200,000; and similar maps for the Tokyo, Nagoya and Osaka regions on the scale 1:200,000 were issued in 1971. These maps have been compiled every three years since 1962.

The map showing interprefecture traffic volume and that of generated traffic density and prefecture traffic volume, both on the scale 1:2,500,000, were issued in 1972 for the first time. These traffic maps were prepared by the Road Bureau of the Ministry of Construction in co-operation with the Geographical Survey Institute, to be used as fundamental data for road administration.

Standard cards for photo-interpretation

For use in improving techniques for photo-interpretation, GSI has prepared 30 standard cards for photo-interpretation each year since 1967; it had completed 180 cards by the end of 1972. The subjects of the cards are divided into three main categories: map symbols for topographic maps; land use; and landform classification. These cards will be put on sale to the public in the near future.

HYDROGRAPHIC WORK

Hydrographic survey

The hydrographic survey operations carried out since 1970 are listed below:

Table 11. Hydrographic surveys, 1970–1972

Type of survey	1970	1971	1972
Harbour survey	8	7	9
Updating survey	153	154	162
Passage survey	2	3	3
Coastal survey	1	1	1
Oceanic survey	1	1	1
Survey for basic map of the sea[a]	1	1	3
Survey for earthquake prediction programme	1	1	1

[a] In 1967, the survey for the Basic Map of the Sea began a 10-year programme to investigate the continental shelves around Japan. Submarine structural, geomagnetic and gravimetric surveys are carried out simultaneously with the bathymetric survey.

For the purpose of determining the status of currents in the adjacent sea of Japan, oceanographic observations were carried out quarterly in co-operation with the Japan Meteorological Agency, the Fisheries Agency and other organizations. In addition, observations of the Kuroshio variations were carried out twice a month over the Kuroshio region, using aircraft and vessels. The results of these observations are published as Charts Showing the Status of the Sea around Japan; and the Kuroshio observations, in particular, are disseminated through radio and in facsimile in the manner used for Notices to Mariners.

Observations of sea ice have been carried out every winter along the coast of Hokkaido.

Integrated oceanographic observations were carried out in the sea east of Honsyu and Bungo Suido, in co-operation with the Japan Meteorological Agency and the Fisheries Agency.

Observations of ocean waves were carried out by means of the floating type of wave meters and by shipborne wave meters.

Continuous tidal observations are carried out at some 100 tidal stations throughout the country. Data observed are being utilized in tidal predictions, determination of datum level of charts and monitoring of the crustal movement in the country. In particular, those data obtained from the stations located at the islands in the southern Honsyu are also used for study of the Kuroshio variations.

Monitoring of sea pollution by oil, heavy metals, PCB and radio-activity in the adjacent seas of Japan was carried out in co-operation with the other organizations concerned.

Issue of charts

The following table shows the status of chart production in the period under review.

Table 12. Charts published, 1970–1973

Type of chart	*1970*	*1971*	*1972*	*1973*[a]
New charts:				
Nautical	16	16	13	12[b]
Basic Map of the Sea	14	53	30	27
Miscellaneous	0	6	6	10
Aeronautical	1	1	0	1
New editions:				
Nautical	22	23	41	35
Basic Map of the Sea	0	0	1	0
Miscellaneous	11	6	3	5
Aeronautical	1	2	2	2
Reprints	8	0	0	0
TOTAL	73	107	96	92

[a] Projected.
[b] Including two international charts at 1:3,500,000 scale covering the adjacent seas of Japan.

The project for the Basic Map of the Sea consists of continental margin, coastal and oceanic subprojects. The first subproject will eventually cover the continental shelf and slope area around Japan at 1:200,000 scale, each set being composed of the bathymetric, submarine geological structure, total magnetic intensity and gravity anomaly charts of 46 × 63 cm. The second consists of the 1:50,000 series, which will cover the coastal waters within 12 miles around Japan; and the 1:10,000 series, which will cover special areas of industrial demands. Both series are composed of bathymetric and geological structure charts of 63 × 92 cm.

Approximately 300 sheets of correction chartlets for keeping charts up to date are issued every year.

A total of 1,434 charts are on issue, comprising: nautical charts, 1,118; Basic Map of the Sea, 112; miscellaneous charts, 118; aeronautical charts, 16.

Japan Oceanographic Data Centre

The Japan Oceanographic Data Centre is now functioning as the National Data Centre, as well as the Kuroshio Data Centre; the latter is a regional data centre for the Co-operative Study of the Kuroshio (CSK) under the International Oceanographic Commission (IOC).

As of February 1973, the Kuroshio Data Centre had received the data of 356 cruises and 13,087 stations from the countries participating in CSK. The information and data thus received are processed, and then compiled and published as the *Data Report of CSK*, the *CSK Newsletter*, the *CSK Atlas* and the *Existing Oceanographic Station Data in the South China Sea*, all of which are widely distributed to the organizations participating in CSK and to those concerned with oceanography in many countries.

From domestic organizations, such as the Maritime Safety Agency, the Japan Meteorological Agency, the Fisheries Agency and universities, oceanographic data are sent in to the Japan Oceanographic Data Centre, where they are processed and preserved in the forms of punched cards and magnetic tapes for distribution in compliance with internal and external requests. The data processed thus far comprise serial station data of about 100,000 stations and current data of about 60,000 stations.

Furthermore, various statistical studies and analyses are conducted for a number of oceanographic elements in the north-western Pacific Ocean.

In 1972, the Japan Oceanographic Data Centre began work on the Report of Observations/Samples Collected by Oceanographic Programmes and other similar active programmes involving compilation of the primary information concerning oceanographic observational cruises and their data, such as an international catalogue of ocean data station and international geological/geophysical cruise inventory, within the framework of IOC.

RECENT CARTOGRAPHIC ACTIVITIES

Preparation for National Atlas of Japan

The project of the National Atlas of Japan was carried on in the period under review. The Committee for the Atlas was established in 1971. Up to the end of the period under review, 20 sheets of the atlas had been experimentally prepared. Some of these sheets will be issued separately in the near future.

Basic mesh system for Japan

In 1969, a mesh system, which serves as a basis for analysing special data, was established for the entire country of Japan.

This mesh system consists of the basic mesh, the subdivided mesh and the combined mesh. The basic mesh is made up of grids drawn every 45 seconds in longitude and every 30 seconds in latitude. This mesh is determined by dividing into 10 sections the netlines of the topographic map at 1:25,000 scale. Each basic mesh unit will not be the same as concerns shape and size, although all units are rectangular. The difference in area of one basic mesh unit differs from 0.905 km to 1,145 km in the territory of Japan. That is, the area of one basic mesh unit is about 1 km^2.

Geographical names on maps and charts

Since 1960, the Geographical Survey Institute and the Hydrographic Department have been co-operating in the unification of the representation of geographical names on their topographic maps and nautical charts.

During this period, almost all of the geographical names for the recompiled edition of the district maps at 1:500,000 scale have been unified. Discussions are currently in progress to determine the unified geographical names for the coastal charts at 1:200,000 scale.

As concerns marine geographical names, the Hydrographic Department has followed the definition of International Hydrographic Bureau Special Publication No. 23, *The Limits of Oceans and Seas,* and the report of the GEBCO Sub-committee on Geographical Names for Ocean-Bottom Features, approved by the International Association for the Physical Sciences of the Ocean (IAPSO). Since 1966, the Hydrographic Department has been standardizing the names of sea-bottom features around Japan according to the decision of the informal organization for geographical names of sea-bottom features represented by oceanographic organizations and academic societies in the country. Discussions are in progress to decide the standardized geographical names in the continental margin around Japan to be included in the Basic Maps of the Sea at 1:200,000 scale.

Other activities

The Japan Cartographers Association published *Cartography in Japan* in English as special edition No. 2 (1972), in commemoration of the tenth anniversary of its establishment. There are currently 1,825 members, which is a considerable increase since the founding of the Association.

In 1972, the Japan Map Centre was established to provide a centralized map information service by collecting all types of maps of Japan and other countries, to publish the maps of the Geographical Survey Institute and to conduct investigations and research related to mapping.

The One-hundred Year History of Surveying and Mapping in Japan was published by GSI in 1972. This publication describes each aspect of surveying and map compilation in Japan from the beginning of modern cartographic works to the current time.

In December 1971, the Hydrographic Department of the Maritime Safety Agency compiled and published a work entitled *1871–1971, Hydrography in Japan*, in commemoration of the centennial of its founding.

Earthquake prediction

Japan has very often suffered from destructive earthquakes, the most violent of which was the Kanto earthquake in 1923. More than 100,000 lives were lost, mainly because of the fires which occurred just after the earthquake. With that earthquake as a starting-point, the demand for the prediction of earthquakes has been very strong in Japan. In 1962, a group of seismologists published a report entitled *Prediction of Earthquakes — Progress to date and Plans for Further Development*, which may be said to be the first step of the national project for earthquake prediction in Japan. In this report, the geodetic method of detecting the anomalous crustal deformation was evaluated as the most reliable method, together with the other suitable seismological, geological and geophysical methods.

The first national five-year plan of earthquake prediction research was initiated in 1965. After various experiences obtained during the Matsushiro swarm earthquakes (1965–1968), this plan was much strengthened.

In 1969, the Co-ordinating Committee for Earthquake Prediction was established in Japan as the headquarters for earthquake prediction. It consists of about 30 specialists of governmental organizations and universities, and is responsible for analysing data submitted and for predicting earthquakes.

In order to further earthquake prediction, three centres have been set up: the Crustal Activity Monitoring Centre (for geodetic data, tidal data, etc.) of GSI; the Seismicity Monitoring Centre (for earthquakes with magnitude higher than three) of the Japan Meteorological Agency; and the Earthquake Prediction Observation Centre (for micro-earthquakes, crustal deformations and other data from universities) of the Earthquake Research Institute of the University of Tokyo. The data processed at these three centres are sent to the Co-ordinating Committee for Earthquake Prediction.

The fundamental strategies for earthquake prediction are described below.

Basic observations, such as levelling, triangulation, trilateration, gravity and magnetic surveys are done regularly throughout Japan.

In addition to these basic observations, particular observations are carried out in the "areas of special observation". These special observation areas are selected according to the following criteria:

(*a*) Areas having experienced destructive earthquakes in the past;

(*b*) Areas with active faults;

(*c*) Areas in which small earthquakes frequently occur;

(*d*) Areas of political and economic importance, e.g. Tokyo or Osaka.

When the Committee confirms that somewhat anomalous crustal deformation is taking place in such an area, the area is classified as an "area of intensified observation". Moreover, an area in the immediate vicinity of a coming earthquake would be classified by the Committee as an "area of concentrated observation", and various kinds of observations would be enforced concentrically.

Figure 33 shows eight areas of special observation and one area of intensified observation which have been assigned by the Committee.

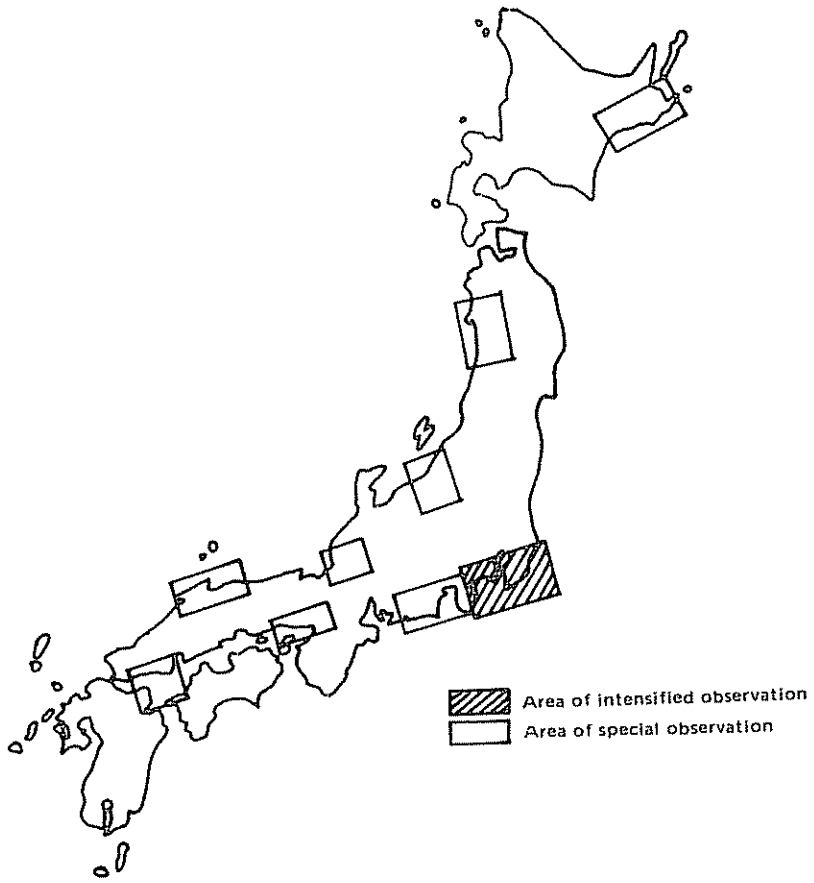


Figure 33. Japan: areas of special and intensified observation for earthquake prediction

CARTOGRAPHIC ACTIVITIES IN LEBANON*

Paper presented by Lebanon

The Direction des affaires géographiques (DAG) is a body reporting to the Ministry of National Defence (Army High Command) of Lebanon. It is under the authority of a director who is a senior Army officer. DAG comprises an administration and four operational services.

FUNCTIONS AND RESOURCES OF DAG

The functions of DAG are as follows:

(*a*) Provision of a basic geodetic network for the country;

(*b*) Preparation of topographic maps on various scales for the use of the public and private sectors;

(*c*) Preparation and publication of official national maps;

(*d*) Aerial photography and its various applications;

(*e*) Organization of instruction in the geographical sciences.

DAG has a staff of 500, including 38 engineers. I addition, it owns the following equipment:

(*a*) *Geodetic equipment:* 2 mareographs; 1 Ples MRA 3 tellurometer;

(*b*) *Photogrammetric equipment:* 1 Dove aircra specially equipped for aerial photography; 1 Wild R camera with 2 cones, 152 and 210 mm; 2 SEG rectifiers; 10 precision photogrammetric instrumer (including 6 Poivilliers type B stereotopographs, 2 s reometrographs, 1 Presa 225 and 1 Wild B9);

(*c*) *Printing equipment:* 1 automatic offset pr (MAN); 2 flat-bed offset proof presses (Mailande 1 printing-press.

ACTIVITIES OF DAG

Geodesy

Projections

Two projections are used: Lambert and stereograph The Lambert projection, which is employed for sm

*The original text of this paper, submitted in French, appeared as document E/CONF.62/L.115

scale and medium-scale maps, is of use only for military purposes. The centre of stereographic projection is at Palmyra in Syria, and the projection appears on all maps in the form of graticule intersections.

Triangulation

Lebanon is covered by approximately 1,000 first-, second- and third-order triangulation points; and 10,000 fourth-order and fifth-order points for stereoscopic ground control and large-scale maps.

Work has recently been carried out to update the first-, second- and third-order triangulation points, the computation of which has already been completed.

Levelling

The first-order levelling net covering the entire country, which has already been established, comprises four loops. Second-order levelling is almost complete, and third-order levelling is 50 per cent complete.

Aerial photography

Black-and-white

Aerial photographic coverage of the country at 1:25,000 scale has been carried out twice, in 1956 and 1962; and since then, aerial operations have been carried out on larger scales, averaging 1:8,000. In particular, various areas, amounting to about one eighth of the country, have been photographed since 1970 on scales varying from 1:4,000 to 1:12,000.

DAG also provides aerial photographs to various official bodies of Lebanon.

Colour

Equipment that will make it possible to obtain aerial photographs in colour has recently been acquired.

Photo mosaics

Photo mosaics are being prepared for large towns in Lebanon on scales varying from 1:2,000 to 1:5,000.

Cartography

Base map

Lebanon has an area of approximately 10,700 km^2. Basic map coverage at 1:20,000 scale has already been completed. The total number of sheets is 121. Each 1:20,000 sheet has the following dimensions: 7'30" of longitude and 5' of latitude in the sexagesimal system.

DAG is currently undertaking an updating of the 1:20,000 map in respect of three different areas: highly urbanized areas; moderately urbanized areas; and areas urbanized to a small extent.

In the 1:10,000 map series, which covers principally the main towns and highly urbanized areas, only the capital and surrounding areas have been resurveyed to produce four sheets at 1:10,000 scale.

Maps compiled from secondary sources

The new series of hypsometric maps at 1:50,000 scale prepared from the data of the base map is 60 per cent complete. A total of 12 sheets is planned, each sheet comprising at least 12 sections at 1:20,000 scale. Over the past two years, three maps in this series have been prepared, three are currently being revised and three are in preparation.

The series of small-scale maps, comprising six sheets at 1:100,000 and one sheet at 1:200,000, which was completed five years ago, has been supplemented by the series of chorographic maps, on scales varying from 1:250,000 to 1:1,000,000. In addition, the six 1:100,000 sheets were provided with altitude tints two years ago.

It should be pointed out that typonyms appearing on maps of all scales may appear either in the Arabic or in the Roman alphabet.

Thematic maps

Concurrently with the production of topographic maps, the Direction des affaires géographiques also issues thematic maps for use by various bodies. Examples are geological maps, soil maps, forestry maps, fruit-production maps and hydrogeological maps on scales varying from 1:20,000 to 1:200,000.

Topography projects

Project for the Army

The project for the Army involves the preparation of maps on scales varying from 1:1,000 to 1:5,000, indicating access routes to all the towns and villages in Lebanon. The various maps are prepared either by photogrammetric plotting or by reduction or enlargement of, and additions to, existing maps.

The control necessary for the preparation of relief representation is provided principally through operations on the ground, since the rough terrain requires it and the extremely dense triangulation network facilitates ground surveys.

Hydraulics project

The hydraulics project involves the mapping at 1:2,000 scale of an area covering 12,000 hectares, with a view to the irrigation of the Koura-Zgharta plain (northern region). The maps will be prepared by plotting aerial photographs at 1:10,000 scale by the conventional method, with two-colour presentation on a stable overlay; the project is to include dam-site maps and a map of supply and highway studies.

Statistics projects for the Ministry of Planning

The statistics projects, which are being undertaken for the Ministry of Planning, entail the transfer on to the 1:20,000 base maps of the cadastral limits of all (approximately 1,600) Lebanese villages, on the basis of field data, with indexing of administrative and technical information relating to each village and indication of the limits of each village on separate overlays.

Town-planning project

Maps are being prepared at 1:1,000 and 1:2,000 scales from photographs of Lebanese villages on the scales 1:6,000 and 1:8,000, respectively, with a view to town-planning studies, using photogrammetric plotting and with full detail of the ground.

Project for the municipality of Beirut

Plans at 1:500 scale are being prepared of the entire city of Beirut; these plans include 10 separate overlays, each representing a specific subject.

Special small 10-colour maps at 1:200 scale are being made up for each individual street.

Cadastral project

Cadastral maps are being prepared for property districts, covering 48 villages on the scales 1:1,000 and 1:2,000, either by identification of verticals of the boundaries on enlarged photographs at 1:1,000 scale and photogrammetric plotting, or by conventional topographic surveying

Future prospects

General administration

Lebanon has two specialized departments concerned with topography: the Direction des affaires géographiques in respect of general maps; and the Service du cadastre in respect of cadastral maps and of land apportionment and reallocation. The qualifications required for their staffs are, to a considerable extent, the same. Moreover, DAG is also responsible for preparing cadastral maps, as is the Service du cadastre; and this situation has given rise to the idea of merging the Service du cadastre and DAG into a single, decentralized general administration, so as to combine efforts to improve output

This general administration would be responsible for all topographic and cartographic work, without exception, and for the establishment of a staff training school and a university.

In view of the legal nature of the Lebanese cadastral service and its constant contacts with the real-property courts, it would be preferable to place this general administration under the jurisdiction of the Ministry of Justice; the cadastral service currently comes under the Ministry of Finance and DAG is under the Ministry of Defence.

Technical fields

As concerns working methods, it is expected that a set of orthophoto maps and a set of electronic plotters, linked to a computer, will be obtained.

With respect to scientific research, Lebanon has the Conseil national de la récherche scientifique (CNRS), with which DAG plans to establish links and carry out joint programmes in order to update or establish gravimetric and magnetic networks.

DAG plans also to install and use the two mareographs in order to determine mean sea levels.

REPORT ON MALAYSIA*

Paper presented by Malaysia

Cartographic activities in Malaysia since August 1970

The Director of National Mapping, Malaysia (concurrently the Director-General of Survey, Peninsular Malaysia) is responsible for topographic and geodetic surveys, as well as the production and maintenance of topographic and town maps of Malaysian territories for military and civilian use. Mapping of the states of Sabah and Sarawak is carried out with the assistance of the Directorate of Overseas Surveys (DOS). This assistance is provided for under the technical aid programme of the Ministry of Overseas Development of the United Kingdom of Great Britain and Northern Ireland. DOS has completed its ground control work in both states, and the last survey team left in July 1973. However, both the Directorate of Overseas Surveys and the United Kingdom Directorate of Military Survey of the Ministry of Defence continue to assist substantially in the compilation and production of standard mapping, on the scale 1:50,000, of the two states.

Since August 1970, cartographic activities have been dictated mainly by the Second Malaysia Development Plan, which has as its objective the bringing about of balanced sectoral development and economic growth. Under this plan, about 1 million acres of land are to be developed, say, at the rate of 200,000 per annum. Priority, other than military requirements, is given to the production of plans and maps of these areas for development purposes.

Triangulations

In Peninsular Malaysia, the triangulation network is adequate; and no further primary or secondary triangulation activities were undertaken, except for observations to establish a common datum between Malaysia and Indonesia.

In Sabah and Sarawak, the main breakdown of the existing triangulation network is carried out by electronic distance-measuring traverses, either for provision of ground control or for cadastral survey purposes. In Sarawak, however, six stations were established by the conventional triangulation method in areas where it was easier and more expedient to do so.

Common datum and fundamental point between Malaysia and Indonesia

Observations were carried out by a joint Malaysian and Indonesian survey team to establish a fundamental point at Pulau Pisang (in Malaysia) and a second point at Gunung Jantan (in Indonesia) for the purpose of establishing a common datum between the two countries. Two Malaysian trigonometrical stations were connected to the fundamental point and the check point

The project was carried out in three phases:

(1) Geodetic-order astronomical observations for latitude, longitude and azimuth at the fundamental point at Pulau Pisang were conducted by each team independently from 18 March 1972 to 17 April 1972;

(2) Angular measurements were taken by the Malaysian surveyors, and MRA 101 Tellurometer measurements of four lines (forwards and backwards) by the

*The original text of this paper, prepared by the Directorate of National Mapping, Malaysia, appeared as document E/CONF. 62/L.81

Royal Malaysian Navy team during the above-mentioned period;

(3) Geodetic-order astronomical observations for latitude, longitude and azimuth at the second point, Gunung Jantan, carried out by each team independently from 7 May to 18 May 1972.

The objectives of the project were: (*a*) the establishment of a common datum to be used by both countries for the purpose of positioning any point in the Straits of Malacca; (*b*) the integration of the respective geodetic networks of each country with the common datum; with further geodetic ties, the whole triangulation network will be unified under one integral system.

Normal field-checks and computations were carried out in the field independently, but final computations and adjustments were processed jointly and completed on 29 May 1973.

Levelling

In Sarawak, precise levelling networks have been completed in Kuching and Sibu, and a beginning was made to establish a line of levels along the trunk-road connecting those towns. A tide-gauge station was constructed at Tanjong Kidurong near Bintulu and will soon be in operation. This station will provide a mean sea level datum at the central coastal area.

In Sabah, only third-order levelling was carried out to establish bench-marks for urban development.

Aerial photography

Peninsular Malaysia

In 1966–1967, complete photo coverage was undertaken of Peninsular Malaysia for standard mapping, as well as for standard revision for certain parts. Further coverage, to the extent of 3,688 square miles, was undertaken at various scales ranging from 1:10,000 to 1:25,000, for special-purpose mapping and for revision purposes.

It was planned to rephotograph the developed and the developing areas of Peninsular Malaysia in 1973 as part of the natural resources evaluation project. This coverage will update the previous aerial photography of Peninsular Malaysia taken in 1966–1967.

Sarawak

Sarawak has carried out an annual air photography programme. Since 1970, about 60,000 square miles have been covered at scales ranging from 1:3,000 to 1:40,000. A considerable amount of this photography was specially taken for mapping blocks. Other photography was carried out for land-use surveys, forest inventory, town-planning and special requests by other departments.

Sabah

The whole of Sabah has been photographed on the scale 1:25,000. These photographs, though intended for forest inventory projects, were also used for current land-use surveys, soil surveys and land-capability classification.

Aerial photography at small scales, 1:30,000–1:40,000, for mapping of the unmapped areas of Sabah at 1:50,000 scale also was completed. Several sorties of large-scale aerial photography were also carried out for production of large-scale maps, route selection, etc.

Map compilation

Topographic maps

The basic scales and projections of topographic maps are as follows:

(a) *Peninsular Malaysia*: series L.8010 at 1:25,000 scale and series L.7010 at 1:63,360 scale, both with rectified skew orthomorphic projection;

(b) *Sabah and Sarawak*: series T.735 at 1:50,000 scale, rectified skew orthomorphic projection.

Series L.7010 and T.735, the basic map series for Peninsular Malaysia, and for Sabah and Sarawak, respectively, are primarily designed to meet the requirements of the armed forces, government departments and the general public. Series L.8010, with its larger scale, is intended to meet the demand for such maps required for rural development and other planning.

Series L.8010

The L.8010 series forms the basic mapping of the L.7010 series. All topographic map-sheets are compiled at this scale. There are 708 map-sheets, of which 37 sheets have been published during the period under review. The size of a sheet in this series is 21 × 24 inches, the size being so chosen that six map-sheets in this series will fit into the sheet line of one map-sheet in the L.7010 series.

Series L.7010

The sheets in the L.7010 series are fully coloured, gridded and contoured at 50 and 100-ft intervals. There are 135 sheets in this series. Only three more sheets remain to be published. The over-all size of the sheet is 18.7 × 25 inches, but a few sheets have other dimensions.

Series T.735

There are 340 map-sheets in the T.735 series. The old uncontoured sheets are steadily being replaced by the fully contoured and coloured editions. To date, 254 fully contoured and coloured sheets have been published. The contour interval is 100 ft with provision for 50-ft supplementary contours at certain intervals, as well as 250-ft contours in very steep areas.

Series L.5010

Series L.5010 (1:250,000 scale) was designed to replace the older series L.501 (1:253,440 scale). This series is compiled from the L.7010 series and series 1501 (JOG). There are 14 sheets in this series, of which 12 sheets have been published.

Town maps

Peninsular Malaysia

Series L.808 at 1:10,000 scale and L.905 at various scales are the town map series of Peninsular Malaysia. These maps are fully coloured, gridded and contoured at 25-ft vertical intervals. The L.808 series consists of 45 map-sheets covering Kuala Lumpur and its surroundings, of which one sheet has been published. The other sheets are currently in various stages of

compilation. Series L.905 has a total of 43 sheets, with a sheet for each town in Peninsular Malaysia; 32 sheets have been published.

Sabah and Sarawak

Series T.931 covers the towns of Sabah and Sarawak. Their revised sheets have been published. They are Sibu, Miri, Kota Kinabalu and Simanggang. The town map of Kuching is under revision.

State maps of Peninsular Malaysia

The state maps of the 11 states of Peninsular Malaysia were compiled by the Cadastral Division of the Survey Department in each state. They show details of communications, drainage patterns, administrative boundaries, alienated lands, forest and other reserves, and other details of interest. In general, three versions of state maps are published: contoured in three colours and ungridded; contoured, fully coloured and ungridded; and contoured, coloured and gridded. The publication scales vary from state to state.

Thematic and special-purpose maps

The Directorate of National Mapping follows closely and very often takes an active part in the production of thematic maps by other government and statutory bodies. All the maps are printed by the Directorate's Lithographic Division. The Directorate also provides assistance from the colour-separation stage to the printing stage of thematic maps.

The principal maps printed include the following (see also table 1):

(*a*) Thirty-five current land-use maps, soil maps, land utilization and soil-suitability maps for the Economic Planning Unit of the Prime Minister's Department;

(*b*) Twelve geological maps for the Geological Survey Department;

(*c*) Two sets of maps for the Johor Tenggara and the Pahang Tenggara master-plans;

(*d*) Thirteen census maps for the Department of Statistics in connexion with the findings of the 1970 census;

(*e*) Nineteen miscellaneous maps for various departments, including Forestry, Telecoms and Malayan Railway, and the Kuala Lumpur postal code maps.

Table 1. Map-sheets produced by the Cartographic Division and the Photo-lithographic Division, August 1970–March 1973

	Cartographic Division		*Photo-lithographic Division*			
	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	6	22	6	9	188	929,650
Series L.8010 1:25,000	34	2	37	—	6	74,206
Series T.735 1:50,000	14	—	24	—	—	159,414
Series L.5010 and T.503 1:250,000	2	—	4	—	—	12,410
Series L.905 and T.931 town maps and L.808 various scales	23	—	30	—	—	125,314
Miscellaneous maps and charts	5	—	416	7	—	2,070,074
TOTAL	84	24	517	16	194	3,371,068

Map production

The Topographical Division of this Directorate is responsible for the trigonometrical and topographic survey of the country and the periodic revision of such data as may be found necessary from time to time. The map reproduction component consists of the Cartographic and the Photo-lithographic Divisions. Assembly, scribing, fair-drawing, colour separation, annotating and masking are done in the Cartographic Division, while all camera work and printing are done in the Photo-lithographic Division.

Electronic Services Division

The Electronic Services Division has an IBM 1130, which was installed three years ago. It has processed more than 150,000 lots, which has reduced the backlog in cadastral computation by more than 50 per cent.

An automatic electronic plotter, the EAI 430 data plotter, was installed in early 1973 to assist in clearing the existing backlog of cadastral plan drawing in the Department, as well as in expediting the drawing of topographic and other maps.

PHOTOGRAMMETRY AND MAP-PRINTING EQUIPMENT

The photogrammetric equipment listed below has been acquired since the last report was made:

1 Wild NF28 aerial navigation sight
4 Kern PG 2 stereoplotting instruments
1 Wild RC10 camera with three interchangeable lens cones
1 Wild NF2 aerial navigation sight
1 Electronic dodging printer
1 Radial Secator RS11
1 Densitometer transmission digital, model DS.DM.253

A complete list of photogrammetric equipment is given in table 2.

Table 2. Photogrammetric equipment available in Malaysia, August 1970–March 1973

Name of equipment	With Directorate of National Mapping	With Department of Lands and Surveys, Sarawak	With Department of Lands and Surveys, Sabah	Total
Wild A7	1	1	—	2
Wild A8	2	1	2	5
Wild B8	4	2	3	9
Kern PG2	4	—	—	4
Multiplex	4	—	1	5
EK5A or EK3D-5A	1	1	1	3
PUG Point transfer	1	1	1	3
Rectifier	1	1	—	2
EMI Logetronic printer	1	1	—	2
Electronic dodging printer	1	—	—	1
Zeiss contact printer	2	1	1	4
Film processer	2	1	2	5
Enlarging camera	1	2	1	4
Wild RC8 camera	2	1	1	4
Wild RC10 camera	1	1	—	2
Zeiss film viewer	1	—	1	2
Wild NF28 aerial navigation sight	1	—	—	1
Wild NF2 aerial navigation sight	1	—	—	1
Radial secator RS11	1	—	—	1
Densitometer transmission digital, model DS.DM.253	1	—	—	1

NATIONAL REPORT FOR NEPAL*

Paper presented by Nepal

BACKGROUND INFORMATION

In Nepal, the process of building up the country has been initiated with great spirit and plans for its social and economic development have been made. As maps are essential tools for the successful execution of the plans, the Survey Department of the Government is currently developing cartographic activities in Nepal to meet the needs of the country. Other technical departments in Nepal, in particular those concerned with forests, mining, roads, irrigation, and housing and physical planning, also are undertaking cartographic activities. These departments set up their own survey (cartographic) offices or units to cover only their needs; such activities, however, are not dealt with in this paper. Most of the small-, medium- and large-scale topographic maps produced thus far have been, apart from small site surveys, done by outside sources.

Geography of Nepal

Nepal may be divided geographically into three regions:

(*a*) The Tarai and Inner Tarai, which are the plains lying between the Mahabharat Ranges and the Indian border, the plains of the Inner Tarai being separated from the main Tarai by a lower range of hills;

(*b*) The Kathmandu valley, at one time a lake, which is approximately 1,300 m above sea level;

(*c*) The mountain region between the Mahabharat and the great Himalayan ranges, which forms the greater part of the country.

Communications in the mountain region are difficult; the valley sides are steep and the bottoms are narrow. The areas and rural populations of the three regions are given below.

Table 1. Area and population of regions of Nepal

Region	Area (km^2)	Population
Tarai and Inner Tarai	36,500	4,874,696
Kathmandu Valley	560	618,911
Mountain region	104,000	6,062,376
TOTAL	141,060	11,555,983

*The original text of this paper, prepared by A. B. Basnyat, Director of Surveys, H.M.G. Survey Department, Kathmandu, Nepal, appeared as document E/CONF.62/L.86

Administration

Nepal has adopted the *panchayat* system of democracy as the basis of its political and administrative framework. The country is divided into 14 zones for administrative purposes, comprising a total of 75 districts. On average, there are 48 village units (called village *panchayat*) in each district, and each village *panchayat* is divided into nine wards. In the Tarai and Inner Tarai, the average area of a ward is approximately 3.5 km², while in the mountain region, it is somewhat larger. In the Kathmandu Valley, however, the average area of a ward is only about 1/3 km².

Economy of Nepal

Nepal has a predominantly agricultural economy; 65 per cent of the Government's revenue comes from the agricultural sector. Approximately 96 per cent of the people depend directly or indirectly upon agriculture. Agricultural products constitute the main export item.

Organization of the Survey Department

The Survey Department, which was at one time attached to the Ministry of Finance, is currently under the Ministry of Land Reform. Before 1969, the main task of the Survey Department was the carrying out of the cadastral survey under the provisions of the Land (Survey and measurement) Act of 1963, for the systematic making of a new edition of the tax register on the basis of cadastral plans, with classification of the cultivable land both for land reform and for revenue purposes. The Survey Department currently has three branches: the Trigonometrical Survey Branch; the Cadastral Survey Branch; and the Survey Training Centre.

Furthermore, a plan has been formulated to set up a modern topographic survey branch in 1974. This plan is described more fully below in the section dealing with topographic maps.

Trigonometrical Survey Branch

The Trigonometrical Survey Branch was established at the beginning of 1970 with technical assistance provided by the United Nations Development Programme (UNDP). The need to establish the Trigonometrical Survey Branch arose when the cadastral survey parties were finishing their surveys in the Tarai (plains close to the Nepal-India boundaries) and were preparing to undertake the survey in the Mahabharat range of hills. Consequently, the main task of the Trigonometrical Survey Branch is to establish a sufficient number of trigonometrical control stations for the use of cadastral survey parties.

National grid system

The Trigonometrical Survey Branch established the national grid system on the basis of the Universal Transversal Mercator (UTM) system. For cadastral mapping, the 3° belts were accepted with control meridians of longitudes 81°, 84° and 87° east (using nomenclature of 44.0, 44.5 and 45.0), and with the scale factor of 0.9999. For international connexions and for work concerning large areas of Nepal, the UTM system of 6° belts was accepted, with control meridians of longitudes 81° and 87° east (using nomenclature of 44.0 and 45.0) and scale factor of 0.9996.

The metric system has been adopted. The circle gradations of the surveying instruments are in *gons* (400 g).

Equipment

The Trigonometrical Survey Branch currently has the equipment listed below.

Table 2. Equipment in Trigonometrical Survey Branch

Type of equipment	*Number of units*
Theodolites:	
Wild T3	5
Wild T2	13
Wild T16	60
Levelling instrument:	
Wild N3	1
Geodimeters:	
Aga 6A	2
Aga 8 (laser)	1
Calculators:	
Hewlett-Packard model 10	1
Busicom	2
Facit 1004	13
Co-ordinatograph:	
Haag-Streit 1200 × 1200	1

Method and system of production

The productive work of the Trigonometrical Survey Branch began in the 1970–71 season. For the first-order stations, some of the trigonometrical stations established in Nepal by the Survey of India for topographic mapping on the scale 1:63,360 (1 inch to 1 mile) during the period 1954–1959 were selected. The density of those stations was about one station per 100 km². Currently, approximately 60 per cent of these stations have been damaged. The cadastral survey is based on district bases, as is the trigonometrical survey. Among all existing trigonometrical stations (established by the Survey of India) within one district (an average of eight per district), two couples are selected, each couple either west and east or north and south. The geographic co-ordinates of these stations are converted into co-ordinates of the national grid system. The entire area of one district which is lying between these two couples is covered by a second-order framework, which is again broken down to a third-order framework. Thus, the density of the third-order framework is approximately one station per 4 km². This density is then again broken down by the use of fourth-order stations up to a density of approximately one station per 0.15 km². This system provides three or four trigonometrical stations for one map-sheet 50 × 50 cm, on the scale 1:1,250.

The progress made in setting up the trigonometrical survey is set forth in table 3.

Table 3. Progress in establishing trigonometrical stations

Field season	*Second- and third-order stations*	*Fourth-order stations*	*Total number of stations*
1970/71	97	901	998
1971/72	223	2,830	3,053
1972/73	209	4,928	5,137

To cover all requirements of seven cadastral parties, the Trigonometrical Survey Branch will have to establish approximately 10,000 trigonometrical stations within one field-season. With the increasing skill and educational background of the observers and the higher level technical staff, this objective could be achieved in the field-season 1975/76.

Laplace stations and first-order framework

The Trigonometrical Survey Branch has found, during the past two years of field-work and computation work, that the trigonometrical stations established by the Survey of India for topographic mapping do not have sufficient accuracy for modern cadastral and large-scale topographic mapping. Therefore, it is proposed to establish and observe several astonomical Laplace stations and to connect them with first-order chains, using Geodimeter model 8. Nepal would then have a very modern first-order framework with top-level accuracy and orientation. Then, all previously selected trigonometrical stations also should be included in that first-order framework to permit adjustment of the current co-ordinates.

National base line

The national base line has been established in the shape of a triangle, 25 km east of the capital. The sides of the triangle are 3.6, 6.7 and 8.1 km, respectively. One of its points—Nagarkot—has been selected as the site for the proposed geodetic observatory, which is planned to be established in the near future. The Trigonometrical Survey Branch carried out two expeditions to compare geodimeters on the known base lines, to Dohra Dun, India, in 1971; and to Negembo, Sri Lanka, in 1972.

High-precision spirit levelling

There is great demand from various departments and offices to have a system of bench-marks providing highly accurate data on the altitude above mean sea level. However, no first-order bench-mark with an altitude above mean sea level exists in Nepal. Levelling, which was done by different departments and offices for their own special tasks, was fixed on different "zeros". The Government of Nepal has asked the Government of India to provide first-order bench-marks at two locations on the Nepal-India border. After receiving these bench-marks, the Trigonometrical Survey Branch will be ready to begin immediately with first-order level traverses, following the current highways and roads. For that purpose, the precise levelling instrument, Wild N3 with invar staves, was imported and staff have been trained in its use.

Proposed sections of Trigonometrical Survey Branch

The Trigonometrical Survey Branch is planning to establish some other sections, in addition to the levelling section which is currently in progress. The proposed sections are as follows: (*a*) astronomy; (*b*) gravity; (*c*) research.

Then, of course, it would be logical to change the title of the Branch to "Geodetic Branch" to cover all its activities.

Cadastral Survey Branch

In the past, cadastral surveys of specified areas for fiscal purposes have been made from time to time by the Army. Thirty-two years ago, the military survey unit was enlarged by the addition of civilians who were trained for cadastral work. In November 1964, when the land reform programme was launched in Nepal for its economic development, the cadastral survey began to function in a more systematic way. Thus, the cadastral survey is currently organized into seven survey parties, each under a settlement officer (gazetted officer). Each survey party consists of 80 surveyors (*amins*) and other supervisors, comprising eight survey teams.

Equipment

The seven cadastral survey parties currently have 630 Watts microptic alidades and other necessary accessories for plane-table surveying.

Method and system of production

The cadastral plans for the revenue survey are surveyed by plane table, using a telescopic alidade and stadia rod (graduated in metric units). The distances are measured by tacheometry. Two years ago, the simple sight-rules previously used were replaced by microptic alidades. As the Trigonometrical Survey Branch was established at the beginning of 1970, there are not enough trigonometrical control stations for use by all seven cadastral parties. Currently, only two cadastral parties in the two hilly districts (Makawanpur and Dhankuta) are carrying out cadastral surveys based on a system of permanently marked co-ordinated points. In most cases, in the method of cadastral surveying currently used, a framework of controls is established graphically and the boundaries of the ward (the smallest administrative unit) and plots are marked by wooden pegs. But the ends of the base line are mostly marked by reinforced concrete or stone pillars. The direction of the magnetic north is drawn on the plan with the help of a trough compass. The extents of the plots are measured by the computing scale and trace. The metric system has been adopted for the measurement of distances and areas; but during the change-over period, areas are recorded both in metric units and in local units, using different colours to avoid confusion.

The scales of the cadastral plans vary between 1:500 and 1:5,000, according to land values and parcel areas. The cadastral survey also classifies land to bring uniformity in land tax. The broad classification is: (*a*) low-lying (*dhanhar khet*) land; and (*b*) elevated land (*pakho*).

Each area is subdivided into first-, second-, third- and fourth-class land, as defined by the land survey and measurement act.

Consolidation of scattered holdings into larger single units is not carried out at the current time.

Objectives and progress

In order to provide the necessary data for the land reform programme, a plan and a programme have been formulated to complete the cadastral survey of the 75 districts over a period of 17 years. The total extent of cultivated and cultivable land to be surveyed is 2,144,000 ha, or approximately 21,440 km^2. By July 1973 (in a nine-year period), the cadastral survey of 27 districts, including the Tarai and Inner Tarai, the Kathmandu valley and three other districts of the mountain region, had been completed. The remaining area to be mapped cadastrally in the hilly and mountain

regions amounts to 536,000 ha, or approximately 5,330 km², which represents approximately 25 per cent of the total area for cadastral survey.

Cadastral surveys of the built-up areas (i.e., towns) have not yet commenced. The foregoing paragraph concerns only the survey of rural properties. As plane-table surveying is not suited for preparing cadastral plans of the town areas, it is proposed that the chain survey method should be adopted.

Topographic Survey

Current topographic maps of Nepal

In order to obtain modern basic medium-scale topographic map coverage of Nepal, arrangements were made in the early 1950s, under the Colombo Plan, for the Survey of India to undertake the survey and publication of a 1:63,360 (1 inch to 1 mile) topographic map of the country. The field-work for that undertaking was completed about 12 years ago. Each sheet covers a 15′ × 15′ area, and 270 of these sheets cover the whole of Nepal. As of July 1973, printed copies of 186 sheets had been received, and 84 sheets remained to be completed. On an average, 10–20 new sheets (250 copies of each sheet) are received from India each year. If the current production rate is maintained, the task should be completed by 1978 at the latest.

These maps, however, are badly in need of revision in areas where much development has taken place over the past 12 years, especially as concerns roads and district boundaries.

The small-scale maps of Nepal currently available are on the scale 1:506,880 (1 inch to 8 miles) in two sheets; and 19 sheets on the scale 1:250,000, published by the War Office of the United Kingdom of Great Britain and Northern Ireland and the Army Map Service of the United States of America, respectively. Both these small-scale maps are based on a survey at 1 inch to 4 miles, carried out by the Survey of India in the 1920s. The lack of up-to-date scale maps is keenly felt in the administrative offices of the country.

Establishment of a topographic survey branch

To meet the pressing needs of the country for basic topographic mapping at various scales, the Government has decided to establish a modern topographic survey branch within the existing Survey Department with the assistance of UNDP. The UNDP has already approved the request and has taken the necessary action to provide technical assistance, under the Special Fund component, which includes expert services and equipment and supplies. This project will get under way in mid-1974 and UNDP assistance will continue up to 1978. It is expected that during the period all Nepalese staff of the Branch will be well trained to run the branch smoothly. The construction of the building for the new branch has begun; it is being financed by the Government of Nepal.

Responsibilities and objectives

The main responsibilities and objectives of the proposed topographic survey branch will be:

(*a*) To act as a central co-ordinating body for all topographic survey services within the country;

(*b*) To revise and update the current "1-inch" maps;

(*c*) To reproduce in quantity and on demand the 1-inch map-sheets of Nepal;

(*d*) To compile and publish up-to-date small-scale maps of Nepal on the scale 1:250,000 and on smaller scales for administrative and general development purposes;

(*e*) To survey and publish large-scale topographic plans of the towns;

(*f*) To undertake surveying and mapping for development projects;

(*g*) To print (and, if necessary, to draw) the maps prepared by other government departments, such as the forest resources survey and the geological survey.

Survey Training Centre

In 1967, the Survey Training Centre was established on a permanent basis within the framework of the Survey Department in order to make proper arrangements for the training of personnel in survey techniques and methods, and thus to meet the requirements for skilled and technician-level personnel. The Centre teaches three courses: the Recruit (*amin*) Course; the Junior Surveyor's Course; and the Senior Surveyor's Course. The principal and the four instructors of the Centre are currently seconded from the Survey of India under the Colombo Plan; and the vice-principal and the other junior instructors are Nepalese. Thus far, the advanced courses of surveying have been pursued by Fellows who are sent abroad to study.

Courses

The Recruit (*amin*) Course (C1) covers all that a field surveyor of a cadastral survey team should know. The trainees are taught large-scale plane-table surveys, establishment of property boundaries from survey and other records, tracing of plans, measuring areas, classifying land, preparation of land registers and registration laws. This is an eight-month course. It is scheduled twice a year, from 1 November of one year to 30 June of the next, and from 15 July to 14 March of the next. The entrance qualification for this course is class X completed with mathematics. In each term, 75 trainees are taken into the course.

In the Junior Surveyor's Course (C2), trainees are taught minor triangulation, tertiary traversing and levelling, chain surveying, large-and medium-scale plane-table surveys, contouring and draftsmanship. The entrance qualification for this course is matriculation or completed equivalent examination with mathematics, or a completed recruit course and five years of service in a survey organization. Approximately 30 trainees are admitted to this course. It is scheduled once a year, from 1 November of one year to 31 October of the following year. The objective of this training is to enable one to act as a field-survey team leader of the cadastral survey or to be an observer of the trigonometrical field-survey team.

In the Senior Surveyor's Course (C3), trainees are given training in various branches of surveying, such as triangulation, traversing, levelling, medium- and small-scale plane-table surveys, contouring, aerial surveys, field astronomy, triangulation and compilation. This training enables them to act as field-team leaders or as assistant executive field-survey officers. Prerequisites of this course are completed intermediate science with mathematics or the Junior Surveyor's Course, and students must have stereoscopic vision. About 10 trainees are admitted to this course; which also is a one year course lasting from 1 November of one year to 31 October of the next year.

CARTOGRAPHIC ACTIVITIES IN NEW ZEALAND, 1970–1973*

Paper presented by New Zealand

This report records progress and developments in New Zealand in the period 1970–1973.

The Department of Lands and Survey, as the national survey and mapping organization, is responsible for:

(*a*) The land survey system, including all plan records, cadastral mapping, and maintenance and development of the network of ground marks;

(*b*) Urban and rural control surveys, including precise levelling and selected earth deformation surveys;

(*c*) Topographic mapping both for engineering purposes and for basic mapping;

(*d*) Aerial photography with emphasis on regular coverage and on the national index;

(*e*) Aeronautical charting;

(*f*) General mapping, including mapping for other government departments and agencies; thematic and special-purpose maps.

The Department of Lands and Survey is strongly decentralized, with 12 district offices and four suboffices spread throughout New Zealand. Attached to the head office are three branches providing specialized services in photogrammetry, cartography and computing. In addition, the cartographic staff of the Department of Lands and Survey is seconded to the Department of Scientific and Industrial Research, which is responsible for geological, geophysical, oceanographic and soil surveys.

Some mapping operations related to forestry are undertaken by the New Zealand Forest Service, and surveys for marine charting are carried out by the Hydrographic Branch of the Royal New Zealand Navy.

Most of the 9,000 plans added each year to the land survey records are done by private practising surveyors who undertake work for the State as well as for private landholders. This flow of work is a significant factor in the maintenance and development of the survey system.

LAND SURVEY SYSTEM

For well over 100 years, land title surveys had been measured in chains and links; but since 1 January 1973, all work done in terms of the survey regulations has been in metres, with areas in square metres and hectares. The 750,000 plans held in the records will not be changed, but new titles issued there in future will be in metric terms. The change gave opportunity for further improvements and the record of survey now comprises a survey plan and a title plan on standard transparent plan forms drawn in black to specifications designed for 35-mm microfilming.

The change to microfilm became necessary to preserve the records because many of the old plans were disintegrating from continuous handling. The other benefits of a microfilm system are significant; and with good progress in filming, all offices should be operational on microfilm records by May 1974.

Since 1876, co-ordinates for cadastral surveys in New Zealand have been in terms of an initial station for a designated area described as a "plane meridional circuit." Although the plane co-ordinates have been retained, metric co-ordinates are now based on a false origin to make all values north and east.

URBAN AND RURAL CONTROL SURVEYS

In all control surveys, new developments in equipment have brought improved results and extended coverage. For horizontal control, emphasis has shifted to some extent to the growing urban areas where extension and upgrading of existing control has been made necessary by heavy construction programmes associated with development. In rural areas, road construction, special projects and intensified land use have brought a need for further breakdown of the existing control.

Precise levelling has been extended steadily along routes given priority because of pressing needs for accurate heights, but completion of the network to allow computation of a precise datum for New Zealand is still not in sight.

Earth deformation surveys are undertaken in conjunction with the Geological Survey; and by pooling resources, a worth-while number of patterns, including one encompassing Cook Strait, has been observed and measured.

During the period under review, increased emphasis has been given to maintenance of permanent reference marks and survey control monuments. A policy of improving the ease with which marks can be identified has been worth while. This system has involved the use of more steel signals, concrete pillars; and, in towns, cast-iron cover boxes and brass plaques carrying the words "Survey Mark".

Details of survey control for year ending 31 March 1973

	1971	*1972*	*1973*
Triangulation (square miles)	5,712	3,137	2,145
Rural control traverse (miles)	339	666	240
Urban control traverse (miles)	29	108	315
Precise levelling (miles)	453	278	275

TOPOGRAPHIC MAPPING

With a sense of achievement, it is reported that the basic mapping of New Zealand on 1 inch to 1 mile has been completed. Although the last of these maps will not be published until 1975, plan prints of the full specification mapping are available in the meantime. Another significant milestone in 1973 was the publication of full topographic coverage of New Zealand at 1:250,000 scale. The event drew considerable publicity and a corresponding increase in map sales.

With these goals in sight, it was time to plan for metric mapping; and the result is specifications for an integrated series of topographic maps and cadastral records designed to upgrade existing maps to standards adequate to meet the needs of the future. The scales selected for the maps proposed for publication are 1:250,000, 1:50,000 and 1:10,000, with respective contour intervals of 100, 20 and 5 m. Map-sheets are to be slightly larger,

*The original text of this paper, prepared by I. F. Sterling, Surveyor-General, New Zealand, appeared as document E/CONF.62/L.98.

with the 1:50,000 map covering an area 30 × 40 km, and bled to the edge north and east.

The new maps would be patterned on the newly devised New Zealand map grid, which would, for the first time, permit both the North and the South Island maps to be compiled on a single projection and co-ordinate system.

Cadastral maps

New Zealand, with full cadastral coverage, has found value in having a counterpart cadastral map to match the topographic map at 1 inch to 1 mile. This principle will be continued with the metric maps at 1:50,000 scale and also will be available for the topographic map at 1:10,000 scale because the primary survey plan and cadastral record sheet are to be at this scale. In urban areas, the cadastral record sheets break down to 1:2,000 and 1:1,000 scales. The larger scale cadastral record sheets are subject to daily revision and will not be published, but plan prints of the revised sheet or of the line drawing only will be available to the public.

With a sophisticated survey system and the ability to identify any property in New Zealand in terms of the New Zealand map grid, the opportunity exists to establish a comprehensive computer-based land data information system and investigations towards this end are proceeding.

Aerial photography

With full coverage achieved, the objective in recent years has been to recover rural areas at least every 10 years and urban areas every five years. Within that framework, priority is given to areas where new photography meets the greatest number of requirements as ascertained from all public bodies. Some economy has resulted by including in the index of photography any significant coverage not Crown copyright. As part of the metric change, scales for interpretation or resource photography are now 1:25,000 for rural areas and 1:10,000 for urban areas.

Aeronautical charts

In the period under review, nearly all charts were redrawn to improved standards; but of greater importance was the replacement of the instrument approach and landing charts with the instrument flight guide in flip style.

Development work included new visual terminal charts and, in conjunction with Australia, a radio navigation chart of the Tasman Sea as a joint production to a common specification.

General, thematic and special-purpose maps

During the period, a programme has been developed for a group of maps to cover the area of interest of New Zealand in the south-western Pacific. The project includes both small-scale and large-scale maps, and involves close liaison with island Governments and other authorities.

The land inventory mapping of New Zealand at 1:63,360 scale has not progressed as envisaged; only five counties have been completed. However, these are large land areas; and with six others close to completion and eight in preparation, the picture should improve.

The National Resources Survey handled by the Ministry of Works has made steady progress with publications being issued for three regions during the period under review. The publication is designed as a basic tool for regional planning with maps at 1:500,000 scale. Eight regions are now covered, leaving seven yet to be completed.

CARTOGRAPHIC ACTIVITIES IN THE PHILIPPINES*

Paper presented by the Philippines

This report is an outline of the significant surveying and mapping activities in the Philippines during the three-year period since the last Conference, and it includes brief statements on the steps taken by the Government of the Philippines on resolutions of the Sixth United Nations Regional Cartographic Conference for Asia and the Far East.

Geodesy and ground control

The primary triangulation network in the Philippines is of second-order accuracy and sufficiently covers most parts of the archipelago. However, there has been limited co-ordinated and sustained effort to densify the horizontal controls for mapping purposes, outside of what was undertaken by the Army Map Service of the United States of America in the early 1950s. On the other hand, isolated control surveys executed in support of bathymetric activities along the coastal areas and those executed in connexion with special mapping watershed areas, irrigation systems and other infrastructure projects, are, in most cases, tied to existing second- or third-order triangulation/traverse stations.

Since the last Conference, geodetic control activity been confined mostly to the west coast of Palawan where hydrography of the unsurveyed coastal waters begun in 1971. A second-order traverse, connected both ends to existing second-order triangulation tions, was measured by Tellurometer, model MR along the rocky coastline. Astronomical observations Polaris were made at both ends of the traverse and a middle portion. Picture points along the coastal were identified and located in the field, and recipr double-zenith distances were measured in all the traverse stations.

Vertical ground controls established during the pe under review are mostly of lower order, good only mapping, except in the Greater Manila area, where existing first-order level loops were re-run to deter the stability of the bench-marks after the strong e quakes that hit the city.

*The original text of this paper, prepared by the Philippine Coast and Geodetic Survey, appeared as document E/CONF 62/L 110

The United States Coast and Geodetic Survey (now the National Ocean Survey) established a geodetic satellite station at Zamboanga City in the southern Philippines. This project is in consonance with resolution 6 of the Sixth Conference;[1] and it will be used as the tie point to connect the second-order triangulation network of the Philippines to the Unified World Geodetic Datum. Furthermore, in 1971, the Philippine Government entered into a co-operative agreement with the Defense Mapping Agency of the United States for the establishment in selected locations of additional satellite stations using the Doppler method of satellite observations. To date, nine stations have been occupied and observations made by a team from the Naval Oceanographic Office of the United States. Arrangements for the establishment of more satellite stations are under consideration, and it is anticipated that in a few years such control stations will be of sufficient density to form the main framework for the Philippine first-order horizontal control network. Secondary triangulation/traverse stations will be established by conventional ground methods or airborne systems

Aerial photography and photogrammetry

About 90 per cent of the total land area of the Philippines, 30 million ha, is covered by aerial photography of good cartographic quality. In addition to this, aerial photography is undertaken for specific purposes, such as irrigation and hydroelectric projects. The photography is used mostly in connexion with the Land Reform Programme of the Government. Some agencies involved in land reform have adopted graphic methods of subdividing alienable lands, in favour of the conventional ground survey, to effect speedy and economical parcelling of agricultural estates, the ownership of which is to be transferred to the tenant farmers. The photo map, controlled or uncontrolled, has been found to be an effective tool in land reform and developmental planning; it fills the void caused by the absence of large-scale topographic line maps. Private surveying and mapping agencies have also done their share by carrying out isolated photogrammetric mapping for economic development projects.

Medium-scale and large-scale surveying and mapping

Topographic mapping

The national topographic map series on the scale 1:50,000, which covers the whole archipelago, consists of 969 map-sheets which were originally military maps compiled in the middle 1950s by the Army Map Service of the United States of America, from aerial photographs taken as early as 1947 and up to 1953. After the military information was deleted, these maps were then declassified and reproduced for sale to the public. Most of these maps are extremely out of date and require extensive revision in the planimetry and in other cultural details, particularly in those areas of rapidly expanding population. It is envisioned to undertake a revision of these maps using the most recent aerial photography. In flat areas, photo maps at 1:25,000 scale will be produced from controlled photo mosaics, and these will be published as interim map substitutes pending the publication of the new national topographic map series on the scale 1:25,000. Only the regional capitals and centres of population will be entirely covered by this new map series.

Cadastral surveying and mapping

In view of the need for an accelerated programme of land ownership transfer from the landlords to the tenant farmers, the graphic method of cadastral surveying was adopted in place of the numerical cadastral system. Sketching of lot boundaries was made on large-scale photo prints, after which the sketches were compiled altogether in the form of parcellary maps. This method facilitated the issuance of the certificate of land transfer which can be utilized by a farmer to secure credit from the banks. Parcellary maps at 1:4,000 scale show graphically the relative positions, shapes and sizes of farm lots. However, for purposes of issuing titles to the lots, the usual ground survey is still necessary. A total of 591,247 ha of land was covered by cadastral surveys during the period under review.

Urban mapping

Large-scale mapping of urban areas is undertaken as the need arises. The Greater Manila area, including the towns bordering the Laguna de Bay, is covered by topographic maps, on the scale 1:10,000. The planimetric map of Cebu City at 1:10,000 scale is currently being revised to incorporate information from new aerial photographs and will also include Lapu-Lapu City, Mandaue City and some neighbouring towns. Other cities, regional capitals and centres of population will be mapped using, at first, photo bases.

Maps and surveys for integrated planning and development of urban and regional areas

The Department of Public Works, Transportation and Communications has recently finished an integrated survey covering different facets of the Philippine economy. The results of the survey were presented graphically by means of 51 different thematic maps, which formed the bases in drawing up the guidelines for a "physical planning strategy" for the Philippines. From the results of the integrated survey, the planners were able to define the leading development areas, the land-reform priority areas, leading tourist areas, etc., which now form the basis of government planning on major infrastructure projects.

Orthophoto maps

The significance of modern orthophoto techniques in the production and revision of maps can not be overemphasized. To a limited extent, these techniques are applied in the production of photo-based maps for flat areas. However, due to the prohibitive cost of the equipment required for this method, it is very unlikely that orthophoto maps could be produced in the near future. Soil maps on photo base have been produced on the scale 1:10,000 for two pilot areas in Nueva Ecija Province; production of those covering the Pampanga River delta and the Candaba swamps at 1:25,000 scale is in progress. It is hoped that the photo maps produced from fully controlled photo mosaics could provide the planimetric detail for topographic line maps on the same scale.

[1] *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol I, *Report of the Conference* (United Nations publication, Sales No. E.71.I.15), pp. 15–16.

Small-scale mapping

The Philippines is fully covered by small-scale topographic maps on various scales. There are 55 sheets on the scale 1:250,000; six sheets at 1:1,000,000; and one sheet each on the scales 1:1,500,000, 1:2,000,000, 1:4,000,000 and 1:5,000,000. Several special maps, such as geological maps, land-classification maps, land-use maps, soil maps, and surface-water resources maps, are published at 1:1,000,000 scale.

The topographic maps at 1:250,000 scale are being revised, and the new editions incorporate the most recent changes in geographical names, political boundaries and the road system. No new photography is used in the revision. Like the 1:50,000 scale topographic maps, these small-scale topographic maps were also originally compiled by the United States Army Map Service; and it is planned to phase out the present series as soon as new editions are compiled from new aerial photography coverage.

The topographic maps at 1:1,000,000 scale follow closely the sheet lines and specifications of the International Map of the World on the Millionth Scale (IMW).

Thematic cartography and photo-interpretation

The preparation of a Philippine National Economic Atlas at 1:4,000,000 scale is almost finished. There will be a folio of 37 maps using the Lambert conformal conic projection. The atlas measures approximately 22 × 27 inches and is expected to be available before the end of 1973.

Other atlases have been prepared by different government agencies for their own particular use, and one still under preparation deals with higher education. Copies of these atlases will be furnished to Thailand for inclusion in the Regional Atlas for Asia and the Far East.

Thematic cartography has gained wide acceptance as an effective management tool in government agencies involved in economic development planning. Thematic maps can depict graphically the results of feasibility studies, statistical data and such information which bears on the subject under study. As mentioned above, the Department of Public Works, Transportation and Communications utilized some 51 thematic maps to portray graphically the results of an integrated survey which was conducted to establish the guidelines on the physical planning strategy for the Philippines. Leading development areas were defined, land reform priorities were set and the major tourist areas were pinpointed. These three main considerations were then used as the principal guidelines in drawing up detailed developmental plans. The 51 thematic maps were grouped into 12 general categories as follows: general information; leading development areas; services; population-employment; agriculture; industry; fishing; forestry; tourism; transportation; water resources; power resources.

Photo-interpretation is one of the subjects offered at the Training Institute for Applied Geodesy and Photogrammetry of the University of the Philippines. Recently, an Asian seminar on photo-interpretation was held at the same institute, but the principal emphasis was on satellite imagery. Agencies under the Department of Agriculture and Natural Resources have a select group of photo-interpreters whose primary objective and orientation concerns land classification and land uses. The National Committee for Mineral Exploration and Survey Operations (NACOMESO), an interagency body set up by the President of the Philippines to co-ordinate activities on mineral exploration, has accelerated its programme of acquiring satellite or aircraft remote-sensing imagery which is used in photo-interpretation in various disciplines. The same co-ordinating body is gradually building up a modest inventory of equipment for coloured and infra-red photography. This kind of photography is gaining acceptance as a faster means of survey in the development of natural resources, such as forestry, minerals, water, soil and agriculture.

Aeronautical charting

Since 1963, aeronautical charting has been a joint responsibility of the Philippine Coast and Geodetic Survey and the Civil Aeronautics Administration. During the period under review, activities along this line dealt with the production of the 1:1,000,000 scale World Aeronautical Chart (WAC) of the International Civil Aviation Organization (ICAO); obstruction charts, types A and B; air traffic services system chart, terminal area charts; and, recently, the 1:500,000 ICAO charts.

Hydrography and oceanography

Hydrographic surveying within Philippine territorial waters, with the exception of isolated harbour surveys conducted by the Bureau of Public Works, is an exclusive function of the Philippine Bureau of Coast and Geodetic Survey (PCGS). The task of keeping the shipping lanes, harbours and anchorages well charted is a continuing activity programmed on the basis of priorities laid down according to the needs of commercial shipping and the relative importance of the harbour port or anchorage.

In the past three years, hydrographic activity has been confined mainly to investigations of charted doubtful hydrographic information; revision surveys of Manila harbour, Iloilo harbour and the port of Davao; hydrography in connexion with feasibility studies in the Cotabato River and the northern portion of Manila Bay; and the basic survey of the uncharted coastal waters along the west coast of Palawan, which was begun in 1971. Reconnaissance hydrography was undertaken along a strip 2 miles wide, beginning from Table Point running south-westerly to Eran Bay, in conjunction with the establishment of second-order traverse stations along the coast to control off-shore hydrography. In 1973, the basic hydrography between Bluff Point and Peñascos Point was completed, and it was expected that the PCG survey ships RPS *Atyimba*, RPS *Arinya* and RP *Arlunya* would continue the work in this area during April, May and the early part of June. The United States Naval Oceanographic Office, by mutual agreement between the Governments of the Philippines and the United States of America has been undertaking hydrographic operations in the Mindoro Strait since 197. Additional hydrographic surveys will be undertaken in selected areas each year until the termination of the agreement in 1978.

Oceanographic and marine geophysical observations on a limited scale were also undertaken by RPS *Atyim* in Manila Bay and in the coastal waters off the west coast of Luzon. Private oil-prospecting firms have utilized the services of private surveying firms to undertake seismic surveys within their respect

reservations. In the Manila Bay area, oceanographic studies, including current and siltation observations, were carried out in connexion with the master sewerage plan for the metropolitan Manila area. The Fisheries Commission has also been involved in both biological and physical oceanography, primarily in connexion with studies on fish culture and allied disciplines.

Responsibility for the maintenance of the General Bathymetric Chart of the Ocean (GEBCO) plotting sheets Nos. 134, 135, 164, 165, 194 and 195 was transferred to the Philippine Coast and Geodetic Survey in 1972. The plotting sheets on the scale 1:1,000,000 cover the entire South China Sea; but, specifically, sheets 194 and 195 cover the "Dangerous area", which is proposed to be surveyed as a co-operative effort under the supervision of the proposed South China Sea Hydrographic Commission. In some portions, track line soundings are spaced sufficiently close to serve as initial hydrographic information for the benefit of survey ships that would operate in the area.

With respect to the Pacific Tsunami Warning System, arrangements are under way for the establishment of another monitoring station in the Mindanao area, in addition to that already established at Legazpi City, in southern Luzon. The Philippine Coast and Geodetic Survey is co-ordinating with other government agencies to improve further the local communication network so as to reduce to a minimum the elapsed time from the observation of the tsunami up to the transmission of the warning through the Pacific Tsunami Warning network.

Earth resources satellite for surveying, mapping and earth resources studies

In 1971, the Philippines negotiated with the Government of the United States of America for its inclusion in the Earth Resources Technology Satellite (ERTS) programme to help speed up the exploration and development of oil/mineral deposits and other natural resources of the country. The negotiations were subsequently formalized and NACOMESO has since been co-ordinating the acquisition and release of ERTS imagery to the end-users.

In line with this activity, the Government launched the Philippine Earth Resources Survey Programme, which envisages the utilization of operational and promising remote-sensing technologies to improve the country's information system with respect to its environment and natural resources. Its first objective is to consolidate and improve in-country capability and to enrich existing resources survey projects, before embarking on a massive programme involving more sophisticated systems, the technical and economic feasibilities of which have yet to be demonstrated. An information paper submitted to the Conference Secretariat for distribution gives a brief outline of the different phases and details of the programme.[2]

In surveying and mapping, ERTS imagery has not been fully used outside of its utility in photo-interpretation and in small-scale mapping for reconnaissance purposes. The western part of the country is covered by satellite photographs of good quality, in particularly, those of the island of Mindoro and the west coast of Luzon, which appear sharply on the enlarged prints on the approximate scale 1:250,000.

[2] For more details, see "Philippine earth resources survey programme", under agenda item 14, pp. 512–514.

Geographical names

The Philippines participated in the Second United Nations Conference on the Standardization of Geographical Names, held in London from 10 to 31 May 1972. During that Conference, the Philippine delegation presented a paper entitled "Geographical names of certain bodies of water within Philippine territorial waters" E/CONF.61/L.110, the contents of which are given below:

The Philippine Committee on Geographical Names has unanimously approved the inclusion in the official maps, charts and publications of the Philippine Government of the following geographical names for the corresponding bodies of water within Philippine territorial waters as defined and described hereunder:

1. LUZON SEA. To include all water areas west of Luzon Strait, west of Luzon Island, west of Mindoro, Calamianes and Palawan, and included within the western treaty limits of the Philippines, but excluding Palawan Passage.

2. BOHOL SEA. To include all water areas between Bohol and Mindanao Island, heretofore called Mindanao Sea.

3. MINDANAO SEA. To include all water areas of Samales Group and Basilan Island, south of Moro Gulf and Cotabato province and north of the southern treaty limits of the Philippines.

The foregoing decision of the Philippine Committee on Geographical Names was made after due consideration of the aspects of international law regarding the territorial sea and of the fact that the ocean waters along the affected shores of the Philippines should of necessity be given place names of national character, the bodies of water named being in close proximity to the corresponding islands from which their names are derived.

It is to be noted that the adoption and use of these geographical names in Philippine maps, charts and publications do not in any way prejudice the interest of other States. Likewise it is considered that the adoption and use by other States of these same geographical names will not in any manner adversely affect their interests.

The paper was submitted in consonance with the recommendation contained in resolution 4 of the First United Nations Conference on the Standardization of Geographical Names,[3] namely, that each national authority on geographical names should disseminate as widely as possible, particularly to other national authorities concerned, and to the Cartography Section of the United Nations, not only the latest decisions on national geographical names, but the names included in their geographical dictionaries, gazetteers, etc.

The Philippine Committee on Geographical Names was established in 1951, with the Executive Secretary as chairman; among its members are the chiefs of agencies involved in mapping, such as the Bureau of Census and Statistics, the Bureau of Lands and the Bureau of Coast and Geodetic Survey. The Committee follows closely the policy of the United States of America on the standardization of geographical names.

[3] *United Nations Conference on the Standardization of Geographical Names*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.68.I.9), pp. 10–11.

CARTOGRAPHIC ACTIVITIES OF PORTUGAL SINCE OCTOBER 1970*

Paper presented by Portugal

GEOGRAPHICAL ACTIVITIES IN PORTUGUESE OVERSEAS PROVINCES

Timor Province

The Portuguese province of Timor is composed of the eastern part of the island of the same name, Atauro Island and the enclave of Ocussi. Surveying and mapping in this province are carried out by a geographical mission.

Geodesy

The triangulation was completed before March 1967, and the purpose of subsequent geodetic activities has been to continue to cover the province with precision-levelling and gravity-surveying networks.

Levelling

The precision-levelling network (see figure 35), which covers 1,359 km, plus 20 km of connexions to the markers situated in villages, is made up of 16 lines arranged in six circuits, marked by 1,069 beacons.

During the period covered by this report, measurements were made in both directions, with a total extent of 912 km, which completed all the levelling observations. The observations were made with Wild NIII levels and invar rods, suitably calibrated in the Repsold comparator of the Lisbon Geographical and Cadastral Institute.

Gravity surveying

The main purpose of the gravimetric network of Timor (see figure 36) is the mapping of the Faye and Bouguer isanomalies using measured values of gravity.

The datum level of this network is that of the NP 36 precision-levelling bench-mark situated at Baucau international airport; its elevation was determined by several connexions to the Darwin international pendulum station, which is itself connected to the Melbourne basic station.

During the period under review, observations were made at the vertices of the basic network, situated at the 11 airfields, and also at 141 stations that are to be part of the second-order gravimetric network, which, it is hoped, will be completed before the end of 1973. A Worden geodetic gravimeter was used for the gravity observations.

Cartography

Geographical map

The 1:500,000 general map of Timor Province, printed in five colours with contours at 500-m intervals, was constructed by reducing the 36 sheets of the 1:50,000 map of Timor, which was mentioned in the report submitted to the Sixth Regional Conference.[1]

Specialized map

A 1:100,000 soil map of the island of Timor, consisting of 10 sheets measuring 30 × 30 inches, has been prepared for printing.

The soil markings appearing on photographs were plotted on the scale 1:50,000 on the sheets of the 1:50,000 geographical map and then reduced photographically to the scale 1:100,000.

The colour separation was done on Stabilene sheets by the scribing method. It is hoped that this map will be published before the end of 1973.

Cadastral surveys

The cadastral surveys will be carried out by the newly established Geographical and Cadastral Services of Timor. A 1:10,000 cadastral survey will be made by photogrammetry, with the co-operation of the Overseas Geographical Centre.

PORTUGUESE STATE IN INDIA

The Portuguese state in India has been removed from the full and effective exercise of Portuguese sovereignty since December 1961.

MACAO PROVINCE

A second edition of the following hydrographic charts of Macao Province was published in 1972: (a) *No. 520*: Macao, Taipa and Coloane, 1:20,000 scale; (b) *No. 521*: port of Macao, 1:10,000 scale; (c) *No. 522*: islands of Taipa and Coloane, 1:10,000 scale.

*The original text of this paper, submitted in French, appeared as document E/CONF.62/L.117.

[1] "Cartographic activities in the Portuguese overseas provinces", *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II. *Technical Papers* (United Nations publication, Sales No. E.72.I.20), pp. 66-69.

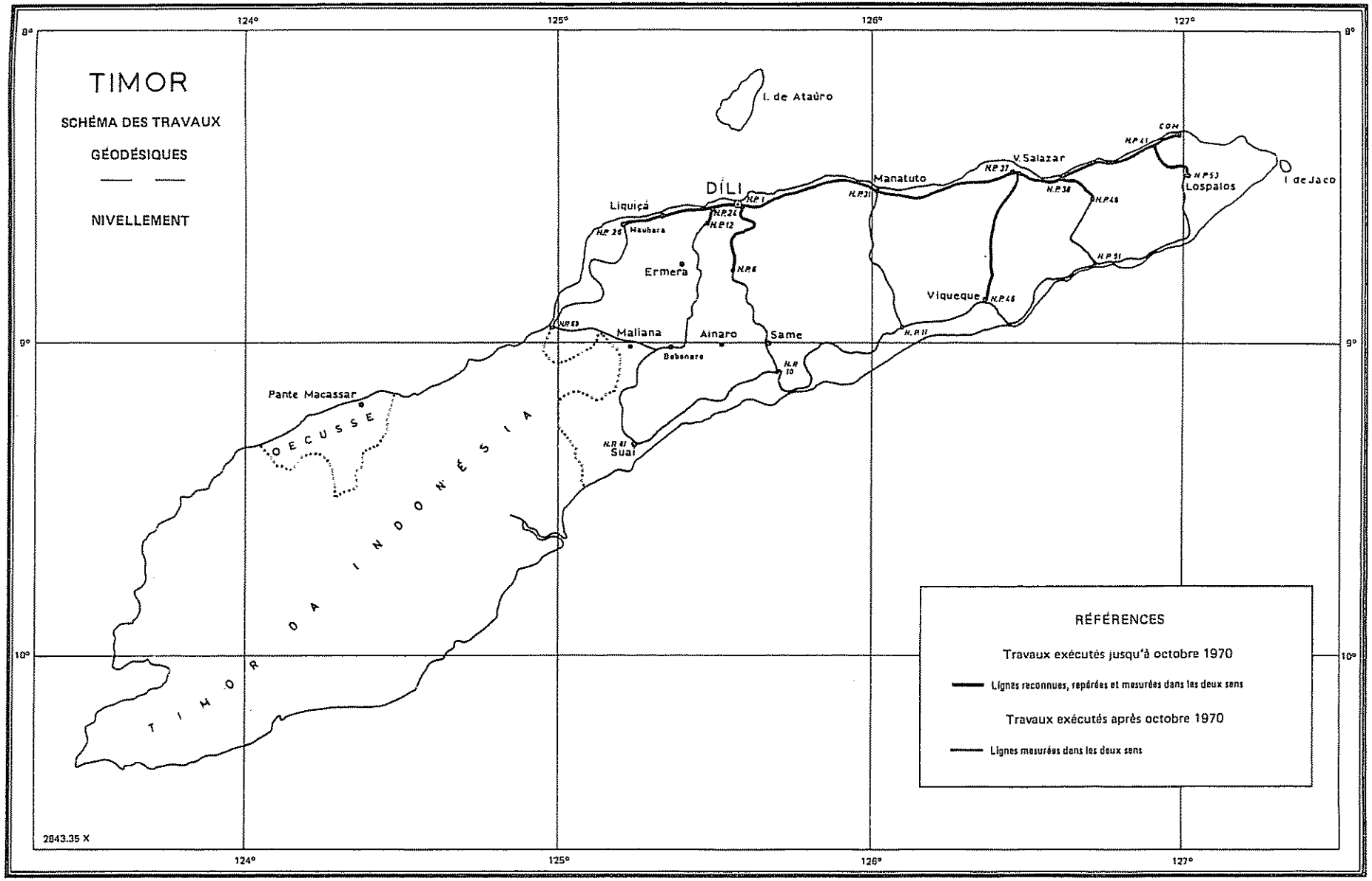


Figure 35. Portugal: levelling network in Timor Province

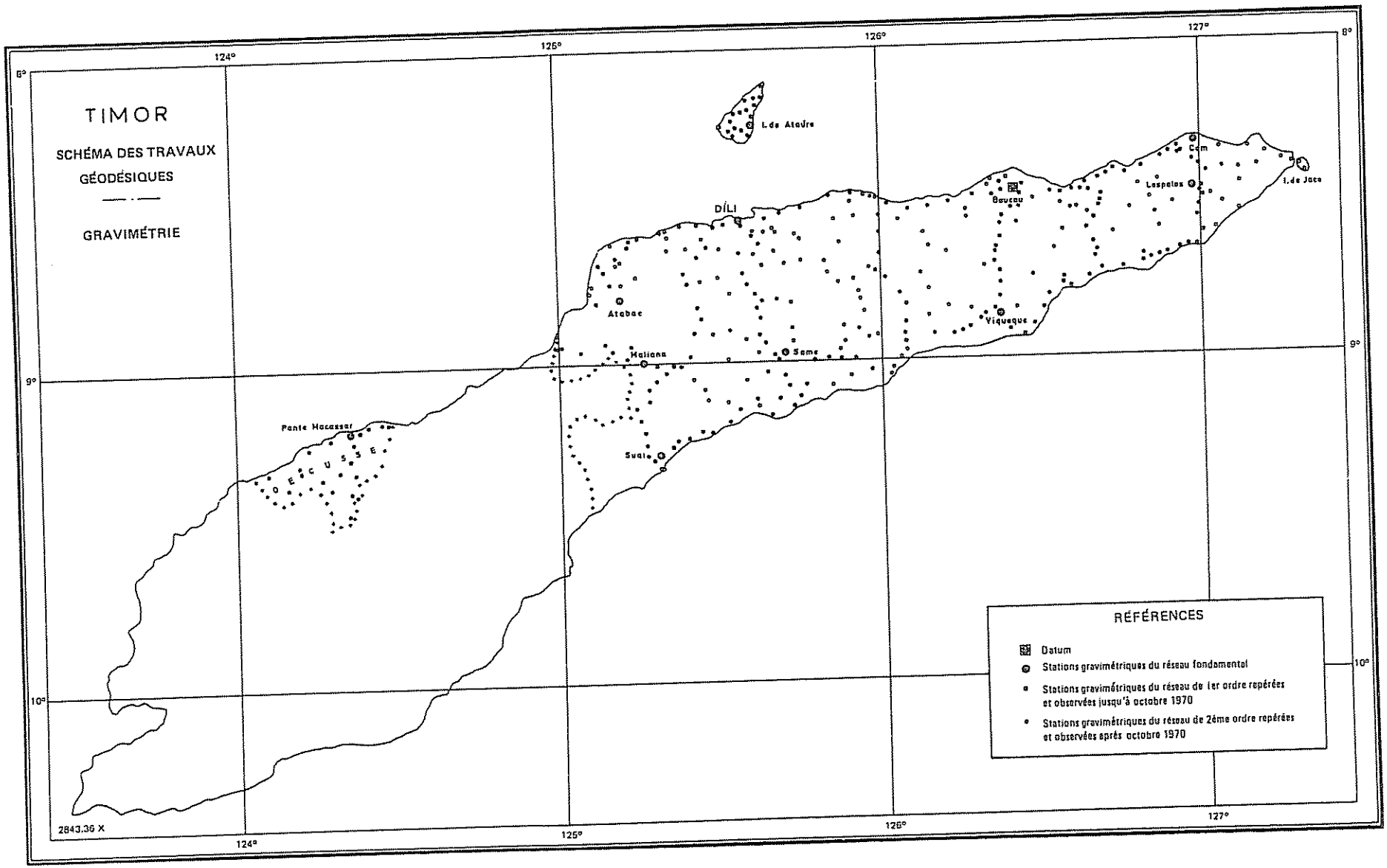


Figure 36. Portugal: gravimetric network in Timor Province

MAPPING IN THE REPUBLIC OF KOREA*

Paper presented by the Republic of Korea

For several reasons, the Republic of Korea has been unable to participate in many of the previous United Nations Regional Cartographic Conferences for Asia and the Far East; consequently, little information on mapping in the country has been available to the participants.

The Republic of Korea has, however, relatively modern mapping organizations with cartographic and photogrammetric capabilities; and during the past decade, the importance of mapping has been well recognized by the map-users for its contribution to the continued development of the country.

A large volume of mapping, on many different scales, is being undertaken by the mapping agencies of the Government, as well as by civilian mapping firms, for various purposes, such as highway construction, harbour construction, plant site design, land-use planning and preservation of historic remains.

GOVERNMENT MAPPING ORGANIZATIONS

Three major mapping organizations are responsible for mapping and charting in the Republic of Korea. By the authority of the Survey Law, the National Construction Research Institute (NCRI) of the Ministry of Construction has full responsibility for all geodetic surveys and topographic mapping. The Republic of Korea Army Map Service (ROKAMS) of the Corps of Engineers, is responsible for military mapping and some portions of the geodetic survey which are allotted to it by NCRI. The Hydrographic Office of the Ministry of Transportation is in charge of hydrographic chart production and waterway surveys.

The National Construction Research Institute was established in 1961 under the Ministry of Construction through the phase-out of the Geographic Research Institute of the Ministry of National Defence; and it undertook the national mapping responsibility as the primary government mapping agency. It was agreed, at the same time, that those three agencies of the Republic of Korea would mutually assist and exchange mapping information and materials to avoid duplication of efforts for the co-ordination of activities in planning and carrying out national mapping.

The Republic of Korea Army Map Service has a rather long history and background, with capability for production of tactical and strategic maps, such as the 1:25,000, 1:50,000 and 1:250,000 series. In 1956, the Army reached a mapping agreement with the United States Army, and many remarkable results for the improvement of mapping in the Republic of Korea have been achieved through the mutual exchange of mapping information and reproduction materials. In particular, the Republic of Korea and the United States of America have convened annual joint mapping conferences for many years, in which all the cartographers of the Republic of Korea and foreign concerns participate; many problems have been solved through beneficial discussion at the conferences.

The Hydrographic Office of the Ministry of Transportation was originally activated in the Navy and was transferred to the Ministry in 1963. It also has a form of agreement with the United States Navy Oceanographic Office; and has undertaken a number of joint projects, for instance, sounding along the coastal area and charting for the major harbours.

In addition to the above-mentioned organizations, three other organizations produce special-purpose maps, such as geological maps, forest maps and soil maps. Those agencies are the Geological and Mineral Institute of Korea (Industrial Advancement Administration); the Forest Resources Survey Research Centre (Office of Forestry of the Ministry of Internal Affairs); and the Plant Environment Research Institute (Office of Rural Development of the Ministry of Agriculture and Fisheries). Each of those agencies publishes many useful maps of various purposes at different scales and also undertakes research projects in its own field.

MAPS PRODUCED

National Construction Research Institute

The Republic of Korea had a full coverage (722 sheets sized 10 × 15 inches) 1:50,000 mono-colour topographic map, which was completed in the early part of the twentieth century by plane-table method. That coverage was used for various purposes until a new coverage at 1:50,000 scale was completed by photogrammetric method in the 1950s.

Although the new series was produced for military operations, it is currently being widely used for civilian purposes, after periodic planimetric revisions. The format of the 1:50,000 scale maps is currently 10 × 15 inches as mentioned above; however, it will be recast in 15 × 15-inch neat lines in the near future in order to reduce production costs.

In respect of the map at 1:25,000 scale, NCRI initiated the photogrammetric compilation project in 1967 for an area of approximately 100,000 km², and this project will be completed by the end of 1973. This five-colour map is currently the legal national base map of the Republic of Korea. The photography is 1:37,500 wide angle, the contour interval is 10 m, the projection is Transverse Mercator and the format is 7½ × 7½ inches (see figure 37).

Upon completion of the mapping at 1:25,000 scale, NCRI has planned a very extensive programme of 1:5,000 national base map production. Project areas for mapping at this scale have already been selected in accordance with the given priority, and the required photos will be flown in the near future on the scale 1:20,000. The map will be single colour with a 2-m contour interval and true planimetric expression.

Along with the above-mentioned routine national mapping, 15 *ad hoc* photogrammetric projects for large-scale engineering maps have been accomplished during the period 1967–1972. The scales of the maps range from 1:1,200 to 1:10,000 for the construction purposes of highways, plant sites, dams, harbours, parks, etc.

In 1972, a special project for a land-use map covering an area of 22,500 km² along the existing highways was

*The original text of this paper, prepared by the National Construction Research Institute of the Ministry of Construction, Republic of Korea, appeared as document E/CONF.62/L.63.

executed. This map is based on the 1:25,000 national base map with gray-colour line-map details, including geographical names; and the land-use classification is expressed in 12 groups and 45 subgroups with colours and symbols. This coverage has been already used for land-use planning which has legal validity for future development and will be extended over the remaining area in a few years (see figure 38)

The National Construction Research Institute has also undertaken small-scale map coverages, such as shaded relief maps at 1:250,000 scale and no-contour maps at 1:500,000 scale.

Republic of Korea Army Map Service

As explained in the paper presented at the Third United Nations Regional Cartographic Conference for Asia and the Far East,[1] this organization also is an active mapping agency in the Republic of Korea.

Among the various scales and types of maps being produced are topographic maps on the scales 1:25,000, 1:50,000 and 1:100,000; strategic maps at 1:250,000 scale, the road map at 1:700,000 scale and the map of the Republic of Korea on the scale 1:1,000,000.

Hydrographic Office

The Hydrographic Office is publishing 79 sheets of nautical charts of the coast of Korea on the scale 1:50,000. Thirty-four sheets have recently been revised according to the hydrographic survey of an area of 8,296 square miles (35,000 linear miles), and the remainder will have been continuously revised by the end of 1981, along with another extensive hydrographic survey of 104,600 square miles around the coast and the off-shore islands. The Raydist system and the C4 beam-sounder are being used for positioning and sounding, respectively, for this project.

The Hydrographic Office has another programme for the production of 10 sheets of a bathymetric chart at 1:200,000 scale, which will replace the existing 1:250,00 series.

EQUIPMENT

Aerial photographs are mostly taken by private co tractors which are survey firms in the Republic of Kore and detail plotting is done both by NCRI and by co tractors.

The photogrammetric equipment currently in oper tion is listed below.

Photogrammetric equipment available

Type of equipment	*Number of u*
Aerial cameras	
Wild RC8 15/23	1
Zeiss RMKA 15/23	1
Universal stereoplotter, Wild A7	1
Precision stereoplotters	
Wild A10	1
Wild A8	4
Topographic stereoplotters	
Wild B8	8
Kelsh	7
Balplex	1
Multiplex	4
Zeiss stereotope	1
Rectifiers	
Zeiss SEG V	1
Bausch & Lomb	1
Reflecting projector, K & E	3
Vertical reflecting projector	4
Radial secator	1

The instruments listed above belong to the Gov ment and private firms in the Republic of Korea, many more plotting instruments are expected t imported for 1:5,000 national base-map plotting i coming years.

The photogrammetric capabilities of the Republ Korea will be enhanced with a new comparator an orthoprojector, which will be installed at the Nati Construction Research Institute in the near future.

[1] "Progress of Korean mapping", *Third United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II. *Proceedings of the Conference and Technical Papers* (United Nations publication, Sales No. 64.I.17), pp. 55–57

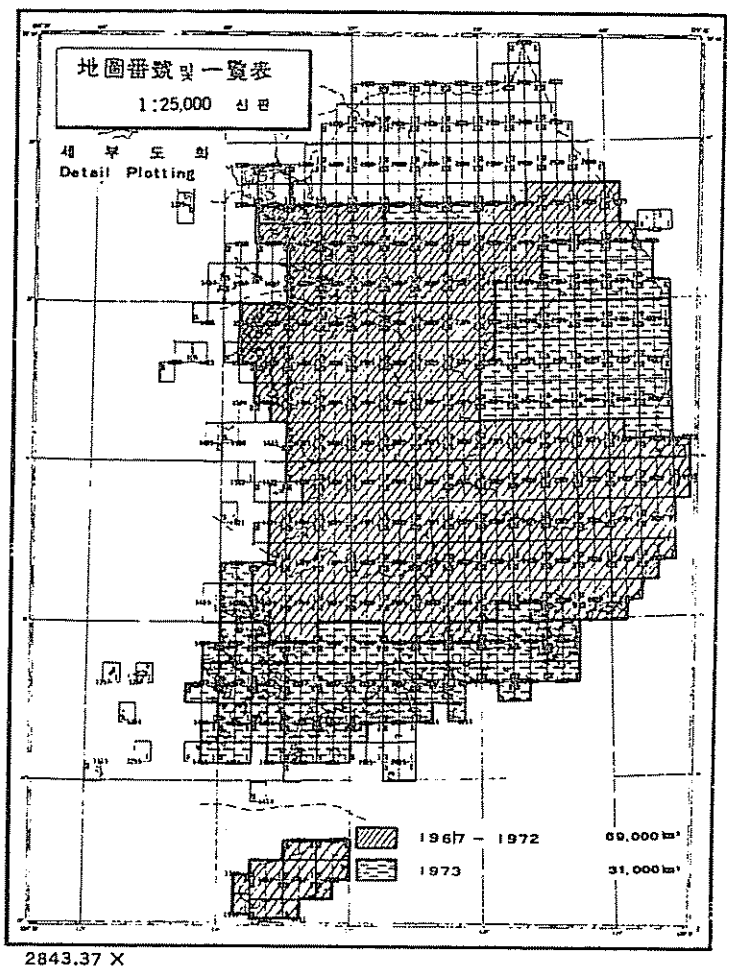


Figure 37. Republic of Korea: National Construction Research Institute detail plotting map at 1:25,000 scale

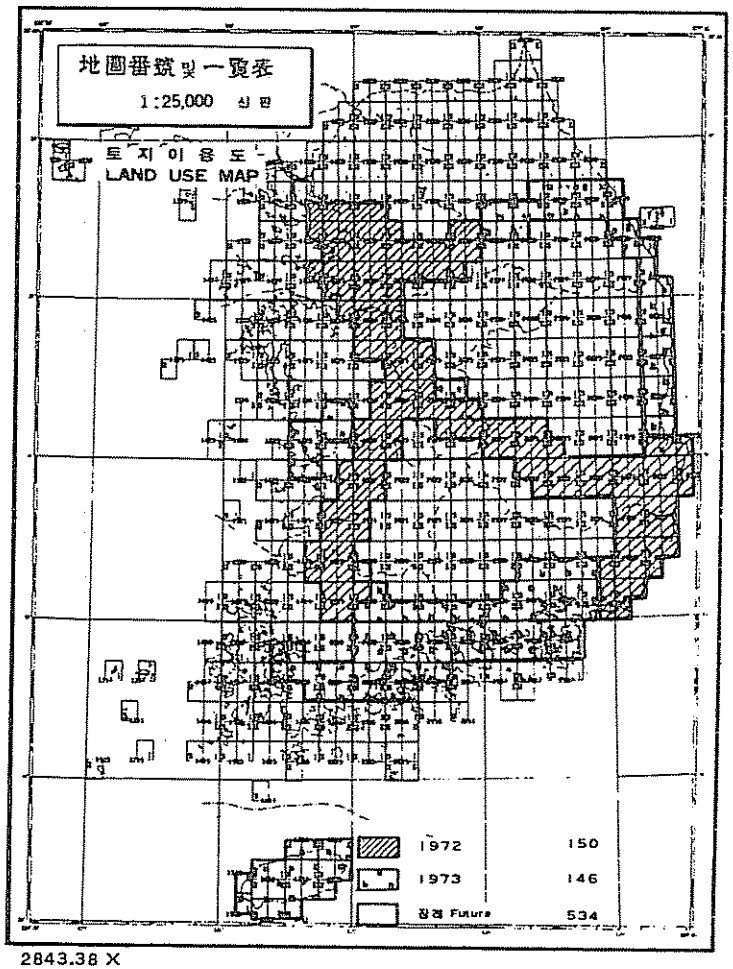


Figure 38. Republic of Korea: National Construction Research Institute land-use map at 1:25,000 scale

CARTOGRAPHIC ACTIVITIES IN THE REPUBLIC OF VIET-NAM, 1970-1973*

Paper presented by the Republic of Viet-Nam

As a general observation, during the period covered by this report, the National Geographical Directorate of the Republic of Viet-Nam continued its work in the fields of cartography assigned to it.

These activities relate mainly to: (*a*) geodetic work; (*b*) preparation and revision of topographic maps; (*c*) preparation of special maps; (*d*) compilation of geographical names for the provinces.

GEODETIC WORK

Triangulation

The National Geographical Directorate is continuing its work in the Mekong Delta. MC8 electronic distance-measuring instruments and Wild T3 theodolites are used; Bilby towers are installed in most of the stations. During the period covered by this report, 360-km traverses were measured with 20 monumented stations of the first and second orders.

Precise levelling

Precise levelling was carried out both in order to re-establish first-order links where bench-marks had been destroyed as a result of road-widening and in order to intensify the existing framework with the use of second-order traversing; 950 km of first-order and second-order levelling were measured with 363 monumented bench-marks.

Publication of lists of triangulation points and bench-marks

The National Geographical Directorate has begun to prepare bilingual lists of triangulation points and bench-marks, in Viet-Namese and English, with the objective of providing users with clear and precise documents which will enable them to find points and bench-marks easily where they occur.

Forty-five lists of triangulation points have been prepared; and 75 lists of bench-marks have been prepared, of which 40 have been issued.

TOPOGRAPHIC MAPS

Revision of the 1:50,000 map

Revision of the basic cartographic coverage on the scale 1:50,000 is one of the principal activities and concerns of the National Geographical Directorate. Use is made of the most recent aerial photographs; the revised data are later checked and supplemented in the field. During the period covered by the report, 35 sheets were revised and published.

Topographic maps at 1:25,000 scale

The National Geographical Directorate is continuing its programme of preparing 1:25,000 topographic maps in populated areas. To date, 51 sheets have been published; and 20 sheets have been plotted, including 10 which are in course of preparation.

Large-scale maps

The programme of preparing large-scale 1:10,000 and 1:5,000 maps is being continued in order to provide exact topographic data for physical planning and economic development. Progress to date is as follows:

(*a*) Twenty-four 1:5,000 sheets of the capital, Saigon, and its surrounding areas have been issued;

(*b*) Seven 1:5,000 sheets of the Gò-Công region covering an area of 9,000 ha have been plotted; these sheets were used immediately for agricultural development purposes in the area;

(*c*) Twenty-seven sheets covering the Tân-An—Mỹ-Tho region (south of Saigon) have been prepared; 23 of them have been issued;

(*d*) Four 1:10,000 sheets of the town of Dalat and one sheet of the town of Mỹ-Tho are in course of preparation.

SPECIAL MAPS

The National Geographical Directorate has added to its collection of special maps by preparing detailed geological maps on the scale 1:25,000, covering the northern Saigon region. Five sheets have been issued. The general geological map on the scale 1:2,000,000 has been revised and issued with a key in three languages—Viet-Namese, English and French.

At the same time, with the co-operation of the Directorate of Civil Aviation, the National Geographical Directorate has undertaken to prepare International Civil Aviation Organization (ICAO) maps on the scale 1:1,000,000. Five sheets covering the Republic of Viet-Nam were planned, of which the sheets covering Saigon (No. 2739) and Qui-Nho'n (No. 2737) have been issued. It should be noted that the topographic data used for the preparation of these maps are also used for preparing world maps on the scale 1:1,000,000, two of which are in course of preparation.

The National Geographical Directorate has also begun work on marine charts on the basis of data and hydrographic surveys provided by the Directorate of Shipping. Sheet Nos. 1001 and 1002, covering the territorial waters of the China Sea and the Gulf of Siam, have been issued.

PROVINCIAL GEOGRAPHICAL NAMES GAZETTEER

At the beginning of 1971, the National Geographical Directorate adopted a long-term programme for the

*The original text of this paper, prepared by the Ministry of National Defence, Republic of Viet-Nam, submitted in French, appeared as document E/CONF 62/L 66.

collection and transcription of the geographical names of the Republic of Viet-Nam. The first part of the programme is limited to the comprehensive and careful collection of geographical names for each province with a view to the publication of a gazetteer.

The work of compiling and editing the gazetteers for each province, and of compiling the definitive dictionary for the entire territory of the Republic of Viet-Nam, are described in detail in a separate technical paper.[1]

The work of collecting geographical names in four provinces has been completed, and the gazetteer for the province of Chuong Thiên has been published.

[1] See "The preparation of gazetteers of provincial geographical names in the Republic of Viet-Nam", under agenda item 15, pp. 527-530.

CARTOGRAPHIC ACTIVITIES IN SAUDI ARABIA, 1970-1973*

Paper presented by Saudi Arabia

The purpose of this paper is to present cartographic progress achieved in Saudi Arabia during the period 1970-1973.

GEODETIC SURVEY

National geodetic network

The national geodetic network has been extended. Traversing of 4,200 km, in addition to the existing 15,000 km of traversing, was completed in the period under review.

Gravity survey network

The gravity survey that was initiated during this period covers the following works: (*a*) establishment of fundamental gravity base stations at three locations; (*b*) establishment of a gravity base reference station network; (*c*) two gravimeter calibration lines near Jeddah and Riyadh; (*d*) a regional gravity survey to be carried out at all bench-mark traverse stations of the national geodetic network.

Air Profile Recorder

An area of approximately 400,000 km² of Saudi Arabia was covered by Air Profile Recorder (APR) during the period 1970-1973. An additional 350,000 km² will be completed by 1974.

AERIAL PHOTOGRAPHY

Super-wide-angle photography

An area of approximately 600,000 km² was covered by super-wide-angle photography at 1:80,000 scale during the period under review. The photography was flown over hilly and flat terrain.

Wide-angle photography

Wide-angle photography coverage during the period was 250,000 km² at 1:80,000 scale in the mountain area.

Medium-scale and larger scale photography

Photography on the scales 1:40,000, 1:30,000, 1:15,000 and 1:5,000 has been flown for regional planning, engineering and other special purpose survey projects.

PHOTOGRAMMETRY

Analytical aerial triangulation of about 200,000 km² has been completed, while the work in progress covers an area of 500,000 km² and should be completed by the end of 1974.

Plotting for 80 sheets of 1:50,000 topographic maps has been completed, while plotting of 200 additional sheets is in progress.

CARTOGRAPHIC MAPPING

Topographic mapping

An area covered by 24 sheets of the 1:50,000 photo map (six colours) has been mapped. The second area commenced during the period 1970-1973 will be covered by 280 sheets of photo maps and line maps at 1:50,000 scale, due for completion early in 1975. These two projects are part of the national topographic mapping programme carried out by the Aerial Survey Department of the Ministry of Petroleum and Mineral Resources.

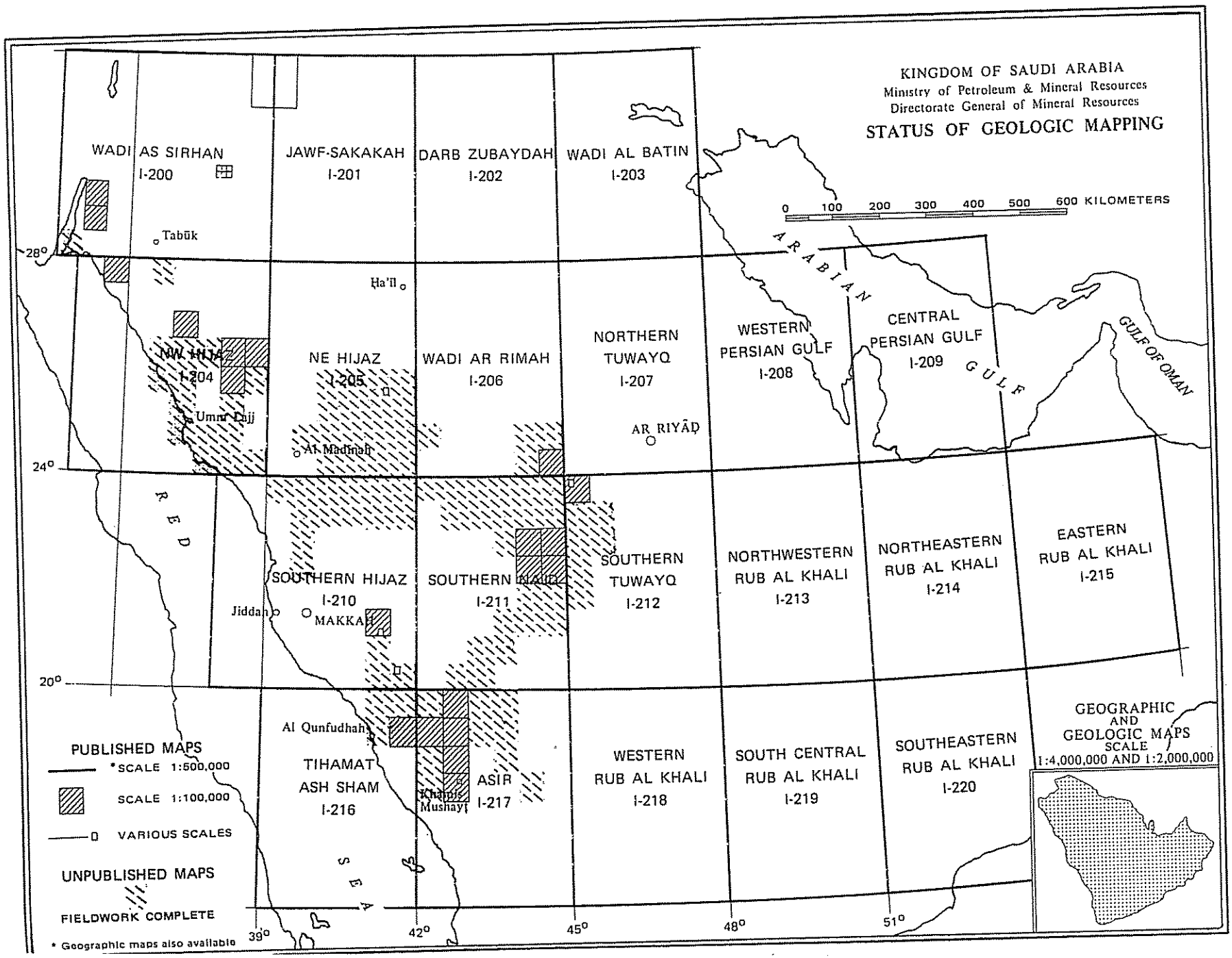
Four sheets of the 1:100,000 photo maps were recently published, while the map of the Arabian Peninsula at 1:4,000,000 scale is being printed.

Geological mapping

Revision of the existing geological and geographical maps at 1:500,000 scale, covering Saudi Arabia, has been begun, and some sheets have been printed. A series of 18 mineral investigation maps, some on the scale 1:100,000 and some on larger scales, was published by the Directorate General of Mineral Resources (DGMR). The primary purpose of these maps is to show the results of mineral investigations carried out by DGMR and other groups working with DGMR.

Systematic geological mapping of the Arabian Precambrian Shield on the scale 1:100,000 was begun in 1965; and as of October 1973, mapping of approximately 260,000 km² (48 per cent of the Shield outcrop) has been completed, with a further 59,000 km² (11 per cent) in progress. Some of this work is for publication as 30-minute quadrangles at 1:100,000 scale. The first five sheets were published prior to October 1973, and a further 32 sheets are in various stages of compilation and preparation.

*The original text of this paper appeared as document E/CONF.62/L.119 and Add. 1


KINGDOM OF SAUDI ARABIA
Ministry of Petroleum & Mineral Resources
Directorate General of Mineral Resources
STATUS OF GEOLOGIC MAPPING
0 100 200 300 400 500 600 KILOMETERS
WADI AS SIRHAN I-200
JAWF-SAKAKAH I-201
DARB ZUBAYDAH I-202
WADI AL BATIN I-203
NW HIJAZ I-204
NE HIJAZ I-205
WADI AR RIMAH I-206
NORTHERN TUWAYQ I-207
WESTERN PERSIAN GULF I-208
CENTRAL PERSIAN GULF I-209
SOUTHERN HIJAZ I-210
SOUTHERN NAJD I-211
SOUTHERN TUWAYQ I-212
NORTHWESTERN RUB AL KHALI I-213
NORTHEASTERN RUB AL KHALI I-214
EASTERN RUB AL KHALI I-215
TIHAMAT ASH SHAM I-216
ASIR I-217
WESTERN RUB AL KHALI I-218
SOUTH CENTRAL RUB AL KHALI I-219
SOUTHEASTERN RUB AL KHALI I-220
Tabūk
Ḥa'il
Umm Lajj
Al Madīnah
AR RIYĀḌ
Jiddah
MAKKAH
Al Qunfudhah
Khamis Mushayt
ARABIAN GULF
GULF OF OMAN
RED SEA
28°
24°
20°
39°
42°
45°
48°
51°
PUBLISHED MAPS
*SCALE 1:500,000
SCALE 1:100,000
VARIOUS SCALES
UNPUBLISHED MAPS
FIELDWORK COMPLETE
* Geographic maps also available
GEOGRAPHIC AND GEOLOGIC MAPS
SCALE 1:4,000,000 AND 1:2,000,000

Base maps for national census

For use in the census to be carried out by the Statistical Department of the Ministry of Finance and National Economy, 700 sheets of base maps on the scales 1:25,000, 1:50,000 and 1:100,000 have been prepared.

Other publications

The Geographic Department of the University of Riyadh has prepared and published an atlas of rainfall maps of Saudi Arabia.

Training programme

The Aerial Survey Department of the Ministry of Petroleum and Mineral Resources has initiated a training programme for new trainees, as well as for working staff. The programme covers basic and advanced surveying and mapping subjects.

Joint project of the United States Geological Survey and Saudi Arabia

Geological mapping

For many years, a programme conducted by the United States Geological Survey and financed by the Directorate General of Mineral Resources of the Ministry of Petroleum and Mineral Resources of Saudi Arabia, has been under way. The works consists of investigating the geology and mineral resources of the Arabian Precambrian Shield. Most investigations are made in the southern part of the Shield, as shown in figure 40. This figure also shows the larger scale mapping of the Thaniyat Turayf phosphate area and the Mahd adh Dhahab-Umm Damar area. Current studies consist, in part, of mapping the geology of 30-minute quadrangles on the scale 1:100,000. Five of these maps have been published by DGMR, three are in the process of being published, six are being edited and reviewed for publishing, and 11 are being compiled and drafted. Seven quadrangles are scheduled for mapping during the current field-season. Five additional quadrangles will be mapped by Saudi geologists assisted by geologists of the United States Geological Survey.

Not identified in Figure 40 is a tectonic map of the Arabian Peninsula, compiled by the joint project and printed in 1973 by DGMR.

Geographical mapping

The locations of geographical and geological mapping at 1:500,000 scale are shown in figure 40. The entire area of Saudi Arabia is covered by this series of maps, some of which are out of print and consequently are being updated and republished. Two of these geographical maps, I-204 and I-217, will be republished in 1974; four others, I-207, I-208, I-211 and I-212, also are scheduled for republishing.

A topographic map of the Arabian Peninsula on the scale 1:4,000,000 was compiled by the joint project and published late in 1972 by the Directorate General for Mineral Resources.

Earth Resources Technology Satellite Imagery

Imagery from the Earth Resources Technology Satellite (ERTS) recently has been used in Saudi Arabia as a means of preparing a 1:100,000 scale base for a geological map. The area covered is along the escarpment east of the Red Sea, where relief is more than 2,000 m and where non-uniformity of scale makes existing photo mosaics unusable for base plates.

Film positives of two of the four Multispectral Scanner (MSS) channels of a scene covering the area of interest were selected as being the most complementary in image resolution. Identical portions of each were enlarged on film through the same ratios to approximately 1:100,000 scale. The base-stable positives produced were then image-matched and registered to form a composite. Graticule points in the north-west, north-east and south-east corners were located by matching and inspection on the overlapping sectors of scale-stable film positives from existing controlled mosaics laid to a polyconic projection. The south-west corner was plotted as an extension of that projection. The average of scale discrepancies measured indicated an error of +1 per cent. The composite positive was then reduced to 99 per cent to a direct film positive. This positive was hand-retouched to reduce the effects of scratches and streaks from some scan lines. A contact continuous-tone negative was then produced, retouched in the same manner, masked along the graticule edges and used to produce an accent-tone intermediate positive and subsequent accent-tone negative. The accent-tone negative will be the final base copy for the geological map. Geological detail originally compiled on aerial photographs will be transferred to a reverse-reading film positive registered to the accent-tone negative. After transfer of all details by inspection, the photo-image will be removed from the compilation positive, and the line work remaining will be used for preparing the geology plate.

Geophysical mapping

Geophysical surveying in Saudi Arabia has been largely confined to aeromagnetics, gamma radiation and gravity. By far the greatest effort has been in the field of aeromagnetic surveying. Essentially all of the Arabian Precambrian Shield has been flown in two major surveys, one during 1965–1966, in which more than 300,000 km^2 were flown; and the other in 1966–1967, when nearly 250,000 km^2 were flown. Several smaller surveys account for an additional 41,000 km^2. Most of the Shield survey area, shown in figure 41, was flown at an elevation of 150 m above the terrain along lines spaced 800 m apart. Map compilations are on the scales 1:50,000, 1:100,000, 1:500,000 and 1:2,000,000. Publication of the 1:500,000 scale maps in eight colours is under way; each colour represents a contour interval of 100 gammas. Plans are to publish the 1:2,000,000 composite aeromagnetic map of the Shield in two colours: red for anomaly highs; and blue for anomaly lows. Intermediate values will be shown in white.

The Red Sea magnetic map project, delineated in figure 41, represents another major effort in map compilation. Both aeromagnetic data along the margins of the Red Sea and oceanographic magnetic data are included. The numerous individual surveys include data provided by several firms, as well as data resulting from nine international oceanographic surveys in the Red Sea dating from 1958. The map is being compiled on the scale 1:1,000,000, using ERTS-A satellite imagery as a base. As the imagery agrees closely with the Lambert conformal conic projection, widely used in Saudi Arabia, the magnetic join with the Shield magnetic map will be satisfactory.

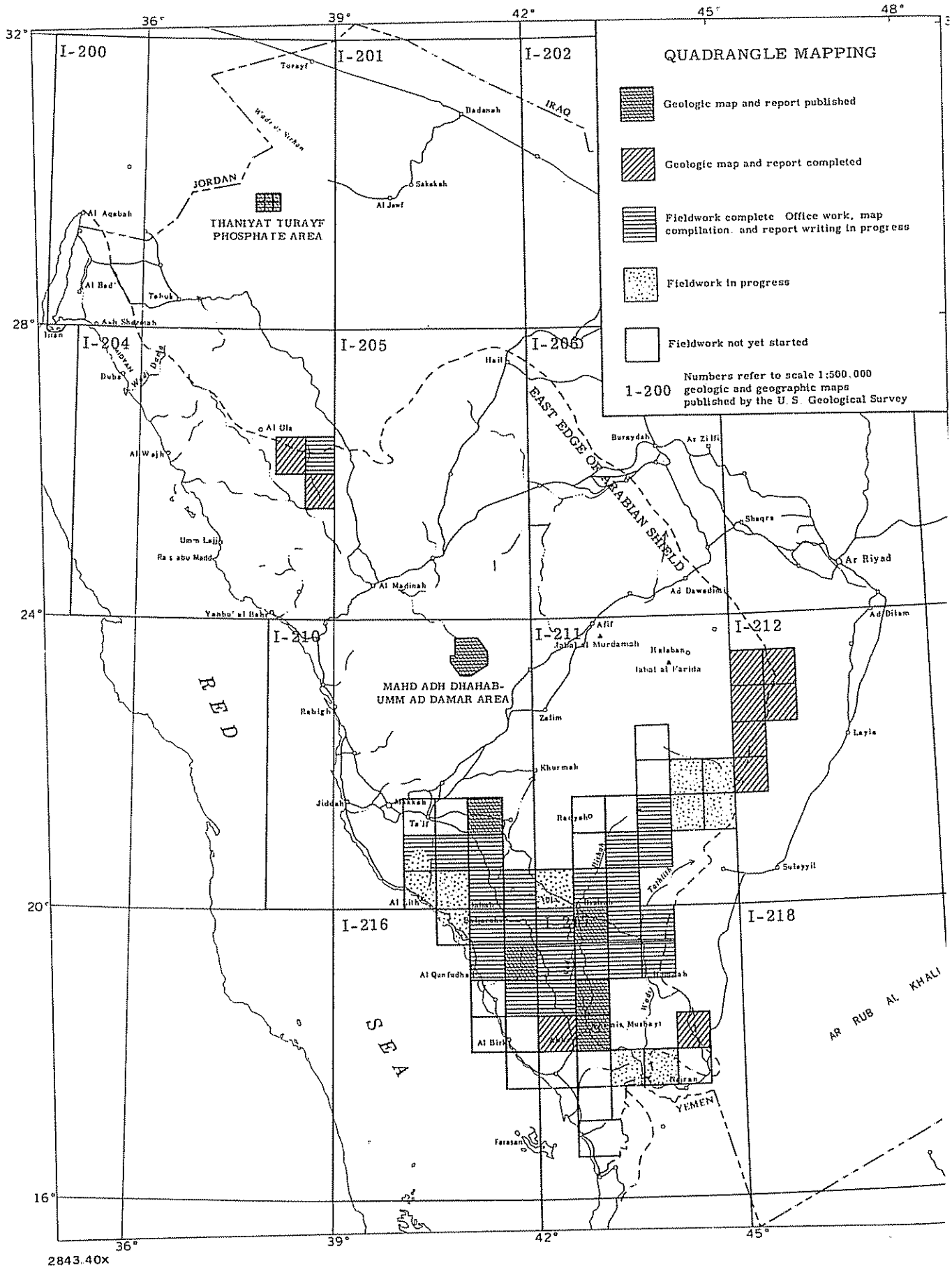


Figure 40. Saudi Araba: 30-minute quadrangle mapping of Precambrian Shield at 1:100,000 scale

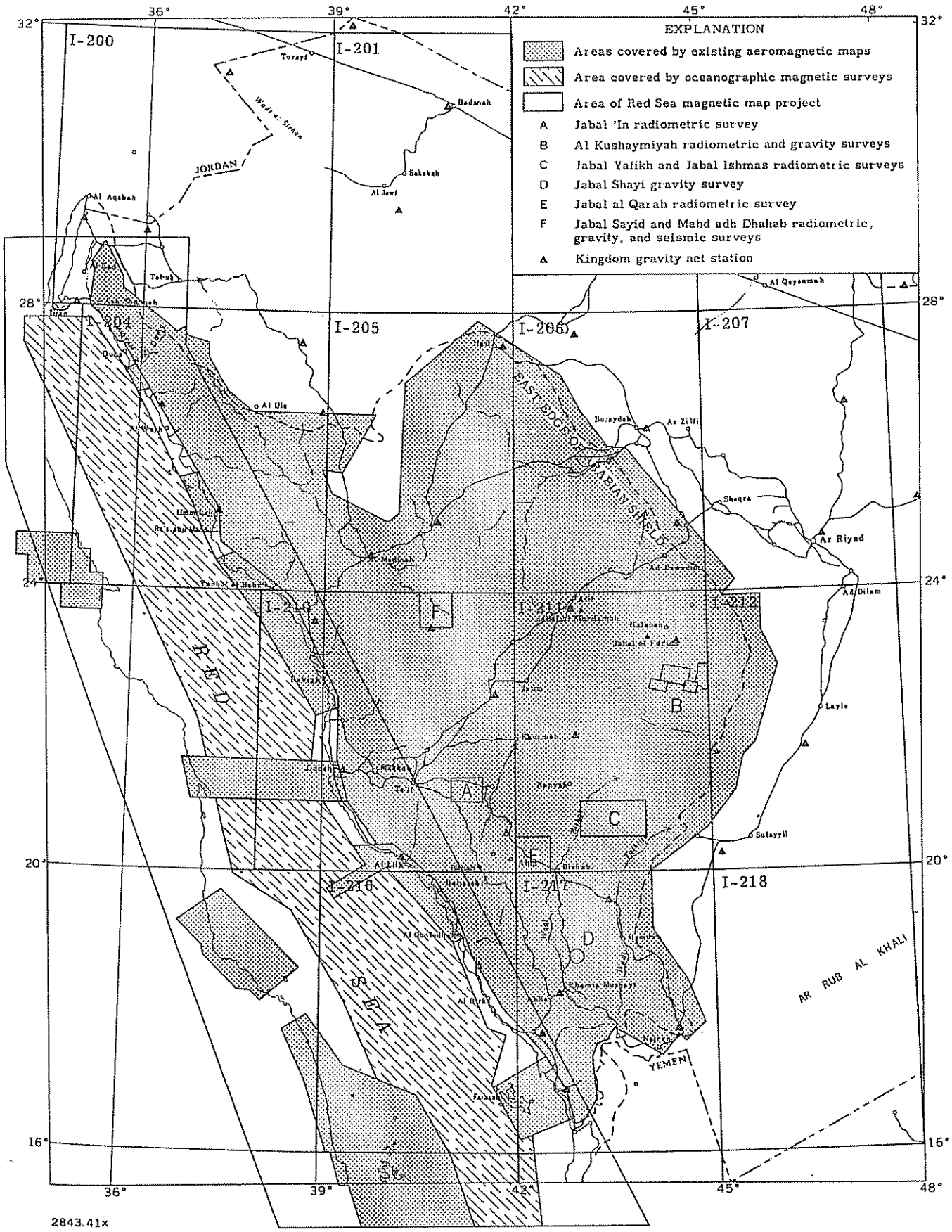


Figure 41. Saudi Arabia: geophysical investigations as of September 1973

Airborne gamma-ray spectrometry maps have been compiled on the scale 1:1,000,000 for areas equivalent to six 30-minute quadrangles. Four channels of natural gamma radiation, representing relative quantities of thorium, potassium, uranium and total count, were recorded on computer-compatible magnetic tape. The system of data acquisition and reduction providing automatic computer-generated contour maps for all channel information was developed in Saudi Arabia.

Detailed gravity maps have been compiled for three areas of special mineral interest. A very generalized Bouguer gravity anomaly map has been compiled at a 10-mgal contour interval, based on measurements at the geodetic stations in Saudi Arabia. A major regional gravity survey is under way which will significantly refine the current gravity map by the addition of more than 3,000 measurements. The new map will cover nearly the entire country on the scale 1:2,000,000

CARTOGRAPHIC ACTIVITIES IN SINGAPORE,* 1970–1973

Paper presented by Singapore

In Singapore, nearly all cartographic works are undertaken by government and semi-government departments. Of these departments, the Mapping Unit is the only organization which has the necessary facilities for complete cartographic processing. Established in 1971, the Mapping Unit represents the most significant progress made in the field of cartography since the Sixth Conference. Its principal function is the compilation and maintenance of all topographic maps required for national development purposes. Other departments that undertake cartographic work are the Survey Department and the Port of Singapore Authority (PSA). The major function of the Survey Department is in the production and maintenance of cadastral plans, whereas PSA is primarily concerned with the production and revision of hydrographic charts.

Topographic maps

Mapping at 1:63,360 scale

The basic map on the scale 1:63,360 was produced by reduction and generalization from the 1:25,000 maps. Due to repeated revision over the years, this map on the scale of 1 inch to 1 mile has lost considerable planimetric accuracy. Further revision of this map has now been discontinued as it is intended to replace it by the series at 1:50,000 scale.

Mapping at 1:50,000 scale

The map on the scale 1:50,000 was designed to replace the existing map at 1 inch to 1 mile; it will be fully metricated. This map was stereoplotted using Wild B8 aviographs from 1:30,000 contact scale aerial photographs flown in 1971. Negative scribing methods were used for fair-drawing. Two sheets are required to cover Singapore, and good progress is being made.

Mapping at 1:25,000 scale

The basic survey for the map at 1:25,000 scale, which was done by the tabling method, dates back to 1937. Since that time, revisions have been made on a sporadic basis. The last revision was done in 1964. To meet the demand for an up-to-date map of this scale, the Mapping Unit comprehensively revised this series in 1972 and the revised map has been published. However, this revision by aerial photography and B8 stereoplotting disclosed considerable planimetric errors in map details in several areas. To rectify these errors, the Mapping Unit is currently remapping the 1:25,000 series by stereoplotting from aerial photos on B8 aviographs. It was also decided to add one sheet to the existing seven sheets, in order to extend the coverage to include the Southern Islands, thus giving a complete coverage of Singapore.

Mapping at 1:2,500 scale

The 1:2,500 mapping was carried out in 1969 with aid from the United Kingdom of Great Britain and Northern Ireland, and was completed at the end of 1971. This topographic map with 10-ft contours, which consists of 401 sheets, was produced for development purposes. It has been used for such projects as planning of new towns and drainage patterns, road-alignment feasibility study and control of unauthorized structures. For this map to be useful for the purposes mentioned above, it must be continuously revised. To date, approximately 100 sheets have been updated by the Mapping Unit.

Hydrographic surveys

Since 1966, the Port of Singapore Authority has been carrying out surveys for dredging and navigation purposes. Up to August 1973, visual fixing and precomputed sextant lattice charts were used to control the surveys. In order to increase the output of work and to ensure greater accuracy in surveys of off-shore areas, an electronic position-fixing device is employed. A Decca sea fix chain in the hyperbolic mode was installed in August 1973. Nautical charts are produced in conjunction with the Hydrographic Department of the United Kingdom. In order to produce local nautical charts, PSA is currently compiling metric harbour charts at 1:7,500 and 1:12,500 scales for publication.

Cadastral surveys

Metrication of printed map-sheets

The Survey Department is in the midst of metricating their ½ chain:1 inch, 1 chain:1 inch and 4 chains:1 inch printed map-sheets to 1:1,000 scale. Assistance is provided by the Mapping Unit in photographically reducing or enlarging the various scales to 1:1,000. This photographic method has resulted in at least a 50 per cent saving in man-hours as compared with manual replotting. The entire project, consisting of about 1,300 sheets, is expected to be completed in 1975. The metricated 1:1,000 map-sheets are cadastral maps with no topographic details.

*The original text of this paper appeared as document E/CONF. 62/L.87

Electronic distance-measurement traversing

Electronic distance-measurement (EDM) traversing using the Wild DI10 and Wild T2 is being carried out by the Mapping Unit to provide controls for future large-scale mapping by photogrammetric methods. These traverses follow the main roads and are connected to first-order triangulation stations. This task was commenced in late 1971; and thus far 70 km of traversing have been completed and approximately 200 stations have been co-ordinated.

Education

Since 1964, the Singapore Polytechnic has conducted a four-year part-time diploma course in land surveying to provide technicians an opportunity to acquire theoretical and practical knowledge of cadastral, engineering, hydrographic and topographic surveys. This course thus gives all-round training to a student and helps to train a nucleus of skilled personnel for the various survey organizations. Courses on oceanography, hydrography, aerial photography, etc. also are being introduced in the geographical departments at the local universities.

CARTOGRAPHIC ACTIVITIES IN SWITZERLAND*

Paper presented by Switzerland

Switzerland, being well covered by various types of modern maps at different scales and having a dense network of triangulation and levelling points of different orders, has, in the period under review, mainly been involved in the revision and maintenance of the above-mentioned items, as well as in the upgrading of its cadastral survey for urban and mountainous regions. The application of electronic distance-measurement equipment, orthophotography and computer techniques for this purpose is replacing, to a great extent, conventional methods.

In order to solve the considerably increasing environmental problems, a new survey of Swiss lakes has recently been marked. Suitable instrumentation and data-processing for the special requirements have been developed in advance.

There is considerable activity in the field of engineering surveys for transportation facilities and general infrastructure, the most extensive survey being for the 50-km railway tunnel under Mount Gotthard.

Recently, a new geomagnetic survey of Switzerland was begun. Under the guidance of the Observatory of Neuchâtel, a new portable vector-magnetometer has been developed; it is described in a paper presented at the symposium on geomagnetism held at Kyoto, Japan, in September 1973.

Other activities are related to research and development of new survey methods and instrumentation, as well as scientific research, such as studies of crustal movements and geoid undulations in the Alpine region.

In the field of education, the Swiss School for Photogrammetric Operators has, in the period under review, gained wider international acceptance and importance. The photogrammetric operators' course, which was originally a six-month course, has been extended to seven months, mainly in order to provide more basic theoretical background.

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CARTOGRAPHIC ACTIVITIES IN THAILAND*

Paper presented by Thailand

Cartographic activities in Thailand have been undertaken by various governmental agencies. The responsibility placed upon each agency depends upon its over-all mission. The progress made in the field of cartography and related fields is described below.

Mapping

Base maps

Topographic maps on the scale 1:50,000, covering the entire country, have been produced. The entire coverage consists of 791 bilingual sheets; the main part, which was completed in 1963, has been updated since 1964 up to 1973. It is expected that in the next five years recompilation will be carried out in certain areas to increase map accuracy.

Other topographic maps

Other topographic maps have been produced as follows:

(*a*) Bilingual topographic mapping at 1:25,000 scale was undertaken during the past three years. The areas to be covered by these maps had been specified in accordance with military needs. To date, 51 sheets have been published;

(*b*) Bilingual city maps on the scale 1:12,500 covering the urban areas of all 72 *changwats* (the first administrative level) throughout the country, as well as 81 lower administrative levels, have been published. These maps have been updated from time to time; it is planned to publish 39 revised sheets out of the total in December 1973;

(*c*) The Defense Mapping Agency Topographic Center of the United States Army Topographic Command has produced 48 sheets of bilingual topographic maps on the

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scale 1:250,000, covering the area north of latitude 7° north. The remainder of the coverage is expected to be completed in the near future. In order that these military maps can be widely used by the public, they have been adapted to provide a special series based on them.

Thematic maps

The following thematic maps have been published by the governmental agencies concerned:

(*a*) A new set of bilingual national resources maps on the scale 1:2,500,000 consists of two new topics and 17 revised topics. The set also was bound together into a new volume of the National Resources Atlas, including an explanatory text for each topic;

(*b*) The water resources development map of Thailand on the scale 1:2,000,000 shows dam sites, reservoirs and irrigation areas which have been and will be accomplished under the national economic and social development programme up to 1976. One sheet at 1:200,000 scale showing land class groups for the central plain area also has been published;

(*c*) One sheet of the geological map of Thailand on the scale 1:250,000, showing geological descriptions and other related information in English within a certain area in the northern part of the country, has been published;

(*d*) Forest types have been overprinted on 150 sheets of 1:50,000 base maps covering parts of the northern and eastern areas of the country;

(*e*) A map showing vegetation types within the area of two *changwats* in the north-eastern area has been produced; 10 vegetation types have been classified and overprinted on 1:50,000 base maps;

(*f*) A set of 29 physical and human resources maps on the scale 1:250,000, covering one *changwat* in the north-eastern area of the country, has been produced.

General-purpose maps and road maps

A set of six general-purpose map-sheets covering the greater part of Bangkok metropolis on the scale 1:20,000 was published in 1973. Road maps on the scales 1:1,000,000 and 1:2,000,000, showing the road network throughout the country, were produced and updated during the period under review.

Nautical charts

During the past three years, Thailand continued its programme of hydrographic surveys in harbour and coastal areas. Five new charts at various scales, as well as six new publications, were published.

Aeronautical charts

To meet the requirements of the Ministry of Communication, the Hydrographic Department of the Royal Thai Navy has been responsible for the production of the world aeronautical charts on the scales 1:1,000,000 and 1:500,000 covering Thailand. During the report period, three revised editions were published.

Geodesy and ground control

Triangulation

The extension of first-order triangulation networks in the north-eastern and central areas of the country, connecting those already existing, has resulted in the establishment of 18 and 22 first-order triangulation stations in the former and latter areas, respectively. The next three-year programme has been formulated for the remeasurement of five existing base lines and the connexion networks between the central and north-eastern areas.

Astronomy

The first-order astronomical observations were made for the establishment of seven Laplace stations in the eastern and north-eastern areas, including one satellite triangulation station in the northern area. It is expected that an additional 12 Laplace stations will be established in the next three years.

Levelling

First-order levelling was carried out in the northern, north-eastern and central areas; 183 principal bench-marks, 758 secondary bench-marks and 6 tertiary bench-marks were established at the distance of 1,200 km.

Satellite geodesy

Since 1968, Thailand has participated in the satellite geodetic programme of the United States of America. One of the governmental agencies co-operating in these programmes is the Royal Thai Survey Department.

Optical satellite system

Satellite triangulation observation has been made by teams from the United States, using PC-1000 and BC-4 cameras. The camera sites were tied to the Thai first-order triangulation stations located in the vicinity.

Dynamic satellite system

The satellite monitoring teams of the United States have been operating over 16 stations throughout the country. The purpose of this programme was to observe low-altitude Doppler-equipped satellites in order to measure, by Doppler technique, gravity drag on low-flying satellites to obtain scientific information which would be useful to the space and mapping programmes. As a part of the programme, United States monitoring teams attached to the Royal Thai Survey Department staff have also occupied four first-order triangulation stations in order that the existing geodetic data might be checked against the data obtained from satellite observations.

Sequential Collection of Ranges system

The system for the Sequential Collection of Ranges (SECOR) was set up by the United States team and the connexion to the existing ground control stations was made.

Aerial photography

Aerial photographs have been taken for 44 national development projects under the responsibility of 12 governmental agencies. The area covered by aerial photographs for these purposes on scales ranging from 1:6,000 to 1:20,000 was about 150,833 km². For mapping purposes, aerial photographs on the scales 1:12,500, 1:25,000 and 1:30,000 were also taken. The total coverage of about 29,755 km² was mainly urban areas, on

which the compilation and revision of city maps at 1:12,500 scale were executed; the remainder are the rural areas mapping programme at 1:25,000 scale.

To increase its capability to meet the needs of various governmental agencies for aerial photography, the Royal Thai Survey Department procured two additional fully equipped photographic aircraft, Beech Craft King Air E90 and Queen Air B80, as well as a Wild RC10 aerial camera and other aerial navigation equipment. Thus, the Flying Section of the Royal Thai Survey Department is fully equipped with five photographic aircraft. For photo production, various items of equipment, including three Zeiss SEG V rectifiers, also were acquired.

Map production

The map reproduction plant of the Royal Thai Survey Department is the largest in Thailand. It serves the main needs of governmental agencies in the final stage of map production. During the report period, about 4.2 million copies of various types of maps were published. Of this number, 85 per cent were maps on different scales which had been compiled by the Department.

The capability of the plant has been increased from time to time by its development. Additional equipment has been procured. Among the others are one Roland RU VII 43″ × 63″ automatic offset press and one Invicta 33 offset press, one Klimsch 50 × 60-inch reproduction camera and one Pakoral Super-E automatic film developer.

Geophysics

Land gravity survey

The expansion of land gravity stations was carried out in the north-eastern area; 300 new stations were thus obtained. Elevation of 146 existing stations in the south was also determined during the period under review.

It has been planned to increase the density of the land gravity stations in order that the gravity anomaly map of Thailand may be produced.

Geomagnetism

In the central and southern areas, 34 stations were observed. The procurement of one Universal torsion magnetometer during the period is expected to accelerate this programme in future.

Personnel training

Despite courses for survey engineers and technicians which have been regularly given in some universities and technical colleges, the Survey School, which is the responsibility of the Royal Thai Survey Department, has conducted training courses to meet the needs of all governmental agencies dealing with surveying and mapping.

During the report period, seven in-country training courses were given, resulting in the graduation of 12 classes. Among those classes were two classes of the five-year survey engineering course, one class each of basic and advanced surveyor courses, two classes each of basic and advanced technician courses, one class of the professional course and three classes of surveyor courses.

The Royal Thai Government has been assisted through scholarships provided by various countries including the Federal Republic of Germany, Japan, the Netherlands, the United Kingdom and the United States of America. In this way, 13 officers of the Royal Thai Survey Department have been trained abroad in the fields of photogrammetry, cartography, aerial survey and survey navigation, integrated survey, seismology, English instructor course and military survey. In addition to those mentioned, training for maintenance and repair of survey instruments and equipment has been given to two trainees in factories at Wild Heerbrugg, Switzerland; and at Carl Zeiss Oberkochen, Federal Republic of Germany.

Instruments and equipment have also been procured by the Survey School to eliminate its interference with the Department's working schedule, especially in the field of photogrammetry.

Hydrography and oceanography

Hydrographic surveys were conducted in five harbours and three coastal areas of Thailand, for the purpose of nautical chart production and the development of coastal industries. The programme resulted in the publishing of five new charts and six new publications.

Oceanographic surveys were carried out in 1971, as a part of the five-year programme. Those in the Gulf of Thailand were done by H.M.T.S. *Chantara,* while the coastal oceanographic surveys were conducted by O.V.1 and O.V.2. The survey was also conducted in the Andaman Sea by H.M.T.S. *Kled Keo* in 1972.

The current programme consists of observations in the bight of the Gulf of Thailand in order to establish bases for pollution study. The programme is being carried out jointly by the Hydrographic Department of the Royal Thai Navy and the Department of Fisheries of the Ministry of Agriculture and Co-operatives.

Report on matters that formed the basis of the resolutions of the last Conference

With respect to the resolutions of the last Conference, various recommendations have been followed in some depth. The experience in modern techniques and financial conditions are the main factors governing the extent of progress.

Resolutions 5 and 6: Extension of geodetic and mapping control and satellite geodesy

The Doppler method of satellite observations in Thailand was proposed by the United States of America in 1972. The purpose of this programme was to initiate a special satellite observation on which low-altitude Doppler-equipped satellites would be observed to measure, by Doppler technique, the gravity drag on low-flying satellites. The scientific information gained would be useful both to the space programme and to the establishment of a single datum for South and South-East Asia. It was also expected that low-flying satellites would be used for more accurate geographical positioning, leading ultimately to more precise maps.

The proposal was approved and the operation began in January 1973. A Geoceiver station was set up at Udon Thani in the north-eastern area of the country. The

station was in operation from early January to early March 1973, and from early May to early July 1973.

During the two-month period between those mentioned, the United States provided another satellite monitoring team. The two teams, attached to the staff of the Royal Thai Survey Department, were put into operation to establish more accurate geodetic points within Thailand. Geoceiver stations were set up at four first-order triangulation stations and the field-work was completed. Those stations were Khao Kra Dong, Buriram, in the north-eastern part of the country; Khao Sakae Krang, Chainat, in the central part; Khao Kralat, Chumphon; and Khuan Bu, Pattani, in the southern part.

It was agreed that all information obtained by the Doppler programme would be made available to the Government of Thailand, if desired, either in raw form or after being analysed by means of computer. This information would be used to check the existing geodetic data in order that the geodetic control networks might be accurately readjusted in future.

Resolution 7: Geodetic contributions to the study of crustal movements

A gravimetric earth tide station has been established in Thailand. The station is already connected to the existing first-order triangulation network and will be in operation under the responsibility of the Royal Thai Survey Department.

The station was designed to house the Askania G.S. 11 recording gravimeter and was scheduled to be completed in October 1973. The gravimeter will be sent for calibration at the Observatoire Royale de Belgique at Brussels before installation. It is expected that the observation will commence early in 1974.

If financial conditions permit, a horizontal pendulum will be procured by the Royal Thai Survey Department in the near future.

Resolution 11: Application of mapping techniques

In accordance with resolution 11 of the sixth conference,[1] reaffirming the importance of the subject covered by resolution 8 of the fifth conference,[2] which recommended that the application of techniques and instrumentation be considered in all cases where the conditions are favourable, and further recommended that any news of additional information on these or similar techniques and instrumentation should be sent to the Map Information Office of the Royal Thai Survey Department, Bangkok, Thailand, for distribution to all countries of the region and other interested countries, only the two items described below, out of 87 items received, are technical publications, while the remainder are various kinds of maps.

The first item, *The Australian Map Grid,* is a technical manual published by the National Mapping Council of Australia, Canberra, in 1968. The objectives of this manual are:

(*a*) To define the Australian geodetic datum and the Australian map grid;

(*b*) To define standard symbols, terms and sign conventions for use throughout Australia;

(*c*) To provide a set of numerical examples, using the full rigour of the defining formulae, as a standard against which computer programmes and other more convenient but less accurate formulae can be judged;

(*d*) To provide standard first-order formulae for routine computation, each with numerical examples;

(*e*) To provide simpler approximate formulae, with numerical examples, for use on surveys of limited extent or of lower accuracy;

(*f*) To show how to use grid references.

The second item, *Electronic Survey Computing 16,* was produced on behalf of the National Mapping Council of Australia by the Director of National Mapping in July 1973. This publication summarizes the programmes developed by various agencies in Australia for electronic survey computing.

Resolution 13: Training facilities

Despite the fact that there are quite a few educational facilities in cartography in Thailand, run either by the Government or by the private sector, the courses of which lead to degrees as well as to diplomas, they are not really appropriate to be made available to foreign students since the teaching is in the Thai language and a special arrangement must be provided in order that foreign students may be admitted.

However, at the Survey School of the Royal Thai Survey Department, a 24-week course in cartographic drafting and topographic surveying under the special assistance programme, has been designed to accommodate foreign students who are familiar with the Thai language. A request has also been made that a 20-week practical training programme in geodesy and control survey be arranged for a group of foreign trainees by the Survey School. The former training programmes were conducted in 1971, while the latter has been awaiting the final decision.

Resolution 14: Earth Resources Observation Satellites

In accordance with the declaration made by the representative of the United States of America to the General Assembly of the United Nations in September 1970, and the Thailand National Programme of ERTS, presources Technology Satellite (ERTS) was originated.[3] A co-ordinating committee was appointed in 1971, and the Thailand National Programme of ERTS prepared by its sub-committee, was submitted to the National Aeronautics and Space Administration (NASA) which subsequently approved the participation of Thailand in its resources survey.

Upon acceptance from NASA to participate in its ERTS programme, the Thailand National Co-ordinating Programme of ERTS was set up and the participation of all interested Thai departments in the programme was co-ordinated. An interdepartmental task force of Thai scientists was organized for programme development and implementation. ERTS data in the fields of the interest of participating agencies has been regularly transmitted to Thailand from NASA for analysis and interpretation. Research, development and findings are reported and compiled.

[1] *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.71.I.15), p. 17.

[2] *Fifth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.68.I.2), p. 10.

[3] For details relevant to this report, see "An account of the Thailand National Programme of the Earth Resources Technology Satellite," under agenda item 14, pp. 514–518.

Resolution 15: Topical maps and national atlases

In accordance with resolution 15 of the sixth Conference,[4] in which it was recommended that the Cartography Section of the United Nations should activate the corresponding working group, composed of members from Australia, the Federal Republic of Germany, India, Israel, Japan, the Philippines, Thailand (chairman), the Union of Soviet Socialist Republics and the United States of America, letters were sent from the section to the members urging them to inform the chairman about their continued interest in the project and to offer him all necessary co-operation. The chairman was also requested by the Cartography Section to contact the members in order to encourage their willingness to continue as members of the group, and if so, inviting them to outline in which way they could contribute to the report to be presented to this Conference and to nominate their contact personnel.

Response to the correspondence of the Cartography Section and the chairman showed that members from only four countries had confirmed their previously stated intention to participate in the working group, namely, India, Israel, Japan and Philippines. The chairman has not received any information concerning the procedure for the sort of contributions which the members can utilize as source documents for the report to be presented to this Conference.

It was therefore decided that preparations should be made to hold a working group meeting at Tokyo during the Seventh Conference in order that a report might be presented.

Resolution 17: Regional Economic Atlas for Asia and the Far East

In accordance with resolution 17, Thailand prepared a questionnaire (see annex I), copies of which were distributed in 1971 by the Cartography Section of the United Nations to countries in the region. The objective of the questionnaire was to obtain information concerning the availability of source materials. Ten countries have answered it, and the data obtained are shown in annex II.

During the past three years, Thailand has requested technical assistance in the form of an adviser from the Government of the Federal Republic of Germany. Although this request was not directly achievable, the technical co-operation has been fruitful. A new base map was designed by a cartographer from the Federal Republic of Germany and prepared by Thailand for review at this Conference. The German professor who came to a Thai university under the DAAD programme is currently working with the Royal Thai Survey Department as a special adviser to the project. The map of the climatic regions presented at this Conference is the result of close co-operation among the divisions of the United Nations Economic Commission for Asia and the Far East (ECAFE), Thai governmental authorities and the German adviser.

Resolution 19: Geographical names

Thailand participated in the Second United Nations Conference on the Standardization of Geographical Names, held in London, 10–31 May 1972; and represented the South-East Asia Division (Burma, Indonesia, Khmer Republic, Laos, Malaysia, Philippines, Republic of Viet-Nam, Singapore and Thailand) in the second, third, fourth and fifth sessions of the United Nations Group of Experts on Geographical Names.

After Thailand had been unanimously elected in 1970, in support of resolution 19, by delegates representing most of the countries in South-East Asia, to represent the area, questionnaires were sent to all countries in the area so that information concerning works and national bodies dealing with geographical names could be summarized. Information obtained from the replies was reported to the Group of Experts at its second session, although the statement covered in that report did not fully reflect the activities of the whole area. At the end of the session, a brief report of the session was sent by the division representative to all countries in the division; papers dealing with the spelling of names and transliteration of certain writing systems also were sent to the individual country concerned.

At the Second United Nations Conference on Geographical Names, only four out of nine countries in the division attended. The Romanization of the Khmer geographical names was accepted as the standard international system. A draft report of the Conference was then sent to all countries by the division representative, along with the programme of the Group of Experts and the items referred to them from the Second Conference. Attention was drawn to the programmes and items which should be studied by the individual country and reported by the division.

The division representative attended the third and fourth sessions of the Group of Experts, which were held immediately prior to and after the Second Conference, respectively. In pursuance of the programme for the fifth session, which was arranged at the fourth session, a meeting within the division had been initiated by Thailand by seeking proposals from all countries concerned. If there had been appropriate co-operation, the division meeting would have been convened at Bangkok prior to the fifth session of the Group of Experts.

In order to carry out its work and to achieve the results required, items referred to the Group of Experts concerning Thailand solely have been studied and reported, and the division representative attended the fifth session. A summary report has already been sent to all countries in the division.

Cadastral photo maps used as basis for land certificates and land-use certificates

The Department of Lands has been entrusted with issuing land titles and certificates of land use to Thai landowners. In this connexion, a particularly urgent project is the coverage of an area of 200,000 km^2 that is of special agricultural importance. The Bureau of Cadastral Survey, which is responsible for the technical aspects of this matter, has decided to use a series of graphical cadastral maps on the scales 1:4,000 and 1:2,000 as a basis for issuance of land titles and on the scale 1:5,000 as a basis for the issuance of certificates of land use. As compared with a cadastral line map prepared by conventional field survey, a photo map produced by the technique of aerial photogrammetry contains not only the data required by the cadastral authorities, but additional information that is of great importance, above all for the agricultural development of a country.

Thus far, only a 1:50,000 topographic map of Thailand has been available. There is still no larger scale

[4] *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. I, *Report of the Conference*, p. 18.

economic map that might be used for special planning purposes. Since the issuance of land titles has made it necessary to produce a uniform series of maps, it is advisable to make full use of the wealth of information contained therein and to make this photo map available to all Thai government agencies engaged in agricultural planning. From 1963 to 1973, the Department of Lands obtained aerial photographic coverage of 140,000 km² in various provinces of Thailand. Within five years, the Department of Lands will have obtained aerial photographs covering the entire area of the country.

The method selected by the Department of Lands for the production of a series of graphical cadastral photo maps may be summarized as follows:

(*a*) Photographic flight in the form of a pin-point strip over the centres of the future map-sheets, using 6-inch Pleogon and Aviogon wide-angle lenses, 9 × 9-inch negative size. The photo scale is 1:15,000; flying height, 2,300 m; 80 per cent endlap; 42 per cent sidelap; distance between adjacent flight lines, 2 km;

(*b*) Determination of four control points per map-sheet (4 km²) for plotting by aerotriangulation of independent models, using the C-8 stereoplanigraph and the A-8 autograph. Co-ordinates are automatically recorded on punched cards by means of electronic recording units;

(*c*) Observation of a minimum number of ground control points for block adjustment of aerotriangulations (size of block, 400–10,000 km² = 10–2,500 map-sheets) by electronic distance-measurement;

(*d*) Block adjustment of control points required for photogrammetric restitution, using data-processing installations with high capacity;

(*e*) Photogrammetric restitution in flat terrain; the photo map will be produced by rectifying individual photographs in a semi-automatic SEG V rectifier. In rolling and mountainous terrain, this method is not sufficiently accurate. True-scale photo maps of these areas are therefore produced by the orthophoto technique with the aid of a GZ-1 orthoprojector. In addition, the orthoprojector automatically provides elevation data on the configuration of the terrain;

(*f*) The photo-maps for the issuance of certificates of land use will be produced by enlarging individual photographs on the scale 1:5,000 by using the SEG V rectifier;

(*g*) After reproduction, this half-tone photo map can be used by the staff of the Department of Lands in order to determine and mark the property boundaries and to issue the land title or certificate of land use.

Explanatory note on new map of climatic regions of Asia and the Far East[5]

Definition of climate

Climate, the general conditions and periodical variations of the atmospheric elements near the earth's surface, can be regarded solely as the most important geofactor of the natural environment. Climate determines, to a large extent, the formation of soils and the growth of natural vegetation. Climate thus influences the economic utilization of the land for agricultural purposes and, in part, determines its ability to support a population. It determines, to a large extent, the drainage pattern and water discharge of rivers. It thus influences the economic utilization of water resources for agricultural and industrial purposes. It can favour or restrict the growth of parasitic organizations which influence the health of the population and the durability of equipment. It also exerts a direct influence on man's physiology and man's ability to work. Therefore, it must be considered an important economic factor.

The general condition of the atmosphere can be expressed by a combination of various types of weather or climatic elements, as follows: (*a*) air pressure; (*b*) wind or air mass movement; (*c*) temperature and evapotranspiration; (*d*) precipitation and humidity.

While weather is the momentary state of the atmosphere of any place, climate is a composition of the variety of the day-to-day weather conditions for the world or certain parts of it. A reliable portrayal of climates and its characteristics can be obtained by two methods: (1) the average of the climatic elements, in particular, temperature and precipitation; or (2) the summary of the succession of various types of weather.

The second method can be used to set a dynamic-genetic classification of climates emphasizing the instability of climatic boundaries. The first method can be used to establish a descriptive classification of climates which relates a certain value of climatic elements to distribution patterns of other phenomena of the natural environment. While the second method is necessary for meteorology and weather forecasting, the first method with its relation to other phenomena appears to be more appropriate for the explanatory description of the human habitat.

The Köppen climatic classification

The best known empirical-descriptive classification of climates was elaborately prepared by Wladimir Köppen. After the first paper on this subject in 1917, Köppen published many contributions, including a book (1931), a handbook on climatology (1936 with R. Geiger) and a wall map of the world's climatic regions. The original classification has been revised and extended by Köppen and his students to become the most widely used climate classification. Detailed maps of the distribution of climate have been worked out for many regions of the world.

The Köppen classification is based upon the most easily obtainable weather data, air temperature and precipitation, which can be obtained from most parts of the world. Each climate is defined by fixed values of temperature and precipitation computed according to the averages of the year or of individual months. The values of the climatic elements have been selected after careful consideration of the zonal vegetation and the zonal soil. In general, the boundaries of the climate types coincide with the zonal limits of important types of vegetation and soils.

The description and designation of the climate types of the Köppen classification are given in a shorthand code of letters to distinguish five principal climates and their subdivisions. Of the five major climates, four are defined by averages of temperature:

(1) The tropical or megathermal climate (A), by means of monthly temperatures of 18°C (64.4°F) or more which support the growth of tropical plants (= climate with no winter);

(2) The warm temperature or mesothermal climate (C), by means of the coldest month below 18° C (64.4° F), but above −3° C (26.6° F), whose average roughly coincides with the equatorward limit of frozen ground and a

[5] This section was prepared by Ulrich Freitag, adviser to the Regional Economic Atlas Project, Royal Thai Survey Department.

snow cover lasting for a month, and by means of the warmest month above 10° C (50° F) (= climate with summer and winter);

(3) The snow or microthermal climate (D), by means of the coldest month above −3° C (26.6° F), the average of the warmest month above 10° C (50° F), which coincides approximately with the poleward limit of forest (= climate with short summer and long winter);

(4) The polar or ice climates (E), by means of the warmest month below 10° C (50° F) (= climate with no summer).

The fifth principal climate is defined by empirical precipitations-to-evaporation ratio.

It is the dry climate (B), in which the average evaporation exceeds the average precipitation, thus restricting the growth of trees.

Such empirical ratios, which consider the annual temperature and the total annual rainfall, as well as the season of maximum precipitation, are utilized to define two subgroups of this principal climate. They are designated by a second letter, W, for desert climate with less than 25 cm annual rainfall; or S, for steppe climate. Lastly, a third letter is used for further differentiation of these subgroups; it refers to an average of temperature and distinguishes hot and warm (h) from cool and cold (K) dry climates by the mean annual temperature of 18° C (64.4° F).

The subdivision of the other major climates takes into consideration the precipitation, both its annual amount and its seasonal distribution. The second letter of the code designates as follows:

f = a moist climate with average monthly precipitation of at least 60 cm (24 in);

w = a climate with a dry season during the low sun-period (winter); the wettest month of summer has at least ten times as much rain as the driest month of winter;

s = a climate with a dry season during the high sun-period (summer), and at least ten times as much rain in the wettest month of winter as in the driest month of summer.

Differentiations within the subgroups of climates are indicated by a third code letter which refers to the seasonal variation of temperature. The main code letters for the C and D climate are:

a = mean temperature of the warmest month over 22° C (71.6° F) (= hot or warm summer);

b = mean temperature of the warmest month under 22° C (71.6° F), but at least four months with an average of 10° C (50° F) (= cool summer);

c = less than four months with mean temperature of 10° C (50° F) (= cool short summer).

Besides the listed code letters, more code letters are utilized to characterize minor subdivisions of the major climates. The letter i, for instance, limits a tropical climate with a range of the mean monthly temperature less than 5° C (39° F); in the temperate climate, this letter indicates the maritime variation with the same small range of temperatures. The letter m, for example, is used to describe a tropical climate that, despite a short dry season, permits the growth of a tropical rain forest.

The combination of different code letters allows a sufficiently precise and definite description of a great variety of zonal types of climate and climatic regions. The descriptive codes of the Köppen classification cannot be applied for a sufficient portrayal of the intrazonal climates of the mountainous areas. Within the tropical zone, the highland climates are designated mainly as Ca-climate, while the highland climates of the temperate zone are designated by the letter H (highland climate) with similar characteristics as the zonal E-climate.

Previous maps of the climatic regions of Asia

The first wall map of the climatic regions of the world according to the Köppen classification proved by its success the utility of this climate classification. A new edition of this map, revised by R. Geiger, was published in 1954. Since then, the revised world map has been adopted by many authors of geographical textbooks and has appeared, reduced in scale and generalized, in many atlases.

Smaller regions have been mapped in greater detail using the same classification system. Some of these maps have been published in climatic or regional atlases, some in geographical books.[6]

Other climate classification systems have been developed recently and used to regionalize areas for special purposes.[7]

In general, more and detailed data on the climatic elements are required to delineate the boundaries of those climates. The lack of information for many parts of Asia restricts the application of those classification systems to certain areas.

Data on many climatic elements in cartographic form can be obtained from climatological atlases.[8] Many of the newly published atlases however, do not include a map that summarizes the climatic elements in the form of climate types and climatic regions. The monthly variations of the elements are the dominant features of these publications.

Map of climatic regions in the Regional Economic Atlas for Asia and the Far East

A climatic map was the first in a list of topics proposed to the participants in the United Nations Regional Cartographic Conference for Asia and the Far East by the atlas committee of the Royal Thai Survey Department as early as 1962, in accordance with resolution 12 of the Third Conference.[9] Despite many efforts and appeals of the Royal Thai Survey Department, the most recent in resolution 17 of the Sixth Conference,[10] only some member countries supply the necessary source materials and information to the Map Information

[6] Examples are: A. Lu, "Climatic regions of China", reprinted in G. B. Cressey, *Land of the 500 Million—A Geography of China* (New York, 1955), p. 74; "Climate", in Royal Thai Survey Department, ed., *Thailand—National Resources Atlas* (Bangkok, 1972), p. 2.1; "Climate", in United Nations Economic Commission for Asia and the Far East, *United Nations Atlas of Physical, Economic and Social Resources of the Lower Mekong Basin*, prepared under the auspices of the United States Agency for International Development; ed, by Engineer Agency for Resources Inventories and the Tennessee Valley Authority (United States of America) (September 1968), p. 13; H. Al-Khayat, "Climatic regions of southwest Asia", in G. B. Cressey, *Crossroads—Land and Life in Southwest Asia* (Chicago, 1960), p. 112.

[7] H. Gaussen and others, *Bioclimats du sud-est asiatique*. Travaux sect. techn. III/4 (Institut Français Pondicherry, 1967).

[8] Examples are: United States Army Air Force, Weather Division, ed., *Weather and Climate of China*, 3 vols (1945); Republic of Korea, Central Meteorological Office, *Climatic Atlas of Korea* (1931-1960) (Seoul, 1962); United States Army, Natick Laboratories, Earth Science Division, ed., *Climatic Atlas of Southeast Asia* (1967); Japan, Meteorological Agency, *Climatic Atlas of Japan*, 2 vols. (Tokyo, 1971).

[9] *Third United Nations Regional Cartographic Conference for Asia and the Far East*, vol. I, *Report of the Conference* (United Nations publication, Sales No. 62.I.14), p. 10.

[10] *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. I, *Report of the Conference*, p. 18.

Centre of the Department. Therefore, the Department asked other international and national institutions for co-operation to compile the climatic map. With the assistance of the Meteorological Department, divisions of ECAFE and Chulalongkorn University, the Geographical Mapping Division of the Department could complete the compilation of a new map of the climatic regions of Asia and the Far East, using the Köppen climate classification. The print has been carried out by the Reproduction Division of the Survey Department in a modified tricolour system. For the compilation of the new map, all previous maps of climate types were used. In addition, the various maps of climatic elements were consulted, as well as maps of vegetation types, soils and hypsometry, where the climate maps proved to be insufficient. The data of climatic stations were used to control and correct the newly drawn boundaries. The result of the compilation is the published map showing the regional distribution of climate types by the area symbol colour. The colours are explained in the legend by descriptive terms.

To visualize the typical variation of the climatic elements of the climate types and to show the varieties within the climate types, a selection of climatic diagrams for about 70 stations is included. The data for the stations were obtained from the World Weather Records, 1951–1960, edited by the Department of Commerce of the United States of America. The short ten-year period, 1951–1960, was selected for reason of comparison on a unified base. Only the mean monthly temperature and the mean monthly precipitation are depicted as relevant climatic elements of the Köppen system.

As a base for the climatic map, it was necessary to use the ECAFE oil and natural gas map. This orthomorphic map proved to be inadequate for an equivalent representation of geographical features. Therefore, the Royal Thai Survey Department has begun work on a new equivalent base map. Before the completion of the new base, however, the old base had to be used for the compilation and printing of the atlas map of the climatic regions.

To show the immediate impact of climate on the economy of Asian countries, an inset map has been compiled. It shows the areas affected by drought or flood caused by climatic elements. It is supposed to connect the new map of the climatic regions with forthcoming maps of the Regional Economic Atlas for Asia and the Far East.

New base map of the Regional Economic Atlas for Asia and the Far East[11]

The Fourth United Nations Regional Cartographic Conference for Asia and the Far East, held at Manila in 1964, recommended in resolution 15 the over-all specifications of the proposed Regional Economic Atlas for Asia and the Far East: (*a*) the published scale is to be at 1:5,000,000; (*b*) the Lambert conformal conic projection is to be used; (*c*) the sheet lines of the maps are to be rectangular; (*d*) the topographic features are to be symbolized according to IMW specifications.[12]

At that time, a map had already been published that closely followed these specifications: the ECAFE oil and natural gas map. The scale of the map is 1:5,000,000; the projection is the Lambert orthomorphic conic projection with two standard parallels at 40° north and 10° south, the map consists of four sheets of rectangular shape. The Royal Thai Survey Department therefore adopted the layout and general features of this map as a base map for the compilation and publication of the first sheets of the Regional Economic Atlas. Administrative boundaries had been added to the base map for the population density map, submitted to the Sixth Regional Cartographic Conference held at Teheran in 1970; and stations have been added to the base map for the climatic regions map submitted to the present Conference.

In the course of the compilation of the two topical maps, this base map proved to be inadequate for drafts of accurate and detailed atlas maps. The projection is not suited for many distribution maps due to its area distortion; an equivalent projection would form a better base map. The coastline and other features are not shown precisely and in detail, due to the insufficient knowledge at the time of the first draft of the base map; the rapid progress of topographic mapping since then would permit a more accurate portrayal of geographical features. The different sizes of the four sheets caused many inconveniences to the map reproduction process; a uniform and smaller size map-sheet would speed up the technical processes.

After careful consideration of the deficiency of the old base map and of the task of the Regional Economic Atlas, the atlas committee of the Royal Thai Survey Department decided, in June 1971, to prepare a new base map for the following atlas sheets. The committee adopted the proposal of the adviser, Ulrich Freitag, to compile the new base map in six sheets of equal size on an equivalent conical projection.

The calculation of the projection, using the dimensions of the standard spheroid of the International Union of Geodesy and Geophysics of 1967 (equatorial semi-axis 6,378,160.00 m; polar semi-axis 6,356,774.72 m) was carried out in 1972-1973 by the Institut fuer Angewandte Geodaesie, whose director is H. Knorr. The equivalent projection is centred on the intersection of 20° north and 100° east in the centre of the area to be mapped. The standard parallels of 45° north and 10° south were selected to reduce the distance and angular distortions to a minimum within the area of the map.

The grid lines of the new projection were plotted by the Photogrammetric Division and the Geographical Mapping Division of the Survey Department in 1973. A sketch of the coastlines and international boundaries was completed and led to the revision of the originally proposed layout of the six map-sheets. The size of the sheets has been reduced, and the outlines have been slightly shifted. The new base map will consist of six sheets of equal size, 68 × 76 cm, without areas of overlap, forming a complete map of 204 × 152 cm. Figure 42 shows the layout of the new map.

The compilation of the geographical features of the new map is currently in progress. The map will be more accurate and will contain more details of natural and/or man-made features. Thus, the new map can serve as base map for forthcoming maps of the Regional Economic Atlas, as well as for other maps of interested international agencies or participants in the United Nations Regional Cartographic Conference for Asia and the Far East.

[11] This section was prepared by Ulrich Freitag, adviser to the Regional Economic Atlas Project, Royal Thai Survey Department.

[12] *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. I, *Report of the Conference* (United Nations publication, Sales No. 65.I.16), p. 12.

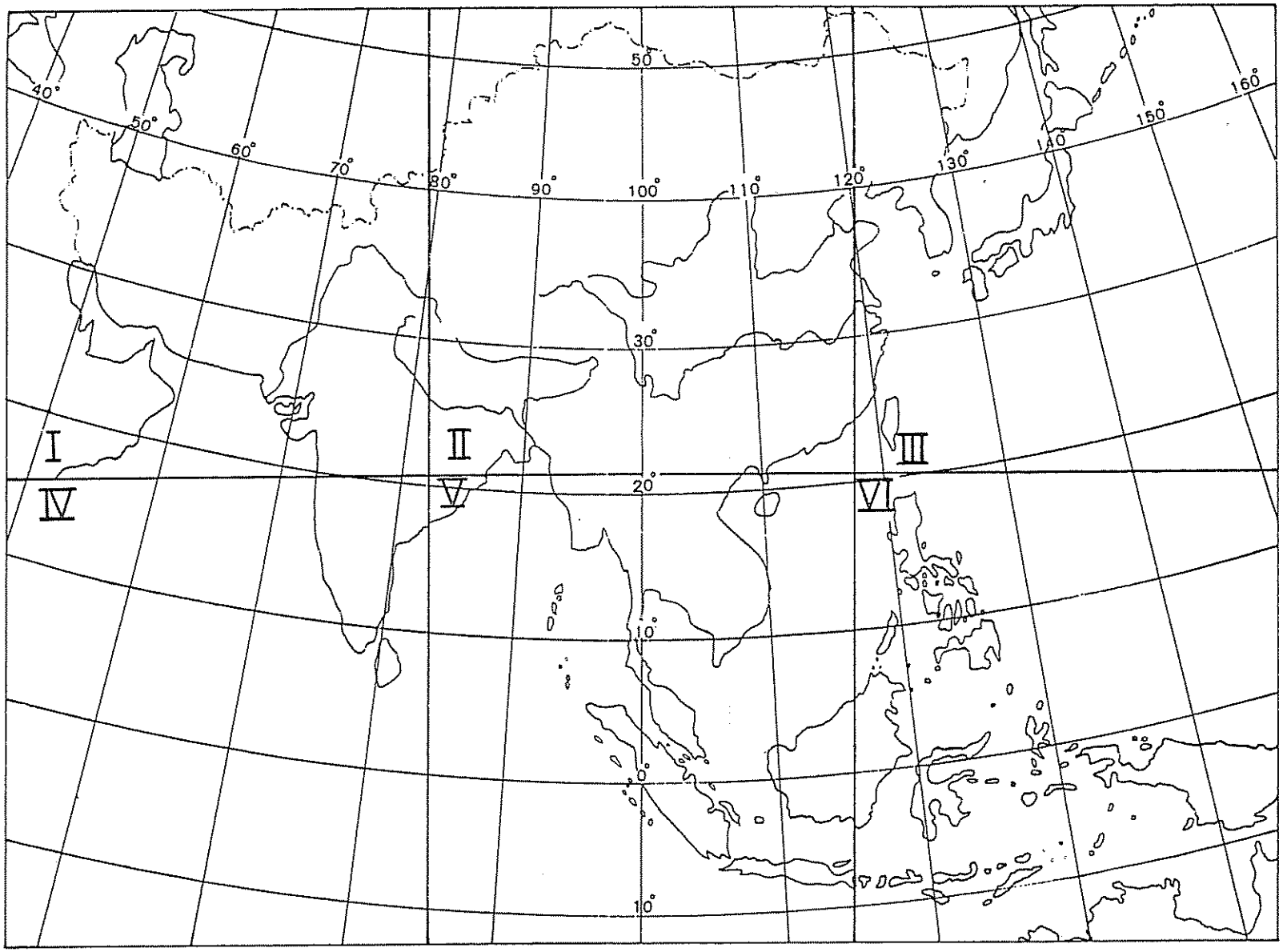


Figure 42. Thailand: layout of the new base map of the Regional Economic Atlas for Asia and the Far East

ANNEX I

Questionnaire on Regional Economic Atlas for Asia and the Far East

Following a resolution adopted at the Sixth United Nations Regional Cartographic Conference for Asia and the Far East, held at Teheran, 24 October–7 November 1970, the following information is requested:

1 Is there any institution in your country dealing with the production of a national atlas or thematic maps?

2 If not, is there any individual interested in this work?

3 If the reply to 1 and 2 is yes, what is the name and address of the body?

4 Is there any atlas or thematic map published in your country?

5 If the reply to 4 is yes, please state topics, scale, projection and other information related to the nature of such publications.

6 What language(s) and writing script(s) are used for such publications?

7 Will those publications be available, free of charge, upon request by the producer of a regional atlas?

8 If the reply to 4 is no, are there any statistical data available?

9 If the reply to 8 is yes, please be sure that a statement equivalent to 5, 6 and 7 is given along with the address of the data possessor.

ANNEX II

Information gathered from answers to questionnaire on Regional Economic Atlas for Asia and the Far East

Country \ Answer / Question No.	1	2	3	4	5	6	7	8	9	Remarks
Afghanistan	Y	–	G	Y	G	P,E	Y	–	–	
Australia	Y	–	G	Y	G	E	Y	–	–	Atlas with booklets
Fiji	Y	–	G	Y	G	E	Y	–	–	Mainly geological maps detached from bulletins and memoirs
Japan	Y	–	G	Y	G	E, J-E	N	–	–	
Laos	Y	–	G	Y	G	F, E-F	Y	–	–	
Malaysia	Y	–	G	Y	G	M-E	Y*	–	–	* Only complimentary copies
New Zealand	Y	–	G	Y	G	E,R	Y	–	–	
Republic of Viet-Nam	Y	–	G	Y	G	V,F,E	Y	Y	Y	
Singapore	N	–	–	N	–	–	–	–	–	
Sri Lanka	Y	–	G	N*	G	E	Y	–	–	* No atlas is available, initiate to prepare one
Western Samoa	Y	–	G	Y	G	E	Y	–	–	

Y = Yes, N = No, G = Given

E = English, F = French, J = Japanese, M = Malaysian

P = Pushtu, R = Roman, V = Vietnamese

TOPOGRAPHY, GEODESY AND CARTOGRAPHY IN THE UNION OF SOVIET SOCIALIST REPUBLICS, 1970–1972*

Paper presented by the Union of Soviet Socialist Republics

In the period 1970–1972, geodetic, aerotopographic and cartographic activities were continued in the Union of Soviet Socialist Republics in order to contribute to further development of industrial, agricultural and urban construction, exploitation of natural resources and land reclamation. Particular importance was attached to large-scale surveys (1:10,000 and larger scales) and revision of existing maps. Progress was achieved in publication of school, tourist and other types of maps and atlases. On the basis of research and experimental work, a number of new instruments and devices were developed with the objective of securing acceleration of geodetic work and topographic surveys, and raising accuracy of measurements. Research was continued in the field of automation and mechanization of map-making.

Geodetic activity

The existing state astronomical-geodetic network of the country corresponds, on the whole, to requirements connected with the study of the shape and dimensions of the earth, as well to those of practical problems of mapping the national territory. In the course of the period under consideration, the geodetic service of the USSR pursued its work on control extension in several regions of intensive economic development. Theoretical and practical work connected with establishing cosmic networks from geodetic observations of satellites was continued. This work was being done in the frame of international programmes.

In the USSR, an extensive first-and second-order levelling net has been developed; relevelling is being carried out. Data of relevelling on lines totalling over 40,000 km have been collected and systematized. The said data are used in the study of vertical movements of the earth's crust.

In 1971, compilation of a summary map of the recent movements of the earth's crust on the scale 1:2,500,000 was completed for the territory of Eastern Europe. This map was made in accordance with a programme and methods elaborated by the (corresponding) commissions of the International Association of Geodesy. The map was published in 1973 in two editions—in Russian and in English. It consists of six sheets.

Owing to progress achieved in raising the accuracy of linear measurements in geodesy, the study of horizontal movements also was made possible.

*The original text of this paper appeared as document E/CONF 62/L 76.

To this purpose, investigations on special geodynamic test areas established in regions of seismic activity were undertaken in search of fore-runners of earthquakes. In the test areas situated in some regions of the Kopet-Dag, the Altai and Tien-Shan, in the rift zone of Lake Baikal, in Kamchatka and the Kuril Islands, and in the Trans-Caucasus, high-precision geodetic activity is being developed in order to reveal dynamic deformations of the earth's surface.

New improved technology and methods of geodetic measurements have been introduced in the Soviet Union. An optical distance-measuring instrument, "Quartz", which is equipped with a helium-neon laser, was put into operation. This instrument permits high-precision linear measurements to be made at any time of the day. There has been wider application in geodetic measurements (especially in the far north) of radio-distancing instruments, for instance, the "Luch"—a radio-distancing equipment that permits its transmitting-receiving arrangement to be raised to heights of up to 25 m.

The geodetic network for surveying at 1:10,000 and smaller scales utilizes an airborne radio-distancing system, which is continuously being improved.

Aerial photography

All the topographic maps and plans of the USSR are compiled on a geodetic base in accordance with the existing standards of accuracy, with a mean square error in planimetry of 0.5 mm at the scale of the map; and in altitude, from one fourth to one third of the accepted contour interval. The contents of the maps are sufficiently detailed to satisfy all principal needs of various agricultural and industrial departments and organizations using maps for planning, projecting, construction, etc. Recently, the publication of photo maps was begun.

Regular revision of maps of the whole scale series (1:10,000, 1:25,000, 1:50,000, 1:100,000 and smaller scales) is a continuous and steadily growing work executed by the topographic service of the Soviet Union. During the current five-year period (1971–1975), the volume of work connected with revision of topographic maps in the USSR should increase by 4.2 times, as compared with the previous five-year period. An airborne radio-distancer is being widely used for map revision.

In a still larger proportion, the volume of work connected with making plans and maps on the scales 1:10,000, 1:5,000, 1:2,000, 1:1,000 and 1:500 has increased.

As a principal method of large-scale surveying, aerial phototopography is used. Experiments with utilization of helicopters in aerial survey work are in progress. Photogrammetirc methods are successfully applied in surveys made for projecting new roads, and in large-scale mapping with a contour interval of 0.5–1.0 m for the purpose of land reclamation. In a large volume, revision of planimetry on agricultural maps at 1:10,000–1:25,000 scales is being carried out, and new surveys at 1:5,000 scale are being executed.

In line with the general all-state topographic surveys, the volume and types of topographic-geodetic work executed in connexion with engineering projects of various kinds has considerably increased. As a rule, such investigations make use of the available geodetic base and data of all-state surveys, but they have some features which are peculiar to them. Therefore, topographic-geodetic work intended for engineering projects is carried out in accordance with specially elaborated technical instructions and methods which take into consideration requirements put forward by urban and rural planning and building; industrial, agricultural and housing construction; etc.

Cartography

In its efforts to satisfy more fully the needs of the population of the country, the cartographic service each year increases its output of maps and atlases for mass consumption. Publication of cartographic works that are necessary for solving problems of national economy, and for further development of science and culture, is being steadily broadened. The number of published tourist maps is nearly trebled every year. Demands for school maps and atlases for general education are being fully satisfied.

In 1970–1972, nearly 40 million copies of maps and atlases were published annually in the Soviet Union. Among the published cartographic works there are a considerable number of national atlases edited in connexion with jubilee dates in the history of the Soviet State.

In 1970, in commemoration of the centennial of the birthday of V. I. Lenin, founder of the Soviet State, an historical-biographical atlas, dedicated to his life and work, was published; and the realization of his ideas and plans was demonstrated by cartographic means.

In 1971–1972, maps dedicated to the principal constructions of the current five-year plan (1971–1975), and to achievements of individual branches of industry and agriculture, were published. In 1972, the atlas *The USSR in the Ninth Five-Year Plan*, in which the perspectives of evolution of national economy are shown, was published.

In commemoration of the fiftieth anniversary of the founding of the USSR (1922), an atlas entitled *Formation and Evolution of the Union of Soviet Socialist Republics* was published, consisting of 116 pages (sized 25 × 34 cm), of which 57 pages are multicolour maps; 34 pages, diagrams and tables; 8 pages, colour illustrations; and 8 pages, text. In the atlas, the principal stages of the history of the Soviet State are shown, as well as its national and all-state construction and the historical achievements of the Soviet people in the field of economics and culture. The design, compilation and preparation for print of this atlas were carried out with the participation of over 200 cartographers and scientists.

A considerable part of the cartographic production is represented by school atlases, which are issued every year in many national languages of the Soviet Union. During the period 1968–1972, 6.5 million copies of school atlases were produced in national languages, apart from Russian.

The compilation of maps and atlases for foreign countries also was continued. In 1970, an Atlas of Cuba appeared that represented a result of co-operation of geographers and cartographers of both Cuba and the Soviet Union.

Soviet cartographers are working on the further improvement of contents and the artistic presentation of maps, and on perfecting the equipment and technology of map publication. The cartographic service is currently

provided with high-speed two- and four-colour flat offset presses, and with modern photomechanical and binding-and-stitching equipment. Bimetallic plates are being widely introduced into production, which leads to the raising of both the durability (printing strength) of printing-plates and the quality of print. Parallel with the application of photomechanical methods of colour separation, electronic methods are mastered. Better kinds of paper and printing-inks are developed. A technology is being introduced for the simultaneous reproduction of the background and linear elements of maps, utilizing a photomechanical colour-separation process developed in 1970. This technology contributes to the solution of the problem of automation of the process of making photo plates and that of four-colour printing of multicolour maps. Standardization of dimensions of maps and atlases was introduced in 1971. In that same year, a new technology of map protection with a plastic film of the "Minofol" type was introduced into production; for that purpose special pasting machines had been designed and put into operation. By the end of 1972, the cartographic factories had delivered to schools about a million copies of multicolour maps with their right side plastic-protected. Such maps have a much longer life, as compared with those having no protection film. The making of relief plastic maps was begun as was publication of a new type of map, namely, the photo map which combines the usual cartographic representation of the terrain with its photographic image and which therefore has increased informational capacity.

At every stage of map compilation, polymeric materials (plastics and folics) are widely used in cartographic production.

Research work

In the USSR, the topographic-geodetic and cartographic service is steadily increasing the volume of work executed to meet the requirements of the national economy for maps and plans. Every five years, the volume of work increases nearly 1.5 times; this increase is accomplished, principally as a result of increased labour productivity and the continuous utilization of the achievements of science and technology. Thus, the great importance of the anticipated development of scientific research and experimental construction work in the fields of geodesy, photogrammetry and cartography is evident.

During the past few years, a number of new instruments and methods have been developed which have considerably increased labour productivity in astronomical-geodetic, photogrammetric and cartographic work. A number of these instruments and methods are already being utilized; the remainder are in the stage of experimentation.

Important investigations have been carried out co
cerning further introduction of new technical mean
and, in particular, of electronic computers and devic
intended for solving various kinds of geodetic problem
In the calibration test areas, methods of physical redu
tion of distance measured with radio distancers, and t
analysis of instrumental errors and of the influence
external conditions on accuracy of angular and astr
nomical observations are being investigated.

In the field of photogrammetry, research was conti
ued on further improvements of the technology
establishing block-and-strip phototriangulation n
through use of electronic computers; and on develc
ment of a technology for photogrammetric heig
bridging by means of aerial photographs with sm
contour intervals (1 m and smaller) with the aid
analytical and analogue-analytical methods, which
of great practical importance for improving the met
dology of large-scale topographic surveys. Much att
tion is paid to elaborating digital models of terrain.

Photogrammetry is currently faced with new proble
connected with the general progress achieved in
study of the cosmos, and, more particularly, with m
ping of the moon and Mars, as well as with explorat
of the earth's surface from the cosmos. The processin
data received from automatic lunar stations of
"Lunokhod" type has been carried out with the objec
of exploring the relief and soils of the moon.

Much attention is being paid to determinatior
further ways of development of photogramm
instrument-making. Ways to broaden the applicatio
modern electronic and electronic-optical devices in
togrammetric instruments have been explored.

In the field of cartography, research work has
directed towards:

(*a*) Automation and mechanization of cartogr
processes, including development of an automatic c
graphic system of searching for information;

(*b*) Standardization of the principal types and sca
topographic and thematic maps;

(*c*) Formulations of scientific criteria and metho
compilation of maps for mass consumption—to
school, reference, etc.

The technology and methods of map editior
publication have been further improved, includir
designing of more convenient and effective instru
for scribing. Work was also pursued on developm
technical means of transforming the cartographic
into digital form and of automatic reproduction
plotted cartographic information in the form of
original.

In the field of economics and organizati
topographic-geodetic and cartographic productic
vestigations with respect to the application (int
tion) of automatized systems of production contr
continued.

UNITED KINGDOM REPORT*

Paper presented by the United Kingdom of Great Britain and Northern Ireland

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 agencies of the Government of the United Kingdom of Great Britain and Northern Ireland between July 1970 and the end of May 1973.

Land survey work has been carried out by the Directorate of Overseas Surveys (DOS), a part of the Overseas Development Administration, under the technical assistance programmes of the United Kingdom of Great Britain and Northern Ireland. Field survey parties have worked overseas in co-operation with the Survey Departments of the British Solomon Islands Protectorate, Cyprus, the Gilbert and Ellice Islands, Malaysia, the New Hebrides and Tonga. Military survey parties have worked in Australia, Indonesia, Oman and the United Arab Emirates. The Royal Air Force has flown aerial photography of parts of the British Solomon Islands, Indonesia, Kuwait, Maldives, the New Hebrides, Oman, the United Arab Emirates and the Yemen Arab Republic.

Hydrographic surveys have been undertaken in the Persian Gulf, the Arabian Sea, the Indian Ocean, the Bay of Bengal, the Malacca Straits, the China Sea and the south-west Pacific; and, as in previous years, the needs of deep-draught oil-tankers have been a major factor in determining the programme of hydrographic surveying.

Further regular contoured topographic maps on the scale 1:50,000 have been published for the British Solomon Islands and Malaysia, and large-scale mapping is being undertaken for the Gilbert and Ellice Islands and for Tonga. Experimental photo maps have also been published for the latter areas.

Contributions have also been made by the provision in United Kingom government organizations of training facilities for overseas personnel. Such training has been provided in land survey, cartography, photogrammetry, photography and hydrographic survey, and in allied subjects. It has been provided for holders of technical assistance awards granted by the United Kingdom, for holders of United Nations and Colombo Plan Fellowships, and for those sponsord by their own Governments. Sixteen students joined the army survey courses at the School of Military Survey, Newbury; they came from Hong Kong, Iran, Jordan, Malaysia, Saudi Arabia and Thailand. Sixteen trainees came to the Directorate of Overseas Surveys in order to follow individual courses geared to their particular requirements; they came from the British Solomon Islands, Cyprus, Hong Kong, India, Indonesia, Jordan, Malaysia, Nepal and New Zealand. Local surveyors worked with DOS field-parties in their own countries in Tonga and in the Gilbert and Ellice Islands.

At the Royal Naval Hydrographic School in Plymouth, overseas personnel received training at various levels in hydrographic surveying. Two officers and 10 ratings from the Royal Malaysian Navy attended the school, one of the officers completing both the intermediate and advanced courses in the period. Three officers from Pakistan, two from Indonesia and one from New Zealand also completed courses. In April 1973, the Hydrographic School was expanded both in number of instructional staff (including one officer from the Royal Netherlands Navy) and in class-room space, in order to meet increasing demands from countries in many parts of the world for courses for hydrographic surveyors, thus permitting the United Kingdom to continue to perform this very valuable service.

TOPOGRAPHIC SURVEY, AERIAL PHOTOGRAPHY AND MAPPING

Australia

In 1971, a detachment of military surveyors visited Australia to take part in the survey of a photogrammetric range, which is being established to facilitate aerial camera calibration.

British Solomon Islands Protectorate

Some aerial photography was taken of the British Solomon Islands in September–December 1971, in order to assist mapping and land resource investigations. Three sorties were flown by the Royal Air Force in 1972.

A DOS field-survey party worked in the area from April 1971 to September 1972, in collaboration with the Lands and Surveys Department. Their main tasks were to establish control for the 1:50,000 mapping of Choiseul and Santa Cruz, to put in extra tertiary control to assist mining and forestry activities in Santa Isabel, and to carry out levelling in Honiara and extra heighting in east and west Guadalcanal. Contoured maps at 1:50,000 scale of the whole of San Cristobal, Malaita and Choiseul were published during the period, as were the final sheets of Santa Isabel (see annex I). Work was also taken up on Santa Cruz; Russell Islands, the Florida Group and Guadalcanal. A considerable number of thematic maps were produced to assist land resource investigations.

Cyprus

New coverage of Cyprus at 1:50,000 scale has been published in 24 sheets; a number of large-scale photomaps and one sheet at 1:250,000 scale also have been produced.

At the end of the period, the Directorate of Overseas Surveys commenced, under technical assistance arrangements, a joint project with the Lands and Surveys Department to produce large-scale mapping of the south-eastern part of the island to assist water development schemes.

Fiji

Fourteen sheets of Fiji were published in the 1:250,000 series, and a number of specialist maps were produced to illustrate forest and land resource investigations.

Gilbert and Ellice Islands

In July 1971, aerial photography of the Ellice Islands was flown by the Fiji Department of Lands and Surveys. A DOS field-party worked in the group until March 1971

*The original text of this paper, prepared by the Directorate of Overseas Surveys, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF.62/L.50.

and returned again in August 1972. The main tasks were to establish framework and basic mapping control of the Gilbert Islands and to put in control for the mapping of Tarawa at 1:2,500 scale.

An experimental photo map of Marakei covering the surrounding reef was published at 1:12,500 scale; and large-scale maps of Betio, Bairiki, Nanikai, Teaoreleke and Bikenibeu were completed.

Hong Kong

The final sheets of the initial dual-scale 1:10,000/1:25,000 contoured series covering the entire territory of Hong Kong were published in 1971. The series was then maintained by the revision of individual sheets as required.

A two-sheet geological map, at 1:50,000 scale based on a topographic map produced by the Crown Lands and Survey Office in Hong Kong, reached proof stage by the end of the period under review.

Indonesia

Between June and August 1970, a joint survey took place in West Kalimantan, in which British military surveyors co-operated with Indonesian and Australian survey parties. Control was fixed by traversing; and astronomical, gravity and magnetic surveys were carried out. In 1971, the Royal Air Force completed the survey photography of the area.

In 1972, aerial photography was flown on the island of Madura to assist proposed water and land resource investigations sponsored by the Overseas Development Administration of the United Kingdom.

Kuwait

Complete survey photographic cover of Kuwait at 1:30,000 scale was obtained by the Royal Air Force during 1972. It is being used at first to revise existing mapping at 1:100,000 scale.

Laos

A series of topographic base maps of Laos on the scale 1:125,000 were prepared for the Institute of Geological Sciences in the United Kingdom; they will form the basis of a geological series.

Malaysia

Throughout the period under review, DOS field-parties continued to work in East Malaysia, in co-operation with the Director of National Mapping, Malaysia, and with the Directors of Lands and Surveys in Sabah and Sarawak.

Field-work was undertaken primarily to pre-mark survey stations for new aerial photography and to establish planimetric and height control for 1:50,000 contoured mapping. In Sabah, the surveyors worked mainly in the northern and eastern parts of the country in the Dent Peninsula, the Sugut area and around Lahad Datu; helicopters were used to transport parties in the most inaccessible jungle areas. Subsidiary work included the establishment of tertiary control on off-shore islands, around timber concession areas and along roads to assist local mapping schemes. In Sarawak, work continued in the central part of the country to provide heights for the Kanowit-Mukah and Tubau-Belaga mapping blocks at 1:50,000 scale and to establish tertiary control for l large-scale mapping of the Miri-Bintulu Long La agricultural development area. In January 1972, D surveyors completed their programme of work in Sa wak and withdrew from the country after a perio 13 years.

Work continued on the production of regular toured maps at 1:50,000 scale: 14 were published DOS during the period; and work was in hand or additional 64. The Directorate of Military Su (DMS) is currently recompiling a number of the 1:50,000 sheets of East Malaysia.

Two land systems maps of south-western Malaysi the scale 1:250,000 were prepared in conjunction the United Kingdom Road Research Laboratory publication by Malaysia.

Maldives

Eight new 1:250,000 sheets covering the island Maldives were produced.

The Royal Air Force flew large-scale aerial photo phy of Male and Hulule in November 1971. Gro control was established by surveyors from the Ce Survey Department, and mapping on the scales 1:1 and 1:500 is being produced by DOS.

Nepal

A number of specialist base maps of the Nawal P areas of Nepal were produced to illustrate investiga being undertaken under technical assistance arra ments by the United Kingdom Land Resources Divi

New Hebrides

In August 1972, the Royal Air Force obtained al complete aerial photography coverage of the Condo ium on the scale 1:25,000.

A DOS field-survey party worked in the area May 1971, by which time it had completed its gramme of establishing framework control throug the Condominium in order to connect and supple existing isolated schemes and to provide a homoger basis for future cadastral work. During the period u review, the surveyors worked mainly in the islands southern area; and they observed a connexion bet the Passive Geodetic Earth Orbiting Sat (PAGEOS) satellite station on Efaté, operated b United States Coast Guard Service, and the DOS fi work established in 1964.

Specialist maps were published to illustrate the l and land-use surveys carried out by the United Kin Land Resources Division, and the first of a new ser 1:100,000 geological maps was produced for the Geological Survey Department.

Oman and the United Arab Emirates

Field surveys by military parties to provide contr mapping and development projects took place in O and in the United Arab Emirates. Selected areas of countries were photographed by the Royal Air Fo assist in development projects and to update ex mapping. Maintenance of the mapping at 1:100,00(of Oman and the United Arab Emirates has conti and a number of large-scale photo maps have produced.

Tonga

Aerial photography of some of the islands and reefs of Tonga not previously photographed and a new cover of Nuku'alofa was taken by the Fiji Lands and Surveys Department in June 1971.

A DOS field-survey party worked in Tonga in co-operation with the Tonga Lands and Surveys Department until August 1972, when the surveyors withdrew after a period of four years. Their main tasks had been to establish mapping control for a 1:25,000 series of maps of the islands, to connect existing cadastral work to the new framework and to provide control for large-scale mapping of Nuku'alofa.

The experimental photo map of Tongatapu and adjacent reefs was published on the scale 1:50,000. Work was taken up on 22 contoured sheets at 1:25,000 scale and on five sheets of Nuku'alofa at 1:2,500 scale.

Yemen Arab Republic

In January and February 1973, the Royal Air Force obtained complete survey photographic coverage of the Yemen Arab Republic at 1:60,000 to permit the compilation of a new map at 1:250,000 scale. Limited areas were flown at larger scales to assist development projects.

Satellite geodesy

During the period from 1970 to 1973, British military surveyors continued to take part in projects of the United States of America to establish networks of control points throughout the world for satellite geodesy. The net for Sequential Collection of Ranges (SECOR) was completed in 1970, and the BC4 camera net was finished in 1972; the results have not yet been published.

The Doppler method is currently being used for position-fixing, and the following sites in Asia and the Far East have been occupied by teams from the United Kingdom: in 1972, Pitcairn Island; in 1973, Masira Island in the Arabian Sea, Guadalcanal Island and Gizo Island in the British Solomon Islands Protectorate and Viti Levu in Fiji.

Hydrographic surveys

During the past three years, hydrographic operations by surveying ships of the Royal Navy continued in waters of Asia and the Far East and in the Western Pacific Ocean, as detailed in annex II; Admiralty charts were published as listed in annex III.

As has been the case for some years, the increasing draught of oil-tankers has been a major factor in dictating the requirements of hydrographic surveys; and up to 1972, surveys were concentrated on the Persian Gulf and Malacca Straits, where tanker traffic is particularly heavy.

H.M.S. *Vidal* was employed in the Persian Gulf during 1971 before returning to the United Kingdom to pay off after 18 years of service as a Royal Naval surveying ship. It will be replaced in 1974 by H.M.S. *Herald*, a new ocean survey ship currently being built in Scotland. The work of H.M.S. *Vidal* in the Gulf was continued in the first months of 1972 by the two coastal survey ships, H.M.S. *Beagle* and H.M.S. *Bulldog*. For the remainder of that year, as in 1971, these two ships were employed in the Seychelles Islands, where the grounding and subsequent loss of a tanker emphasized the need for modern surveys. In addition to their work in the Seychelles H.M.S. *Beagle* and H.M.S. *Bulldog* carried out a survey of Male anchorage in Maldives at the request of the Maldivian Government.

For the first part of the period, H.M.S. *Hydra* was employed in the Malacca Strait, continuing a survey begun at the end of 1969 in response to the need of deep-draught tankers. At the end of 1970, it was diverted to support the relief force sent to East Pakistan,[1] stricken by an exceptionally severe cyclone followed by widespread flooding. There it carried out the vital task of finding and marking a channel for small craft to land food and supplies from the larger ships anchored some 30 miles off shore. By the time it completed the Malacca Strait survey in March 1971, a strip 10 miles wide and over 180 miles long, stretching from north-west of One-Fathom Bank to the Brothers had been closely surveyed and swept by sonar. *En route* to England for refitting, it carried out surveys in Hong Kong waters. Returning to the Far East in the spring of 1972, it was employed on surveys in the British Solomon Islands, and subsequently in Hong Kong. After a refitting in Singapore, H.M.S. *Hydra* is again working in the Solomons; later in 1973, it will be surveying in the Fiji Islands.

Although continuing to survey in this area puts an appreciable strain on the limited surveying resources of the United Kingdom, made more difficult by the long uneconomical passages round the Cape of Good Hope necessitated by the closure of the Suez Canal, it is intended to continue to work in the Far East for the foreseeable future, and one ship at least will be permanently stationed in those waters, as was H.M.S. *Dampier* up to 1967.

Aeronautical charts

Work on aeronautical charts in the report period was as follows:

(a) *Scale 1:1,000,000.* The United Kingdom is supporting the United States of America in the production of the Operational Navigation Chart (ONC) series at 1:1,000,000 scale, which is to replace the Topographic Navigation Chart (TNC) series. The United Kingdom has almost completed work on the sheets for which it is responsible;

(b) *Scale 1:500,000.* The United Kingdom is sharing with the United States of America the production of the Tactical Pilotage Chart (TPC) series at 1:500,000 scale, which is to replace the Topographic Tactical Chart (TTC) series. The United Kingdom has produced a total of 46 sheets within Asia and the Far East and is now responsible for the maintenance of 25 sheets;

(c) *Scale 1:250,000.* The United Kingdom has produced 48 sheets covering Cyprus, Fiji, Maldives, Oman, and the United Arab Emirates;

(d) *ICAO 1:1,000,000.* Seven sheets of the International Civil Aviation Organization (ICAO) series at 1:1,000,000 scale were revised by the United Kingdom during the report period.

Specialist (topical) maps

The Directorate of Overseas Surveys produced a variety of specialist maps both for overseas geological

[1] Now known as Bangladesh.

survey departments and to illustrate investigations undertaken by organs of the Government of the United Kingdom, such as the Land Resources Division, the Institute of Geological Sciences and the Road Research Laboratory. The maps were produced from specialists' draft material, and some of those for the Land Resources Division were working documents to be incorporated into reports for foreign Governments.

Maps were produced of the British Solomon Islands, Fiji, Hong Kong, Laos, Malaysia, Nepal and New Hebrides. Details of published sheets are given in annex I.

ANNEX I

Summary of maps of Asia and the Far East published by the United Kingdom Directorate of Overseas Surveys between July 1970 and May 1973

	Scale	Type of map	Number of sheets
British Solomon Islands Protectorate			
Santa Isabel	1:50,000	Contoured	1
Choiseul			10
Malaita			12
San Cristobal			9
		Total	32
Brunei[a]	1:50,000	Contoured	2
Fiji			
Viti Levu	1:600,000	Forest cover	1
Vanua Levu	1:600,000	Forest cover	1
	1:50,000	Forest types	29
		Total	31
Gilbert and Ellice Islands			
Marakei	1:12,500	Photo map	1
Tarawa[b]	1:2,500	Contoured	7
		Total	8
Hong Kong			
Entire territory	1:10,000	Contoured	1
Entire territory	1:25,000	Contoured	9
		Total	10
Malaysia			
Sabah	1:50,000	Contoured	7
Sarawak	1:50,000	Contoured	7
		Total	14
Nepal			
Nawal Parasi area	1:125,000	Population	1
	1:63,360	Specialist maps	4
	1:31,680	Tea suitability	1
		Total	6
New Hebrides			
Eromango	1:50,000	Vegetation	1
Eromango	1:50,000	Forest inventory	1
Malekula	1:50,000	Landforms	1
	1:100,000	Geological	1
		Total	4
Tonga			
Tongatapu	1:50,000	Photo map	1

[a] Printing only arranged.
[b] Dye-line series.

ANNEX II

Hydrographic surveys by H.M. survey ships in Asian and Far Eastern waters since May 1970

Area	Scale	Ship	Ye
Persian Gulf			
Eastern approaches to Jazirat Das	1:50,000	H.M.S. *Vidal*	19
North-western approaches to Abu Zabi	1:25,000	H.M.S. *Vidal*	19
Banks north of Rostem oilfield	1:50,000	H.M.S. *Vidal*	19
Umm al Qaiwan to Ras al Sadi	1:50,000	H.M.S. *Beagle* and H.M.S. *Bulldog*	19
Ras al Khaima	1:25,000	H.M.S. *Beagle* and H.M.S. *Bulldog*	19
Arabian Sea			
North-eastern approaches to Masira	1:10,000	H.M.S. *Vidal*	19
Indian Ocean			
Seychelles Islands:			
Northern approaches to Mahé Island	1:50,000	H.M.S. *Beagle*	19
South-western approaches to Mahé Island	1:100,000	H.M.S. *Bulldog*	19
Eastern approaches to Mahé Island	1:100,000	H.M.S. *Beagle*	19
Eastern approaches to Mahé Island	1:50,000	H.M.S. *Bulldog*	19
Approaches to Port Victoria	1:12,500	H.M.S. *Beagle* and H.M.S. *Bulldog*	19
Northern approaches to Mahé Island	1:100,000	H.M.S. *Beagle* and H.M.S. *Bulldog*	19
Aride I to Madge Rocks	1:50,000	H.M.S. *Beagle* and H.M.S. *Bulldog*	19
Curieuse to La Digue	1:25,000	H.M.S. *Beagle* and H.M.S. *Bulldog*	19
Denis I	1:25,000	H.M.S. *Beagle* and H.M.S. *Bulldog*	1
Port Victoria	1:5,000	H.M.S. *Beagle* and H.M.S. *Bulldog*	1
Maldives			
Male	1:25,000	H.M.S. *Beagle* and H.M.S. *Bulldog*	1
Bay of Bengal			
Ganges Delta: Approaches to Rabnabad channel	1:100,000	H.M.S. *Hydra*	1
West Malaysia			
Malacca Straits: North Sands to Pulau Undan	1:50,000	H.M.S. *Hydra*	1
Pulau Undan to Pulau Pisang	1:50,000	H.M.S. *Hydra*	1
China Sea			
Western approaches to Hong Kong	1:50,000 and 1:25,000	H.M.S. *Hydra*	1

ANNEX II (*continued*)

Area	Scale	Ship	Year
Eastern approaches to Hong Kong	1:75,000	H.M.S. *Hydra*	1972
Hong Kong, E Lamma channel	1:25,000	H.M.S. *Hydra*	1972
Hong Kong, Urmston Road to Brothers Point	1:25,000	H.M.S. *Hydra*	1972
South-west Pacific			
Solomon Islands: Bougainville Strait and New Georgia Sound	1:100,000 and 1:50,000	H.M.S. *Hydra*	1972-1973

ANNEX III

British Admiralty charts of Asia and the Far East published between October 1970 and May 1973

Chart No.	Title	Scale	Date
	Persian Gulf		
1214	Al Kuwayt Harbour	1:50,000	Dec. 1970
	Port of Al Kuwayt	1:25,000	
1223	Approaches to Mina Saud	1:50,000	Sept. 1972
	Mīnā al Ahmadi	1:37,500	
1235	Khawr 'Abd Allāh and Apps to Shatt al 'Arab	1:100,000	May 1972
1269	Approaches to Khowr-e Mūsa	1:100,000	Dec. 1970
	Bandar Shahpur to Bandar-e Mahshahr	1:25,000	
	Bandar-e Mahshahr	1:7,500	
2883	Jazīreh-ye Lavan to Katat and Ra's Tannūrah	1:350,000	Feb. 1971
2886	Jazīreh-ye Lavan to Jazirat Das and Ra's Tannūrah	1:350,000	Jan. 1972
	Shah Allum Shoal	1:50,000	
3774	Ra's as Saffānīyah to Mina Saud	1:150,000	March 1971
	Ra's al Khafji	1:30,000	
3775	Ra's Abu' Ali to Ra's as Saffānīyah	1:150,000	Oct. 1971
3777	Approaches to Ra's Tannūrah and Ad Dammam	1:75,000	June 1972
	Ra's Tannūrah	1:25,000	
3787	Fasht al 'Arif to Ad Dawhah	1:50,000	Sept. 1971
3842	Entrance to Shatt al 'Arab	1:25,000	June 1971
3843	Shatt al 'Arab—Inner bar to Kabda Point	1:25,000	Feb. 1972
3956	Strait of Hormuz	1:100,000	Sept. 1971

ANNEX III (*continued*)

Chart No.	Title	Scale	Date
	Indian Ocean		
920	Diego Garcia	1:25,000	April 1971
5126(1)	Routing chart—Indian Ocean (Jan.)	1:13,880,000	Dec. 1970
5126(2)	Routing chart—Indian Ocean (Feb.)	1:13,880,000	Jan. 1971
5126(6)	Routing chart—Indian Ocean (June)	1:13,880,000	June 1971
5126(7)	Routing chart—Indian Ocean (July)	1:13,880,000	May 1971
5126(8)	Routing chart—Indian Ocean (Aug.)	1:13,880,000	April 1971
5126(10)	Routing chart—Indian Ocean (Oct.)	1:13,880,000	Oct. 1970
5126(11)	Routing chart—Indian Ocean (Nov.)	1:13,880,000	Jan. 1971
5126(12)	Routing chart—Indian Ocean (Dec.)	1:13,880,000	Dec. 1970
	Pakistan		
40	Karachi harbour	1:10,000	Nov. 1971
145	Plans on the Makrān coast:		March 1972
	Khalij-e Jask	1:50,000	
	Khalij-e Chah Bahār	1:150,000	
	Gwādar bays	1:125,000	
	Pasnī bay	1:200,000	
	Ormara bays	1:125,000	
	India—West Coast		
655	Port of Bombay—southern portion	1:15,000	Aug. 1971
1566	Cape Comorin to Alleppey	1:300,000	Sept. 1972
	West Malaysia		
1355	Malacca Strait	1:1,000,000	Aug. 1971
3943	Ko Terutao to Pulau Penang	1:200,000	Oct. 1971
3944	Pulau Penang to Sembilan Islands	1:200,000	Aug. 1970
3945	Sembilan Islands to Port Swettenham	1:200,000	Dec. 1971
	Singapore		
2578	Pulau Seletar to Johore Bahru	1:12,000	Jan. 1971
2582	Tanjong Kopok to Tanjong Punggol	1:12,000	Jan. 1971
2583	Tanjong Tajam to Sembawang dockyard	1:12,000	Jan. 1971
2588	Sembawang dockyard	1:6,000	Jan. 1971
3939	Pulau Bukom	1:7,500	Sept. 1972
	East Malaysia		
1680	Darvel Bay	1:100,000	Oct. 1971
	Japan		
3548	Middle part of Tokyo *wan*	1:50,000	Sept. 1971
3604	Osaki Kami Shima to Ta Shima	1:75,000	March 1973

CARTOGRAPHIC ACTIVITIES OF THE UNITED STATES OF AMERICA, 1970-1973*

Paper presented by the United States of America

Cartography in Asia and the Far East spans the range of conditions. For some areas, the cartographic products reflect the most advanced state of this art and science. For other areas, the cartographic products reflect a periodical concern and sporadic effort. And, lastly, some areas are essentially unmapped. The threshold of capability for cartographic excellence for the poorly mapped

*The original text of this paper appeared as document E/CONF.62/L.62.

and unmapped areas is, however, being approached. The use of very high-altitude photography, the application of computers, the advances in satellite geodesy and the developing semi-automated photogrammetric equipment will permit relatively rapid and economical production of cartographic products. Despite these advances, cartographic excellence still requires access to the ground in deriving correct geographical names and in establishing "ground truths" or field edits. Full use of this evolving capability requires co-operation within and among countries if the economic and scientific needs for cartography are to be met in a minimum of time and with excellence. There is no other way.

Organizational changes

Organizational changes in mapping agencies of the Government of the United States of America effected since 1970 have resulted in new titles for several activities. These new titles, listed below, are used in this report.

The Defense Mapping Agency (DMA) was established, and the Directorate of Mapping, Charting and Geodesy of the Defense Intelligence Agency was disestablished. DMA includes among its components:

(*a*) The Defense Mapping Agency Topographic Center (DMATC), formerly the Army Map Service and a major component of the United States Army Topographic Command of the Corps of Engineers;

(*b*) The Defense Mapping Agency Hydrographic Center (DMAHC), formerly a major component of the United States Hydrographic Office. The hydrographic survey elements were retained in the United States Naval Oceanographic Office;

(*c*) The Defense Mapping Agency Aerospace Center (DMAAC), formerly the Aeronautical Chart and Information Center of the United States Air Force.

The National Ocean Survey (NOS) was formerly the Coast and Geodetic Survey and is a component of the National Oceanic and Atmospheric Administration (NOAA). There is in progress an organizational study of United States federal agencies for civil mapping, charting and geodesy to determine the feasibility and economy of organizational restructure and procedural innovation.

Geodesy

The past three years were an active and fruitful period in geodetic activities in the United States of America. Substantial progress was made on the National Ocean Survey high-precision transcontinental traverse, field observations for a world-wide satellite network were completed, new observations employing Doppler satellites were undertaken and a major survey effort in Africa was completed.

SECOR equatorial network

Field operations for the Sequential Collection of Ranges (SECOR) equatorial network were completed in March 1970, when the earth had been encircled by a network of 37 stations which gathered all their data from a high-altitude satellite. To add further validity to the data, an adjustment of the network was completed using six sets of BC-4 lines, common to SECOR lines. This adjustment provided the required directional constraints with data from 594 satellite passes and with the c ordinates of the station at Worthington, Minnesot being held fixed as the origin.

Analysis of the solution indicates that for a sing range measurement the standard deviation is 2.7, and f the adjusted co-ordinates the standard deviation rang from 4 to 8, which indicated a very good relati accuracy between the stations.

Satellite Doppler programme

Since the last report, the United States Navy l developed a light-weight, portable Doppler satel receiver, the "Geoceiver", an exceedingly valuable g detic instrument. Using the Geoceiver, the United Sta Naval Oceanographic Office established a centre mass positions for three Omega stations and seve LORAN-C and LORAN-A stations. It was also usec establish antenna locations for precise electro positioning systems in support of hydrographic sur operations off the coasts of Greece, the Philippi and the United States. Five Geoceiver sites in Icel were established in a joint United States-Iceland proj and six sites in the Philippines were occupied to pro points for developing a revised national primary work.

In 1971, the Defense Mapping Agency underto test programme to evaluate fully the capabilities of new surveying instrument. A network of obser stations was established in the United States at p where geodetic control was known precisely. The consisted of 22 stations, with 19 either connecte scheduled to be connected to the National Ocean Su high-precision Geodimeter traverse. The test data processed and the results were tabulated in a D report.[1] The accuracy of point-positioning (long arc established at 1.5 in each component (90 per assurance) with 35 satellite passes. The transloc concept requires two geoceivers observing sim neously. Its accuracy was shown to be 0.5 plus two per million in distance. Both the long-arc and translocation concept require a precise ephemeris fc Doppler satellite. The short-arc technique does require the use of this precise ephemeris. Its acc was shown to be approximately 2 m in latitude, 4 longitude and 3 m in geoid height (90 per cent a ance).

During and after this test, DMATC personnel performed observations throughout the world effe datum ties, establishing positions in remote areas which conventional surveys can establish geodetic mapping control, strengthening existing control positioning navigation stations on a common sy Between July 1970 and November 1972, DMAT tablished a total of 115 Doppler positions throu the world.

Survey of the twelfth parallel

A significant contribution to world geodesy i survey of the twelfth parallel in Africa, a 2,90 precise Geodimeter traverse from the Sudan-Chac der through Chad, Cameroon, Nigeria, the Nige Upper Volta, Mali and Senegal. This survey was pleted in May 1970. With the exception of the Ni

[1] United States of America, Defense Mapping Agency, *Repo DoD Geoceiver Test Program* report 001 (July 1972)

portion (25 per cent), the work was contracted by the United States to the Institute géographique national (IGN) in France. The Federal Survey Department of Nigeria accomplished the segment in that country with a limited number of technical advisers from the United States. The purpose of the survey was to provide the longest east-west geoidal profile survey in the equatorial belt for figure-of-the earth studies and to provide the geodetic data required for referencing various independent surveys in Africa to a common datum.

Field operations for the traverse were initiated by IGN in the fall of 1966 at the Sudan-Chad border, and they worked four winter seasons with each season being approximately six months in duration. During the last two seasons, IGN provided two parties, accompanied by contract inspectors from the United States, and worked both ends of the traverse.

The traverse of the Survey consisted of 325 lines with an average of 14.5 km per line, while the Laplace observations averaged 30 km. The accuracy of the results approaches one part per million.

Ionospheric refraction study

A study of ionospheric refraction was undertaken by DMATC in support of a Defense Navigation Satellite System (DNSS) study. This study involved detailed analysis of all data collected by SECOR stations with respect to the following parameters: time of day; latitude of observations; elevation angle; and season of the year. Information from this study was used to develop various ionospheric refraction models, which were compared with other collected data and yielded favourable results which were incorporated in a paper in the DNSS study. The problem of ionospheric refraction in relation to satellite geodesy continues to be an area of study in the Defense Mapping Agency.

GEOLOGY

Geological mapping in Indonesia

The Office of International Geology of the United States Geological Survey is engaged in a co-operative geological mapping programme in Indonesia. The objective of this programme is to assist the Geological Survey of Indonesia (GSI) in developing its capacity to identify and appraise mineral and other geological resources of the country. Emphasis has been placed on co-ordinated use of geological field investigations, geophysical and geochemical surveys and analyses, and the production of geological maps and interpretive reports. Development of facilities to publish these maps and reports in Indonesia is also an integral part of the programme.

The programme will produce small-scale maps for geological studies and for the selection of areas favourable for mineral or petroleum prospecting, and medium-scale maps for such specific uses as mineral exploration or dam and reservoir site studies. Use is made of all available data. Many of the first map products are compilations of available published and unpublished material supplemented and revised by current field-work.

The Regional and Photogeology Sections of the Geological Mapping Division of GSI are preparing the small-scale or regional maps, and the Systematic Mapping Section is preparing the medium-scale or systematic maps. Geologists from other divisions of GSI also contribute to the medium-scale mapping.

Regional maps

Geological maps covering all of Indonesia on the scale 1:1,000,000 are to be published in 16 sheets. Field-work, except for some probable field-checks, has been completed on two, Makasar and Surabaya. Six geologists, plus two geology professors at Unpad University, spent a total of 27 man-months in the two map areas during the field-season ending in December 1972. Seven assistant geologists and two advanced students from Gajah Mada University worked an additional 32 man-months with the geologists. Compilation of the two maps is in process and is expected to be completed in about six months.

Systematic maps

Geological maps of Java are prepared on the scale 1:100,000; their boundaries follow 30-minute lines of longitude and latitude, adjusted to the coastline. There will be 57 maps of Java and Madura. Of these, one was printed during the year; a colour proof has been made of the second, and a third map is ready for colour proof. Geological mapping is complete, or nearly so, on another eight maps and is in process on seven others.

Medium-scale geological maps, other than those of Java, will be published at 1:250,000 scale. On Sumatra, field-work was completed during October on the Padang and Solok maps which together form a belt from the west coast nearly across Sumatra between the equator and latitude 1° south. The Padang map has been compiled, and the map and report are being reviewed. The larger Solok map is being compiled.

On Sulawesi, the field-work was completed during December for the Madjene and western part of the Palopo maps, which make a strip across the south-west arm of Sulawesi between latitudes 3° and 4° south. Compilation of the maps is in progress. Mapping of the Palopo map east of the Gulf of Bone has not been begun.

At year-end six geologists and three assistant geologists were working full time in the systematic mapping. During the eight-month field-season, these nine geologists worked a total of 41 man-months in the field on Sumatra and Sulawesi. One of the six geologists, departed in November for one year of training in the United States. Another returned during December from training in the United Kingdom of Great Britain and Northern Ireland.

In addition, three geology professors at Pajajaran University, Bandung, worked for GSI and completed one map in West Java. Three students from Pajajaran University assisted as GSI geologists on another map of West Java.

Water resources projects

Since 1940, water scientists and engineers of the United States Geological Survey have completed 384 project-oriented assignments in 82 countries. These water scientists and engineers have worked with a wide variety of host-government organizations, including geological surveys, hydrological investigative and research services and institutes, hydropower and flood control agencies, agricultural and irrigation departments, water-development and land-reclamation authorities, and health and sanitation or public water-supply agencies. Some current and recent past activities under

the auspices of the United States Agency for International Development are described below.

Afghanistan

During 1971, three USGS hydrogeologists, working in co-operation with the Afghanistan Helmand-Arghandab Valley Authority, completed ground-water appraisals of six areas in south-western Afghanistan, including two advanced-reconnaissance studies of the Kandahar and Zamin Dwar areas. The latter studies included hydrogeological mapping and development inventories to provide guidance for ground-water development. This region experienced a prolonged drought which had reached critical proportions in the summer of 1971.

Pakistan

In mid-1972, a four-man team of USGS hydrologists completed, in co-operation with the West Pakistan Water and Power Development authority, a four-month intensive analysis of the responses of the hydrological system of the upper Indus basin. The analysis attempted to predict future responses of the system to a range of potential imposed stresses and management decisions

Nepal

Ground-water investigations in the Terai belt of western Nepal have been in progress since March 1969, under the guidance of two USGS hydrogeologists working in co-operation with the Nepalese Department of Hydrology. The work includes exploratory drilling with borehole surveys and aquifer tests, hydrogeological and water-quality mapping, and ground-water use inventories. Similar work is currently in progress in the Nepalganj area

India

Three ground-water studies in three hydrogeological provinces of India have been under way since January 1972, under the guidance of three USGS hydrogeologists and in co-operation with the Indian Central Ground-Water Board. The areas include a coastal deltaic plain in the Broach-Baroda area of Gujarat, the alluvial valley of the upper Narmada River in Madhya Pradesh and a crystalline rock area in Mysore

GEOMAGNETICS

Since 1970, the United States Naval Oceanographic Office has conducted three geophysical research cruises in the Pacific Ocean, two in the eastern equatorial Pacific and one in the western part of the south Pacific Ocean and the Indian Ocean. During these surveys, 75,000 track miles of seismic reflection, magnetic and bathymetric data were recorded. Reconnaissance and detailed scale oceanographic surveys were conducted in the north Pacific Ocean, resulting in the collection of over 40,000 miles of seismic profiles, 75,000 miles of magnetic data and 11,000 miles of bathymetric data.

The United States Naval Oceanographic Office Project Magnet, a continuing world-wide airborne magnetic survey, gathered approximately 99,000 nautical miles of magnetic data in the western Pacific, including 73,000 nautical miles of special fine-grain surveys in the Sea of Japan, the Korean Straits and the East China Sea. Figure 43 shows the tracks and the special survey areas flown during the period from January 1971 to March 1973. The two survey aircraft used in the project, a Douglas Skymaster and a Lockheed Super Constellation, have been retired from service and have been replaced with a Lockheed Electra aircraft. This aircraft is especially configured for world-wide magnetic surveys and its new survey system provides an extensive data-recording and data-processing capability.

GRAVIMETRY

Helicoper gravity-measuring system

The United States of America, during the report period, continued development of the helicopter gravity-measuring system which contains positioning and elevation systems. Computer programmes were developed to permit data editing, filtering and least-squares simultaneous adjustment of multiple data sets. Analysis of available data indicated that a consistent set of system constants (linear and non-linear) could not be extracted from the current system. The desired goal of ±3 milligals accuracy was not reached. Computer investigations disclosed several error sources. The areas identified for potential improvement were: calibration and operational techniques; flight-speed optimization; gravimeter servo-loop to allow reduction in settling time; and treatment of variation in the height of the isobaric surface.

Gravity surveys in North America

DMATC conducted marine gravity surveys using LaCoste and Romberg marine and underwater gravimeters in the Great Lakes (Superior and Michigan); Lake Okeechobee, Florida; and Pamlico Sound, North Carolina. In addition to the marine gravity surveys, systematic regional land gravity surveys were accomplished in 21 states and associated with the national gravity base net.

Gravity Library

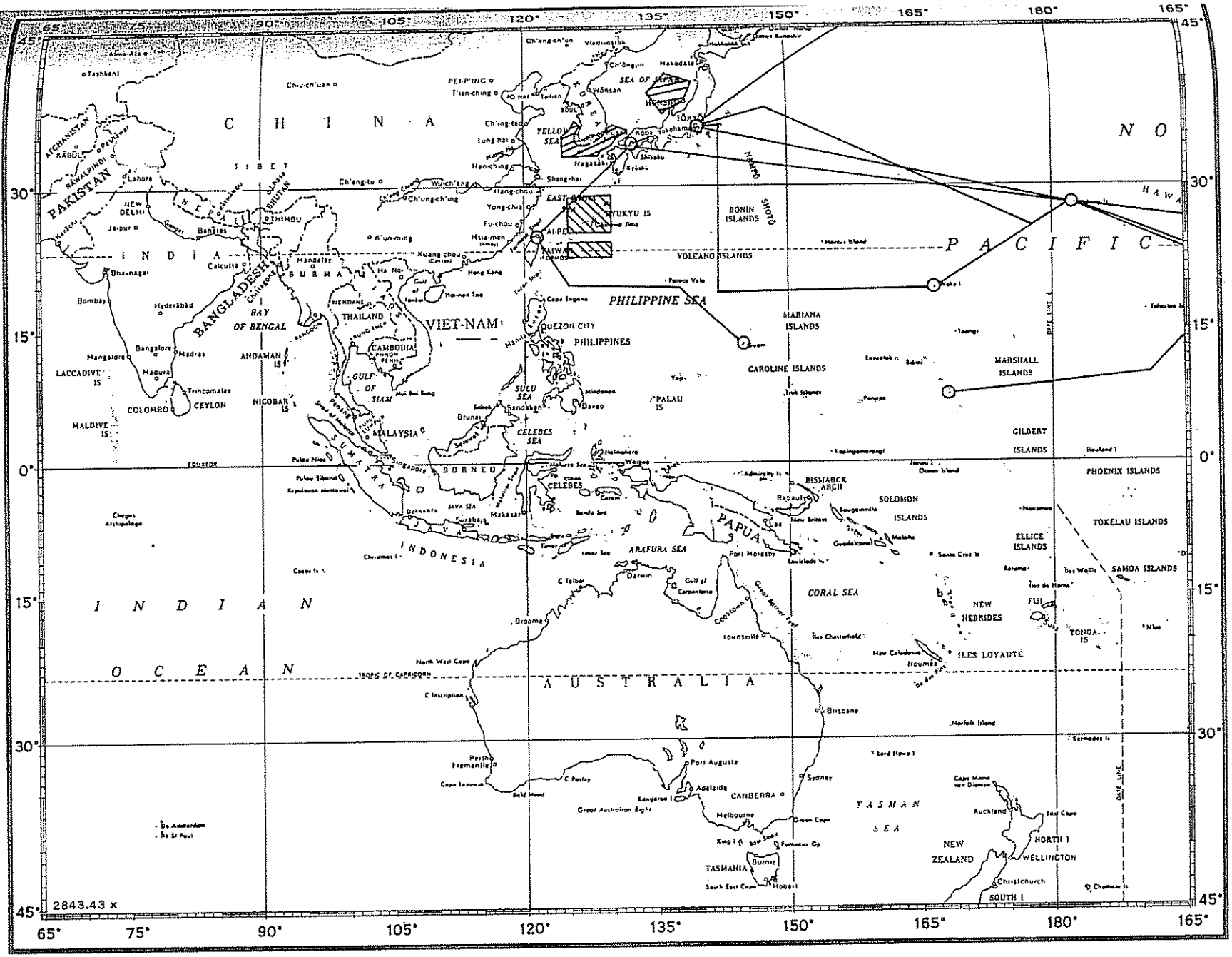
The Defense Mapping Agency Aerospace Center is the depository for all Department of Defense gravity data. The Gravity Library has an automated file which has grown from 434,000 individual gravity observations in 1965 to approximately 4,000,000 at the current time. In addition, automated files of mean gravity anomalies and mean elevations are maintained for use in computing deflections of the vertical, gravity-geophysical correlations, etc.

In 1970, DMAAC produced, from data contained in this library, the first volume of a catalogue of gravity reference base stations; this volume covers those throughout North America.[2] Subsequent volumes, covering the rest of the world, have been published. In 1971, a reference work covering world-wide free-air anomalies was completed.[3]

The Bouguer Gravity Anomaly Map of Asia, the first gravity anomaly representation of Asia based entirely on terrestrial data, was published in November 1971. The map is based upon predictions of 1° × 1° mean Bouguer anomalies. Some of the predictions were computed

[2]United States of America. Defense Mapping Agency Aerospace Center. *World Relative Gravity Network*. vol. I, Reference publication No. 25 (August 1970).

[3]United States of America, Defense Mapping Agency Aerospace Center, *1° × 1° Mean Free-Air Gravity Anomalies*, Reference publication No. 29 (August 1971).



Note: Boundaries and names appearing in this figure are not authoritative.

Figure 43. United States of America: Project Magnet

directly from observed gravity data; most, however, were determined by gravity-geophysical correlation techniques.

Aeronautical charts

The increasing number of international and local flight operations give rise to continuing problems in the adequate control of air traffic as a result of congestion and air-space limitations. Changes in air traffic control procedures, the introduction of new air navigation systems and the continued emphasis of air safety call for a continuous review of charting requirements and redesign of aeronautical charts and Flight Information Publications (FLIPs).

DMAAC produces aeronautical charts world wide and FLIPs for much of the world. These products, which are produced for the Department of Defense, are also made available to commercial and federal agencies, as well as to private persons, who may purchase them from the United States National Ocean Survey. NOS produces and distributes aeronautical charts and flight information publications covering the United States, including Alaska and Hawaii, as well as charts for long-range flights over the Pacific and Atlantic Oceans. United States aeronautical charts and flight information publications are also made available to many countries and organizations through mutual exchange agreements.

Flight information for the Asian and Far East areas is currently provided jointly by the Pacific South Asia series of FLIPs; and the Australia, New Zealand and Antarctica FLIPs. These FLIPs consist of instrument approach procedures (terminals) designed to provide the air crew with all aeronautical information necessary to flight operations. There is a continuing programme to improve, expand and modify the content of these publications to satisfy changes in air traffic control procedures and navigation systems.

High-altitude *en route* charts of the United States, low- and high-altitude *en route* charts of Alaska, standard instrument departure charts and instrument approach procedure charts for civil aerodromes in the United States have been revised for joint use and published by NOS, replacing separately produced civil and military chart series.

Coverage of all major land masses is available in the large-size Operation Navigation Chart (ONC) series at 1:1,000,000 scale. Maintenance will be continued to assure currency of these charts.

Of the Tactical Pilotage Chart (TPC) series at 1:500,000 scale, 340 sheets are now available. This series is designed primarily for low-altitude high-speed navigation. Sheet lines reflect a quadrant division of the ONC series. Coverage of Europe, Asia, South-East Asia, Japan, the Philippines and most of the area of Indonesia is available.

For general navigation and planning purposes, DMAAC 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 to provide for pre-flight planning. Complete coverage of the world is currently available.

The Aircraft Position Chart series, produced by NOS, provides coverage for long-range flights from California, Hawaii and Alaska to Japan, the Philippines, the Republic of Viet-Nam, Tahiti, Fiji, Samoa, New Zealand and Australia. These charts are on the Lambert conformal conic projection on the scale 1:6,250,000 and the Mercator conformal projection at 1:5,000,000. Full aeronautical data for long-range navigation are furnished, including LORAN and navigation grids.

Approved joint specifications provide also for the preparation of compilation bases at 1:500,000 and 1:1,000,000 scales of Alaska and the conterminous United States, from which both civil and military editions of visual flight charts are produced. Both the compilation bases and the complete civil editions are produced by NOS. Both editions feature relief shading. Coverage of Alaska is provided by eight sheets at 1:1,000,000 scale and 16 sheets at 1:500,000. Coverage of the conterminous United States is provided by 11 charts at 1:1,000,000 scale and 37 charts at 1:500,000 scale.

An instrument flight rule planning chart is also produced by NOS under joint specifications for use by both civil and military aviation. A visual flight rule planning chart backs up the instrument flight rule planning chart for the civil edition. These charts cover the conterminous United States on two sheets at a scale of 32 nautical miles to 1 inch. Both charts are used for flight planning.

The Federal Aviation Administration, in support of commitments of the United States of America 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 in Hawaii, Alaska, the conterminous United States, Puerto Rico and the Virgin Islands.

Hydrographic charting

Bathymetric plotting sheets

In accordance with an agreement made at the Eighth International Hydrographic Conference, held in Monaco in May 1962, most maritime countries are producing bathymetric plotting sheets. These plotting sheets are forwarded to the headquarters of the International Hydrographic Organization (IHO) in Monaco for compilation of the General Bathymetric Charts of the Oceans (GEBCO). The commitment of the United States of America, being fulfilled by the National Ocean Survey and the Defense Mapping Agency Hydrographic Center, includes the eastern half of the north Pacific Ocean, part of the Arctic and the western half of the Atlantic Ocean. The United States has completed 49 bathymetric plotting sheets, which are available for sale to the public.

Hydrographic charts

Since January1971, DMAHC has published 56 new nautical charts or new editions of nautical charts in the Indian Ocean and the Pacific Ocean (excluding North and South America, Hawaii and the coast of Africa). New chart coverage is described using the following categories: (*a*) small-scale general ocean and sailing charts—smaller than 1:600,000 scale; (*b*) medium-scale coastal charts—1:75,000–1:600,000; and (*c*) large-scale harbour approach and port coverage—larger than 1:75,000.

Among these 56 new nautical charts or new editions of nautical charts produced for the Pacific and Indian

Ocean were: (*a*) four small-scale charts for the east coast of Asia and the Japanese islands; (*b*) 20 medium-scale charts in the Sea of Japan, South China Sea, south Pacific Ocean, Persian Gulf, Red Sea, Arabian Sea and Bay of Bengal; and in numerous ports and harbours, including Diego Garcia, Osaka Ko, Kobe Ko, Cebu and the Singapore Strait.

Nautical publications

In addition to nautical chart coverage, DMAHC 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 *Sailing Directions Planning Guide for the Mediterranean, Sailing Directions Enroute for the Western Mediterranean,* the *World Port Index,* 25 sailing direction changes and 11 light list changes for various areas of the world.

International exchange of charts

To provide global chart coverage to mariners, the United States of America has entered into bilateral agreements with 27 other countries whereby each may issue for sale to the general public modified facsimile reproductions of the other's nautical charts. As of April 1973, agreements were in effect with seven countries in the Far East; and with 21 countries in the western hemisphere. These agreements are in accordance with resolutions of the International Hydrographic Organization (IHO).

Hydrographic surveys

Since the last Conference, the United States Navy has decommissioned two small hydrographic ships and commissioned two large new ships. Surveying continues in the Republic of Korea, with additional surveys in Greece and the Philippines. Navy surveys during the reporting period included 56,000 miles in South-East Asia and 8,600 miles in the Guam area.

The United States Navy Harbor Survey Assistance Program is worthy of mention. This programme was initiated in late 1964 and is designed to develop a hydrographic surveying and charting capability in developing countries. By sending hydrographic engineers from the United States into the field to assist and train host-country personnel in carrying out hydrographic surveys of their ports and harbours, these countries can then produce and maintain accurate charts. Equipment and technical assistance have been provided to Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Honduras, Guatemala, Jamaica and Nicaragua. Efforts to date have been quite successful, and several of these countries currently have an adequate capability. Although this programme has been limited to Latin America and the Caribbean, a similar programme for Asia and the Far East, supported by the United Nations or one of the leading maritime countries, seems worthy of consideration by participants in this Conference.

TOPOGRAPHIC MAPPING

Topographic mapping of the United States

The preparation of new maps and the maintenance of existing maps of the National Topographic Map Series of the United States continued apace during the period under review. Efforts were made to make the National Topographic Program as responsive as possible to national mapping needs. A map sales benefit study was completed; and the results indicated that map sales are distributed 45 per cent, 33 per cent and 22 per cent, respectively, to economic, educational and general users. Annual benefits from published topographic maps were estimated at more than $900 million.

Over 7,800 new and revised topographic maps were published in the 7½-minute and 15-minute series covering about 1,158,275 km². This series included mapping in the 50 states, the District of Columbia, Puerto Rico, Guam and American Samoa. Approximately 38,000 quadrangles of the National Topographic Map Series have been published and distributed.

Preparation and maintenance of the 1:250,000 scale topographic map series covering the United States has continued. Complete coverage of the 50 states is currently available in this series.

Topographic maps of 25 states on the scale 1:500,000 were published. Nine special topographic maps of national parks were published at various scales. A state base map series was completed for the country on the scale 1:500,000. The series comprises 46 maps, with several of the smaller and contiguous states being shown on one map; it is prepared in three editions—base, topographic and shaded relief. These maps are maintained on a 10–15 year basis.

Geodetic control obtained for topographic mapping included spirit levelling to provide vertical control for approximately 948,225 km², electronic traverse for 561,413 km² and third-order triangulation for 68,295 km². In addition, second-order horizontal control was established over an area of about 109,908 km².

The main emphasis in the National Topographic Program continued to be completion of map coverage of the conterminous United States and Hawaii at 1:24,000 scale, and coverage of Alaska at 1:63,360 scale. As of 1 January, 1972, 79 per cent of the United States was covered by published maps of the 7½-minute or 15-minute series. An additional 6 per cent was available as advance manuscript coverage. Another 9 per cent was in early stages of mapping for 7½-minute coverage, mapping at 1:63,360 scale in Alaska or resurveys of existing 15-minute coverage.

The new programme of using advanced techniques to revise the map series at 1:250,000 scale was proved satisfactory. Of the 474 maps covering Hawaii and the conterminous United States, 149 were in preparation and 45 new revisions were printed. Between 55 and 60 maps will be added to the programme each year, so that a revision cycle of approximately 8–10 years can be maintained.

Work continued on the programme to replace the 153 reconnaissance series maps at 1:250,000 scale, covering Alaska, with a modern topographic series prepared from original surveys and large-scale source materials. Of this total, 139 of the new maps had been published and the remaining 14 were in progress.

Revision of maps of the United States

During the reporting period, the map revision programme grew steadily because of the impact of interim revision, which accounts for about 80 per cent of the current map updating. The remaining 20 per cent consists of normal revision. Revision production reached

more than 900 maps per annum, more than a fourfold increase since 1967. More than 8,000 maps at 1:24,000 scale needed updating. Annually, about 1,300 maps become out-dated—700 of these in urban areas.

The concept of interim revision (photo-updating) was expanded to permit a second, or subsequent, interim revision of a given quadrangle. Furthermore, a system of "photo-inspection" was initiated whereby areas considered for updating are reviewed by comparing existing maps with recent photography. Those not needing updating have a review date included in the marginal legend, so that map users may be aware of the currency of the map.

Military topographic maps

During the period under review, the DMATC mapping programmes for Asia and the Far East included new areas of large- and medium-scale mapping coupled with the revision of existing mapping, including the design of new formats. These programmes were accomplished through co-operative mapping arrangements with various countries. Progress of the programmes will be reported by representatives from the co-operating countries. These programmes are important to the participating countries because of their potential usefulness in the development of physical, economic and social resources.

Comprehensive planning for the Lower Mekong Basin is being carried out by the United Nations Committee for the Co-ordination of Investigations of the Lower Mekong Basin. In connexion with this task, DMATC may be requested to produce 1:20,000 scale topographic maps of the potential Stung Treng reservoir dam site located in the north-eastern part of the Khmer Republic along the Mekong River.

PHOTOGRAMMETRY

Aerial photography

The 153-mm (6-inch) focal length camera is still the mainstay of the topographic mapping programme of the United States of America, because of its compatibility with the compilation instruments currently in use and its metric and operational stability. However, requests for super-wide-angle 88.5-mm (3.5-inch) photography are increasing and represented approximately 20 per cent of the total procurement of the United States Geological Survey during 1972. The latest models of the super-wide-angle (120°) cameras have lower distortion factors and greater over-all resolution than the earlier models.

Photographs taken with a 153-mm focal length camera from a high-altitude jet aircraft (37,000 ft or higher) are currently used for quadrangle-centered photo mapping. On photographs flown at this altitude with the exposure stations at the south edge, centre and north edge of a standard 7½-minute quadrangle, the entire quadrangle is stereo-covered by three photographs (two stereo models). It is suited for producing a single negative of a 7½-minute orthophotoquad when compiled on the dual model Geological Survey orthophotoscope. The single negative thus eliminates the customary assembly of mosaics of several prints for each orthophotoquad and increases the internal accuracy. It also eliminates the tonal mismatches that are common in mosaic assembly.

Aerial photographs taken from high-flying jet aircraft had considerable application in the topographic operations. These photographs are used to aerotriangulate large areas, produce orthophotographs and revise existing maps. In 1970–1971, over 22,000 square miles of high-altitude photographic coverage were flown for aerotriangulation, orthophoto mapping or revision.

Experimental photo-image maps

Applications of very high-altitude photographs were continuously investigated during the report period to determine their potential. A U-2 type aircraft equipped with a calibrated mapping camera of 154-mm focal length photographed the area of Phoenix, Arizona, and vicinity. The plane flew at 21.3 km (70,000 ft) above sea level. The original film was used to produce several significant experimental orthophoto products:

(*a*) A 1:24,000 scale orthophotoquad of Mesa, Arizona, was produced by simple rectification. This photo-image product was printed on the back of the corresponding conventional line map to illustrate two approaches to mapping and their complementary aspects. The orthophoto map had horizontal and positional accuracy at least equal to that of the line map;

(*b*) A 1:50,000 scale orthophotoquad of the Mesa 15-minute quadrangle was also produced, with combined differential rectification (by orthophotoscope) with conventional rectification. The positional accuracy (ground reference) was practically the same as that of the product at 1:24,000 scale, which meant that it significantly exceeded national map accuracy standards for horizontal position. The product was first reproduced in diazo form and subsequently in lithographic form on the back of the corresponding line map;

(*c*) A 1:250,000 scale (1° by 2°) orthophotoquad was also produced of the Phoenix area, again combining orthophotoscope scanning and conventional rectification. Image quality was excellent, limited only by the reproduction process; and positional accuracy met the requirements of the national map accuracy standards.

All three of the above-mentioned products were prepared for reproduction in random-dot form so that the use of rectilinear screen was not required. This relatively new image-processing technique showed promise of significantly improving the resolution (image quality) of photo products that are reproduced by diazo or lithographic methods.

Orthophoto mapping

In certain areas of the United States orthophoto maps are published as standard editions replacing the conventional line maps. Near the close of the report period, projects totalling nearly 500 7½-minute quadrangles were in the programme. The areas included the Florida Everglades and Keys, the Mississippi River delta, coastal areas of North Carolina, southern Georgia and northern Minnesota. Standard-edition quadrangles that had been published included the Okeefenokee Swamp, Georgia; the Great Salt Lake and Desert, and the Prudhoe Bay area in Alaska.

The Department of Housing and Urban Development (HUD) requested orthophoto-map coverage of the urban areas of the United States. The request included the 25 largest cities in the country and encompassed about 56,000 square miles.

Preparation of an interim orthophoto product of some areas is under way to satisfy the need of the public until topographic maps can be published. This ortho-

photoquad is an orthophoto or rectified photograph in standard 7½-minute quadrangle format with a minimum of cartographic drawing or interpretation.

Work was completed on the production of 49 orthophotoquads in Arizona for the Bureau of Indian Affairs. They were produced from photographs at 1:79,000 scale taken with a KC-6A camera. Mosaic assemblies were controlled by fully analytical aerotriangulation, using either the Haag-Streit or the PG-2 co-ordinatograph for fast measurement of diapositives.

Photogrammetric instruments and techniques

Development was undertaken of a photogrammetric instrument system to automate production of orthophoto products. The components of the system are the profiler, the Autoline and the Orthophotomat. Profile plots for input to the Autoline are derived by various manual and digital techniques. The Autoline follows the profiles automatically and generates electric signals to control the profiling motions (z direction) of the Orthophotomat. The Orthophotomat is a single-projector differential-rectification instrument for off-line, automatic production of orthophotographs. It scans and exposes the photo-imagery in a narrow strip along the profile in the y direction and steps over automatically in the x direction to the next step at the end of each scan.

During the period under review, the trend was to convert direct-viewing stereoplotters (Kelsh and ER-55) to use tungsten-halogen lamps. These new lamps, introduced commercially, have many features which make them superior to conventional incandescent lamps. Tungsten-halogen lamps are small, extremely bright and non-darkening; and they retain full efficiency throughout their life. Bulb envelopes are made of fused quartz, which has a high softening temperature, low coefficient of expansion and optical clarity. The halogen inside the lamp, through a regenerative cycle, practically eliminates lamp-blackening.

Photogrammetric point-positioning data base

DMATC is engaged in a programme designed to exploit the point-positioning capabilities of aerial photography in the field environment.

Procedures have been developed which utilize a Zeiss Stereotope, modified with a Bendix data grid and a shaft encoder for measuring plate x, plate y and delta x. The image measurements are computed using a Hewlett-Packard programmable calculator, which is equipped with a magnetic-tape cassette unit for storage of the geodetic constants, camera calibration values and photograph parameters needed to reconstruct mathematically a stereo-model. Once the model is set up within specified tolerances, the system operator is ready to stereoscopically measure the plate x, plate y and delta y for each point of interest, to be used with the data on tape to compute the Universal Transversal Mercator (UTM) ground co-ordinates and the height of each point.

Photogrammetric point-positioning data bases, as compiled by DMATC, consist of the following materials:

(*a*) The set of annotated photography and control source data;

(*b*) The precise elements of internal and external orientation of the data base photography stored on magnetic tape;

(*c*) The computer routines designed to fit the user's mission, function and environment.

Digital control for the Gigas-Zeiss orthoprojector

In support of the DMATC objective to use digital techniques wherever feasible, a digital control unit has been developed and installed on the Gigas-Zeiss orthoprojector (GZ-1). This new unit, built by Concord Control Inc., controls the operation of the orthoprojector by digital data stored on a magnetic tape, rather than the storage plates normally used in the LG-1 scanning unit. These tapes can be produced on any compatible stereoplotter and can be used directly in the production of digital contours.

Superimposing Stereo Viewer

A new instrument, the Superimposing Stereo Viewer (SSV), was developed by DMATC to improve the speed and accuracy of map revision from aerial photography.

The prototype SSV is mounted on the tracing table of a Kelsh-type stereoplotter and features straightforward optics with an ingenious arrangement for continuous conjugate distance adjustment. The SSV superimposes the map manuscript detail on the stereo-model, permitting simultaneous viewing of map and photographs.

Conversion from glass to film diapositives

Agencies in the United States are modifying stereoplotters to accept film in place of glass diapositives. This action follows the favourable results of an investigation of film *versus* glass as an emulsion base for diapositives.

In summary, the investigation included: measuring grid patterns of glass and film media on a comparator; bridging a five-model grid extension; and bridging an 18-model terrain extension on a stereoplanigraph, using both glass and film diapositives.

Four methods of holding film diapositives in projection plotters were investigated, and the problems induced by each method were considered. Theoretical studies of the film-holding methods (electrostatic, vacuum frame, glass sandwich and lamination) indicated that the vacuum frame is a safe and convenient method of holding film diapositives.

DMATC designed and built vacuum film-holders for the following equipment: UNAMACE; automatic point transfer instrument; multiscale point marker; and Kelsh-type stereoplotter.

Simultaneous analytical block triangulation

Two variations of a programme for simultaneous analytical block triangulation have been completed during the report period. The first is called Multiple Station Analytical Triangulation (MUSAT); and the second, expanded MUSAT. These rigorous least-square adjustment programmes represent an accumulative effort to develop a practical; unlimited version of a simultaneous block triangulation technique suited for production use. The expanded MUSAT programme features automatic error correction of photographic observations, blunder elimination, control verification, data edit, simultaneous triangulation and adjustment of up to 2,000 photographs, statistical analysis of results and error propagation. The programmes are coded in Fortran IV language to run on the IBM 7094 and UNIVAC 1108 computers.

In a recent test of the expanded MUSAT programme, a block of 1,000 fictitious photographs was computed. The block combined two strips of 500 photographs containing 68 complete control points, 1,000 exposure stations and 9,000 image points. Three iterations were performed, each requiring the simultaneous solution of 6,000 equations with 6,000 unknowns. The solution was completed in 57 minutes on the UNIVAC 1108 computer.

Digital topographic data collection system

In place of a single digital graphics recorder unit that was formerly used for digitizing topographic data, DMATC now has two complete digitizing systems. Called the "digital topographic data collection system", each system consists of the five digital graphics recording tables, five IBM Selectric typewriters, a plotter, a teletypewriter and a small computer assembly.

The digital topographic data collection system provides a unique solution to the problem of translating graphic information into digital computer language. Maps, photographs, instrument recordings and other graphical data can be converted to digital form and recorded in digital computer format. As the operator traces curved lines or selects discrete points with the freely moving stylus, the system automatically digitizes and records the path data or point locations. Auxiliary information, contour values, spot heights, etc., may be added at the control panel. Each digitized record of map data is held on a magnetic disc in temporary storage. When approximately 2,000 lines have been recorded, these are plotted back on the Calcomp plotter, checked, corrected if necessary and then transferred to magnetic tape. The system is primarily used in recording terrain data for the digital mapping programme. However, digital mapping is not limited to the storing of hypsographic data; eventually other symbolized information on the graphic map will be stored as digital data.

Some of the uses of digital maps are: (*a*) preconstruction planning of highways, utilities, canals, dams and reservoirs; (*b*) inundation and erosion analysis; (*c*) snow surveys; (*d*) high-speed, low-level flight planning; (*e*) line-of-site installation planning; (*f*) radar prediction; (*g*) military geographical information studies; (*h*) geological interpretation; and (*i*) automatic terrain model production.

SATELLITE RESOURCES INVENTORY

First Earth Resources Technology Satellite

On 23 July 1972, the first Earth Resources Technology Satellite (ERTS-1) was successfully launched into orbit. The mission objective was to provide for acquisition of high-resolution multispectral data of the earth on a global basis. The satellite carried two sensor systems for that purpose: the three-camera Return Beam Vidicon (RVB) system; and the Multispectral Scanner (MSS) system. Image data are telemetered to receiving stations of the National Aeronautical and Space Administration (NASA) and forwarded to Goddard Space Flight Center for processing. Two basis products—bulk imagery and precision imagery—are reconstituted from the data. Since there are three RBV spectral bands and four MSS bands, a variety of image forms can be produced for any one scene. Visual examinations of samples of both kinds of images indicate that MSS bulk imagery has better non-geometric image quality with respect to spectral consistency and object detectability; however, it lack the geometric properties exhibited by the precision processed products and the RBV bulk imagery.

ERTS-1 is scheduled to remain in orbit for one yea but its effective life may be much longer. Repetitiv sensor coverage of the earth (except for a small circula area at each Pole) is completed every 18 days, providin continuous up-to-date data in a form for cartographi expression at 1:1,000,000 scale. To evaluate the carto graphic potential of the imagery, the United State Department of the Interior, through the Earth Re sources Observation Systems (EROS) programme, ha developed a number of experiments, such as phot mapping of the United States, interpretation of cultu of map revision, basic thematic mapping, polar regio mapping and mapping from orbital data. Proposa involving the cartographic application of MSS image and photo mapping of foreign countries are being nego tiated.

The first cartographic products from ERTS images a false-colour lithographed photo-images at 1:1,000,00 scale with a UTM grid superimposed. Though not trul maps, these photo-images contain much useful informa tion which can be correlated with medium- or smal scale line maps of the same area by means of a commo reference grid. Similar cartographic products on scale as large as 1:500,000, possibly 1:250,000, can also b prepared from ERTS imagery.

Data bank of space-photo control

Photographic control points in the 50 states of th United States, Guam and in American Samoa wer selected for a data bank for use in locating and positio ing ERTS imagery. Each point in a state has a uniqu number, geodetic co-ordinates, elevation and descrip tors, which are recorded on a standard 80-colum punched card. In addition, each point is circled on 1:250,000 scale map. The control is retrievable by are state or 1° × 2° map blocks. A computer programm reads the data-bank cards, converts the co-ordinates t UTM grid values if required and generates commands t plot the points on transparent paper at 1:250,000 scale i map format. The transparencies can be easily repro duced for users who wish to mark the points on 1:250,000 scale map.

Autographic Theme Extraction system

The Autographic Theme Extraction (ATE) syste was developed to provide a binary representation of subject or theme. The product depicting an isolate subject retains the precise geometry and resolutio spectral signature with respect to its surroundings, s that semi-automated processes rather than human inter pretation can isolate the theme on the basis of hue an density differences.

The ATE system was scheduled to be in operation b 1973. The RBV cameras and multispectral scanner o ERTS will provide the basic inputs to the system Th initial experimental effort will concentrate on mappin the following basic themes: (*a*) open water; (*b*) snow an ice; (*c*) infra-red-reflection vegetation; and (*d*) masse works of man.

EROS Data Center

The EROS Data Center, at Sioux Falls, South Da kota, is operated for the EROS programme to provid

ERTS imagery, aerial photography and NASA aircraft data for the general public, government agencies at all levels and foreign Governments. Facilities are available for storage, retrieval reproduction and dissemination, and for user assistance and training.

The ERTS-1 and the scheduled ERTS-B will be the first major sources of data. The satellites carrying photographic and remote-sensoring equipment will return several coverages (10,000 square nautical miles per scene imaged) annually of a wide variety of land and water features of the United States. Repetitive images provide the opportunity to monitor natural resources and changing environments.

Imagery browse films (16 mm) are available for purchase. They are designed to provide pre-purchase evaluation of aerial coverage, cloud cover and sensor angle. ERTS-1 imagery browse films are updated regularly (every 18 days) and can be acquired on a subscription basis. All products of the EROS Data Center are for sale, and price lists are available on request.[4]

Land use

The Geographic Applications Program of the United States Geological Survey focuses on land-use analysis and mapping. The programme includes an automated information system for land-use and environmental data from various sources, but principally from remote-sensor imagery received from high-altitude aircraft and ERTS.

USGS recently published a description of a two-level land-use classification system.[5] The system is being tested in several research projects and promises to be of great value to planners at the federal, regional and state levels of government. It can be refined for local planning needs.

Two current research projects of the Geographic Applications Program involving land use and changes in land use are the Central Atlantic Regional Ecological Test Site (CARETS) project; and the Phoenix, Arizona, quadrangle project, which includes a large area of Arizona. The CARETS project covers the region of the Chesapeake and Delaware Bays, as well as urbanized areas, and will serve as a model of an integrated regional land-use information system. The project will encompass both inventorying of the land resources base and monitoring of land-use changes along with environmental effects.

The Phoenix investigations test the feasibility of mapping land use on the scale 1:250,000; of using computerized techniques for updating the information and of relating land use to other environmental and socio-economic factors. A land-use data bank for the Phoenix quadrangle has been prepared; and a map of detected land-use changes for the period from November 1970 to February 1972 has been produced, utilizing data interpreted from remote-sensor imagery.

A land-use analysis project currently under way in the geography programme is the census cities project, which uses multispectral photography acquired for a rank-size sample of 26 selected urban areas in the United States at the time of the 1970 census. The data are being used for standardized measurement and comparison of land use in urbanized areas. Other photography, requested in 1972, along with ERTS-1 satellite imagery, will provide a basis for analysing gross land-use changes. Work is under way at eight of the 26 urban test sites: Boston, Massachusetts; New Haven, Connecticut; Cedar Rapids, Iowa; San Francisco, California; Pontiac, Michigan; Washington, D.C.; and Phoenix and Tucson, Arizona. The urban change detection and analysis of land use at the time of the 1970 census have been completed for five of the test sites. Controlled and gridded photo mosaics have been prepared for all of the test sites. These photo mosaics, the land-use information and the corresponding census statistical areas for the test sites will ultimately be combined as elements comprising a prototype loose-leaf atlas of urban and regional change. During 1971–1972, prototype atlas sheets were prepared for Washington, D.C.; and San Francisco; and experimental computerized land-use maps using 1970 census and other data were also made for Boston and Cedar Rapids.

National Atlas of the United States

Based on a recommendation of the National Academy of Sciences, USGS began in 1963 the preparation of the National Atlas of the United States of America. Its publication in 1971 culminated eight years of planning and co-operation involving more than 80 federal agencies and bureaux, non-governmental organizations, commercial firms, specialists and consultants.

The National Atlas is designed to be of practical use to decision-makers in government and business, planners, research scholars and others needing to visualize country-wide distributional patterns and relationships between environmental phenomena and human activities.[6]

A hard-bound volume, the atlas measures 19 × 14 inches (483 × 356 mm) closed, weighs 14 pounds (6.5 kg) and contains a total of 430 pages, including 355 map pages and an 82-page index. The 765 multicoloured maps are presented in two broad divisions, general reference maps and special-subject maps.

To continue to meet objectives of the atlas, individual sheets will be prepared as new information becomes available. Current plans call for periodical publication of completely revised editions of the atlas.

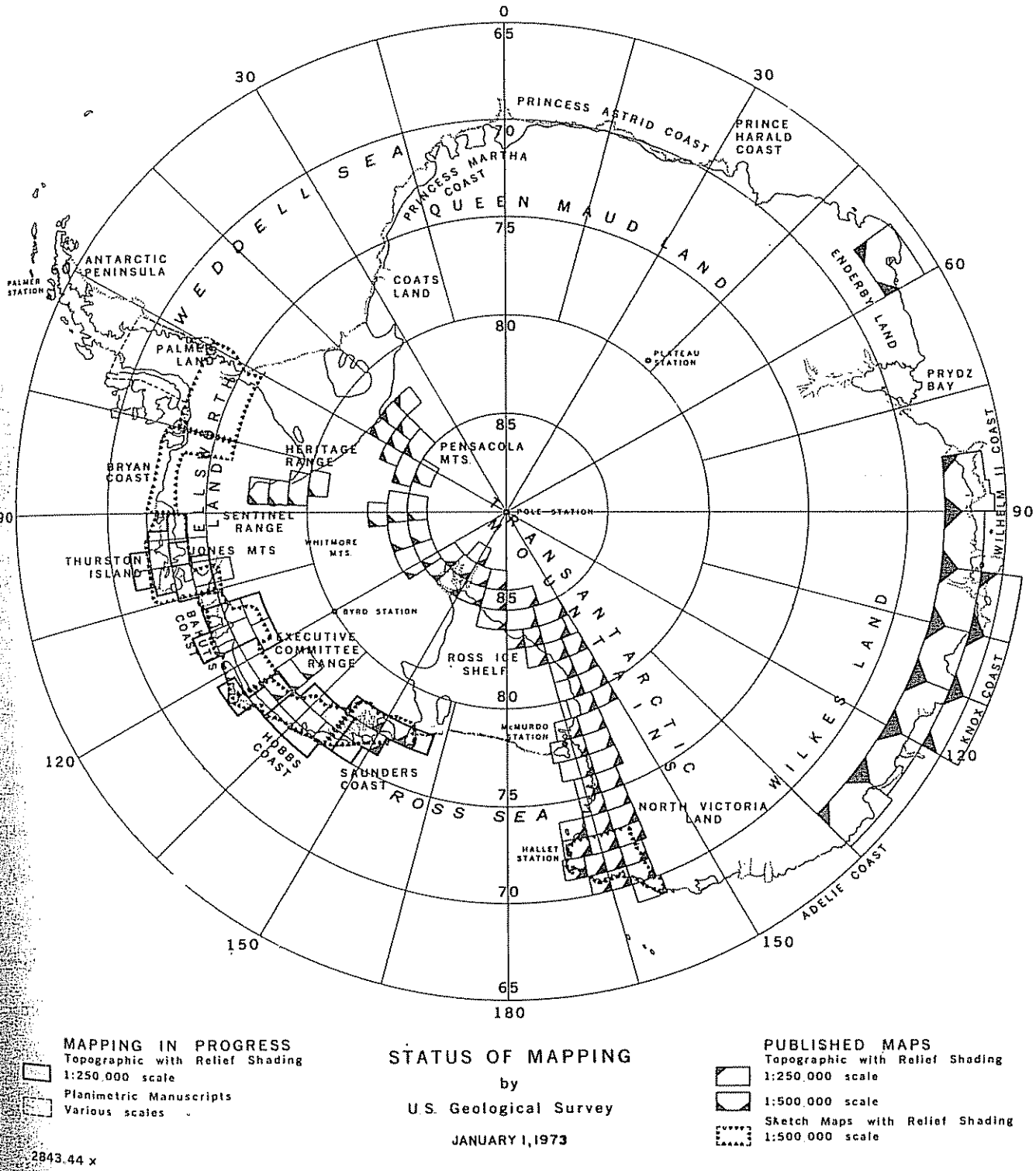
Antarctica mapping

The United States Antarctic Research Program (USARP), which is administered and funded by the National Science Foundation, is the mechanism by which the United States participates with 11 other signatory nations of the Antarctic Treaty in a co-operative scientific research, map and study effort of Antarctica. Topographic maps, sketch maps and orthophoto maps of Antarctica are compiled by the Topographic Division of USGS. For the past 16 years, the Topographic Division has annually assigned from four to eight men to Antarctica in support of compilation of these products.

[4] Address inquiries to EROS Data Center, Data Management Center, Sioux Falls, South Dakota 57198, United States of America.

[5] United States Geological Survey, *A Land-Use Classification System for Use with Remote Sensor Data*, circular No. 671 (Washington, D.C.)

[6] The National Atlas of the United States may be ordered from: Distribution Section, United States Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202, United States of America. The price per volume is $US 100. On orders of 25 or more copies, a 25 per cent discount is allowed. Prepayment is required, and cheques or money orders should be made payable to the United States Geological Survey. Individual pages of the National Atlas are available at prices ranging from $US 1.00 to $US 1.75. A listing of separate sheets is available upon request.



Note: Boundaries and names appearing in this figure are not authoritative.

Figure 44. United States of America: status of mapping of Antarctica as of 1 January 1973

CARTOGRAPHIC ACTIVITIES OF THE INSTITUT GÉOGRAPHIQUE OF ZAIRE, FROM 1966 TO THIRD QUARTER OF 1973*

Paper presented by Zaire

The cartographic work done in Zaire between 1966 and 1971 was the subject of a report submitted to the Third United Nations Regional Cartographic Conference for Africa, held at Addis Ababa, 30 October–10 November 1972.[1]

The present report covers the period from 1966 to the third quarter of 1973. During that period, the rapid development of industrialization (expansion of urban areas) and growth of the inventory of natural resources in Zaire led to an increased need for maps at various scales. Beginning in 1971, therefore, the Institut géographique of Zaire began a new programme of activities in keeping with the current objectives of the National Executive Council. These objectives relate to the development of three economic growth centres, one each in the western, north-eastern and south-eastern regions of the country.

AERIAL PHOTOGRAPHY

Thus far, 85 per cent of Zaire has been covered from the air. The coverage was made for photogrammetric purposes with a view to the production of topographic maps and of some special thematic maps essential to the conception and execution of investment projects.

Despite the serious problem of almost continuously unfavourable atmospheric conditions in some regions of the country, aerial coverage progressed satisfactorily.

Systematic work

An area of 240,000 km² was photographed on the scale 1:40,000 in the regions of Kinshasa Bas-Zaire, Haut-Zaire, Kivu and Shaba.

Special work

A number of special surveys were also carried out on various scales between 1:7,000 and 1:20,000. Mention should be made, in particular, of the surveys of the following areas:

(*a*) Kinshasa-N'djili: for the location of water-purification and tyre-manufacturing plants;

(*b*) Kinshasa-Kimpoko-Malaku: for the location of the iron and steel works;

(*c*) Kinshasa-Plateau des Bateke: for rural development;

(*d*) Shaba Ocean: for the study of the railway;

(*e*) Kinshasa-Nsele: for the development of the telecommunications network (ground station, axis of the radio relay network);

(*f*) Busanga: for a dam project;

(*g*) Banana Bas-Zaire: for a study for the port;

(*h*) Inga-Banana: for the study of the railway and high-tension-line project;

(*i*) Atlantic coast: for a study in preparation for the extension of the town of Moanda in conjunction with the development of the port of Banana;

(*j*) Lake Fwa and Mukamba: for tourism facilities;

(*k*) Haut-Zaire: for geological prospecting;

(*l*) Shaba: for the study of a bridge over the Lukuga River;

(*m*) Kinshasa-Maluku: for the study of a railway joining Kinshasa, N'djili and Maluku;

(*m*) Shaba: for urban facilities

GROUND OPERATIONS

The ground teams operating in the economic development areas are engaged in setting up and extending the triangulation net in preparation for systematic topographic mapping.

There are altogether eight teams working on the ground: four topographic teams; two geometric-levelling teams; and two field-astronomy teams. They are distributed as follows:

(*a*) Topographic team No. 1 (Pool 1—Kinshasa) is doing stereographic ground control work for 1:50,000 scale mapping of the Madimba, Kasangulu, Luozi, Mbanza-Ngungu, Tshela and Lukula blocks;

(*b*) Topographic team No. 2 (Pool 2—Shaba) is continuing the ground control in the Kolwezi-Likasi-Lukafu block;

(*c*) Topographic team No. 3 (Pool 3—Haut-Zaire) is working on a ground control in preparation for the extension and completion of the Kisangani local triangulation;

(*d*) Topographic team No. 4 (Pool 1—Kinshasa), which has just been set up, has been assigned the task of extending the triangulation net from Kimpoko towards Maluku and of doing the ground control stereographic work for the study of the route for a railway to link the Maluku iron and steel works with Kinshasa;

(*e*) Astronomy team No. 1 is working in the Kasai region on the fixing of astronomical points;

(*f*) Astronomy team No. 2 (Pool 3—Haut-Zaire) has been assigned the task of fixing astronomical points in the Lubero-Lubutu-Beni region for an astronomical triangulation required for geological prospecting;

(*g*) Levelling team No. 1 (Pool 2—Shaba) is working on a first-order triangulation in the Shaba region;

(*h*) Levelling team No. 2 is working on a first-order triangulation in the Bandundu region.

The following elements were added to the triangulation network of Zaire in 1973: 1,826 control points; 42 new astronomical points; 350 barometric levelling points; a number of levelling chains with a total length of over 5,000 km.

CALCULATIONS

The main calculation work was the general readjustment of the horizontal control network within the continental system of the 30° meridian arc. This work

*The original text of this paper, submitted in French, appeared as document E/CONF 62/L. 121.

[1] "Report of the cartographic activities of the Institut géographique of Zaire, 1966 to 1971" (E/CN 14/CART/330)

was held up by the relatively large volume of work required for calculating cartographic co-ordinates. Nevertheless, both this programme and the programme relating to the work on precision-levelling lines are now continuing.

After adjustment of the 6° south arc, work was begun on the adjustment of the major basic regional networks, with the exception of the Shaba network. The Shaba adjustment currently in progress will include the adjustment of the Fort Rosebery loop in Zambia and will require the solution of a system of 800 conditional equations.

In 1967, the primary undertaking was the adjustment of the so-called "Popokabaka loop" (Bas Zaire—Kwango), which is connected to the 6° south arc and includes a significant part of the 6° south chain in Angola.

Mention should also be made of a preliminary study of tectonic movements in the Kasai region.

Publications

A 144-page brochure entitled *Le Canevas Planimétrique du Kivu-Maniema—ajustement et résultats* was published in 1968. A 94-page brochure, *Canevas altimétrique de Kinshasa,* was published in 1969. Three publications are currently being prepared and will appear shortly; these are sections 30 and 31 of the general levelling, relating to the Bena Dibele-Dibaya and Dibaya-Kabindi-Penge axes.

The Bandundu brochure of the regional control network has been completed, as has the brochure dealing with the Kimpoko regional control network.

Cartography

The national base map is a 1:50,000 scale topographic map prepared from aerial photographs. All other, small-scale maps are derived from the base map series.

The current status of cartography in Zaire is as follows:

(*a*) Standard topographic sheets from aerial surveys, showing relief, 6 per cent;

(*b*) Semi-standard topographic sheets from ground surveys, showing relief, 4.5 per cent;

(*c*) Standard or simplified planimetric sheets from aerial surveys, no relief shown, 72.5 per cent;

(*d*) Provisional planimetric sheets (reconnaissance maps), no relief shown, 17 per cent.

This situation shows clearly how much work still remains to be done.

During the period under review, work continued on the preparation of both ordinary and special topographic and planimetric maps. It should be mentioned that since 1970, the Government's policy of economic and social development and the consequent increase in public and private investments have caused a considerable increase in the demand for cartographic documents. For this reason, many specialized maps on various scales were prepared, often to the detriment of regular systematic cartographic work, in order to meet the pressing needs of a number of investment programmes. Several thousand square kilometres were covered for this purpose.

Plans on the scale 1:10,000 were prepared and published for the main towns of Zaire as follows: Kinshasa in 8 sheets; Kalemie in 2 sheets; Likasi in 5 sheets; Mbandaka in 1 sheet; Kolwezi in 6 sheets; Lubumbashi in 6 sheets; Matadi in 1 sheet; Boma in 1 sheet.

It should also be mentioned that the Cartographic Service is now using the scribing process for map-making. The Institut géographique of Zaire hopes that this new technique will increase output and improve the quality of drafting.

Atlas

The Institut géographique is working on the compilation of an atlas of Kinshasa, with the assistance of the Mission française d'urbanisme.

Reproduction and printing

All maps are printed at the Institut géographique of Zaire. Ozalid copies of documents that have been completed, but not published, are available upon request.

Training

The Institut géographique of Zaire believes that the training of personnel is a prime need. Since 1972, it has devised a topography training programme.

The first graduating class consisted of eight students. It is worth noting that two students subsequently passed the entrance examination for the Ecole nationale des sciences géographiques of the Institut géographique national in Paris.

REPORT OF THE *AD HOC* GROUP OF EXPERTS ON PROJECTIONS AND PLANNING IN CARTOGRAPHY FOR THE SECOND UNITED NATIONS DEVELOPMENT DECADE*

Paper prepared by the United Nations Secretariat

The *Ad Hoc* Group of Experts on Projections and Planning in Cartography for the Second United Nations Development Decade was convened at United Nations Headquarters from 8 to 19 November 1971, in pursuance of Economic and Social Council resolutions 345 (XII) and 1079 (XXXIX).

The Group was composed of six experts, namely: B. P. Lambert (Australia), G. Larssen (Sweden), J. O. Phillips (United States of America), N. K. Sen (India), J. I. Thompson (Canada) and J. A. Villasana (Mexico). The Group elected J. I. Thompson as Chairman and B. P. Lambert as Rapporteur. C. N. Christopher of the United Nations Secretariat acted as Secretary for the meeting and F. L. Petrie, also of the Secretariat, at-

* The original text of this paper appeared as document E/CONF.62/L.5.

tended the meeting as consultant on United Nations technical assistance activities.

The task assigned to the Group included: (*a*) advising on planning and projections of United Nations action in cartography for the Second United Nations Development Decade and beyond; and (*b*) finding ways to stimulate national efforts in surveying and mapping for economic and social development in general. The Group was asked to pay particular attention to the needs of developing countries and to prepare recommendations that would stimulate policy-makers and planning officials to pay due attention to the importance of cartography to most activities of modern nations.

To facilitate the achievement of the objectives set out for the meeting of the Group, particularly with respect to policy-makers at high level, who are not necessarily concerned with all technical details, the present report is composed of two parts: the first is devoted to conclusions and recommendations of general concern; and the second contains detailed consideration of such items as the need for maps by the developing countries. Maps provide the indispensable basis for planning activities in the field of cartography: international cartography, with particular reference to the Cartography Section of the Department of Economic and Social Affairs, which is the substantive office concerned with the question of international co-operation in cartography and related matters; national cartography, with respect to problems encountered in developing areas and measures to deal with them; and modern cartographic practices which open many new avenues for more efficient techniques.

The recommendations set out in this report refer not only to the future work of the United Nations, but to activities of other appropriate bodies, both national and international, for action.

Report and conclusions

In dealing with the task allotted to it, the Group first gave consideration to *Modern Cartography: Base Maps for World Needs*,[1] which reports on the work of the Committee of Experts on Cartography, which met at Lake Success, New York, in 1949, at the invitation of the Secretary-General of the United Nations, to lay out an initial basis for the work of the world body in the field of cartography. The *Ad Hoc* Group of Experts reached a general conclusion that the intervening years had proved the recommendations of the Committee to be well-founded and worthy of continued forceful implementation.

Consideration was next given to the cartographic needs of developing countries, beginning with a review of the status of world mapping. In this connexion, the Group also examined questions relating to the need for geodetic control and the permanent marking of survey stations, the need to map coastal zones, the desirability of a sound cadastral survey system, the current and future importance of urban mapping, the role of cartography for resources studies and the role of national and regional atlases.

With respect to topographic mapping, the Group took note of a recent United Nations report[2] that substantial progress had been made but observed that very much more remains to be done.

In respect of cadastral and urban mapping, the Group found that there was much valuable basic data for their considerations in a recent article concerning land registration in developing countries.[3]

With respect to hydrographic surveying and bathymetric mapping, the Group noted that the report of the *Ad Hoc* Group of Experts on Hydrographic Surveying and Bathymetric Charting (E/CONF.57/L.1) adequately covered the subject.

In considering resources mapping, a first-hand report was given of the combined topographic and resources mapping operations in Mexico and some account was taken of the work on physical resources investigation for development as undertaken and reported on by the Organization of American States.[4]

In addition, the Group considered the United Nations publication, *Towards Accelerated Development. Proposals for the Second United Nations Development Decade*,[5] which provided a wider picture of the important proposals relating to the 1970s which the General Assembly intended to launch as the Second United Nations Development Decade.

The Group paid special attention to problems encountered by developing countries in meeting their cartographic needs, as such problems must be taken into account in formulating realistic policies and programmes for action. The Group studied institutional problems, such as problems of personnel, equipment, financial resources and appreciation of cartography by decision-makers at higher levels; and technical problems, including the transfer of techniques and the dissemination of information. It also studied remedial measures advocated, including the strengthening of the technical capacity of national cartographic services, particularly in developing areas; the promotion of cartographic research and development, the improvement of communications between cartographic management and the higher levels of national administration for the purpose of stimulating appropriate appreciation of the usefulness of mapping, a more efficient local regional approach to mapping; and an intensification of international co-operation in cartography, including the exploration of new avenues of co-operation. The Group observed that the United Nations Secretariat had in the previous 20 years contributed significantly to the solution of problems and could advantageously continue to do so in the future. The Group also stated that future development programmes would increasingly be linked with the concept of United Nations development decades and stressed the responsibility of map-makers to make known their views and suggestions to planning bodies.

The Group made an assessment of modern cartographic practices upon which efficient and economical cartographic work depended. The practices reviewed included: (*a*) geodetic control techniques, with particular stress on the current and future value of Doppler satellite techniques for geodetic positioning; on the desirability of establishing a uniform world geodetic datum; on the ease of completing a national levelling survey with modern equipment and on the possibility of extending height control with airborne profiling equipment; (*b*) photo-

[1] United Nations publication, Sales No. 49.I.19.

[2] "The status of world topographic mapping", *World Cartography*, vol. X (United Nations publication, Sales No. E.70.I.4), pp. 1-96.

[3] G. Larsson. "Land registration in developing countries", *World Cartography*, vol. XI (United Nations publication, Sales No. E.71.I.6), pp. 33-67.

[4] Organization of American States, *Physical Resources Investigations for Economic Development* (1969).

[5] United Nations publication, Sales No. E.70.II.A.2.

grammetric techniques, such as the use of super-wide-angle photographs, the potential of large block adjustment, the possibility of orthophoto maps for rapid mapping operations and the usefulness of side-looking airborne radar (SLAR) for mapping areas that are continuously cloud-covered; and (*c*) modern map production techniques together with the need to plan new cartographic procedures compatible with those techniques. In connexion with the last item, the Group took note of the advantages of adopting uniform standards and urged appropriate parties to encourage international organizations to standardize cartographic practices.

With respect to new methods still in the development stage, the likelihood of useful mapping assistance from satellite-borne remote sensors was discussed. The Group observed that the whole subject of remote sensing, either from conventional aircraft or from spacecraft, was seen to carry exciting, but as yet unproved, possibilities for cartography. Similarly, the review of electronic data-processing and automation techniques indicated that while tremendous advances had been made in computation techniques, automated cartography was a long way from becoming a routine civilian mapping agency operation. Eventually, however, application was expected.

As one of its main objectives, the Group made a careful study of United Nations activities connected with international co-operation in cartography. The Group considered a number of papers covering the establishment of the work and current and future activities, particularly in connexion with regional cartographic conferences, seminars and other *ad hoc* multinational meetings; technical assistance and publications on cartography. It also considered the function of the Central Bureau of the International Map of the World on the Millionth Scale (IMW) and the standardization of geographical names and its projected work programme. Included also were intended research studies on the world status of various forms of mapping, on new technologies in cartography, uniform standards in surveying and mapping, the establishment of a uniform world geodetic datum, standard map scales and map indexing systems, and the application of satellite technology to the cartography of natural resources. Of special importance was information on a new concept of Special Natural Resources Advisory Services which offered a unique opportunity for international assistance in cartographic projects.

International co-operation in cartography in the United Nations had five major objectives in the stimulation and acceleration of cartographic work throughout the world, namely: (1) to stimulate international co-operation in cartography by arranging and servicing international and interregional conferences; (2) to provide substantive assistance for implementing modern surveying and mapping techniques in developing countries through United Nations technical assistance activities; (3) to diffuse technical knowledge gained through international seminars and training projects; (4) to conduct studies and research for assessing world cartographic needs; and (5) to evaluate new technology in surveying and mapping for developing countries. The legal bases for the programmes in international co-operation in cartography were contained in various resolutions adopted by the Economic and Social Council of the United Nations since 1949.

On the basis of the background studies mentioned above and of the consideration of relevant resolutions adopted by—and reports submitted to—recent regional cartographic conferences and other United Nations bodies, particularly the paper entitled "Base map for world needs" (E/C.7/5/Add.1) presented by the Secretary-General to the Committee on Natural Resources (February-March 1971),[6] which provided a useful summary of practically all matters studied at its meeting, the Group summarized its findings in general and technical conclusions together with specific recommendations, all intended to facilitate meeting world cartographic needs in the Second United Nations Development Decade. These findings are presented below under appropriate headings.

The Group pointed out that it, just as the Committee of Experts which met in 1949, could not foresee all future developments and therefore advised those responsible for future arrangements to retain a flexible approach and, as necessary, to fit even newer developments into the existing pattern.

Need for and value of cartographic work

In its report,[7] the Committee of Experts which met in 1949 dealt at some length with the need for maps. Since that time, there had built up a continuing history of projects, both national and international, in which the need for maps had been accepted and in which that provision had proved essential to the efficient planning and successful conclusion of the project. There was also a continuing history of the need for provision of topographic and bathymetric base maps prior to the exploration for, and exploitation of, mineral and other natural resources. They could be used just as effectively in the conservation of the environment and were continually used as a base for the presentation of statistical and administrative data. They were essential for planned urban development and provide an economically viable aid to land use in the assessment of governmental income from land. The need for accurate charts and accurately positioned navigation aids to assist air and sea transportation, especially with the increasing traffic and size of craft, was evident. Accurate maps of international land and sea borders, related preferably to a universally accepted World Geodetic Datum, would serve to eliminate misunderstandings in border areas and thereby help to achieve the peaceful objectives of the United Nations.

The Group observed that where no mapping existed, or where the programme moved too slowly, there was a tendency for planning and development agencies to arrange for the rapid production of reconnaissance type maps to meet their own particular requirements. This tendency emphasized the need for national programmes to provide an early coverage of this type of map and to eliminate the need for spasmodic, *ad hoc* coverage. In fact, experience had shown that the form of initial coverage would probably pay for itself as an aid to the detailed planning and implementation of the rest of the national programme.

The Group especially emphasized the need for countries to adopt and publicize over-all national mapping programmes covering first topographic and then thematic mapping, and to ensure that all project and development mapping and other surveys should fit into the pattern of this programme. The Group was of the opinion that when private firms or development agencies

[6] *Official Records of the Economic and Social Council, Fiftieth Session, Supplement No. 6* (E/4969).

[7] *Modern Cartography. Base Maps for World Needs.*

sought approval to search for mineral and other natural resources, there was a need for Governments to lay down conditions that required the attendant mapping activities to contribute to the national programme. Even if that contribution was over and above the immediate requirements of exploration, it could be regarded as a proper partial return for the rights given.

The ultimate objective, however, should be basic mapping coverage appropriate to the needs of individual countries and accomplished in a realistic time frame. In view of the coming development of more sophisticated navigational equipment and the ultimate likelihood of automated processing of geostatistical data, the objective should be to have all mapping referenced to a national geodetic datum; and, from the point of view of international co-operation and co-ordination, to have all national datums related to a mutually acceptable World Geodetic Datum.

The Group stressed the need for map-makers and, in particular, map users to clearly, positively—and, if necessary, regularly—bring to the notice of high policy decision-makers and planners the need for and the benefits that would flow from basic map coverage. Only when there was a thorough appreciation of the value of orderly mapping activities at national and international level would it be possible for the world and its countries, both developed and developing, properly to assess and manage world natural resources and the whole environment.

The Group observed that:

(*a*) The United Nations Economic and Social Council had continually supported the advancement of surveying and mapping in developing countries and the promotion and strengthening of international co-operation in cartography;

(*b*) Experience had shown that the resources of a country could not be revealed except by co-ordinated survey, and the potential characteristics of the earth's surface and subsurface could only be depicted through a proper cartographic presentation;

(*c*) In modern society, topographic mapping was an indispensable public service. The Group urged high-level policy-makers to realize that efficiency in planning and carrying out all kinds of economic and social development projects required one common, vital instrument for co-ordinating all phases of development in the early provision of adequate maps and charts.

In view of the fact that although substantial progress had been made since the world status of mapping had been reviewed in 1949, very much more remained to be done, the Group believed that under the impetus of the Second United Nations Development Decade and the surging interest in remote-sensing activities, there was a critical need for a world-wide accelerated programme of basic mapping.

To meet the immediate and long-term needs for cartographic work, the Group stressed the necessity of good management to provide an optimum solution. In fact, essential to the whole accelerated programme, were management systems at both national and international levels capable of recognizing needs, conducting research, implementing plans and supervising day-to-day operations.

International cartographic activities

Looking first at the management aspect of the United Nations, the Group was aware that the successful development of international cartography required very active co-operation between the United Nations and individual countries, and this awareness led it to make specific recommendations on regional conferences and seminars, the technical assistance programme of the United Nations Development Programme (UNDP), bilateral and multilateral schemes for cartographic assistance, and the United Nations Special Natural Resources Advisory Services. The Group was particularly concerned that regional conferences and seminars did not price themselves out of existence, but rather, that they be arranged along economical and effective lines of maximum benefit to the developing countries.

The Group took note of the fact that the Committee for Development Planning had earlier recommended a streamlining and strengthening of United Nations developmental activities in order to ensure implementation of the Second United Nations Development Decade and had advocated utilizing existing machinery to the utmost for the attainment of that objective, but warned that attendant budgetary and administrative consequences should be expected.

The Group considered the Economic and Social Council request to the Secretary-General to implement the resolutions of the fifth and sixth United Nations Regional Cartographic Conferences for Asia and the Far East, as appropriate, emphasized that speedy follow-up action by Governments should also be taken, and concluded that:

(*a*) Regional cartographic conferences should be held in the regions of the United Economic Commission for Africa (ECA) and of the United Nations Economic Commission for Asia and the Far East (ECAFE) at three-year intervals as advocated by those conferences;

(*b*) Annual reports of follow-up action after each conference should be published by the Governments concerned, and those reports should be distributed widely in the respective regions and to the United Nations.

The Group observed that interregional cartographic seminars had proved to be an efficient means to facilitate the exchange of technical information and experience and to foster international understanding and co-operation among national mapping agencies, and recommended that such seminars be given strong support by both the United Nations and the Governments. It further recommended that countries having excellent surveying and mapping capacity and experience should assist the United Nations in the organization and conduct of such seminars, including the provision of technical experts and host facilities as required.

The Group took note of the success of the current operational programme of the United Nations carried out through the UNDP technical assistance programme and concluded that the United Nations should continue to offer assistance in the form of expertise as required in all phases of cartographic activities, including the management of national mapping activities.

The Group took note of the success achieved by the existing bilateral and multilateral schemes for cartographic assistance and concluded that:

(*a*) Such assistance should be expanded by the United Nations and other bodies;

(*b*) Developing countries should seek out bilateral assistance in addition to the United Nations assistance, taking great care to work out co-ordinated programmes in order to avoid possible duplication. The Group

pected that such co-ordinated programmes would be e function of national mapping organizations.

The Group took note of the establishment by the nited Nations of Special Natural Resources Advisory ervices under Economic and Social Council resolutions 372 (L) and 1616 (LI), involving short-term tasks and ith the objectives of widening the range of technical rvices to developing countries, reducing problems of ecruitment and costs, transferring expertise between ountries with similar problems, broadening the experi- nce of the United Nations experts and creating further pportunities for technical co-operation; recognized the esirability of making this scheme succeed in the carto- raphic field; and concluded that countries, through their artographic services, should give full co-operation to his concept.

The Group recognized the desirability of ensuring the ffectiveness of cartographic assistance programmes and oncluded that United Nations inspections of cartogra- hic assistance projects should be carried out annually y highly qualified experts who could make a thorough ssessment of the technical and managerial aspects of the mplementation of the project and make appropriate ecommendations for post-project technical evaluations. It further concluded that when preparing plans for United Nations cartographic assistance projects, both the Government concerned and the United Nations should make provision for follow-up technical field evaluations with a view to assessing the continuing effectiveness of the projects.

United Nations Secretariat

The Group concluded that the United Nations Secretariat had followed a vigorous and well-planned programme of work along the lines recommended by the Committee of Experts meeting in 1949, and that it had done much to improve international cartographic activity and, in particular, to help meet the mapping needs of developing areas. Perhaps the original recommendations for the setting-up of a panel of experts could have been implemented, but the Group observed that that could merge into the recent United Nations proposal for Special National Resources Advisory Services and believed that those Services would also provide an avenue for worth-while cartographic assistance to developing countries.

The Group recognized that in view of the wide variety of development projects sponsored by the United Nations and its specialized agencies, requiring cartographic services, it was inevitable that duplication of effort and waste of scarce resources in this field can occur if appropriate co-ordination is not carried out. It concluded that regular meetings of United Nations agencies should be scheduled in order to improve the economy and efficiency of future technical assistance in cartography, including aerial photography.

The Group recognized the value of preparing up-to-date statistics on world cartography for developed countries desirous of rendering assistance to developing countries and for developing countries in assessing their national mapping progress, and concluded that:

(*a*) A periodic review should be made every five years by the United Nations on the status of topographic mapping and should be published in the *World Cartography Bulletin*;

(*b*) Periodic reviews should also be made for other subjects in cartography, such as geodesy, cadastral surveying and mapping, and related fields in succeeding years.

Standardization of geographical names

The Group recognized that the standardization of geographical names at both the national and the international level was one of the important problems faced by map-makers in efforts to update and improve the effectiveness of maps and that the practical work to be carried out by agencies on geographical names was a long-term undertaking. The Group therefore concluded that a five-year interval between international conferences on the subject would be adequate to discuss progress made, provided that the meetings of the Group of Experts on Geographical Names took place periodically between the conferences in order to deal with special problems which might require preparatory studies to facilitate agreement at the conferences.

Co-operation in satellite geodesy

The Group took note of recent developments in satellite geodesy, progress made in the World-wide Geometric Satellite Programme and the proved ease and capability of determining the co-ordinates of geodetic stations by the Doppler method of satellite observations. It therefore recommended that: (*a*) the United Nations should consider favourably the acceptance of a Unified World Geodetic Datum to which national datums might be referenced for the purpose of solving a number of world-wide problems, such as navigation, seaward boundaries and coastal zone developments; (*b*) geodetic and mapping control should be extended from this datum by modern ground and aerial survey methods supplemented by satellite observations; and (*c*) the United Nations should encourage the continuation of the current Doppler satellite system and take action to ensure that monitoring of geodetic and navigational satellite orbits should be continued and extended and that the resultant information should be made available to all users.

The Group recognized that position determination by satellite techniques could be undertaken by small, mobile and suitably equipped parties supported by the local provision of transportation and other logistic support. It further recommended that those countries and agencies which could do so should render assistance to the developing countries in the form of satellite Doppler observations for geodetic positioning.

Technical training

The Group recognized that the training of technical staff remained an urgent and primary task of developing countries and advised that assistance should be provided in building up cartographic training and research organization in developing countries, that cartographic operational and training institutes in developed countries should enlarge facilities to provide for training personnel from developing countries; and that developing countries should confer themselves and exchange visits of experts with a view to both disseminating and gaining knowledge of equipment, techniques and training. The United Nations regional cartographic conferences, seminars and meetings of international geodetic and cartographic associations offered opportunities for such training and exchanges of information.

The Group observed that a lack of appropriate facilities for training technical staff in surveying and mapping

remained a critical problem in developing countries. National cartographic services had a pressing need for adequately trained personnel at all levels, including the management level. On the basis of personal experience of all participants in the meeting, the Group was aware of cartographic courses and training assistance schemes available at various centres throughout the world, but was of the opinion that detailed information on all such courses and schemes was not readily assembled. The Group concluded that a special effort should be made to fill the gap. The Group therefore recommended that: (*a*) the United Nations should undertake a world-wide survey of existing national training facilities in all cartographic techniques which could be made available to alien trainees and should make the results of this survey available to interested bodies; and (*b*) countries offering such facilities should supply full details on their programmes and registration requirements.

The Group further recommended that information obtained in this survey should be used to facilitate the study of the establishment of regional or subregional centres for training.

Taking a lead from the Committee for Development Planning of the United Nations, the Group advised that the developed countries, the more advanced developing countries and international technical and professional associations should deliberately devote parts of their research activities towards the development of equipment and techniques that would be of practical assistance to developing countries. In doing so, however, care should be taken to ensure that inappropriate technologies should not be forced on developing countries.

National cartography

Dealing with management aspects of national cartography, the Group stressed, first of all, the necessity for competent national cartographic centres. As cartographic products were indispensable to good government and national development, the Group recommended that: (*a*) countries which did not already have national cartographic centres should make special efforts to establish them; (*b*) where national cartographic services existed, they should be examined in the content of the development needs of the country and strengthened where necessary; and (*c*) the United Nations should give priority to requests for assistance in such undertakings.

The Group further stressed the necessity for properly phased over-all national mapping programmes which should be planned and directed to provide a maximum of assistance in solving critical economic and social problems. In particular, developing countries should set out details of their national mapping plans so that proposals for various forms of assistance in natural resources fields could be geared to the national plan. Successive stages of development might, with advantage, be geared to successive United Nations development decades, as they would certainly be required to provide supporting services to other developmental field activities planned for the decades.

The Group, recognizing that in order to be effective a national mapping programme should normally have as its objective the basic coverage of a country in a 10 to 15-year interval as appropriate, recommended that map scales should be selected and funds, manpower and equipment applied generally to meet that concept.

The Group recognized that an integrated approach to national cartographic problems promoted economy and efficiency and therefore recommended that: (*a*) nati mapping programmes should provide an integ approach covering planning, geodetic control sur aerial surveys, aerial photo-interpretation; and compilation, production and distribution in all typ mapping activity, including topographic, cadastral ban, thematic and bathymetric mapping, and hydro phic and aeronautical charting; (*b*) the national map organizations of developing countries should at institute well-ordered manual systems of cartogra records from which information could be made avail quickly and easily and which could readily be ph into automated data systems as and when appropri

The Group advised that consideration should be gi to the co-ordination of topographic and resource surv by the use of simultaneous black-and-white air phot raphy and colour air photography and by organizing resources surveys immediately to follow the topograp mapping operations (orthophoto maps might provic most useful base).

In connexion with topographic mapping, the Gro stressed one particular aspect that while the finan resources of a developing country might admittedly meagre, it was false economy to delay the developm of some form of topographic mapping programme.

The Group stressed that cadastral and urban surv were essential national activities that would lead to early return for funds expended and that they should integrated into national cartographic activities and th data be substantially monumented and adequately doc mented. The Group also recognized the potential cap ity of land and the fact that it was the basis of all futu development. It recommended that: (*a*) cadastral surve ing and land registration should be given a high prior in the development of any country; (*b*) a multipurpo system should be adopted covering a fiscal cadastre a registration, backed by appropriate legislation and bas on a sound but simple survey system. The Group too note of the large increase in urban population in ma areas, considering that as a result the need for urb mapping and development was critical; and recor mended that one of the main objectives of cartograph activity for the next decade should be urban mappir appropriately combined with cadastral mapping an properly referenced to geodetic control.

With respect to bathymetric mapping, the Grou recognizing its importance to economic developmer and supporting the recommendations in the report of th *Ad Hoc* Group of Experts on Hydrographic Surveyin and Bathymetric Charting (E/CONF 57/L 1), recom mended that: (*a*) bathymetric mapping of the conti nental shelves should be expedited; and (*b*) coastal bas lines and national seaward boundary lines should b determined on a World Datum and be widely published.

Modern cartographic practices

The Group stressed that in order to stimulate progres in cartography throughout the world as efficiently and quickly as practicable, it was most desirable that coun tries developing and making use of new techniques should thoroughly assess them and widely circulate timely, factual reports on techniques of value to others.

To those who might be given responsibility for the development and/or the expansion of national carto-graphic organizations, the Group suggested that careful consideration be given to such reports and the techniques of the most advanced organizations in the field.

he most appropriate facets of these reports and practices should be combined to suit local circumstances and hen incorporated into future cartographic programmes.

Mapping by photogrammetric methods

The Group took note of recent operational trends in photogrammetry which had led to improvements in all stages from aerial triangulation to map compilation. It therefore recommended that: (*a*) analytical aerial triangulation should be considered a practical means of obtaining model control referenced to national geodetic control; (*b*) where possible, super-wide-angle photography should be used for photogrammetric purposes; and (*c*) developing countries should consider the use of photo maps as a provisional substitute for conventional line maps in order to provide users with a working tool in less time and at low cost.

Spaceborne remote-sensing techniques and automation techniques

The Group considered that the spaceborne remote-sensing techniques soon to be tested were likely to go through an assessment and development during the current decade; and, if proved successful, would come into regular application in the next decade. It also was of the opinion that much the same situation existed in the development of automatic cartographic processes. However, the Group considered that cartographic management should actively participate in the testing and development of those techniques which might have enormous potential for the gathering and presentation of cartographic data.

It again stressed that the imminence of those new techniques was a very patent reason for speeding up basic national mapping programmes to the stage where they could provide, in anticipation, a permanent geodetic and cartographic reference base.

The Group affirmed that the development and management of a country could be regarded as a huge project and that the need for the early provision of national map coverage was essential to the major project that constituted the good government of a country, just as the early provision of maps had been shown to be essential and beneficial for specific projects. Mapping was one of the most important tasks that should be undertaken in the Second United Nations Development Decade, and the resultant maps and charts would provide a basic instrument for co-ordinating all phases of investigation, planning and development.

Cartographic needs of developing countries

Without question, maps form the basis for the systematic identification and exploitation of resources and are essential for the orderly economic development of a country, especially for developing countries. It is on maps that the data pertinent to natural and human resources are assembled in order to visualize their interrelationships, to assess needs and to plan future action.

The principal assets of the developing countries are human and natural resources, but these resources can only be utilized if they are identified and exploited. The essential prerequisites in their utilization are:

(*a*) Rapid, but stage-by-stage, development of national technological advancement in order to help the acquisition of knowledge about natural resources;

(*b*) Indigenous growth of management expertise for the optimum exploitation and utilization of that technology.

In formulating the objectives of the Second United Nations Development Decade, it has been recognized that spectacular progress made by the developed countries makes it even more necessary to accelerate the rate of advancement of the developing countries. If that progress is not achieved, it could aggravate world tension. It is also apparent that the current and forseeable difficulties of developed countries may become future problems in developing countries and vice versa. The acceleration of progress in the developing countries is to the mutual advantage and interest of both the developing and the developed countries of the world, and the United Nations has a most active part to play in that respect.

It is in this context that the need for accelerated cartographic programmes in the developing countries of the world should be viewed. National programmes often require consideration on a time rather than a cost basis, and the approach taken may well be a combination of short-term projects designed to meet the more urgent priorities, with other activities designed to fulfil longer term needs. The creation of employment opportunities and the introduction of labour-intensive technology are important considerations, as is the need to incorporate new inventions and developments.

Essential to the entire accelerated mapping programme is a management system capable of recognizing needs, conducting research, implementing plans and supervising day-to-day operations. Each phase of cartographic development requires timely information and the personnel facilities to use it wisely.

Topographic mapping

The Group studied the status of world topographic mapping as presented in *World Cartography*,[8] and observed that the report in its current form gave no indication of the extent to which developing countries had built up an independent mapping capacity in that it did not distinguish between the work done by the national mapping organizations of the developing countries from that done under agreements with other national and commercial agencies. It was considered that a definite need existed for a further build-up of the national mapping capacity of developing countries; and to identify that need more positively, the Group suggested a revised questionnaire for circulation by the United Nations at five-year intervals (see annex). It also appeared that some countries were not supplying information for reasons of security; and in that respect, it was stressed that the function of a map in the process of economic development would only be fulfilled when it was reproduced in quantity and widely disseminated without restriction.

Substantial progress had been made since the situation had been reviewed in 1949. However, an enormous amount of work still must be done before it could be said that the necessary basic world-wide coverage was available. Experience had shown that basic topographic mapping coverage was an invaluable aid in good government and in the development of natural resources. The Group was of the view that there was a need for all developing countries to adopt a basic mapping pro-

[8] United Nations publication, Sales No. E.70.I.4

gramme; and scales of 1:50,000, 1:100,000 and 1:200,000 or 1:250,000 were suggested, depending upon local conditions.

To be effective, a national mapping programme should be designed for basic coverage of a country in a period of 10–15 years and for its periodic revision.

Geodetic control

Geodesy is the discipline that determines the relative and absolute position of survey control points on or near the earth's surface. It provides the reference framework for cartographic operations, for engineering and cadastral survey activities and for scientific studies. It was noted that a primary need existed for the completion of geodetic surveys where these did not exist.

In the past, geodetic surveys have generally been established on independent, national and regional bases; but recent developments in satellite geodesy have facilitated the interrelation of data and the likely establishment of a world datum. The availability of satellite navigation techniques and the improvements in accuracy that will probably occur will make it possible for charts and all other navigation aids to be referenced to a uniform, world-wide set of co-ordinates.

The importance of establishing horizontal and vertical datums and the maintenance of datums by re-observation and assimilation of new data has been documented in the report of a United Nations Conference on Science and Technology for the Benefit of Less Developed Areas.[9] In that report, particular emphasis is placed on the fact that the concept had not been widely accepted by the developing areas. This Group reaffirmed the concept.

There is need to establish and maintain permanent reference marks in the course of all cartographic and engineering and cadastral survey operations, which would build up an integrated pattern of control data that would lead to economies in future survey activities and would also permit re-establishment at a later date if necessary. It is essential that all positional data relating to these marks be systematically documented for continuing future reference, preferably in a form suited for subsequent automatic data-processing.

A new emphasis is currently being given to the development of coastal zones as men and countries enter into a new phase of world interest in the sea, in which commerce, industry, recreation and eventual settlement are all being stressed. Geodetic control from the land masses should be extended into the coastal zones and the continental shelf, which is only an extension of the continents and islands themselves, and made an integral part of the national datums so that their exploitation may be controlled. The national data in turn must be referenced to a world system for the resolution of attendant boundary problems and for international co-ordination.

There is need for individual countries to do all in their power to encourage the establishment of a World Geodetic Datum. A continuing world-wide system for the monitoring and analysis of geodetic satellite orbital data would ensure that an optimum of positional accuracy should be readily available to all users. It was stressed that the early provision of geodetic control was a necessary prerequisite of systematic mapping and that the Doppler satellite technique could produce that accuracy at appropriately placed stations.

Cadastral surveys

In most developing countries, there is an increasing need for the cadastral maps which are essential for the efficient management of land. Population growth has given rise to pressure on rural land, often leading to the fragmentation of holdings; while the migration of people to cities and towns has led to an uncontrolled growth of urban centres. The absence of maps and registers of land rights not only complicates dealings in land unduly, but is a great hindrance to land reform and to the establishment of proper land revenue systems. In circumstances where private ownership applies, the absence of cadastral maps and registers leads to disputes and litigation, and to difficulties in financing improvements in agriculture and housing production through mortgages.

Historically, cadastres have been designed and used to serve land taxation. Currently, it is becoming more accepted that the cadastre should be combined with land registration and that its multiuse characteristics should be more generally utilized. Most of the advantages of a multipurpose cadastre can only be realized if its records are integrated in a formal land registration system, which also facilitates keeping records up to date. Such a land register, supported by cadastral maps, gives a clear description and shows the actual state of occupancy and other rights for every piece of registered land. It is a great advantage if the State, by legislation, guarantees the right shown in the register, as there is then no need to trace all deeds influencing the rights in the land in order to be sure of the title.

Land registration and mapping could be undertaken sporadically or systematically on an area basis. The Group favoured the systematic approach, as it provided complete and effective coverage most economically.

Cadastral surveys and maps should be referenced to the national geodetic system; and, where possible, integrated with other mapping activities in the community. The same basic material may be used for both cadastral and topographic maps, and it is especially important to integrate cadastral surveys with urban mapping for development planning. The Group agreed, in general, with the description of survey procedures set out in *World Cartography,*[10] except that it was of the opinion that greater emphasis should be given to traditional group survey methods.

However, cadastral mapping is only one corner-stone in setting up a proper cadastre. The other is adjudication, that is, defining existing rights in land. The objective of the adjudication procedure is to make all interests in the land so clear that the resulting register can safely be declared indefeasible and guaranteed by the State. Methods are not discussed here, but the Group stressed that a land register should be as simple as possible and designed for adaptation to automatic data-processing.

Serious consideration should be given to the use of data-processing techniques at the outset. The advantages increase greatly if the land registration unit was also used for such purposes as population registers and agricultural records, as the lot number becomes the key unit in an integrated data system. It had been shown in Sweden that this system can be further developed by identifying

[9] United Nations publication. Sales No. 63.I.28.

[10] G. Larsson, *loc. cit.*

ellings and the midpoints of all lots by their approxi-ite co-ordinates. All information could then be located maps automatically, a great advantage in inventory d planning operations.

Urban mapping

The migration of people to cities and towns has ulted in an uncontrolled growth of urban centres, ding to exceedingly complicated problems in manage-nt and the maintenance of service. The lack of rmanency of marks defining land boundaries or "corn-" and the need for their subsequent re-establishment pose more stringent demands on the surveyor, while nning, engineering design, underground utilities, tax-on, statistical service, fire and police departments and many other municipal government agencies require ps of a high standard of completeness and accuracy a wide variety of scales and composition.

The major impetus of all urban control surveys and pping should be to provide the basic reference system d graphics so that all data can be placed on a single co-linated system. For example, underground facilities an integral part of an urban centre and must be nsidered in a three-dimensional network. The need for ban planning is of the greatest importance and unless eeps pace with the increase of urban population, the ults will be disastrous.

Hydrographic charting and bathymetric mapping

The Group agreed with the report on the Meeting of *Ad Hoc* Group of Experts on Hydrographic Survey-and Bathymetric Charting (E/CONF.57/L.1) and rticularly stressed that in the next decade emphasis ould be placed on bathymetric mapping depicting the ography of the sea-floor. When used in conjunction th overlays and descriptive data reports depicting gnetics, gravity, seismic profiling, sediment overlays d other geophysical parameters, a logical base was ailable for the orderly exploration, development and nagement of the living and mineral resources of the rine realm. The recent discoveries of mineral and oil posits in the sea-bed in many parts of the world, the ventory of mineral resources of immediate potential d the need for co-ordinated national and international tion to assure adequate protection of the natural vironment from the increasing dangers of pollution, quired increased topographic and bathymetric know-lge of all parts of the globe.

It was observed that the scales of charts, considered to satisfactory for exploratory work on the continental elves, were from 1:200,000 to 1:500,000. The scale and ntour interval should vary with the complexity and the pe of the bottom. For example, where the bottom was tremely complex, as in glacially scoured areas, a ntour interval of 5 m and a scale in the vicinity of 25,000 were suggested.

It was considered imperative for the safety of sea nsport that the establishment of hydrographic survey-capabilities in developing countries be expedited, d the relevant sections of the referenced report were ongly endorsed. The delineation of base lines for the ablishment of seaward boundary lines should be on a iform world system or at least on one that was ceptable to neighbouring countries. Topographic, drographic and bathymetric mapping should all be co-ordinated and referenced to the same unified world system.

Cartography for resource studies

Resource information can be made available to potential users by a number of means, but one of the most effective is through proper cartographic representation. In most instances, the topographic mapping coverage also becomes the base on which resource data, such as geology and pedology, are plotted and published.

Skills in photo-interpretation have developed to the point that broad general studies in such fields as geology, land use, forestry and soils can be carried out from the smaller scale aerial photography normally used in the preparation of the basic topographic mapping coverage. Compilation procedures are often simplified when the same aerial photography is used for the studies, as well as the base mapping.

More detailed studies are often required for selected areas within the country which gave indications of special potential and generally require aerial photography at larger scales designed specifically for the investigation. In some cases, colour, and, less frequently, multispectral photography, provide additional information which outweighs the higher costs involved in their use.

Major development programmes often require extensive cartographic support and may be delayed or even fail if it is not adequately provided for. The planning takes into account the various conditions encountered and places special emphasis on the type of problems the surveys can help to solve. For example, an agrarian reform programme would probably require a topographic base map which would provide for the location of unused or unoccupied land, soil classification; and for the exploration for water resources for irrigation purposes, including the location of underground water resources. A property cadastre or a land-use map would be essential before any activities could take place at the implementation stage.

The rapid growth of population in the developing country makes it even more necessary to have a fuller knowledge of the resources available, especially in soils and land use. Integrated surveys become a vital necessity, and the resulting thematic maps command a high priority in the planning and implementation stages of major development programmes.

National and regional atlases

The Group considered that the need for this type of thematic mapping was adequately covered in *Modern Cartography: Base Maps for World Needs,* which states: "Probably the most significant uses to which compiled maps on many subjects are put are those in connexion with planning the use of the land and all economic resources, and with the study of social, political and all other human relationships".[11]

It was considered that most developed countries had found those uses of sufficient value to initiate and maintain national atlases; and it would appear that developing countries could, with advantage, assume a similar responsibility as soon as their progress in topographic and resources mapping and their availability of technical manpower and funds permitted.

[11] United Nations publication, Sales No. 49.I.19, p. 93.

The purpose of this section is to provide background information on the participation of the United Nations in cartography. It briefly sets out the activities of the United Nations and indicates the actual and proposed programmes for the Second United Nations Development Decade.

United Nations participation in cartographic activities commenced in 1948 following the adoption of resolution 131 (VI) of the Economic and Social Council, which could be summarized as requesting that the Secretary-General:

(*a*) Further the stimulation of national programmes of surveying and mapping by promoting the exchange of technical information and other means, including the preparation of a study of modern cartographic methods;

(*b*) Co-ordinate the plans and programmes of the United Nations and specialized agencies in the field of cartography;

(*c*) Develop close co-operation with the cartographic services of interested Member Governments.

As an initial step towards the fulfilment of this request, the Secretary-General convened a meeting of a Committee of Experts on Cartography in 1949.

Briefly, the Committee recommended that for the purpose of discussing cartographic matters, the United Nations should initiate regional meetings of representatives of Governments having a community of interests in some five geographical areas of the world, similar to the consultative meetings then held regularly in the sixth region, the Americas; that the United Nations should establish a cartographic office under a competent director charged with both service and co-ordination functions; that there should be listed a panel of expert cartographic consultants from whom the United Nations Secretariat might seek counsel as necessary and that there should be regular meetings of suggested technical representatives for the purpose of advising on United Nations plans and programmes and reviewing the problems of world mapping.

After consideration of the Committee report,[12] the Economic and Social Council adopted, in 1949, resolution 261 (IX), part A, in which it instructed the Secretary-General to take the steps needed to implement the recommendations of the Committee. The Council also instructed the Secretary-General to publish periodical summaries on cartography that would constitute a report upon activities, progress and plans in this field, in order to facilitate "the co-ordination of national programmes and eliminate the duplication of costly experiments".

Following the adoption of resolution 261 (IX), the Economic and Social Council considered a report submitted by its Co-ordination Committee, relating to the integration, within the United Nations, of the Central Bureau International One Million Map of the World. This report was prepared in accordance with Council resolution 171 (VII), "Relations with inter-governmental organizations".

The Council then adopted a resolution, which was incorporated as part B into the resolution on the co-ordination of cartographic services; requesting the Secretary-General to consider such a step

[12] *Ibid*

Activities of the United Nations

The major objectives of the programme of international co-operation in cartography are to stimulate an acceleration of surveying and mapping as a means for economic and social development. To achieve these goals, the United Nations has five major objectives:

(*a*) To stimulate international co-operation in cartography by arranging and servicing international and interregional conferences;

(*b*) To continue substantive assistance to developing countries in modern surveying and mapping techniques through technical assistance activities;

(*c*) To diffuse technical knowledge gained through international seminars and training projects;

(*d*) To conduct studies and research for assessing world cartographic needs;

(*e*) To evaluate new technology in surveying and mapping for the developing countries.

The legal basis for this work is found in a number of resolutions adopted by the Economic and Social Council. The most recent Council resolution, 1570 (L), which was adopted on 13 May 1971, called for the convening of the Seventh United Nations Regional Cartographic Conference for Asia and the Far East, and requested that the recommendations of the Sixth United Nations Regional Cartographic Conference for Asia and the Far East be implemented as appropriate.

Regional cartographic conferences

The United Nations regional cartographic conferences called by the Economic and Social Council for the purpose of assisting Governments in the mapping of their countries, in the exchange of technical information and in the provision of mutual assistance, have proved to be an efficient way to promote international co-operation in cartography. The conferences have contributed to the study of problems of common interest as well as the working-out of regional projects to satisfy the needs of the region. With the participation of technically advanced countries outside the region, the conferences have been able to bridge the gap of communication between the developing and the developed countries. The cartographic exhibits organized in conjunction with the conferences have provided efficient means for the dissemination of information on techniques, activities and their application to economic development, with illustrated examples from various parts of the world. They also have assisted participants in discussing technical matters on a more practical and concrete basis and have stimulated the interest and understanding of the general public and high officials in the host countries.

Six such conferences have been held at regular three-year intervals for Asia and the Far East, and three have been held in Africa.[13] In the Americas, the Pan-American Consultation on Cartography has also been held regularly under the auspices of the Pan-American Institute of Geography and History, a regional intergovernmental body of the Organization of American States. In Europe, international co-operation in science and technology is usually carried out through organizations, associations and committees based on a specific disci-

[13] The Third United Nations Regional Cartographic Conference for Africa was held at Addis Ababa from 30 October to 10 November 1972. A report of the meeting is to be issued as a United Nations publication

pline. Some are regional, such as the European Organization for Photogrammetric Research, while most of the others have world-wide membership.

With respect to the actions and measures outlined above, the United Nations regional cartographic conferences can and must play a leading role in the study of questions of interest to the region, as well as in the design of appropriate measures suited to the environment. For instance, in the strengthening of the technical capability of national services, the conference can assist in promoting mutual help in making arrangements for co-operative projects. In the promotion of research and development towards more suitable methods and equipment, the conference could make a contribution by spelling out the particular problems and short-comings of techniques in a region. With respect to the improvement of communication among all concerned with topographic mapping and the promotion of appropriate appreciation of the vital importance of mapping, the conferences are in the best position to examine in detail all factors involved and to design means and measures tailored to the needs of a particular region and capable of producing efficient results under that environment. International co-operation has always been emphasized by these conferences. New emphasis and impetus should be given as follows:

(*a*) More attention should be paid to all important questions of international co-operation involving mapping;

(*b*) Means and measures to allow the implementation of recommendations by the conferences should be studied more rapidly and more thoroughly by all concerned; that is, by both the Governments and the United Nations.

Technical assistance

One of the powerful, effective and practical means that the United Nations has at its disposal to accelerate economic development in developing areas is technical assistance through the United Nations Development Programme (UNDP). For the past 20 years, vast amounts of experience and information have been gathered; a considerable number of scientists, technical experts, administrators and other personnel have participated in the various projects supported by the programme; and continuing support has been given by countries throughout the world. In the field of topographic mapping, the success achieved in several projects has been considered spectacular; there are also rare cases in which progress has been rather slow owing to unfavourable local conditions, particularly the inability of the recipient Government to provide rapidly the necessary local facilities, such as buildings, staff, equipment, services and supplies, because of lack of financial means in the country as a whole. In certain countries, the limited allocations and insufficient attention paid to technical undertakings, e.g., surveying and mapping, have resulted in inadequate requests for assistance in topographic mapping that have not received United Nations consideration. There is no need for re-emphasizing the grave consequences of the frustration on the part of the mapping agency to all projects it serves. To avoid further deterioration, it would be necessary for all aid agencies at national levels and at international levels to re-examine the guiding principles applied in allocating budgets for country, regional and interregional programmes and in assigning respective priorities. They should also re-examine the appraisal and approval of requests, the evaluation of counterparts, achievements and the implementation of projects in the light of analyses of experience, studies and research, and should seek to identify more accurately the conditions and needs of recipient countries. It must also be borne in mind that each country has its particular problems and special conditions, and that the guiding principles must have reasonably flexible cases covering special environmental problems. Very rigid and very detailed criteria and specifications which have their appeal to a bureaucracy have never simplified the real problems. In some cases, they have done more harm than good.

Seminars and other ad hoc *multinational meetings*

For the dissemination and exchange of technical information, the study of specific questions and the planning and arrangements for co-operative projects and the promotion of technical co-operation among interested countries, the United Nations has organized a number of regional and interregional seminars, study tours and meetings of experts. In many instances, these programmes have contributed to the solution of side problems in addition to their main objectives.

Publications

Various publications issued by United Nations organizations on surveying and mapping, and related fields, have received universal recognition as authoritative sources of information dealing with matters in the field of international co-operation on cartography, particularly those matters concerned with the formulation of national and international policy. These publications have been used, especially by national cartographic services in developing areas, as a means of communication with the outside world and a source of guiding advice for solving local problems. The demonstrated interest in these publications justifies their essential role in the dissemination of technical information and the transfer of science and technology in the furtherance of international co-operation in cartography and in promoting understanding and appreciation of the importance of basic mapping in economic development.

United Nations publications related to cartography include annual reports on the International Map of the World on the Millionth Scale (IMW), the periodical *World Cartography* and reports of regional cartographic conferences and of conferences on the standardization of geographical names. Additional reports and papers are prepared on a variety of cartographic matters and are distributed on a limited basis.

International Map of the World on the Millionth Scale

The International Map of the World on the Millionth Scale, an international project undertaken over half a century ago, was integrated in 1952 into the work of the United Nations. At that time, the functions of the former Central Bureau of the IMW, an intergovernmental body, were transferred to the United Nations by the Economic and Social Council in accordance with its resolution 412 A II (XIII).

The United Nations Technical Conference on the International Map of the World on the Millionth Scale was held at Bonn, Federal Republic of Germany, in

1962.[14] The task of the Conference was to revise the original specifications in order to permit the map not only to incorporate modern cartographic techniques and trends, but to meet new and increasing requirements of its users. It adopted new specifications with a twofold objective:

(*a*) To provide, by means of a general-purpose map, a document that would make possible a comprehensive study of the world for pre-investment survey and economic development planning and also to satisfy the diverse needs of specialists in many sciences;

(*b*) To provide a base map from which sets of thematic maps can be prepared (such as population, soil, geology, vegetation, resources, administrative limits and statistical evaluation). Such maps are a basic tool for efficiently carrying out studies and surveys.

In fact, IMW sheets have been used not only as a base map for compiling thematic and other special maps, but, in conjunction with other data, for the study of various economic and social projects, particularly in developing areas. With respect to cartographic features, the IMW reference system and cartographic symbols have been widely adopted in many national and international maps at variable scales. The frequent demand for up-to-date maps by various groups of users indicate that the need for and interest in IMW sheets is still increasing.

International standardization of geographical names

The United Nations acts as a clearing-house for the international standardization of geographical names and services conferences and expert meetings on the subject.

Projected work programme of the United Nations

Operational programme

From 1972 to 1977, the operational programme in cartography will continue to give assistance in the strengthening of national survey departments or in the establishment of such departments. The projects already in operation are as follows. Phase II, assistance to the survey of India for pre-investment surveying, mapping and training, was extended for a two-year period ending in June 1973. The project will emphasize the strengthening of the Survey Training Institute in Hyderabad. Phase I, the development of the Chocó Valley in Colombia on surveying and mapping, is to be completed in 1973. Assistance to the Geographic Institute of the Ivory Coast will continue until the end of 1973. In the Sudan, a project entitled "Strengthening of the topographical division", was initiated in 1971, and the expected date of completion is the end of 1974. Assistance to the survey of Jamaica has been extended until August 1973. For Sri Lanka, the project on the Institute of Surveying and Mapping, Diyatalawa, was extended through supplementary assistance until early 1973.

Three projects are currently being formulated: a pilot project in cadastral surveying for Liberia; and the establishment of topographic survey departments in Nepal and Guyana. These three projects are expected to be initiated by 1974. In addition, on the basis of the country programming exercises, two countries have indicated the need for UNDP technical assistance in the field of surveying mapping: the Philippines has requested help in strengthening cadastral services and in the establishment of a central map reproduction unit; and Fiji has requested that a hydrographer and an assistant hydrographer be made available under the Operational Assistance (OPAS) programme.

Several countries are considering requests for UNDP projects in future, as follows: Algeria, assistance to the Geographic Institute for the purpose of national mapping; Cyprus, strengthening of the Lands and Survey Department; Fiji, assistance to the Survey Department for the purpose of topographic mapping; Western Samoa, assistance to the Lands and Survey Department; Zaire, strengthening of the topographic base map programme; and Zambia, strengthening of the Survey Department.

On the basis of the United Nations regional cartographic conferences for Asia and the Far East, the United Nations Secretariat has taken note of the likelihood of three regional UNDP projects within the ECAFE region: hydrographic surveying and bathymetric charting of the South China Sea area; assistance to the Royal Thai Survey Department for the preparation and publication of a regional economic atlas and regional thematic maps; and assistance in the establishment of regional surveying and mapping training centres for the training of personnel in the various disciplines of cartography.

The United Nations Secretariat will continue its backstopping operations in United Nations technical assistance activities in surveying and mapping.

Non-operational programme: conferences, seminars and other meetings

From 1972 to 1977, two regional cartographic conferences are planned for Asia and the Far East. The seventh conference will be held at Tokyo, from 15 to 27 October 1973; and the eighth will take place during the second half of 1976. The Second United Nations Conference on the Standardization of Geographical Names[15] was held in London in 1972, and a third will be convened at Athens, Greece, from 1 to 22 June 1977, in accordance with a decision of the Economic and Social Council at its fifty-fourth session.

Several interregional seminars are planned during this period on: (*a*) new methods and techniques in cadastral surveying and mapping; (*b*) hydrographic surveying institutions for developing countries; (*c*) thematic maps for economic development planning; (*d*) aerial and satellite survey methods for mapping and resources inventories; (*e*) a third interregional seminar on the application of cartography for economic development; and (*f*) a second interregional seminar on photogrammetric techniques.

In 1972, there will be a meeting of an *Ad Hoc* Group of Experts on Cadastral Surveying and Mapping at United Nations Headquarters. This meeting is being convened on the basis of resolution 10 of the Sixth United Nations Regional Cartographic Conference for Asia and the Far East[16] and in accordance with resolu-

[14] *United Nations Technical Conference on the International Map of the World on the Millionth Scale*, vol. 1, *Report and Proceedings of the Conference* (United Nations publication, Sales No. 64.I.4), p. 9; and vol. 2, *Specification of the International Map of the World on the Millionth Scale (IMW)* (United Nations publication, Sales No. 63.I.20).

[15] The report (E/CONF.61/3) is to be issued as a United Nations publication.

[16] *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. 1, *Report of the Conference* (United Nations publication, Sales No. E.71.I.15), p. 17.

tion 1570 (L), adopted by the Economic and Social Council on 13 May 1971. The Group of Experts on Geographical Names will continue its annual meetings.

The Section will continue to implement, in accordance with resolution 1570 (L) of the Economic and Social Council, the recommendations of the Sixth United Nations Regional Cartographic Conference for Asia and the Far East. The conclusions and recommendations of the meeting of the *Ad Hoc* Group of Experts on Projections and Planning on United Nations Activities in Cartography for the Second United Nations Development Decade will provide additional bases of future United Nations policy in cartography.

The publication *World Cartography* and the annual report of the International Map of the World will be published periodically. The United Nations Secretariat will continue to function as the central bureau for all matters concerned with IMW.

Research and studies will be continued on new technologies in cartography and towards the achievement of uniform standards in surveying and mapping. Studies and reports will be made on the establishment of a uniform world geodetic datum on implications of the adoption of the metric system in surveying and mapping; the status of basic world geodetic control; standard map scales and map indexing systems; the status of world cadastral surveying and mapping and the status of world hydrographic surveys. Special emphasis will be placed on satellite technology for cartography and the development of natural resources, including the feasibility of photographic imagery and other remote-sensing data from satellites. The United Nations Secretariat will continue its work on the status of world topographic mapping.

The United Nations will continue to serve as the secretariat for the Group of Experts on Geographical Names and will expand its clearing-house functions in accordance with Economic and Social Council resolution 1314 (XLVIII) on the standardization of geographical names.

Liaison with national and international mapping organizations and societies will be continued.

Special natural resources advisory services

Special natural resources advisory services are established in terms of resolutions 1572 (L) and 1616 (LI) of the Economic and Social Council, and the following description is extracted from a letter of 19 October 1971 from the Secretary-General to the permanent representatives of 76 States Members of the United Nations and four non-members. The Secretary-General asked Permanent Representatives to bring the scheme to the notice of appropriate government departments in their countries and also sought from Member States, details of any experts that they were interested in making available for short-term services within the framework of the scheme:

"The main purpose of this scheme is to make available to the requesting developing countries, advisory services in the field of natural resources, of the best available quality and the highest calibre and competence available within the United Nations system, and at a very short notice. The principal advantages of this scheme would be:

"(*a*) Widening of the range of United Nations advisory services in the field of natural resources, that can be made available to the developing countries;

"(*b*) Reduction in the time needed for recruitment of short-term, highly specialized and scarce experts, the demand for whose services is steadily increasing;

"(*c*) Savings in the costs of making such experts available to the requesting country;

"(*d*) The transfer of valuable experience in the field of natural resources from one developing country to another, where conditions are more or less similar;

"(*e*) Broadening of the experience of the expert concerned, thus enabling him to make a more effective contribution not only to the country of his original assignment, but also during the course of other assignments which might be entrusted to him; and

"(*f*) Opening up of new opportunities for exchange of experience and mutual co-operation among developing countries in the spirit of the consensus of the new country programming approach and in accordance with the relevant provisions in the Strategy for the Second United Nations Development Decade".

NATIONAL CARTOGRAPHY: PROBLEMS AND MEASURES WITH PARTICULAR REFERENCE TO DEVELOPING COUNTRIES[17]

Problems

The need for accelerated topographic mapping, including the preparation of new sheets for unmapped areas and the revision of outdated sheets, as shown by the United Nations survey, is common to developing and developed countries alike. The nature of the map coverage and the size of the technical task may vary considerably, depending upon individual conditions. As they progress, developing countries eventually face some of the current problems of the developed countries. On the other hand, problems in developing countries may also throw light on problems in developed countries and facilitate their solution. Thus, without regard to the state of development, problems in any area have mutual importance and interest to all and deserve equal attention by all for the benefit of the world community.

Institutional problems

The task of conducting a topographic survey of a country and the publication of national series of maps is usually assigned to a national technical agency, survey department, cartographic service, mapping institute or topographic survey, which may carry out the entire work or contract out parts of it. To fulfil such a task, the agency must have the necessary technical competence, as well as production facilities. In this respect, the developing countries, particularly those which have recently gained independence, are at a disadvantage. Figuratively speaking, the technical agencies of these countries have been established at different times and have been making individual efforts to climb the "ladder of development" in this technical field. Naturally, the progress achieved varies considerably with individual countries. Few have reached the upper levels, some are still in the initial steps, many others are at various intermediary levels and none has reached the stage of technical self-sufficiency. They all have encountered difficulties in the execution of technical work and in the building-up of their services, particularly in terms of technical personnel and facilities.

[17] This section was prepared by T. L. Tchang, who served as a consultant to the United Nations.

Accurate topographic mapping is a complex technical undertaking in which several branches of science and technology are applied. It requires:

(*a*) Basic geodetic nets to provide a framework of geographic co-ordinates (longitude, latitude and elevation) for the control of features shown on the map;

(*b*) Modern aerial photography and photogrammetric plotting to reduce time-consuming field topographic work now limited to a fewer number of ground control points for plotting photographs and a small number of items for field completion of the machine-plotted map manuscript;

(*c*) Modern cartographic methods to prepare printing-plates;

(*d*) Multicolour printing processes to ensure the high-quality reproduction required for topographic maps.

These operations require both special equipment, some of which is very sophisticated, delicate and expensive, and skilled personnel in each technique and at all levels to plan the operations, supervise and execute the work, maintain the equipment and deal with special problems at the various stages of mapping.

The critical situation faced by developing countries is the lack of both competent technical personnel and modern equipment. The lack of the former is critical, even if all mapping work is contracted out, since competent and experienced technical personnel are needed to draw specifications and to ensure that specifications are observed.

Personnel

Without exception, all developing countries have endeavoured to train their nationals in the various branches of surveying and mapping to serve their national agencies. Substantive results have been obtained by some, but there is still a great gap between the availability of well-trained staff and the requirements for skilled personnel. Basic problems encountered to greater or lesser degree in individual countries are listed below:

(*a*) There are insufficient candidates with appropriate educational backgrounds and other qualifications. The profession of surveying and mapping has not been considered as attractive as other governmental positions;

(*b*) Adequate training facilities are not available in developing countries, nor is equipment for on-the-job training after school;

(*c*) Training received elsewhere cannot be applied directly under local conditions;

(*d*) After training, personnel sometimes do not wish to continue service with the agency;

(*e*) There is insufficient financial support for applicants, who, in most cases, cannot afford to pay training costs.

Equipment and other facilities

Modern surveying instruments and photogrammetric mapping equipment are expensive items, and the developing countries often do not have the financial means to obtain them. This is the physical source of the inability of the national agency to handle even minor urgent work; it is also the source of frustration for qualified personnel just returned after receiving training abroad. The insufficiency in quantity and quality of modern equipment constitutes a general obstacle for accelerated coverage.

Another major difficulty encountered is the lack of facilities for maintenance and repair for instruments and equipment received. In some cases, special procedures have to be worked out because the instruments and equipment received are not built for local conditions and because of the absence of facilities for repair in the vicinity. The accurate checking and testing of instruments also requires special equipment and installations. Insufficient finances and other conditions also give rise to supply problems with materials obtained from outside the country.

Financial resources

Insufficient budgetary allocation for topographic mapping, resulting from a lack of over-all financial resources in the developing countries, is, perhaps, the most serious difficulty which cannot be solved by technical operation. It is understandable that all the efforts of a country cannot be committed to one sole activity, but it is unwise and unjustifiable that some vital undertakings receive a very inadequate share of the budgetary resources for development because of a lack of appropriate appreciation of the need for such undertakings. In the final analysis, this is the key problem and not necessarily found only in developing countries. It deserves very careful attention.

One fundamental source of difficulty encountered by national agencies in many countries in obtaining adequate means and support to carry out the necessary technical work is the lack of sufficient understanding, particularly on the part of high-level policy- and decision-makers, of both the significance of topographic maps and the time factor involved. Not only is the vital role played by topographic mapping in the various projects easily overlooked, since the actual users who know the extent to which such maps are important are those who either prepare plans for decision or are in charge of execution; but a certain time required for completing the various operations of the preparation of topographic maps is often ignored, as the time required for these operations is not apparent at all. In general, it is almost unavoidable for the public to have the impression that the preparation of a map should not involve too much work, since such a map, when available, can be bought at a very low price. In a number of countries, communication between map-makers and policy-makers is not well established, to say nothing of communication with the general public. The need for maps and the need for advanced planning in map preparation can never be over-emphasized.

Recent social events throughout the world clearly show that developing countries, as well as developed countries—whatever the stage they have reached—increasingly require accelerated economic and social advance to meet the impatient, but natural aspirations of their people for a better life. The aspirations can only be achieved through:

(*a*) Better utilization of all kinds of natural resources for agriculture and industry to produce essential goods and facilities and to supply them at the place where they are to be consumed or utilized; and

(*b*) Improvement in public administration by smoothing operations and eliminating the causes of injustice, waste and pollution.

All projects in the sphere mentioned above require topographic maps of the area or areas involved in the project for study, planning, construction and operational purposes.

In addition, such maps, with appropriate notations, provide an efficient means of communication between promoters and the public, with respect to the description and meaning of the projects.

As an illustration, a typical example may be made of projects for the development and control of water resources. Topographic maps are needed at all phases; namely, the preliminary examination, general investigation, intensive survey, plans and specifications and management and operational phases. Such maps, combined with geological data, play the decisive role in selecting sites for dam building, reservoir arrangements, watercourse improvement and watershed management for hydroelectric installation, for irrigation purposes, for fresh-water supply or for flood control. The maps render service to engineers in the evaluation of the cost of construction based on the magnitude of work to be determined by topographic conditions. To a great extent, the same applies to the exploration and development of mineral resources; the construction of communication lines; including roads, railways, airports, cable lines and pipelines; and the location of industry, including tourist industries.

As concerns public administration, mention may be made of improvement of land evaluation and taxation procedures.

It is true that some projects have been carried out without appropriate maps; but the costly hidden mapping work which fits only a specific project is not always disclosed, nor is the waste in extra work and in delayed achievement, as such costs are usually lumped in over-all or miscellaneous expenses. Moreover, it is seldom determined how proper maps might have improved the conception and lowered the cost of projects.

The lack of understanding of the relationship between mapping and all development projects, as well as their timing, is a problem which deserves special attention in dealing with topographic mapping in countries with inadequate coverage. It is not merely the completion of map series; it is the question of the efficiency and economy of development projects themselves.

Technical problems

Under normal conditions, topographic work can be achieved as a standard technical operation and the detailed problems encountered are usually dealt with by the national agency concerned. This section is limited to general problems which have a bearing on the rate of production of topographic maps, in view of large areas of the world still not covered by adequate maps. To have a more precise idea of the magnitude of the problem, one can look at just one large-scale series, such as the 1:50,000 series. According to a recent rough estimate, at least 300 years would be required to complete the world coverage at the current rate of production. With the rapid development in almost every part of the world and with the serious population explosion, such a delay is unacceptable. The amount of work required for the revision of outdated maps is even greater.

It must be mentioned that recent progress in techniques and equipment in topographic mapping have already considerably reduced the man-hours required for the publication of a sheet. With the development of satellite geodesy, space photography, electronic data-processing, automation in compilation, electronic measuring instruments and all-weather mapping systems, the future seems to be promising. But two non-technical questions are still unanswered:

(1) Whether the current rate of technical development can be considered adequate to meet world requirements;

(2) The way in which this new, efficient technology can benefit all the countries that need it.

In this connexion a question of particular concern to developing countries may be stressed. This question is the transfer of technology from technologically advanced countries to developing countries and its adaptation to the particular conditions, environment and needs of the developing countries. It is well known that human motivation and social inertia can be the decisive factors for success or failure not only as concerns techniques, but for procedures in many undertakings.

The dissemination of information to developing countries on new developments and techniques also encounters difficulties, as most of the material is prepared by experts of highly developed countries to suit users in those countries. From the viewpoint of developing countries, there are too many sources of information in the world to look at to find the subject of direct interest to them; yet, there is not enough background and practical information to enable them to have a clear idea of the concrete items. For these countries, there is a need for a central source from which they can obtain more rapidly and more precisely the kind of information that is immediately useful to them.

There are also specific technical problems encountered in developing countries but not elsewhere, such as mapping dense forest areas in tropical zones. These countries have neither the qualified personnel nor the necessary technical facilities to carry out the research, not to mention the financial resources. Such facilities do not exist even in neighbouring countries.

The foregoing remarks, pointing out some basic problems, are confined to conditions existing today. New problems in pollution control and the conservation of the natural environment indicate a continuing and growing importance of topographic maps as tools for research, planning and control.

Topographic mapping has traditionally been referred to land areas, while the sounding and surveying of world water bodies have been carried out mainly for navigational purposes. With the recent discovery of large amounts of submarine mineral and fuel deposits and with the increased use of the seas and oceans for the disposal of wastes, including atomic wastes and dangerous chemicals, a thorough knowledge of marine topography becomes as important as land topography. It is important not only to the proper management of marine and submarine resources, but to the protection of the earth and its inhabitants from dangerous pollution. Thus, topographic mapping and hydrographic surveying are closely linked, though certain of their techniques may differ in detail. Close co-operation between the two technical branches has developed so that the availability of topographic maps covering the entire land surface of the earth can be expected in the not too distant future. Clearly, the problems involved in the provision of adequate topographic maps are even much greater than this short study has indicated.

The problems require urgent attention not just for economical and technical reasons; there is another aspect which may be more compelling in modern society.

Without exception, economically advanced countries and developing countries are equally in need of reliable and suitable topographic maps for their development undertakings, though there may be differences in the scale of maps and the particular features included. The waste of public money in project failures can no longer be tolerated, particularly when the failure can be prevented if the essential basic data are provided and considered at the proper time. Severe public criticism and sometimes anger are justified in the failure of public projects. The economically advanced countries are too rich to care for the insignificant savings to be made by neglecting necessary mapping, as mapping represents only a small fraction of the cost of projects; and the developing countries are too poor to be able to afford the waste of a great amount of their limited resources for ill-conceived and ill-planned undertakings.

Solutions

The ultimate objective of the present study is the development of means and measures to achieve adequate coverage of topographic mapping, together with the related cartographic data, throughout the world. The goal is to make this basic tool available for world-wide use by planners, administrators, policy-makers, engineers and all others concerned with economic and social projects involving heavy expenses and large areas. The specific actions examined below are designed for the improvement of both technical and non-technical background conditions which govern the national activities in mapping. Generally speaking, most of the measures have to be taken conjunctively and along the major lines described below.

Strengthening the technical capacity of national cartographic services responsible for topographic mapping, particularly those in developing areas

There is no substitute for a competent national cartographic service to ensure adequate and permanent production of new sheets for unmapped areas and revised sheets for outdated coverage. In fact, the demand for up-to-date maps is directly linked to the stage of development of a country. The more advanced the stage, the more and more detailed maps are required; and the demand for revision of maps increases with the rate of economic growth. The higher the rate, the quicker the published sheets become obsolete. The technical capability of national cartographic services must be brought to an adequate level to cope with requirements; but, unfortunately, there are a number of developing countries in which national cartographic services are far below the minimum level of adequacy.

For strengthening the technical capability, national cartographic services in developing areas require ample assistance for training administrative and technical personnel, at almost all levels and in most of the technical fields. They also require help with the purchase of instruments and equipment from outside of the country. Training, the granting of scholarships and fellowships for study abroad as professional background education or as specialization in certain new techniques, the strengthening of technical institutes and higher education; and the establishment of multinational centres, each to meet the needs of groups of countries, are all necessary. But the most effective method of training is on-the-job training of a sufficiently long period to enable personnel, including group leaders and supervisors, to acquire the practical experience necessary to work alone under the actual conditions and to gain habits and traditions of a profession which is still considered new in many countries. The instruments and equipment that have to be purchased from industrially advanced countries are often beyond the financial capabilities of the developing countries. Training with modern equipment should not be limited to the class-room and laboratory; it should be extended to on-the-job training. The necessary supplies to operate the equipment should also be included when circumstances justify.

With respect to technical personnel, Governments should take measures to improve the working conditions in all professions involved in topographic mapping to make those professions more attractive. Such measures are necessary to facilitate the recruitment of highly qualified candidates for training and to be able to keep trained personnel in service. Measures should also be taken by all concerned to encourage and facilitate the participation of qualified personnel in international or regional scientific and professional meetings.

Promotion of research and development in topographic mapping techniques and allied fields

In view of the magnitude of the surveying and mapping work required to achieve and maintain an adequate coverage of topographic mapping in all parts of the world and in view of the rapidly increasing need for more and better maps, current methods and techniques are still far from adequate to cope with needs. There has been intensive research on new and improved techniques, and on the development of new instruments and new equipment for physical measurement, for data processing for cartographic presentation and for map reproduction, with a view to increasing the production of new sheets and revised sheets with a reduction in man-hours. Highly co-ordinated and efficient research efforts are required for dealing not only with questions of a purely scientific and technical nature, but with those concerning policy-making in topographic mapping, such as the scope and priorities of such research and the impact of topographic mapping in economic development.

With respect to developing areas, only limited facilities are available for general scientific research and development; and in the field of topographic mapping, some areas are entirely without facilities, even for conventional techniques, to say nothing of more advanced techniques, such as satellite geodesy, space photography, computer processing and all-weather mapping. In these circumstances, the developing countries will, for many years to come, have to depend largely upon the technically advanced countries for solutions to some of their problems and for modern technology. For the benefit of both developed and developing countries, research institutes and technical agencies in technologically advanced countries should continue to pay attention to the needs of their counterparts in developing countries, particularly as concerns the development of more efficient means for the transfer of science and technology.

The scarcity of competent manpower and available funds in developing countries constitute a serious handicap for the establishment of self-sufficient national

research institutes. It is always possible to undertake some fragmentary practical research in conjunction with the execution of surveying and mapping programmes to meet immediate needs; but for a real beginning of research activities, regional or subregional programmes may reduce the initial problems.

Improvement of communication among all those concerned with topographic mapping

In modern society, as topographic mapping is a public service, adequate support from policy-making bodies and major users is necessary to obtain the means to carry out the work. Map-makers and policy-makers should have ample opportunity to exchange information and views on subjects of mutual interest to promote effective decision-making. Map-makers and map users must maintain frequent and effective contact so that they understand each other's needs. Such contacts contribute to efficient mapping and effective map specifications. Stimulation in this direction in technically advanced countries through map users' surveys and map users' conferences, which have proven very fruitful, should receive wide consideration by all mapping agencies.

Similarly, scientists and other workers in the map-making and allied fields should have more rapid means of communication at both the national and international levels for their mutual benefit and, from the topographic mapping viewpoint, for efficiency and economy in techniques and equipment. Environments and problems are common to many parts of the world, and techniques and methods of approach can be applied usefully in many scientific and technical undertakings. Experiences must be quickly exchanged so that all new discoveries and new developments with potential for improving mapping can be evaluated and put to use without delay. Technical problems encountered by map-makers should be brought to the attention of all those who might be able to help in their solution. One of the critical situations faced by the modern world is that time is running short for achieving vigorous improvements to avoid crises in many crucial undertakings. Topographic mapping is one of them. No avenue should be overlooked.

Stimulation of appropriate appreciation on the part of high-level policy-makers of the vital importance of topographic mapping for efficiency and economy in planning and carrying out development projects

As the approval of work programmes and the allocation of funds for their execution are subject to policy decisions at various levels, personnel at all these levels, including the highest, should be fully aware of the important role played by topographic maps and related cartographic data in the various phases of planning and implementing development projects. They must also be aware of the fact that topographic mapping is not an instant operation. The time factor is not measured in days or weeks; but, in most cases, in years. Without an appreciation of this fact, funds from national sources cannot be obtained in time to plan and to execute the technical work of mapping, and mapping work undertaken with other resources may be done in vain. The lack of appropriate appreciation has been encountered in many developing countries, particularly in those in which there has not been a national cartographic service and in which current topographic work has to depend largely upon outside services. The lack of appreciation often leads to indifference, which hampers progress in mapping and in coverage. There have been too many instances in which development projects have suffered serious delay, resulting in a waste of human effort and public funds, because the question of the provision of necessary maps was not dealt with adequately and on time. It is therefore imperative that efforts to promote mapping should not be limited to map-making agencies. Special efforts should be made in non-technical circles to enable the policy-makers to be in a position to comprehend fully the issue and to give the necessary attention to the question in order to make a just decision in every respect. Experience in many fields has proved that a well-prepared seminar and a study tour in selected developed countries, especially organized for the interested policy-makers, have helped non-technical officials to understand and appreciate technical undertakings.

As topographical mapping always requires local intervention and as most of the operations must be done in the country itself, available human resources and the local environment become fundamental factors in the success or failure of the procedures, methods and equipment used in the technical work and in the promotion and planning of projects. Such factors are particularly important in developing areas for the double reason that the social and economic structures in underdeveloped environments greatly influence human thinking and behaviour, and because modern techniques and administrative systems are worked out by developed countries for their own use. In this connexion, there is an urgent need for a more precise identification of these fundamental factors, and special attention should be paid to them in order to work out effective ways to achieve success in general and more efficient techniques and methods to carry out detailed operations. It must be pointed out that while these fundamental factors may seem to be similar everywhere, wide differences in the handling of details exist in various countries. Each case must be dealt with individually. The identification of the fundamental factors requires further study and research carried out by the country involved with the aid of technical assistance from international organizations and other countries.

International co-operation

Progess in surveying and mapping has traditionally benefited from international co-operation. The organization and formation of scientific associations and committees in various branches of cartography and the continuous increase of international activities in the field clearly demonstrate the permanent need for and vital importance of international co-operation. Moreover, with the compelling need for increased production of food, goods and services and the desire of people everywhere quickly to achieve a better life, the magnitude of the task to provide up-to-date cartographic data and maps has become so great in both developing and developed areas that no one country can afford to depend entirely upon its own to undertake all the work involved. The full burden, in terms of both financial and human resources, would be too heavy for a country to carry alone. Indeed, experience has amply proved that many problems can be handled more efficiently, effectively and economically through international co-operation. The new dimension of mapping problems currently confronting countries of the modern world, in which the interdependence of countries grows with advances in development, and particularly with the constant need for more advanced techniques and more

reliable detailed data to reduce the cost and time of mapping and the frequency of revision, requires international co-operation. New efforts have to be made in exploring new avenues and in strengthening the already existing activities which have not produced full results because of the lack of means. This new look is even more important to developing areas in which international co-operation has played a major and decisive role, not only in the provision of topographical maps and related surveys, but in the building-up of national cartographic services.

International co-operative aid in the form of technical assistance has made immense contributions to economic and social development. The need for international co-operation has been gradually increasing because of the requirements for rapid economic growth, but the financial resources available to international bodies and bilateral aid agencies are far from adequate to cope with the requests for assistance. This situation has to be remedied not only for topographic mapping, but for all economic development. Appropriate measures must be taken to stimulate donor countries to place higher priority and emphasis on technical assistance in the field of cartography; and, at the same time, to promote co-operation in the planning and implementation of projects among all aid agencies, including those of the United Nations.

Another activity within the province of international co-operation is the working-out and adoption of common techniques, procedures and specifications for groups of countries. In addition to the technical advantages, such co-operation would reduce the cost of research and development in individual countries and facilitate the production of instruments, equipment and supplies on a mass basis. Mass production would reduce the cost of equipment and installation and would facilitate mutual assistance in emergency cases. This type of activity should be promoted and supported.

In the same way, support should also be given to groups of countries that co-operate to pool resources and set up common facilities for operations requiring highly specialized technical staff and very expensive equipment.

The measures mentioned above should be considered together as a co-ordinated whole. Success in one action can facilitate accomplishment in others. Thus, all the activities involved should be co-ordinated. Fruitful results require concerted effort and close co-operation at levels of Governments, United Nations bodies and other national and international agencies, such as scientific societies, professional associations, research and training institutes and mapping agencies themselves. Indeed, without vigorous national support, especially from Governments, international efforts, experience and means can neither be fruitful for individual countries nor produce lasting results. The United Nations and its specialized agencies, which have made significant use of maps and occasionally engaged in map-making, should play leading roles in promoting work in the field.

United Nations action

Since the early days of the United Nations, the Economic and Social Council has continuously paid attention to the promotion and strengthening of international co-operation in cartography with the main objective of ensuring adequate surveying and mapping for efficient economic and social development. Naturally, topographic mapping has been a primary subject. In the past 20 years, the activities of the United Nations in this specific field have achieved outstanding success in many undertakings, some of world-wide interest and others of regional scope. Because of these activities, it has developed efficient machinery and experience in the field. These facilities and the activities currently carried out could be put to work advantageously for the implementation of the actions envisaged, as well as for the formulation of more detailed measures.

National and international policy, as well as programmes for accelerating economic growth, will be increasingly linked to the measures and plans adopted by the United Nations to achieve the target and objectives of the Second United Nations Development Decade. Topographic mapping is involved in a number of actions proposed for the Decade. For instance, a national cartographic service is one of the essential services in the infrastructure for the efficient execution of technical work; a topographic survey constitutes a part of the systematic collection of scientific data of the physical environment; the methods and techniques applied in topographic mapping cover many branches of science and technology, and the development and transfer of those techniques to developing countries contribute to the technical capability of national services.

Progress towards early, adequate surveying and mapping of the world clearly involves action by the United Nations. The United Nations Secretariat has served as a focal point for communication with all parties concerned and has participated in the preparation and implementation of decisions and projects. Only careful preparatory work can eliminate last-minute complications and facilitate rapid success. The implementation of the measures and the completion of the world-wide mapping effort will naturally entail new, heavy burdens on the United Nations Secretariat.

Conclusion

In conclusion, a statement by the Committee for Development Planning of the Economic and Social Council is appropriate. Indeed, the views expressed therein apply so judiciously and so realistically to topographic mapping both in policy matters and in technical works that one can hardly find more appropriate and more effective words:

> "To improve upon the record of economic and social development requires vigorous efforts and drastic changes in policies. Greater efforts have to be made by developing countries themselves, for economic and social development is primarily a national responsibility; but matching vigorous efforts also have to be made by developed countries which have the resources for improving substantially the international environment within which developing countries can plan and carry out their economic and social development."[18]

As has been pointed out, the provision of topographic maps of a country is a responsibility, a service and a function of the Government concerned; and the survey work in that country cannot be done without the authorization of that Government. Moreover, the maintenance of up-to-date maps is a continuous task which involves frequent surveys, studies and cartographic work. The

[18] *Towards Accelerated Development. Proposals for the Second United Nations Development Decade* (United Nations publication, Sales No. E.70.II.A.2), p. 4.

will and the determination of a Government to pursue the matter as regular activities are decisive factors, not only in the accomplishment of urgent work, but in facilitating aid from outside sources in producing short-term and long-term results. With respect to developed countries, they must also recognize that topographic mapping requires so much in the way of expensive, advanced techniques, sophisticated equipment and complex procedures, all of which are scarce in developing countries, that it is not reasonable nor feasible to expect developing countries to be able to tackle the problems entirely through their own efforts without substantial outside assistance from developed countries. One can also add that the United Nations is unquestionably in the best position to play the leading role in dealing with the question of world mapping by virtue of: (*a*) the universality of its membership and wide responsibility and competence in the field of economic and social development and related matters as embodied in the Charter of the United Nations and in many resolutions of its General Assembly; and (*b*) the long experience gained in technical assistance and various other international undertakings. But what it can achieve depends upon the means made available to it for the purpose.

Modern cartographic practices

Geodetic control techniques

Horizontally, the ultimate goal is the establishment of reliable national geodetic networks referenced to a world-wide datum. Vertically, it is the establishment of a national levelling network properly referenced to standard tide-gauges, all in conformance with the specifications and standards of accuracy promulgated by the International Association of Geodesy or the International Union of Geodesy and Geophysics, properly marked and of sufficient density to meet the requirements of national mapping and cadastral and other surveys.

Dealing first with horizontal control, in the past two decades, both ground and airborne electronic distance-measuring instruments have been developed and successfully employed in the solution of geodetic problems. These instrumental improvements have permitted the increased use of traverses and trilateration in the extension of horizontal control.

Electronic and inertial positioning systems have likewise been developed and improved for positioning in hydrographic surveys.

In the past decade, there has been a similar expansion in geodetic satellite activities. Active and passive satellites have been employed in a variety of programmes with geodetic applications which may lead to the establishment of a world-wide datum.

A number of systems of geodetic satellite observations were initiated in the late 1950s and developed for practical use during the past decade. Optical and Doppler radio-tracking techniques have been improved and refined; the shape of the earth has been determined in detail and measurements made to outer terrestrial objects are being used in a supplementary role.

The stage has been reached where a World Geodetic Datum is possible, and equipment and processes are available to permit immediate position determinations with an accuracy adequate for cartographic purposes. Such a world-wide geometric satellite programme has been initiated by the United States of America and carried out in co-operation with many countries. The geodetic position of 45 stations in a world-wide network was made available in 1972. All major land masses will be connected in a unified reference frame with a 90 per cent confidence level of ±6 m in latitude, longitude and height.[19]

During the past decade, the application of Doppler satellite-tracking methods has resulted in a system that holds great promise for the solution of many problems confronting the geodetic community. In particular, the difficulties of surveying and mapping large, undeveloped areas in many parts of the world will be eased by the next generation of satellite geodesy techniques, including the positioning of off-shore islands with respect to national datums.

The United States Navy Navigation Satellite System (NNSS) positions in an earth-centred co-ordinate system are determined from measurements of the Doppler shift of radio signals and the reception of orbital information transmitted from a satellite during a pass over the ground station. With five satellites currently available, coverage is world wide, operation is independent of weather conditions and opportunities for positioning range from two hours apart at the equator to about 30 minutes above 70° latitude.

Obtainable accuracies vary, depending upon how much data are available and how they are treated in the reduction process. Using available navigation-type equipment and well-proved computing programmes, positional co-ordinates with a 90 per cent confidence level of 10–20 m appear reasonable.

Simultaneous differential techniques give even better accuracy in the relative positions of adjacent stations. The accuracy quoted will meet a large portion of the existing surveying, mapping and charting requirements. Careful monitoring of satellite passes from selected stations, followed by post analysis of field observations may give improved accuracy.

When applied to provision of control for a mapping programme that is developed stage by stage from small-scale or reconnaissance-type mapping to medium and large-scale basic national mapping of a permanent character, the initial control can be obtained rapidly from brief observations; and higher order accuracy may be obtained from longer periods of observation and more comprehensive processing of data.

The Doppler type of geodetic satellite observation requires very limited manpower, and the equipment is readily transportable.

The combination of satellite and sonar Doppler positioning has been successfully used for navigation and for bathymetric positioning on the continental shelves.

With respect to the future, current developments in radio astronomy indicate that the use of the interferometric techniques will aid in the strengthening of national datums and in scientific programmes, the objectives of which are to measure continental drift and expansion and to further the knowledge of movements of large ocean blocks. Laser ranging to satellites and the moon, combined with reciprocal observations between orbiting satellites, are future techniques which may aid cartogra-

[19] H. H. Schmid, "A world control system and its implications for national control networks", *The Canadian Surveyor*, vol 25, No 2 (June 1971)

tion 1570 (L), adopted by the Economic and Social Council on 13 May 1971. The Group of Experts on Geographical Names will continue its annual meetings.

The Section will continue to implement, in accordance with resolution 1570 (L) of the Economic and Social Council, the recommendations of the Sixth United Nations Regional Cartographic Conference for Asia and the Far East. The conclusions and recommendations of the meeting of the *Ad Hoc* Group of Experts on Projections and Planning on United Nations Activities in Cartography for the Second United Nations Development Decade will provide additional bases of future United Nations policy in cartography.

The publication *World Cartography* and the annual report of the International Map of the World will be published periodically. The United Nations Secretariat will continue to function as the central bureau for all matters concerned with IMW.

Research and studies will be continued on new technologies in cartography and towards the achievement of uniform standards in surveying and mapping. Studies and reports will be made on the establishment of a uniform world geodetic datum on implications of the adoption of the metric system in surveying and mapping; the status of basic world geodetic control; standard map scales and map indexing systems; the status of world cadastral surveying and mapping and the status of world hydrographic surveys. Special emphasis will be placed on satellite technology for cartography and the development of natural resources, including the feasibility of photographic imagery and other remote-sensing data from satellites. The United Nations Secretariat will continue its work on the status of world topographic mapping.

The United Nations will continue to serve as the secretariat for the Group of Experts on Geographical Names and will expand its clearing-house functions in accordance with Economic and Social Council resolution 1314 (XLVIII) on the standardization of geographical names.

Liaison with national and international mapping organizations and societies will be continued.

Special natural resources advisory services

Special natural resources advisory services are established in terms of resolutions 1572 (L) and 1616 (LI) of the Economic and Social Council, and the following description is extracted from a letter of 19 October 1971 from the Secretary-General to the permanent representatives of 76 States Members of the United Nations and four non-members. The Secretary-General asked Permanent Representatives to bring the scheme to the notice of appropriate government departments in their countries and also sought from Member States, details of any experts that they were interested in making available for short-term services within the framework of the scheme:

"The main purpose of this scheme is to make available to the requesting developing countries, advisory services in the field of natural resources, of the best available quality and the highest calibre and competence available within the United Nations system, and at a very short notice. The principal advantages of this scheme would be:

"(*a*) Widening of the range of United Nations advisory services in the field of natural resources, that can be made available to the developing countries;

"(*b*) Reduction in the time needed for recruitment of short-term, highly specialized and scarce experts, the demand for whose services is steadily increasing;

"(*c*) Savings in the costs of making such experts available to the requesting country;

"(*d*) The transfer of valuable experience in the field of natural resources from one developing country to another, where conditions are more or less similar;

"(*e*) Broadening of the experience of the expert concerned, thus enabling him to make a more effective contribution not only to the country of his original assignment, but also during the course of other assignments which might be entrusted to him; and

"(*f*) Opening up of new opportunities for exchange of experience and mutual co-operation among developing countries in the spirit of the consensus of the new country programming approach and in accordance with the relevant provisions in the Strategy for the Second United Nations Development Decade".

NATIONAL CARTOGRAPHY: PROBLEMS AND MEASURES WITH PARTICULAR REFERENCE TO DEVELOPING COUNTRIES[17]

Problems

The need for accelerated topographic mapping, including the preparation of new sheets for unmapped areas and the revision of outdated sheets, as shown by the United Nations survey, is common to developing and developed countries alike. The nature of the map coverage and the size of the technical task may vary considerably, depending upon individual conditions. As they progress, developing countries eventually face some of the current problems of the developed countries. On the other hand, problems in developing countries may also throw light on problems in developed countries and facilitate their solution. Thus, without regard to the state of development, problems in any area have mutual importance and interest to all and deserve equal attention by all for the benefit of the world community.

Institutional problems

The task of conducting a topographic survey of a country and the publication of national series of maps is usually assigned to a national technical agency, survey department, cartographic service, mapping institute or topographic survey, which may carry out the entire work or contract out parts of it. To fulfil such a task, the agency must have the necessary technical competence, as well as production facilities. In this respect, the developing countries, particularly those which have recently gained independence, are at a disadvantage. Figuratively speaking, the technical agencies of these countries have been established at different times and have been making individual efforts to climb the "ladder of development" in this technical field. Naturally, the progress achieved varies considerably with individual countries. Few have reached the upper levels, some are still in the initial steps, many others are at various intermediary levels and none has reached the stage of technical self-sufficiency. They all have encountered difficulties in the execution of technical work and in the building-up of their services, particularly in terms of technical personnel and facilities.

[17] This section was prepared by T. L. Tchang, who served as a consultant to the United Nations.

pline. Some are regional, such as the European Organization for Photogrammetric Research, while most of the others have world-wide membership.

With respect to the actions and measures outlined above, the United Nations regional cartographic conferences can and must play a leading role in the study of questions of interest to the region, as well as in the design of appropriate measures suited to the environment. For instance, in the strengthening of the technical capability of national services, the conference can assist in promoting mutual help in making arrangements for co-operative projects. In the promotion of research and development towards more suitable methods and equipment, the conference could make a contribution by spelling out the particular problems and short-comings of techniques in a region. With respect to the improvement of communication among all concerned with topographic mapping and the promotion of appropriate appreciation of the vital importance of mapping, the conferences are in the best position to examine in detail all factors involved and to design means and measures tailored to the needs of a particular region and capable of producing efficient results under that environment. International co-operation has always been emphasized by these conferences. New emphasis and impetus should be given as follows:

(*a*) More attention should be paid to all important questions of international co-operation involving mapping;

(*b*) Means and measures to allow the implementation of recommendations by the conferences should be studied more rapidly and more thoroughly by all concerned; that is, by both the Governments and the United Nations.

Technical assistance

One of the powerful, effective and practical means that the United Nations has at its disposal to accelerate economic development in developing areas is technical assistance through the United Nations Development Programme (UNDP). For the past 20 years, vast amounts of experience and information have been gathered; a considerable number of scientists, technical experts, administrators and other personnel have participated in the various projects supported by the programme; and continuing support has been given by countries throughout the world. In the field of topographic mapping, the success achieved in several projects has been considered spectacular; there are also rare cases in which progress has been rather slow owing to unfavourable local conditions, particularly the inability of the recipient Government to provide rapidly the necessary local facilities, such as buildings, staff, equipment, services and supplies, because of lack of financial means in the country as a whole. In certain countries, the limited allocations and insufficient attention paid to technical undertakings, e.g., surveying and mapping, have resulted in inadequate requests for assistance in topographic mapping that have not received United Nations consideration. There is no need for re-emphasizing the grave consequences of the frustration on the part of the mapping agency to all projects it serves. To avoid further deterioration, it would be necessary for all aid agencies at national levels and at international levels to re-examine the guiding principles applied in allocating budgets for country, regional and interregional programmes and in assigning respective priorities. They should also re-examine the appraisal and approval of requests, the evaluation of counterparts, achievements and the implementation of projects in the light of analyses of experience, studies and research, and should seek to identify more accurately the conditions and needs of recipient countries. It must also be borne in mind that each country has its particular problems and special conditions, and that the guiding principles must have reasonably flexible cases covering special environmental problems. Very rigid and very detailed criteria and specifications which have their appeal to a bureaucracy have never simplified the real problems. In some cases, they have done more harm than good.

Seminars and other ad hoc *multinational meetings*

For the dissemination and exchange of technical information, the study of specific questions and the planning and arrangements for co-operative projects and the promotion of technical co-operation among interested countries, the United Nations has organized a number of regional and interregional seminars, study tours and meetings of experts. In many instances, these programmes have contributed to the solution of side problems in addition to their main objectives.

Publications

Various publications issued by United Nations organizations on surveying and mapping, and related fields, have received universal recognition as authoritative sources of information dealing with matters in the field of international co-operation on cartography, particularly those matters concerned with the formulation of national and international policy. These publications have been used, especially by national cartographic services in developing areas, as a means of communication with the outside world and a source of guiding advice for solving local problems. The demonstrated interest in these publications justifies their essential role in the dissemination of technical information and the transfer of science and technology in the furtherance of international co-operation in cartography and in promoting understanding and appreciation of the importance of basic mapping in economic development.

United Nations publications related to cartography include annual reports on the International Map of the World on the Millionth Scale (IMW), the periodical *World Cartography* and reports of regional cartographic conferences and of conferences on the standardization of geographical names. Additional reports and papers are prepared on a variety of cartographic matters and are distributed on a limited basis.

International Map of the World on the Millionth Scale

The International Map of the World on the Millionth Scale, an international project undertaken over half a century ago, was integrated in 1952 into the work of the United Nations. At that time, the functions of the former Central Bureau of the IMW, an intergovernmental body, were transferred to the United Nations by the Economic and Social Council in accordance with its resolution 412 A II (XIII).

The United Nations Technical Conference on the International Map of the World on the Millionth Scale was held at Bonn, Federal Republic of Germany, in

phy in accelerating and refining control and satisfying unknowns about man's environment.[20]

The establishment of national vertical control datums properly referenced to standard tide-gauges should be encouraged for all countries. Mean sea level is in reality a geodetic datum. National datums should be tied together to effect continental datums. A periodical reobservation and new adjustment of the vertical control network should be encouraged for all countries to monitor the constantly changing earth's crust and the inadvertent modifications resulting from the actions of man, such as the removal of underground water and oil. Over much of the earth, sea level appears to be rising while the coastal areas appear to be subsiding. Man has only been sampling data on these insidious changes in a logical manner in the past century. Observation should be intensified to determine if the trend is continuing, if irreversible consequences can be expected and if corrective steps must be considered in the near future.

Progress in developing and improving instrumentation has led to the development of the automatic level. The proper use of this instrument speeds national levelling surveys. These surveys are largely manpower-oriented operations, and it should be easy for developing countries to build up adequate, local expertise. Independent repetition of surveys and good permanent marking are essential if the surveys are to be of lasting benefit.[21]

Substitutes for spirit levelling in the form of hydrostatic levelling or laser instrument adaptation appear to be near the breakthrough point.

Adequate vertical control is rarely available for the topographic mapping of large areas. For intensification of vertical control of photogrammetric operations, especially topographic mapping, airborne radar profiling has been utilized for wide expanses of flat terrain, with the technique being further improved and laser profiling has been perfected for rugged and tree-covered terrain.

Photogrammetry[22]

It is still foreseen that during the decade of the 1970s most of the cartographic mapping at small and medium scales will be done with the aid of photogrammetric techniques. For developing countries, the types of work can range from a simple photo coverage to the most accurate maps, depending upon the particular conditions and needs of each country.

As a means of improving efficiency in map production, and, of course, reducing costs, special attention should be given to the use of super-wide-angle images, aerial triangulation and photo maps.

The improving quality of modern cameras, the availability of high-resolution films and the accuracy of modern plotters allow the use of smaller scale images, which, in most cases, can only be obtained with the use of super-wide-angle lenses. This type of imagery has been used in many countries with good results. As fewer pictures are needed to cover an area, the ground control is reduced and compilation is speeded up. Vertical accuracy of contouring, or of spot heights, has been proved to be superior if compared with conventional wide-angle photography.

Aerial triangulation is normally performed today with medium-priced plotting instruments by the independent model technique, and block adjustment of 500 models or more can be carried out with the aid of small computers. These procedures can substantially reduce the requirement for geodetic control, as this type of adjustment can be extended to include an additional border of photogrammetric models outside of the perimeter; then even less perimeter control is required.[23] The decision on which system to use should be based on relative costs and acceptance of sensible accuracy requirements.

Practical experience has shown that where 1:70,000–1:85,000 photography is used for 1:50,000 scale mapping of rectangular blocks, a vertical control spacing of from six to eight models suffices for 10-m contouring, and that for horizontal control at a spacing of 50 km is suitable when the aerial triangulation is extended to include strips of models outside the perimeter.

If ground control for the photogrammetric determination of elevation is difficult to establish, airborne profiling adjusted to widely spaced ground control (grids of 100–150 km have proved satisfactory) can provide data that are adequate for 20-m contouring.

There is little doubt that, in the survey aspects of mapping, economy is best served by using the smallest scale of photography that will meet accuracy requirements. However, a scale selected for this reason could be unsatisfactory for photo-interpretation and it may be necessary to photograph all or part of the terrain at two scales, or it may be advantageous to use different film emulsions in order to satisfy particular photo-interpretation requirements.

Some mapping organizations find it more practical to supplement mapping from small-scale super-wide-angle photography with aerial inspection and the spot photography of unidentified detail. The imagery so obtained is transferred to the basic small-scale photography with the aid of differential stereoscopes. As a general rule, linear features can be identified on the small-scale photos with reasonable certainty, but "pin-point" features are often missed.

In aerial photography, the emulsions most generally used are panchromatic, infra-red and colour. Panchromatic is usually used for general mapping coverage in combination with filters appropriate to the local photographic conditions. Infra-red has better penetration of haze and smoke, is useful for the delineation of water features and for certain types of forestry and land-use studies, but its increased contrast may cause loss of detail. Aerial colour photography usually calls for very good weather conditions and for special care in film handling and processing; and, in most cases, the best results are obtained from low to medium flight altitudes. Good aerial colour photography has certain advantages in the recognition of some natural features and is very popular for the photo-interpretation of natural resources.

[20] H. E. Hones, "Very long based interferometry, geodetic ties between continents by means of radio telescopes". *The Canadian Surveyor*, June 1970; M. H. Cohen and other, "Radio interferometry at one-thousandth second of arc"; *Science*, vol. 162 (October 1968); C. G. Lehr, "Satellite and lunar laser ranging, geodetic and geophysical applications of laser satellite ranging," Washington, D.C., Smithsonian Institution Astrophysical Laboratory, 1969.

[21] J. Schone, S. Nitzsche, "Experience with motorized levelling", Technical University, Dresden. *Jena Review*, No. 3 (1971).

[22] H. G. Jerie, *New Concepts of Topographic Mapping in Developing Countries*. (Enschede, Netherlands, International Institute for Aerial Survey and Earth Sciences, 1971).

[23] F. Ackermann, "On the theoretical accuracy of planimetric block triangulation", *Photogrammetria*, Vol. 21 (1966).

The photo-interpretation requirements of various scientific disciplines will vary in respect of scale and emulsion, but it may be possible to organize systematic, area-by-area mapping for both topographic and resource data at medium and large scales by using simultaneously exposed panchromatic and aerial colour photography. It is a matter for management decision as to the best procedure to be followed in particular circumstances.

Photo maps in various forms have been used for many years, but their inherent distortions have restricted their use to a few rather specialized functions where metric accuracy was not a requirement. However, recent developments in orthophoto production techniques and equipment have altered this situation, and it is now possible to produce a photo map to the same accuracy specifications that govern the production of the corresponding line map. Cartographic agencies now have this option at their disposal and can choose the method that best meets their needs.

In developing countries it may be desirable, in the beginning, to produce orthophoto maps by simple rectification in flat terrain and by the use of manually operated, relatively inexpensive projection-type equipment in broken terrain.

There are at least three major points which should be considered: first, the utility of the photo map with respect to its conventional counterpart the "line" map; secondly, the economy in time which may result; thirdly, the economy in resources and funds. Other considerations include the enhancement required and ease of revision.

A system of conventional signs and symbols has been developed which enables the map user to understand the conventional line map with relative ease in most instances. However, in some areas that do not lend themselves to portrayal in this manner, the photographic image can be of much greater value to even the unsophisticated user. In these circumstances, the orthophoto map meets the user's requirements better and should become the standard series map produced, provided contouring is obtained in the process or otherwise achieved.

The basic production steps which take place prior to map compilation: the establishment of survey control, aerial photography and aerotriangulation and adjustment are almost the same for line and orthophoto maps. A drastic reduction in the elapsed time required for the remaining production steps to make the map available to the user can be made by using the photo map (assuming a minimum of cartographic enhancement), a factor which may be of the utmost importance in instances where topographic maps must be available before important development projects can proceed. Field inspection and editing are normally not necessary; but the user of photo maps must undertake his own interpretation and is expected to develop a certain amount of skill in photo-interpretation, which in turn will be beneficial to his own purposes.

Orthophoto maps permit scientific, technical and administrative users to directly plot relevant data in its correct map position by simple image correlation. It could be that the demands that will arise for map revision in areas of intensive development can only be satisfied by the frequent production of orthophoto maps.

In general, savings in production costs resulting from the use of photo maps in place of line maps range from a minimum at the smaller scale to a maximum at the larger scales where a great amount of planimetric detail needs to be shown. In these circumstances, major economies in manpower and costs can be achieved and maps can be placed in the hands of the user at an earlier date. This factor may influence a cartographic agency to use the photo map as an interim solution even though the long-term requirement is the conventional line map.

The value of photo indexes and uncontrolled mosaics which can be produced with a minimum of time and effort from existing aerial photography should not be overlooked in the planning and execution of preliminary resources studies, particularly where time is of the essence. Similarly, photographic enlargements, whether rectified or not, can be of great assistance.

Side-looking radar[24]

Practical air survey experience over many years and the examination of meteorological satellite imagery indicates that parts of the world surface are almost continuously cloud-covered. Over these areas, optical or video methods are unlikely to produce imagery despite repeated coverage. Areas in the equatorial regions of South America and on the island of New Guinea are notable examples. Over parts of these areas, current side-looking airborne radar (SLAR) capabilities have been successfully applied for the production of reconnaissance type maps.

SLAR techniques are being progressively developed and refined, and can already provide imagery that is acceptable for mapping purposes. Very useful equipment is held by various commercial survey firms, which also possess the necessary expertise to apply the technique and process the results. However, its application is fairly expensive; and in areas of great relief, additional coverage will be necessary in order to penetrate radar "shadow" areas.

There is no doubt that improved equipment and processing techniques will become available in future, but SLAR mapping activities will always need to be supplemented by field inspection, by aerial spot photography and often by ground and airborne remote sensing. Bearing these factors in mind, there is now a strong case for applying current SLAR techniques to the production of useful maps of reconnaissance character in areas where dense cloud cover inhibits normal air survey methods.

Remote sensing[25]

Using conventional aircraft, techniques have been developed whereby synchronous images taken with various types of photographic films and filter combinations may be superimposed in projection to accentuate particular spectral responses that are useful for identifying specific resources. In addition to aerial photography, various types of airborne surveys have been, and are being, undertaken for the location of natural resources and to provide data useful for the conservation of the environment. These surveys employ scintillation counters, magnetometers, microwave radiometers, infra-red scanners, etc.

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[24] See H. Robert Gribben and others, "Side-looking radar—state of the art", *World Cartography*, Vol. XI (United Nations publication, Sales No. E.71.I.6), pp. 16–32.

[25] Alan F. Gregory, "Earth—observation satellites: a potential impetus for economic and social development", *World Cartography*, Vol. XI (United Nations publication, Sales No. E.71.I.6), pp. 1–15.

Imagery from aircraft is, in turn, being supplemented by images obtained from spacecraft. In recent years, sporadic photography has been carried out from such craft with spectacular synoptic results, but inferior metric quality. However, these activities have indicated that the possibility of systematic, world-wide aerial photographic coverage is well worth investigating, particularly so if other forms of remote sensing are simultaneously undertaken from the same vehicle and subsequently correlated

In pursuance of these possibilities, two earth orbital remote-sensing operations (ERTS and SKYLAB) are projected by the United States of America for launch during 1972 and 1973. Because of the possible impact of these operations upon world mapping, the projects should be followed in detail.

Sensing from ERTS will be primarily restricted to areas within range of the ground receiving station. At first, the video tapes, as recorded at the ground receiving stations, will be transformed into photographic images and nominal corrections for image distortion and radiometric corrections will be applied in the course of this processing. A proportion of the imagery will be further processed to give more precise results and printed out on the scale 1:1,000,000. Facilities will be available for transformation into computer-compatible digital tape of imagery of common ground recorded in different spectral bands.

Great problems of data and information handling, processing and storage will attend upon this project; and although detail resolution will be fairly coarse on this initial project, exciting photo-interpretation possibilities are suggested, in particular from the examination of accurately superimposed images.

The transformed photographic imagery from the ERTS project and, more particularly, the direct copies of SKYLAB photography will permit production of small-scale (probably 1:250,000) planimetric maps from familiar materials and by methods that are already well established. It is, therefore, most desirable for the sponsoring country to make copies of these photographs readily available to the developing countries, who in turn should accept the responsibility for rapidly producing at least reconnaissance-type topographic maps of such of their territory as still requires mapping or for making such revision of existing maps as may be effected from the imagery, preferably on the basis of orienting and scaling this mapping to position control determined from satellite geodesy.

It is hoped that when useful data become available from satellite sources, both developed and developing countries will co-operate to extract such resources data as may be effectively obtained from this remotely sensed data and information—possibly on the basis of the developed countries predominating in the more sophisticated processing and the developing countries accepting primary responsibility for "ground truth" surveys.

It would appear that the early part of the 1970s will be taken up with the experimental approach; and, depending upon the technical progress made, the effectiveness of operations and the development of a satisfactory cost/benefit structure, progression is likely through a development phase in the second half of the decade to an operation phase from about 1980 onwards. It should be noted that the cost/benefit aspects vary with the outlook of the participant. To the sponsoring countries, it could be of tremendous significance; but to developing countries, the cost factor will be minimal if imagery could be made available at a low price

In so far as cartographic agencies are immediately concerned, there will always be a requirement for more detailed and precise data than that obtainable from satellite-borne remote-sensing operations; and these operations themselves will require the verification support provided by the more detailed ground surveys. Assuming the satellite operations are satisfactorily developed, there will still be a demand for continuation of some of the traditional ground and air survey methods, which should therefore continue until they, it is hoped, become an integral part of a wider programme

Most forms of remote sensing of the earth have an interdisciplinary application. Where the sensors are carried by relatively inexpensive ground and airborne equipment, complete integration of activity is not always practical nor necessarily desirable. With the projected use of extremely expensive satellite vehicles that can carry only packages of limited size and complexity, and with the attendant build-up of expensive and complicated systems of data collection and processing, together with the necessary allocation, and training of, skilled manpower, a multidisciplinary approach is essential in the planning, development and effective use of satellite-borne remote-sensing techniques. Furthermore, account must be taken of the possible use of multipurpose satellites. Indeed, such combined approaches and the cumulative benefits derived from them are the most likely sources of the benefits necessary to offset costs and thereby establish a viable operation. To this end, cartographers must co-operate closely with other interested scientists.

It is stressed that although satellite remote-sensing techniques are as yet unproved, they do appear to have a capability of providing, even during this decade, useful products for cartography at 1:250,000 scale. Undoubtedly, many problems have to be overcome, but it is suggested that the countries sponsoring these projects and the recipients of the space data plan their activities towards the early production of maps of those portions of the earth currently unmapped

Electronic data-processing and automation

The past decade has seen a material increase in the use of electronic data-processing (EDP) techniques in surveying and mapping, principally in computation and storage and retrieval methods. It can be anticipated that EDP activities will increase both in number and in scope in the Second United Nations Development Decade.

Probably the field in which the most progress has been achieved is computing, although the general approach has been to use complex programmes and large and costly computer systems requiring highly trained and experienced technical staff. A more recent development is the desk computer, which is compact and portable and has the added advantage of being serviceable and relatively inexpensive. It has sufficient capacity to handle practically all types of computation undertaken by survey organizations in their routine operations and can be operated by trained technicians who have a knowledge of survey computations.

The survey computation problems encountered by newly formed survey organizations can now be handled by the desk type of computer. As an organization

develops and the scope of its activities and responsibilities increases, steps can be taken to make use of more complex computer facilities and to develop the required technical expertise. A parallel situation exists in the initial operations of a photogrammetric unit in a newly formed mapping organization.

The automated orthophoto equipment and analytical plotters developed in the past decade facilitate photogrammetric observations for aerial triangulation and permit the production of digital terrain data from which computer-processed and automatically plotted contours can be derived or which can be directly used in computer studies for engineering purposes or for geomorphological investigations.

The term "data bank" is widely used today, with the inference that it is required for all survey organizations irrespective of size and that it is the ideal solution for data storage and retrieval problems. Admittedly, it should provide the best answer where there is a large volume of information held by many different agencies and where immediate access is of prime importance; but these conditions are usually only encountered in countries that are relatively well developed. It may be far more important to have a well-ordered manual system of records from which information can be made available quickly and easily than to proceed prematurely into an automated data bank.

In fact, an overlapping pair of aerial photographs in combination with identified control data constitutes a small data bank from which much information pertinent to the terrain covered can be derived using a combination of manual and/or automated processes. Ideally, this type of information should be built up into a national coverage.

Although extensive research is currently being undertaken in the application of automation to map production, the progress attained is barely reaching pilot operational stages. Digitizers and plotters of sufficient accuracy now appear to be available, and the main problem lies in developing the most effective means of operating these in association with a computer. On the other hand, technological support for such operations is in a rapidly changing state.

At this stage, it seems desirable to observe and keep in touch with the progress in these experimental projects; but steps to place them in a production role would be premature until further research is undertaken and experience is gained. This experience might be gained by the gradual introduction of partial automation for specific cartographic operations, making part-time use necessary of outside equipment, particularly so if this were likely to be economically advantageous.

Map production

Scribing on coated stable-base film is now a well-established and widely accepted process for the production of line drawings. Area symbols are produced on similar base material, with a peelable coat; and nomenclature is normally shown by phototype setting on adhesive stripping film mounted on a clear film overlay. Scribing and reproduction material is prepunched, and correct registration of map detail is maintained throughout all production stages by precisely machined register bars and studs.

A wide range of films with light-sensitive coatings is available, and accurate densitometers (reflection and transmission) are used for the control of densities and colour values during photography and printing.

Automated equipment is being used to help keep pace with the increasing requirements for map reproduction. For example, automatic film processors with automatic chemistry replacement are used to develop, wash, fix and dry the various types of film used; and automatic place processors perform a similar function for exposed printing-plates.

Modern photomechanical methods are being applied to the colour proofing of maps. Dye processes are commonly used; and electrostatic processes, which are already widely used in smaller sizes, show promise of becoming an alternative method.

The use of modern multicolour printing machines and the maintenance of temperature and humidity control in all work areas reduces printing times and improves colour registration.

In the production of thematic maps, economy is achieved by the use of limited numbers of primary colours from which tints are produced with the aid of various combinations of percentage screens.

Some of these techniques require sophisticated and expensive equipment which has been designed for the long-run, multicolour map production required to meet demands in highly industrialized countries. However, developing countries can at first make use of simpler techniques and equipment, which, nevertheless, are capable of quality work.

In this context, scribing on dimensionally stable, coated films with standard scribing equipment requires a minimum of training. Precisely machined register bars and studs will ensure good registration, while rub-on diazo-type coatings are available for guide images and rub-on chemical dyes for colour proofing. A wide variety of film and paper products employing fume development for contact printing is available, and silk-screen processes requiring a minimum of equipment and technical training can provide limited runs of good-quality printing.

It is anticipated that the use of orthophoto maps will increase and will lead to improvement in the colour photography reproduction processes, in the methods for the cartographic enhancement of monochrome and multicoloured orthophoto maps and in continuous tone printing techniques for quantity reproduction. A recently developed grainy film which permits the equivalent of half-tone negatives to be made without the use of a screen may have an impact on the production of photo maps in quantity.

Advances in camera and film resolution should improve even further the miniaturization of photographs and maps for the purposes of storage and for use in projection equipment.

From the current trend in development of automatic procedures, it appears that the scribing method will continue in use, as will the earlier pen-and-ink method for preliminary plots. However, the use of automated equipment with photographic writing heads is likely to increase, permitting the drawing of maps directly on the photographic film and the addition of a complicated symbol in a short exposure. Such techniques may accelerate map design, generalization and revision, and facili-

ORGANIZATIONAL STRUCTURE

The Institute is composed of the following Pan American organs: (*a*) General Assembly; (*b*) Directing Council; (*c*) commissions on cartography, currently with headquarters in Guatemala; geography, at Hamilton, Canada; geophysics, at Santiago, Chile; history, at Caracas, Venezuela; (*d*) General Secretariat, with headquarters in Mexico, D.F.

In addition, in each member State there is a national section which functions as the organ that connects the Institute with its Government. In each national section, there is a chairman and the national and alternate members on cartography, geography, history and geophysics, as well as the members of the committees.

During the meetings of the General Assembly, which take place every four years, the scientific and administrative policy of the Institute is formulated. During the intervals, the Directing Council meets annually to review progress on work programmes and to fix goals for the activities of the subsequent year.

Normally, the Pan American Meetings of Consultation are held simultaneously with the General Assembly to adopt reccomendations or resolutions considered advisable for the development of the sciences with which PAIGH is concerned. In addition, the work programme for each of the commissions is established.

The commissions are composed of the various scientific committees to which technicians of the national section belong.

ANNEX I

Programmes of the Pan American Institute of Geography and History

Programme I. Promotion and diffusion

1.1. Publications	1. Periodicals Articles are published in Spanish English. Portuguese or French, but with summaries in one or more of the other languages.	Journals:	Cartography Geography History of America American Folklore History of Ideas Pan American Geophysics
		Bulletins:	Bibliographical Bulletin of American Anthropology Archives
		Informational:	Boletín Aéreo. General Secretariat Commission on Cartography Commission on Geophysics
	2. Technical	Bibliographies Catalogues Glossaries Guides Inventories Manuals Series Basic texts Translations Vocabularies	In the fields of cartography, geography, history and geophysics: Manual of Urban Surveys Manuals on Teaching of Geography (by country) Series on historical and archaeological monuments by country) Glossary of Geophysical Terms
	3. Reports and Acts	Of periodical and technical meetings	
1.2. Meetings	1. Periodicals	General Assembly Directing Council Pan American Meetings of Consultation on: cartography, geography, history and geophysics	
	2. Technical	Of committees and working groups Symposia, conferences. seminars, round-tables, etc., some of which are: Conference on Problems of the Solid Earth Buenos Aires. Argentina, 1970 V Meeting on Natural Resources, Bogotá, Colombia, 1971. I Pan American Meetings on Cadastre, Caracas. Venezuela, 1971. Seminar on Colonial Institutions in the Americas during the XVIII Century, Quebec, 1972. I Pan American Symposium on Remote Sensing, Panama City, Panama, 1973.	

ANNEX I (*continued*)

Programme II. Scientific and technical

Cartographic	Special maps	Inventory of cartographic publications in the member States Map of Communication Means in Latin America Text for thematic maps: "Símbolos temáticos criteria normativos" Index of National and Regional Atlases of America
	Topographic maps	Glossary of Cartographic Terms Maps of topographic and aerial photographic coverage Exchange of technical manuals Technical Manual on Topographic Symbols Library of computer programmes
	Geodesy	Specifications for application of electromagnetic instruments for measuring of distances Glossary of Geodetic Terms
	Gravimetry	Gravimetric verifications Measurement of absolute gravity (verification)
	Hydrography	Glossary of Tidal Terms Standards for tide-gauge stations
	Urban surveys	Manual on Urban Surveys Pilot project (Tandil), Argentina
	Aeronautical charts	Catalogue of Technical Manuals
Geographical	Environment	Phytoecological classification to be used in geographical studies in the Americas
	Urban and regional	Study of role of cities in regional integration
	Geomorphology	Standards for a geomorphological map of America, classification of morphological units, cartographic symbols, scales and recommendations on methodology
	Teaching and texts	Promotion of the improvement of the teaching of geography
	Special working groups	Working Group on Pioneer Areas Study of indications for the geographical analysis of regions in the process of colonization and development Working Group on Regional Effects of Public Investments Study of the effect produced by public investment in the economic and social structure on urban and regional development Working Group on City-Country Interrelations Study to define the relations between cities of different hierarchies in a given urban system and a dependent rural area Working Group on Process of Dissemination Study on the definition and qualification of indicators to measure the process of dissemination of innovations Working Group on Basic Texts Preparation of basic text on methodology for urban and regional research
Geophysics	Solid earth	Standardizations of instruments of magnetic observatories Risks caused by earthquakes (TERRE)
	Special working groups	Information System for Geophysical Sciences: original research, preliminary studies, planning, design and implementation in accordance with necessities and status of information systems for geophysical sciences (reports and maps will be produced) Gravity Information System (SILAG) Seismology Information System (SILAS) Bibliographic Information System (SILAB) Information System on Wells (SILAP)

ANNEX I (*continued*)

Programme III. Technical co-operation

Cartographic	Topographic maps	Cartographic work for publication of maps of the Argentine-Chilean border (collaboration)
	Geodetic	Geodetic work on the Argentine-Chilean border (collaboration)
	Hydrography	Tide-gauge net
	Urban surveys	Project of assistance to Nicaragua
Geographical	Geographical terms	Co-ordination of Pan American activities on geographical terms
	Working groups	Working Group on Use of Water: study of the use of water in arid and semi-arid areas of Argentina and Chile Working Group on Teaching of Geography in Meso-America Inventory of geographical concepts and evaluation of didactic material in use in Central America, Mexico and the Caribbean Working Group on Teaching of Geography in the Andean countries Evaluation of material in use for teaching of geography in the Andean countries and preparation of recommendations Pan American Center for Geographical Study and Research (CEPEIG), Quito, Ecuador Implementation of academic programme Meetings of the Academic Council Working Group on Technical Assistance for Geographical Research Continuation of current programmes in Colombia and Honduras and extension to other countries, at their request
Geophysical	Solid earth	Project Volcano—event counter Geophysical work in Central America
	Oceans and atmosphere	Project for the Decade for Exploration of the Ocean (co-operation) Project on Contamination of the Oceans and Atmosphere (co-operation) Project on Hydrological Resources (co-operation)

UNESCO ACTIVITIES IN THE FIELD OF CARTOGRAPHY*

Paper presented by the United Nations Educational, Scientific and Cultural Organization

The activities of the United Nations Educational, Scientific and Cultural Organization (UNESCO) in the field of cartography are concentrated on a number of scientific and applied aspects, mainly with respect to the study and rational utilization of the natural environment and its resources.

UNESCO is not involved in the preparation of topographic and general geographical maps, this work being co-ordinated directly by the Economic and Social Council of the United Nations and the Cartography Section of the Resources and Transport Division of the United Nations. As concerns the preparation and publication of scientific (thematic) maps and atlases, however, UNESCO does make a significant contribution.

For a number of years, UNESCO has been engaged in the preparation of series of small-scale maps dealing with the physical and biological environment of the earth and its resources. This long-term programme, which has as its objective the coverage of the whole world, including various components of the environment, is unique in its scope and value. It is implemented by UNESCO in co-operation with other agencies of the United Nations and with non-governmental international scientific organizations; and is closely linked with the large international research programmes co-ordinated by UNESCO, such as the Programme on Man and the Biosphere, the International Hydrological Decade and the International Geological Correlation Programme.

A number of these maps have already been published. Many more are in preparation. As the cartographic activities of UNESCO in Asia have been limited to date, it might be useful to give examples of the programmes in other regions as models since it is expected that the same types of maps will be produced in Asia in future.

*The original text of this paper prepared by the Division of Natural Resources Research, Paris; and the Field Science Office for South-East Asia, Jakarta, appeared as document E/CONF 62/L 112

In the field of geology, UNESCO works closely with the Commission of the Geological Map of the World (CGMW) and appropriate regional bodies in the preparation of geological maps which serve as the base maps for a series of synthesis and thematic maps in fields of geology and related sciences (geomorphology, tectonics, metallogenesis, Quaternary, soil science, hydrology, etc.).

Work has begun for the preparation of the Geological Atlas of the World on the scale 1:10,000,000. The atlas will consist of 11 sheets devoted to the continents and five sheets of a smaller scale representing the geological structures of the polar regions and oceans. It is expected that all the maps of the atlas will be published by 1976.

In the series of geological maps, one of the first maps published was the geological map of Africa on the scale 1:5,000,000, comprising nine sheets, which was issued in 1964, as a co-publication of UNESCO and the Association of the African Geological Services. It was followed in 1967 by geological maps of Africa on the scales 1:10,000,000 and 1:20,000,000.

In Europe, the preparation of a new edition of the International Geological Map of Europe on the scale 1:1,500,000, comprising 49 sheets, is being carried out in collaboration with the Commission of the Geological Map of Europe of the International Geological Congress and the Bundesanstalt für Bodenforschung of the Federal Republic of Germany. UNESCO, in collaboration with the International Union for Quaternary Research and the Bundesanstalt für Bodenforschung, prepares and publishes the International Quaternary Map of Europe on the scale 1:2,500,000, nine of the 15 sheets of which have already been published. The metallogenic and geomorphological maps of Europe, on the scale 1:2,500,000, as well as the hydrological maps of Europe, North Africa and South America; and the tectonic maps of Europe, South America and the Karpato-Balkanian region, are in preparation.

With respect to Asia and the Far East, UNESCO, jointly with the United Nations Economic Commission for Asia and the Far East (ECAFE), published in 1971 a geological map of Asia and the Far East on the scale 1:5,000,000.

The thematic maps related to geology that have been published or are in preparation include tectonic, metallogenic, metamorphic, Quaternary, hydrological and geomorphological maps in Europe; and tectonic, metallogenic and metamorphic maps in Africa. In Asia, work is in progress on a tectonic map of Asia and the Far East, in co-operation with ECAFE and CGMW, and preparations are being made for a hydrogeological map of Asia and the Far East. In this connexion, a meeting of the Consultative Group on the Tectonic Map of Asia and the Far East was recently held at Kuala Lumpur and a meeting of the CGMW Subcommission for Asia and the Far East is planned to be held at Calcutta early in 1974.

Under the joint project with the Food and Agriculture Organization of the United Nations (FAO), UNESCO is publishing the Soil Map of the World on the scale 1:5,000,000. The map comprises nine continental units making up 18 sheets: North America, Mexico and Central America; South America; Europe; Africa; south Asia; north Asia, South-East Asia; Australia; New Zealand and the Pacific islands. An additional sheet is devoted to the general legend. As of 1973, four of the continental units and the sheet of the general legend have been published. The other five continental units are expected to be published within the subsequent two years.

The series of maps of vegetation was begun with the publication in 1973 of the vegetation map of the Mediterranean region on the scale 1:5,000,000, and preparation of the vegetation maps of Africa and of south Asia are under way.

In the series of climatic maps, FAO and UNESCO jointly published the bioclimatic map of the Mediterranean zone on the scale 1:5,000,000 (1963). In co-operation with the World Meteorological Organization (WMO) and Cartographia (Budapest), UNESCO was co-publisher of the Climatic Atlas of Europe (1970). The atlas consists of 27 maps on the scales 1:5,000,000 and 1:10,000,000, which contain climatological data collected during the period 1931-1960. This is the most complete and precise climatological atlas of Europe, which can be used for research and educational purposes in various fields of natural and human sciences where such data can be useful.

As concerns oceanographic maps, UNESCO is engaged in the publication of the Atlas of the International Co-operative Investigations of the Tropical Atlantic (ICITA), which will contain maps and vertical sections compiled from the data of international expeditions in the Atlantic Ocean in 1963-1964.

Although the cartographic production of UNESCO relating to the regional needs of Asia and the Far East has been rather limited, it is expected that the same types of maps that were made for other regions, such as those for Europe, Africa and Latin America, will also be produced for Asia.

It should be stressed that all the maps published or co-published by UNESCO are the result of international scientific activities involving many individual scientists and research institutions of different countries.

The process of compiling these maps includes the elaboration of common nomenclatures and general legends, as well as intercalibration of research methods for comparability of data, which can be achieved only through the international scientific collaboration and mutual understanding of different scientific schools. The information they contain make these maps a very useful tool for general study of natural resources, planification of their utilization and management, as well as for various educational purposes.

Among other UNESCO activities with respect to cartography, one should mention the collaboration with the International Cartographic Association in the development and promotion of modern techniques and methods of compiling maps and national atlases, including the automation of cartographic processes, as well as in cartographic education, mainly for the benefit of developing countries. During the past several years, UNESCO took part in the organization of a number of scientific symposia, technical conferences and expert meetings, and published some of their reports.

UNESCO is ready to take into consideration the recommendations of the Seventh United Nations Regional Cartographic Conference for Asia and the Far East when planning its further activities in this field and will be willing to offer its experience to meet the needs of the member States of the region.

AGENDA ITEM 7*

Geodesy and ground control

SURVEY OF GROUND SUBSIDENCE**

Paper presented by Japan

Abnormal ground subsidence in urban areas has become one of the urgent, social problems in Japan. The subsidence is distinguished from ordinary tectonic movements by its speed and is considered to be the result of over-pumping of underground water. The phenomenon has been noticed from the early part of the Showa era (1926-), but its occurrence was then limited to the areas within such large cities as Tokyo and Osaka.

Since the end of the Second World War, however, ground subsidence has accelerated and has been spreading into the surrounding areas. In addition to the areas of Tokyo and Osaka, many large cities situated on the alluvion near the coast have been suffering from the abnormal ground subsidence. Figure 45 illustrates the amount of subsidence in their representative areas. As seen in the figure, the subsidence in Tokyo began around 1910. Its magnitude was decreased during the Second World War because of the interruption of industrial activities. A similar pattern was also recognized in Osaka. The rapid subsidence in the city of Niigata was remarkable in the 1960s. It has been considered the result of pumping of the underground water accompanied by the exploitation of natural gas. Figure 46 shows the areas currently suffering ground subsidence. Occurrences of ground subsidence are detected through the repetition of geodetic levelling.

For effective countermeasures to ground subsidence, it is necessary to measure the expanse of the subsiding area and the amount of the subsidence. Therefore, the Geographical Survey Institute has executed precision levelling annually in most of the areas with large subsidence and has given technical advice to the local governments carrying out the survey of ground subsidence.

The levelling route, amounting to approximately 6,000 km, was surveyed in 1972 by the Geographical Survey Institute and concerned local governments.

*The paper entitled "Topography, geodesy and cartography in the USSR, 1970-1972" (E/CONF 62/L 76), relating to the present agenda item, appears under agenda item 6

**The original text of this paper, prepared by the Geodetic Division of the Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF 62/L 16.

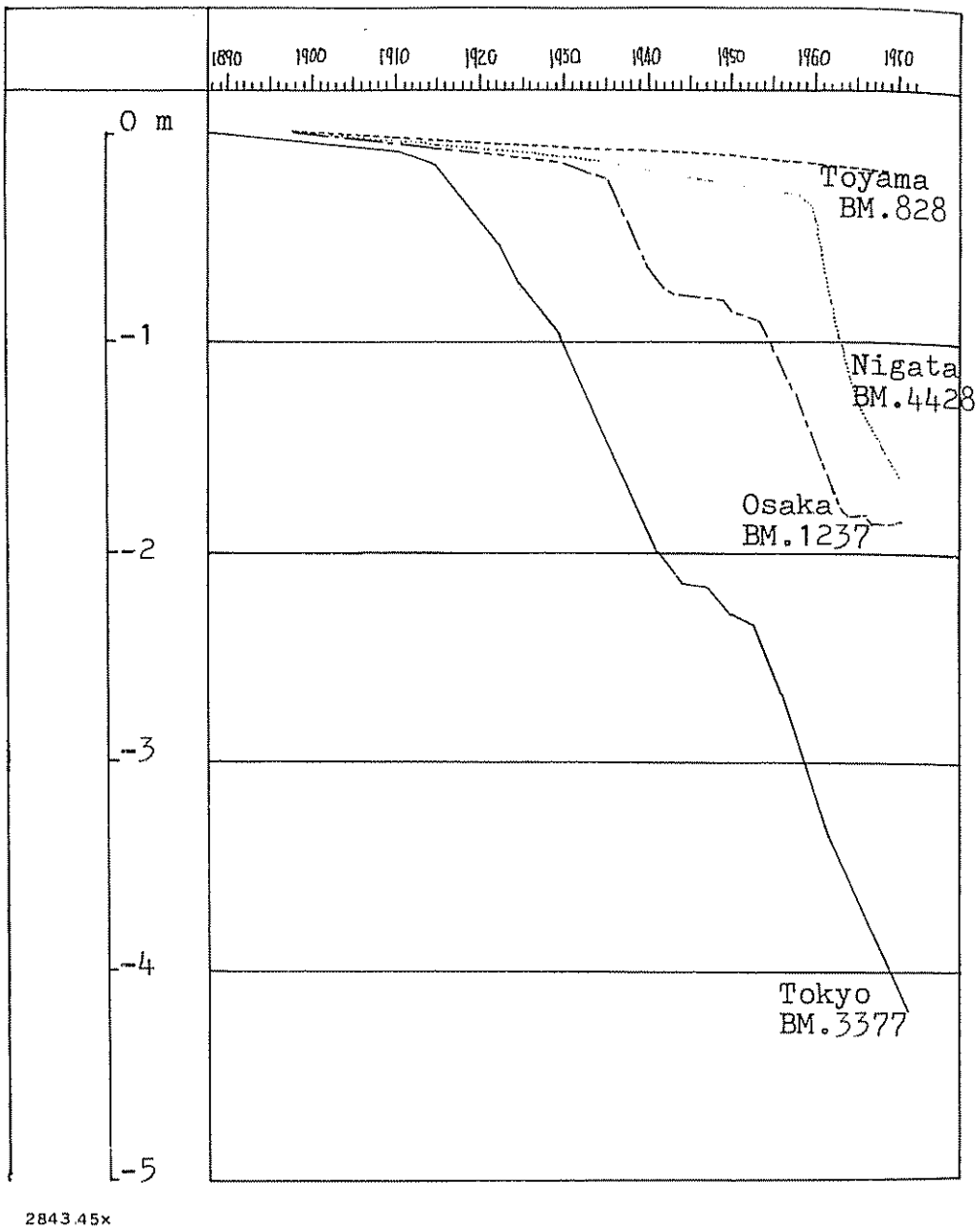


Figure 45. Japan: amount of ground subsidence in representative areas

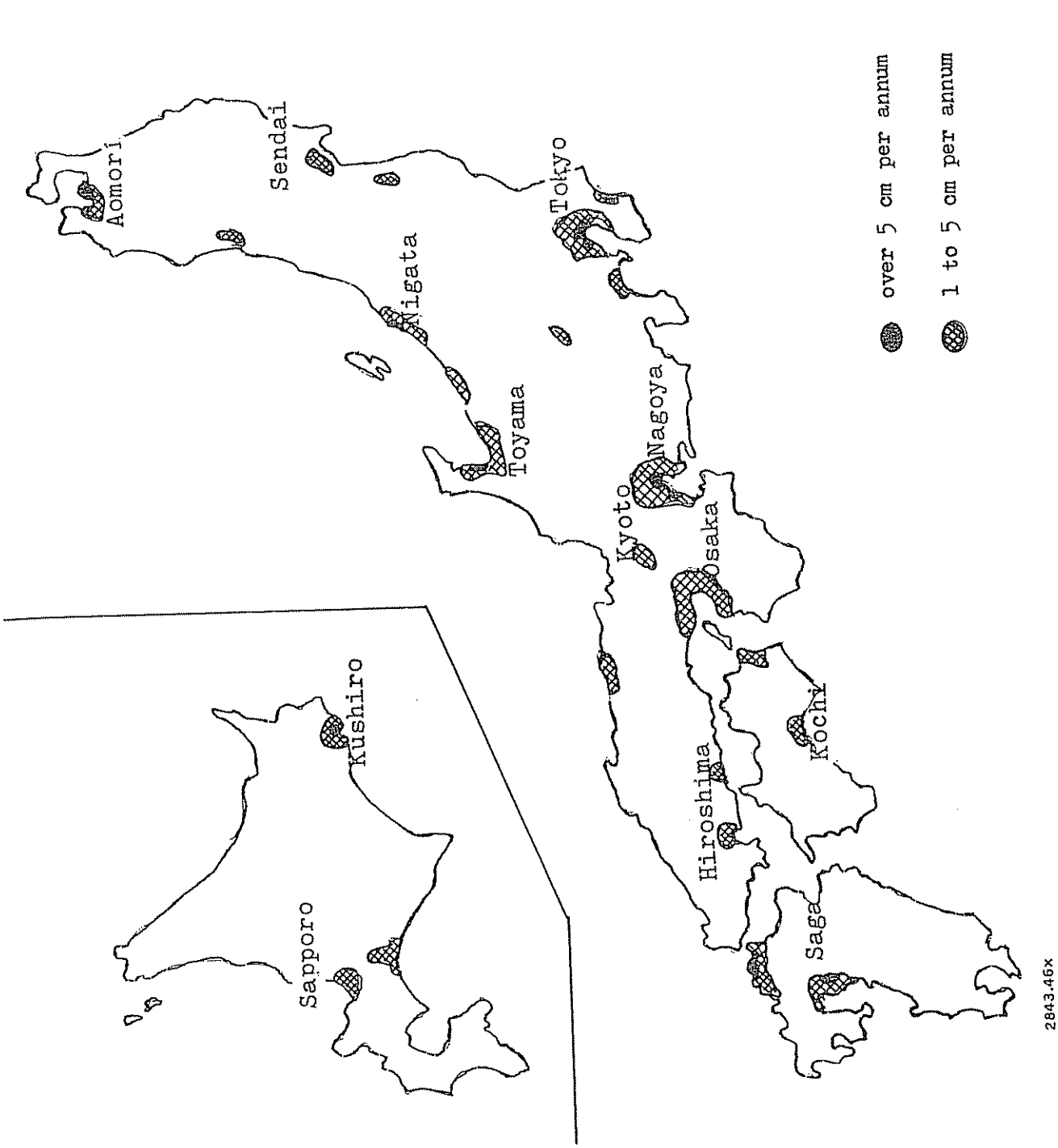


Figure 46. Japan: areas of ground subsidence

DETERMINATION OF THE POSITIONS OF OFF-LYING ISLANDS BY SATELLITE GEODESY*

Paper presented by Japan

Investigations on satellite geodesy in Japan have been jointly carried out by the Tokyo Astronomical Observatory (TAO), the Geographical Survey Institute (GSI) and the Hydrographic Department, although each organization has its own purposes and goals. TAO is studying the motions of satellites in their orbits and the gravity field of the earth. It also has contributed to the establishment of global geodetic nets through the SAO observation network for the past 10 years. GSI plans to control the domestic triangulation net. The Hydrographic Department is mainly interested in marine geodesy.

The present paper describes briefly the joint experiments that have been made for 10 years under the leadership of the Hydrographic Department, on a five-year plan to determine the positions of off-lying islands of Japan and on a planned geodetic satellite which may be useful to this kind of satellite geodesy.

Experiments on space triangulations

Investigations on satellite geodesy made by the Hydrographic Department and GSI have been mainly dedicated to purely geometrical methods through simultaneous photographic observations of bright satellites. The merits of this selection are as follows: Methods using astrometry as software, and astrographs and other equipment as hardware, are applied without severe modifications. Reliable issues are expected with minimum labour because of the simplicity of principle and theory. Moreover, these passive satellites may be regarded as natural celestial bodies for which no user needs negotiations with the countries owning them. However, the last item also involves a difficult problem, for artificial bodies may decay while a user's programme is at midpoint.

In 1961, a BN camera was installed at TAO, Mitaka, Tokyo. ECHO-I, which was launched in 1960, and this most efficient camera stimulated the investigation on satellite geodesy. Hirose proposed the trailing method, which does not necessitate the use of a timing camera except at one of the base stations.

From the first step of the experiments, one of the Hydrographic Department teams was sent each year to isolated islands in the Pacific, since the mainland of Japan is too narrow to construct space triangles. The observation campaigns made thus far are listed below with the names of islands concerned:

(*a*) 1962–1963, Hatizyo Sima;
(*b*) 1964–1965, Tori Sima;
(*c*) 1966, Amami-O Sima;
(*d*) 1967, Ao-ga-Sima;
(*e*) 1968–1971, Titi Sima;
(*f*) 1971, Io Sima;
(*g*) 1972, Minami-Tori Sima.

Of these islands, Hatizyo Sima, Amami-O Sima and Ao-ga-Sima were connected to the mainland by ordinary triangulations. The campaign in 1962-1963 was made for evaluation of the trailing method, and those in 1966 and 1967 were made in order to examine the method of synthetic observations using a new timing device which was developed by the Department. Results of the observations at Tori Sima and Titi Sima have already been reported elsewhere by the present author and others. A conclusion from these experiments is that the method of simultaneous photographic observations is not the best one for practical geodetic survey because of inefficiency due to weather, but it may secure sufficient accuracy and is, perhaps, one of the most reliable currently available which requires less labour.

Plan for positioning off-lying islands

From 20 to 30 off-lying Japanese islands have not been connected with the domestic triangulation net. Almost all of them lie in the Pacific Ocean and form an island arc to the south. Prior to 1945, the Hydrographic Department determined the longitudes and latitudes of these islands by astronomical observations; they are considered to have a significant amount of vertical deflection. The accuracy of the national map generally appears to indicate a certain phase in the development of the country, because the earth's surface is currently the field of human activity. In a practical sense, one of the purposes in determining the accurate position of off-lying islands in the ocean is recognized to be preparation for the coming age of marine activity. Off-lying islands will be authorized control points, and some of them may be used as stations of an electronic shore control system. An accuracy of ±10 m in position would be sufficient for any conceivable practical survey in the ocean. The existing satellite geodesy could then be applied to this attempt.

The Hydrographic Department is attempting to determine the positions of all of the isolated islands. Five important islands, Titi Sima, Io Sima, Minami-Tori Sima (Marcus), Minami-Daito Sima and Isigaki Sima, will be fixed by simultaneous photographic observations of the Passive Geodetic Earth Orbiting Satellite (PAGEOS) and other less bright satellites. As for the other islands, simultaneous Doppler observations of the Navy Navigational Satellite System (NNSS) will be made at two stations, one settled at the unknown island and the other on the mainland or on one of the important islands already fixed by space triangulations. As there is no reason to predict the decay of PAGEOS within the coming several years, nor is there information about an impending end of operation of NNSS in the near future, this plan can be accomplished in five or six years. The geoidal heights of the water, as well as the vertical deflections of the points, will be reduced at the same time.

Use of geodetic satellite in plan

Since 1966, GSI and the Hydrographic Department have done investigations to construct a geodetic satellite, which is useful for such a space triangulation. It will be a balloon satellite with an aluminized surface of which some thousands of retroreflectors will be placed uni-

*The original text of this paper, prepared by Takumi Mori, Hydrographic Department Maritime Safety Agency, Japan, appeared as document E/CONF 62/L 25.

formly; it will be put into a circular orbit of from 1,000 to 1,300 km height and of 45° inclination. This satellite will have enough brightness for photographing with ordinary astrographs and will reflect a laser beam more effectively than do the satellites currently in orbit. It will supply a variety of methods for practical space triangulation.

A simplification of the methods proposed by Hirose (1962) is recommended for observations at islands. That is, at a key station, the position of which is definitely known, laser ranging equipment and an astrograph having a precise timing device are installed. Observations are then made of the direction and slant range of the satellite from the station to fix the satellite in space at a moment. At an unknown station, whose position is to be determined, only a simple astrograph, say, of 10 cm in aperture and 50 cm in focal length, is needed. On this side, they take only photographs of the trajectory of the satellite, as well as the background stars around the same instant as at the key station. In principle, three observations give a fix as intersection point of three planes. The equipment of a moving station is thus made compact and easy to handle. On this account, use of this satellite is effective to fix the positions of such places as isolated islands or mountainous districts where heavier equipment is difficult to transport.

Possible faculties of future geodetic satellites are very prospective. The planned satellite may not be the best one at that time, but it will have some advantages. For instance, there need not be any permanent tracking station nor any expensive system for its use. It is expected that many countries will easily use this satellite for their own projects as well as for international cooperative works.

CRUSTAL DEFORMATION IN SOUTH KANTO DISTRICT*

Paper presented by Japan

Soon after the establishment of the Co-ordinating Committee for Earthquake Prediction (CCEP), results of the first-order levelling conducted in 1969 over the Boso peninsula, South Kanto district, revealed an abnormal upheaval of the crust, as compared with the previous results in 1965. Immediately after this detection, the Geographical Survey Institute (GSI) carried out another levelling along the routes over the Miura peninsula. Those results also proved the upheaval in the peninsula.

It has been widely acknowledged among Japanese earth scientists that the southern parts of both peninsulas have been gradually sinking after the abrupt upheaval of 1.5 m during the great Kanto earthquake of 1 September 1923. Therefore, the observed upheaval was considered to be a quite unexpected one.

Towards the end of 1969, CCEP designated the South Kanto district as an "area of intensified observation" on the basis of the detected upheaval. Since that time, various kinds of geodetic operations have been carried out in order to study the nature of abnormal upheaval to date.

VERTICAL DEFORMATION

The vertical deformation in South Kanto district during the period from 1965 to 1969 disclosed an abnormal upheaval in the central part of the Boso peninsula. The results of the subsequent levelling (1969–1971) made it clear that the abnormal upheaval had prevailed over the Miura and Boso peninsulas. At the same time, the results show the subsidence in the southern part of the Boso peninsula. The most recent levelling was carried out in 1973. The vertical deformation for the entire period from 1965 to 1973 is shown in figure 47.

From figure 47 it can be concluded that there are the secular subsidence in the southern part of Boso and Miura peninsulas and the central upheaval in Boso peninsula. From the point of view of earthquake prediction, it is quite necessary to classify this short-period upheaval as seismic or non-seismic. This problem is very difficult, because there is little experience with such short-period upheavals. Only in the Miura peninsula, frequent levellings have been carried out in order to check the relative height of the datum of levellings of Japan to the fixed bench-mark at Aburastubo Tidal Station on the Miura peninsula. Analysing these results of frequent levellings, it was pointed out that there may be crustal movement with short periods on the Miura peninsula. Therefore, a possibility exists that the current abnormal upheaval may be considered to be this kind of crustal movement in the Miura peninsula. In this case, the detected abnormal upheaval may be non-seismic. To fix the conclusion, there is need for more observations and studies on the nature of short-period crustal movement.

HORIZONTAL DEFORMATION

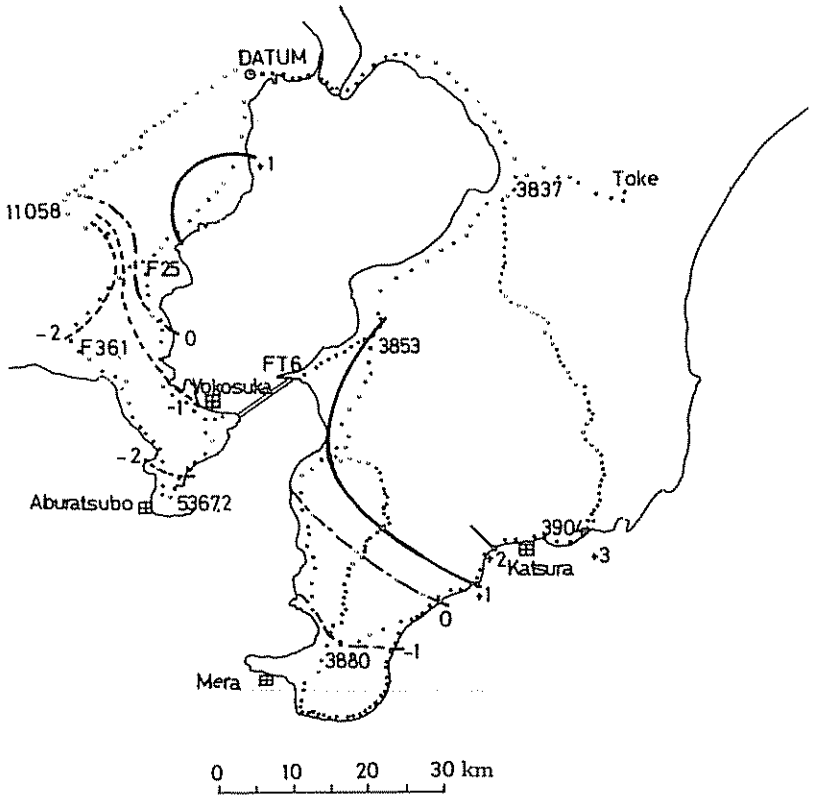
The first-order triangulation net in South Kanto district was established during the period 1883-1891. After the great Kanto earthquake of 1923, the repeated triangulations demontrated the abrupt horizontal crustal movement accompanied by the earthquake. No further triangulations have been carried out. In order to study the nature of the detected abnormal crustal movement, the "precise earth strain measurement" was newly planned and performed in South Kanto district through the use of laser Geodimeters. Figure 48 shows the changes of side lengths of the triangulation nets. Figure 49 shows the earth strains computed from the deformation of triangulation nets.

The results show that the South Kanto district is compressed from east-south to north-west, and the maximum shear strain is 3×10^{-5}. The strain energy stored in the deformed area is estimated to be equal to earthquake energy with a magnitude of 7. Currently, however, there is no fore-runner of the great earthquake. As the observations were carried out only for the large-

*The original text of this paper, prepared by Crustal Activity Research Office, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.62/L.28.

scale nets, there is little information available about the strain in smaller parts of the crust. Therefore, the possibility of the occurrence of an earthquake cannot be denied.

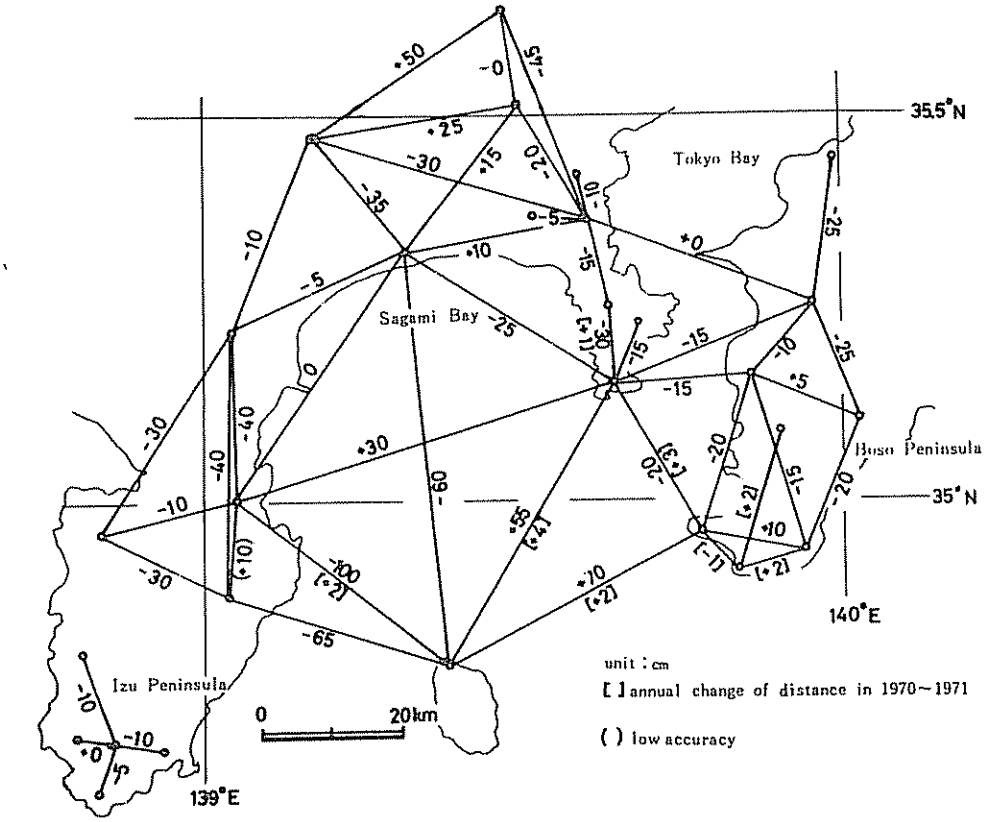
In conclusion, the geodetic operations continued in order to monitor the crustal mo South Kanto district and to detect the fore-r coming earthquake in this district.



2843.47x

Note: Height of the datum of levelling is assumed to be unchanged.
Results of sea cross-levelling in 1965 and 1972 are used in old and new net adjustment, respectively.

Figure 47. Japan: South Kanto district, vertical deformation of the crust, October-November 1965-January-March 1973 (centimetres)



2843.48×

Figure 48. Japan: South Kanto district, horizontal deformation of the crust, distance changes on each side length of triangulation net 1924-1926-1970-1972.

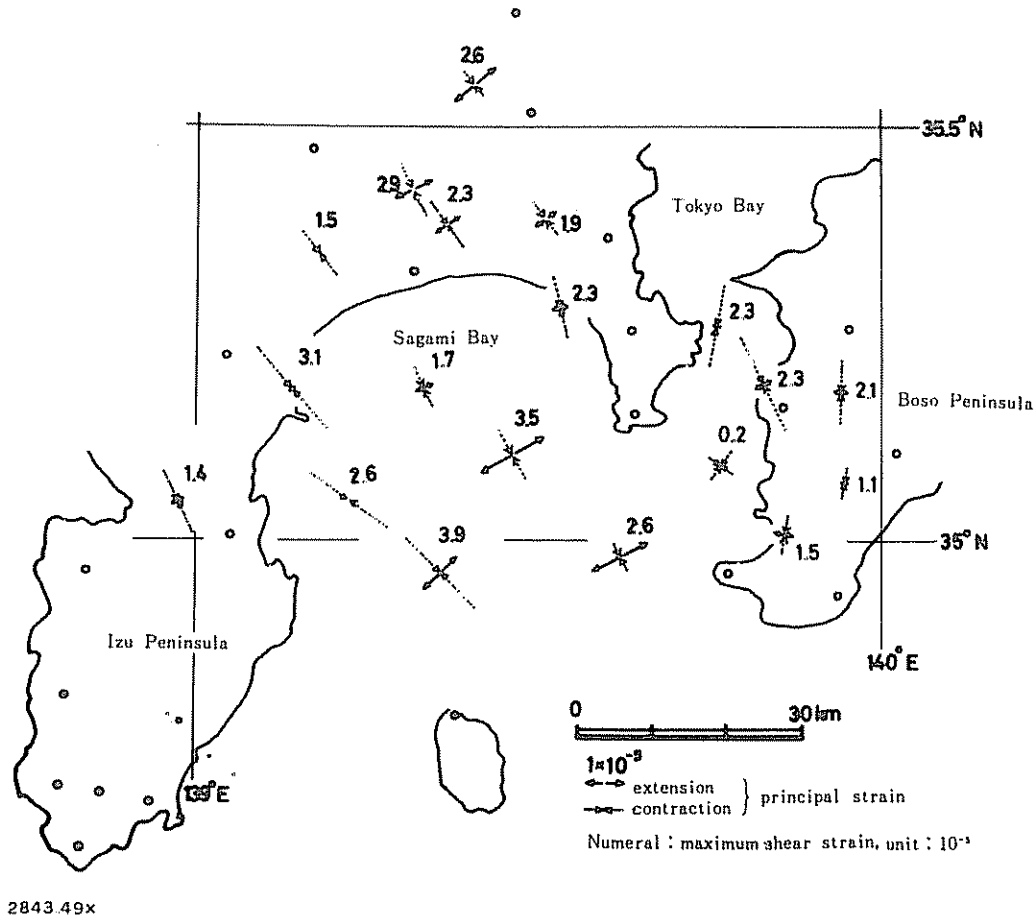


Figure 49. Japan: South Kanto district, horizontal earth strains calculated from results of distance change, 1924-1926–1970-1972

SOME REMARKS ON THE FUTURE ROLE OF GEOMETRIC SATELLITE GEODESY*

Paper presented by the Federal Republic of Germany

This paper relates the influence of improved measuring accuracies to the future role of geometric satellite geodesy and the improvement and densification of the zero-order reference net. The relative merits of combining range, range-rate (Doppler) and directional observations are discussed and illustrated numerically on the basis of two possible European test configurations.

The earlier years of satellite geodesy have seen a preponderance of direction observations, primarily for use in the solution of geometrical problems. Continental and world-wide nets have been observed. The accuracy of point determinations by these means has remained mostly at the 10-m level although the most extensive and ambitious world net, observed by the United States Coast and Geodetic Survey, reached relative values of 4–6 m. The improved accuracies now being reported for laser, Doppler and other techniques have led to changes in emphasis, so that one must ask what purposes future projects should serve, how they should be shaped, what distribution of stations they will require and how those stations should be equipped.

To answer these questions, one must distinguish between programmes of national, multinational and world-wide (international) interest. Recent developments have indicated that, for the foreseeable future, the main effort of satellite geodesy will be concentrated on geodynamic problems. Such problems are, by nature of international interest and require a good distribution of stations at optimal positions in and around the areas under investigation. However, although geometrical information is only to be foreseen as a by-product of these programmes, it can be expected that there will be a continued effort to improve and densify the zero-order reference net.

INSTRUMENTATION

Although no general prediction can be made with respect to the purpose of future programmes, several areas of long-term investigation are crystallizing. Satel-

*The original text of this paper, prepared by Dieter Ehlert, Hermann Seeger and Peter Wilson, Institut für Angewandte Geodäsie, Frankfurt am Main, appeared as document E/CONF 62/L 31

lite geodesy can already be used to determine polar motion with a consistency at least comparable to that obtained by classical means; earthquake prediction and measurement of local movement based on laser ranging to satellites over lines of crustal instability are currently being undertaken; the direct determination of the mean ocean (geoidal-) surface using satellite altimetry will commence next year following the launching of GEOS-C. It is of interest at this point to consider the ground instrumentation which will be used in future investigations. In order to do this, it is necessary to distinguish between fundamental investigations, such as those necessary for the determination of polar motion, earth-rotation rate and the basic tracking of satellite orbits, and local investigations, for example, to determine point positions or crustal movement over a limited area.

For the fundamental investigations, it will be of value to establish a limited number of sophisticated, well-equipped stations in order to determine eventual systematic influences; whereas for the specialized projects of more limited interest, it will suffice to provide transportable instrumentation which can be moved from place to place and brought into operation within a reasonable time-span. Current trends indicate that laser ranging and Doppler tracking units are ideally suited for application in local investigations. Whereas the current accuracy of laser ranging is considered to be between ±1 m and ±0.5 m, with individual stations reaching ±10 cm, and improvement to about ±1 cm can be predicted for the foreseeable future.[1] In order to make use of this measuring capability, it will be necessary to make corresponding refinements in the theory. Doppler is already delivering independent point positions in relation to the geocentre with an accuracy of ±2 m after three weeks of observation. By contrast to these stations, the fundamental points will have multiple capabilities to measure range, e.g., laser, C-band-radar, very long base-line interferometry (VLBI); range-rate, e.g., micro-wave Doppler, laser-Doppler; and directions, e.g., large cameras of long focal length, long base-line interferometry (LBI). There will be an increasing tendency towards systems with a round-the-clock computer-controlled measuring capability. This factor, together with the quantity of observational data being collected, will determine the computer requirements for the individual stations. Figure 50 demonstrates the planned operation of a fundamental station at Wettzell in the Federal Republic of Germany. Combined observational methods will play an increasingly important role throughout, as the following geometrical test examples demonstrate.

A European test network

To investigate the improvements that can be attained through combining laser ranging and direction measurements, a test net covering an area 3,100 km by 3,800 km has been defined (see figure 51), 10 of the 14 positions are identical with positions occupied by existing European observing stations. No station of this basic net is held fixed for the purposes of the computations.

[1] United States of America, National Aeronautics and Space Administration, *The Terrestial Environment Solid-Earth and Ocean Physics Application of Space and Astronomic Techniques*, report of a study at Williamstown, Massachusetts, to the National Aeronautics and Space Administration (August 1969).

Test models

The results from 16 of the 25 models computed are presented here. The altitude of the satellite is assumed to be 1,000 km for all models, excluding Nos 14 and 47. Other characteristics of the models may be summarized as follows:

(a) *Model 13.* Computed from directions only, the accuracies of which are assumed to be $m_d = \pm 1''$. Between nine and 18 directions are used to define each position;

(b) *Model 14.* This configuration is identical to that used for model 13, with the exception of the satellite altitude (3,000 km). Models 13 and 14 are typical balloon satellite networks. They yield 333 observation equations corresponding to 51 simultaneous events. There are 141 redundant observations;

(c) *Model 21.* Here, only distances are measured. Fifty-six events are assumed, with station positions determined generally from four distances, and occasionally from six distances ($m_r = \pm 1$ m). This results in only 45 (~ 20 per cent) over-determinations from a total of 249 observations;

(d) *Model 22.* This is the same as for model 21. The number of observations is increased to 439 and thereby the number of redundancies to 151 (~ 50 per cent). In order to achieve this, from four to nine simultaneous distances ($m_r = \pm 1$ m) are required—a condition which, for practical purposes, must be considered unrealistic;

(e) *Model 33.* This configuration makes use of nearly simultaneous range and direction observations to the same satellite, using cameras of long focal length to obtain photographs of laser reflections against a background of stars. Four stations are assumed to be equipped with cameras only ($m_d = \pm 1''$). All others are taken to have laser ($m_r = \pm 1$ m) and camera ($m_d = \pm 1''$) equipment. The station positions are determined from a total of 108 directions (216 observation equations) and 67 measured distances. This results in 123 over-determinations;

(f) *Model 34.* Identical with model 33, but using $m_d = \pm 0.5$, $m_r = \pm 1$ m;

(g) *Model 35.* Identical with model 33, using $m_d = \pm 1''$; $m_r = \pm 0.5$ m;

(h) *Model 36.* Identical with model 33, but with $m_d = \pm 0''5$; $m_r = \pm 0.5$ m: The accuracies assumed for model 36 have already been achieved; The demands made by model 37 will be attainable very soon;

(i) *Model 37.* Identical with model 33, but with $m_d = \pm 0''5$, $m_r = \pm 0.2$ m.

(j) *Model 41.* This model is a numerical combination of model 13 (directions only) and 21 (distances only, with 20 per cent redudancy). The two combined models may be observed independently. Again, $m_d = \pm 1''$, $m_r = \pm 1$ m;

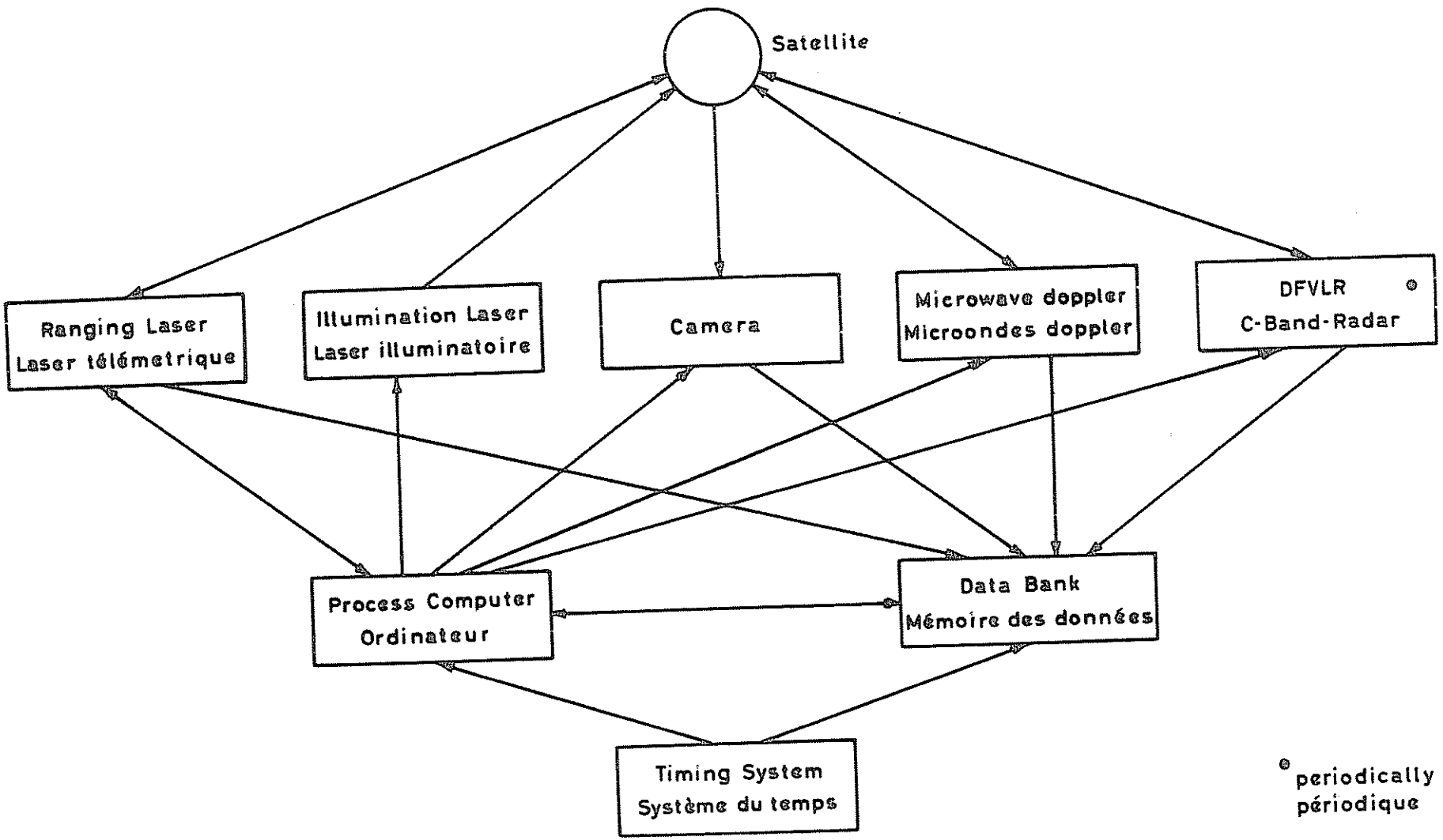
(k) *Model 42.* The same as model 41, using $m_d = \pm 0''5$; $m_r = \pm 1$ m;

(l) *Model 43.* The same as model 41, using $m_d = \pm 1''$; $m_r = \pm 0.5$ m;

(m) *Model 44.* This combines model 13 and model 22 (50 per cent redundancy); $m_d = \pm 1''$, $m_r = \pm 0.5$ m;

(n) *Model 45.* As for model 44, with $m_d = \pm 1''$; $m_r = \pm 0.5$ m;

(o) *Model 46.* The same as model 44, with $m_d = \pm 0''5$; $m_r = \pm 1$ m;


Satellite
Ranging Laser
Laser télémetrique
Illumination Laser
Laser illuminatoire
Camera
Microwave doppler
Microondes doppler
DFVLR ⊙
C-Band-Radar
Process Computer
Ordinateur
Data Bank
Mémoire des données
Timing System
Système du temps
⊙ periodically
périodique

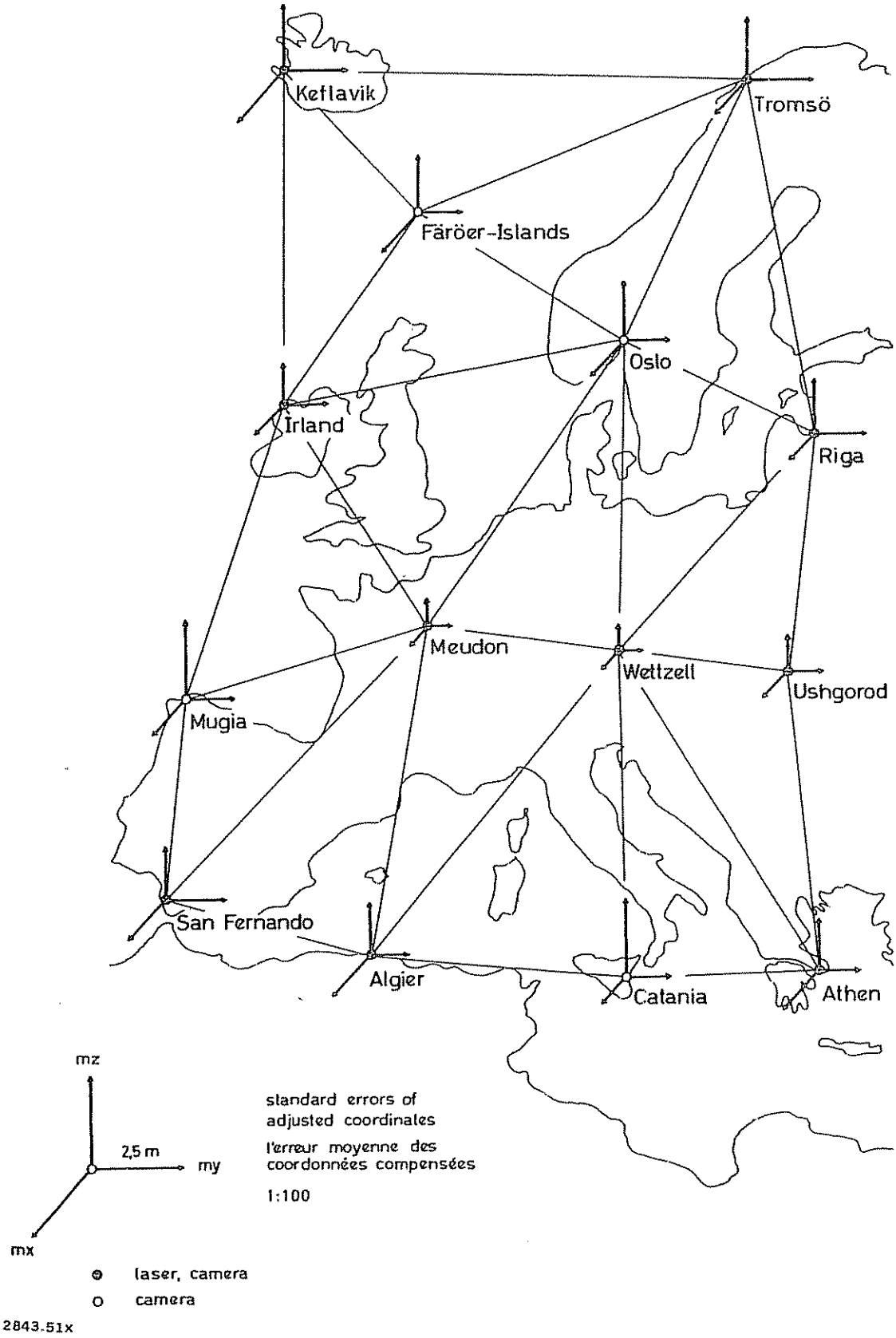


Figure 51. Federal Republic of Germany: European test net—results of model 36

(p) *Model 47*. This combines models 14 (directions only; satellite at 3,000 km altitude) and 22.

Such numerical combinations may be of great interest in future for those parts of the world where spatial triangulation (e.g., BC-4) networks already exist.

Adjustment procedure

All adjustments were performed using the method of observation equations with conditions. The form of the observation equations corresponds to that proposed by Arnold.[2] A null vector of absolute terms was adopted for the purposes of the accuracy analysis based on fictitious observations. The unknowns in the adjustment comprised the three-dimensional rectangular co-ordinates of each of the 14 observation stations plus those of the satellite at the instant of the measurement. Since, however, the satellite positions are of no further significance in the computations, these unknowns were eliminated numerically as the observation equations were read into the computer. Three conditions were introduced for each net to ensure an optimal agreement between the adjusted net and existing terrestrial determinations. Three further conditions were introduced for those nets in which only distances were considered, in order to stabilize the orientation.[3] Lastly, an over-all scaling of models 13 and 14 (directions only) was made by introducing the line Tromsö–Catania as a fictitious observation with a standard error of ±2 m.[4]

Error analysis

Model 13 is adopted here as the reference standard for the following discussions. This model resulted generally in adjusted position errors of the order 3–5 m. The average errors increased to 10 m for model 14. All results are summarized in table 1.

From models 21 and 22, it can be deduced that range measurements alone are unsuited for the determination of point positions. This conclusion is verified by the accuracy of directions computed from the adjusted co-ordinates for lines joining different points of the network (10–50 inches). The internal stability of such nets is apparently very weak.

A drastic improvement in the results may be seen as soon as directions and distances are combined. Model 33 brings the average position accuracy down to 2–3 m. Model 36 reduces this to 1–2 m; and a further improvement is detectable for model 37, which characterizes the accuracies that will soon be attainable. Better ranging accuracy than this will be of little use for geometrical investigations if the accuracy of supporting (directional) observations is not improved. It remains to be seen whether the introduction of observed rate of change in direction (Doppler) can be used to replace the directions themselves in order to stabilize the network.

Similar changes are to be seen when combining networks numerically (models 41–47). Even the combination of the relatively weak model 21 (ranges only with 20 per cent redundancy) with the reference model (13) results in an average standard positional error of 2.5 m, whereas models 13 and 22 together give accuracies in the 1.5–2 m range. Models 14 and 22 together resulted in an unexpected improvement of the position accuracy from 10 m to between 2 and 4 m.

A SECOND TEST CONFIGURATION

Similar tests based on other criterion have been carried out recently at the Geodetic Institute of the University of Bonn.[5] Instead of a free net, these tests analyse the positional errors of two points in relation to the fixed co-ordinates of the points Tromsö, Keflavik,

[2] K. Arnold, *Methoden der Satellitengeodäsie* (Berlin, Akademie Verlag, 1970).

[3] K. Rinner, "Über die Ausgleichung von Prüfnetzen", in *Nachrichten aus dem Karten und Vermesungswesen*, special publication on the occasion of the seventieth birthday of Professor E. Gigas (1969).

[4] K. Kube and K. Schnädelback, "Computation of the European base line, Tromsö–Catania", paper submitted to the First International Symposium on the Use of Artificial Satellites for Geodesy and Geodynamics, Athens, May 1973.

[5] J. Campbell, G. Seeber and B. Witte, *Numerische Untersuchungen zur Genauigkeit von Satellitennetzen unter Verwendung von Doppler-, Laser- und photographischen Beobachtungen* (Bonn, Zeitschrift für Vermessimgswesen, 1973), pp. 12 ff; J. Campbell, "The contribution of optical directions, laser ranges and Doppler range differences to the geometrical strength of satellite networks", paper submitted to the First International Symposium on the use of Artificial Satellites for Geodesy and Geodynamics, Athens, May 1973.

Table 1. European test net: standard errors of the adjusted co-ordinates (*Metres*)

Errors / *Models*	*Maximum* m_x	m_y	m_z	*Minimum* m_x	m_y	m_z	*70 per cent level* m_x	m_y	m_z
13	4.5	4.0	6.4	2.0	1.8	2.8	4.2	2.8	5.0
14	18.2	8.1	21.8	7.8	3.5	9.8	12.2	5.1	18.8
21	42.1	94.6	245.7	25.8	19.7	41.6	167.1	66.6	37.5
22	12.2	29.3	64.9	7.5	5.3	10.5	22.0	24.8	32.4
33	3.7	3.4	3.6	1.4	1.4	1.4	2.0	2.5	4.2
34	1.9	1.8	1.9	0.8	0.8	0.8	1.1	1.3	2.2
35	2.4	5.5	4.1	1.2	1.2	1.3	2.8	3.0	2.6
36	1.8	1.7	1.8	0.7	0.7	0.7	1.0	1.2	2.1
37	1.8	1.7	1.8	0.6	0.6	0.6	1.5	1.2	1.5
41	2.6	2.8	4.7	1.7	1.2	1.8	2.4	2.2	2.8
42	4.7	2.6	5.4	1.9	1.4	2.1	2.8	2.3	3.2
43	2.4	2.6	4.5	1.5	1.0	1.7	2.1	1.9	2.6
44	2.3	2.4	4.4	1.3	0.9	1.5	2.3	1.5	2.5
45	2.4	2.7	4.7	1.2	1.2	1.7	1.7	1.8	2.9
46	1.7	1.8	3.8	0.8	0.6	1.1	0.8	1.2	2.0
47	4.5	4.3	10.0	1.8	1.2	2.5	2.0	2.8	4.9

Höhenpeißenberg taken from the United States BC-4 network. The two points are considered to be determined from directions only, ranges only, Doppler (range rate), and from several combinations of these methods. The models applied use the short-arc method of computation. Some results of these tests are summarized in table 2. The resulting relative standard errors of the adjusted point positions are understandably smaller than in the tests reported in the foregoing section. The best results were obtained from a combination of laser and Doppler measurements, with slightly worse results for combined directions and Doppler observations. These results signify the important role of Doppler for point position determination and support the conclusions to be drawn from the tests on the European network.

CONCLUSIONS

The improved accuracies which are, in particular, characteristic of current laser and Doppler observations have resulted in a change in emphasis from geometrical to dynamic objectives. In future, a limited number of well-equipped stations will be engaged in long-term observing programmes. Other stations with more limited objectives will be established for shorter observing periods. High-quality geometrical information will be available from these stations as a by-product of their current programmes. This information can be used to update and densify existing reference networks. The tests reported here indicate that through the use of combined observations, a reference system of continental, or better still, of global extent with point positional accuracies of 1–2 m can be achieved. Doppler measurements can then be used to densify this net in order to satisfy national demands. The methods described here combine the advantages of high accuracy, speed and economy, and will enable all countries to play a role in exercising the methods of satellite geodesy commensurate with their interests and financial capabilities.

Lastly, it must be emphasized that the tendencies discussed are also influencing the design of the future satellites themselves. Such high measuring accuracies preclude the use of large passive satellites of the balloon type, for which, for example, the reduction of observations to the centre of mass is not possible with an accuracy corresponding to that of the observations themselves.

Table 2. Results of tests conducted at Geodetic Institute of University of Bonn

Number of passes	*Satellite height (kilometres)*	m_o *(a priori)*	*Standard errors of adjusted co-ordinates (metres)*					
			Malvern			*Uppsala*		
			m_N	m_E	m_H	m_N	m_E	m_H
Optical directions								
26	1,300	1.0″	1.4	1.5	2.0	1.2	1.3	2.2
30	4,000	0.5″	1.5	1.4	2.6	1.3	1.2	2.8
Laser ranges								
14	1,500	1.0 m	1.0	1.0	0.6	0.7	0.9	0.4
Combination laser-optical								
44			0.8	0.7	0.5	0.6	0.7	0.4
Doppler range differences								
21	1,500	2.0 m	0.7	0.4	1.2	0.7	0.5	0.9
Combination doppler-laser								
35			0.6	0.3	0.3	0.4	0.4	0.3
Combination Doppler-optical								
51			0.6	0.4	1.1	0.6	0.4	0.9

SOURCE: J. Campbell, "The contribution of optical directions, laser ranges and Doppler range differences to the geometrical strength of satellite networks", paper submitted to the First International Symposium on the Use of Artificial Satellites for Geodesy and Geodynamics, Athens, May 1973.

RECENT ADVANCES IN GRAVIMETRY FOR PHYSICAL GEODESY IN AUSTRALIA*

Paper presented by Australia

Gravimetric solutions for the geoid have been combined with astrogeodetic determinations to give a geoid map over the Australian region.[1] These solutions have been made possible by the existing extensive gravity coverage controlled by the Australian national gravity network.

Improvements to the gravimetric solutions will result from current activities of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics (BMR) directed towards strengthening of the control network, more accurate integration of existing data and extension of the gravity coverage. BMR gratefully acknowledges the assistance of outside organizations; several overseas institutions have made valuable international gravity ties to Australia, compilations of gravity data by several state Mines Departments and private firms are assisting

*The original text of this paper, prepared by the Commonwealth Bureau of Mineral Resources, Geology and Geophysics, Australia, appeared as document E/CONF 6/L.36.

[1] R. S. Mather, B. C. Barlow and J. G. Fryer, "A study of the earth's gravitational field in the Australian region", Proceedings of the Fifteenth General Assembly of the International Union of Geodesy and Geophysics, Moscow, August 1971, section V, International Association of Geodesy

in this work; and, above all, the project is made feasible by the availability of gravity data throughout Australia from state Mines Departments, universities and exploration firms.

International datum value

Until 1971, the base station for the Australian control network was the first-order world gravity station at Melbourne. Adoption of the International Gravity Standardization Network in 1971 (IGSN 71) to supersede the First Order World Gravity Network, completion of an absolute determination of the gravitational acceleration at Sydney and recent international ties have downgraded the importance of the Melbourne base. The value of gravity at Sydney is currently the most accurately known in Australia.

Dooley and others recorded the adoption by BMR of 979,979.0 mgal in relation to the old Potsdam datum for the acceleration due to gravity at the Australian National Gravity Base at Melbourne.[2] This value had been calculated by Cook[3] from the results of a Cambridge pendulum tie in 1950–1951 between the United Kingdom and Australia, and from observations on Worden gravity meters.

Subsequent reassessments of this value took account of further international pendulum and gravity-meter ties.[4] Insufficient evidence was found to warrant changing the adopted value.

A particularly significant international gravity tie to Australia was made during December 1972 and January 1973, following arrangements made by the Soviet Geophysical Committee of the Academy of Sciences of the Union of Soviet Socialist Republics and by BMR. Six Soviet scientists made observations with five sets of OVM pendulum apparatus at Moscow (Ledovo) and Sydney. Moscow has already been accurately tied to Potsdam, and this work gave an accurate tie between Sydney and Potsdam.[5]

Although the datum value at Melbourne has been held unchanged since 1957, improved measurements of the Melbourne-Sydney interval have led to successive determinations of the acceleration due to gravity at Sydney, as listed in table 1. The latest Soviet pendulum tie confirms the accuracy of the more recent determinations.

An absolute detemination of the gravitational acceleration at Sydney was completed by the National Standards Laboratory of the Commonwealth Scientific and Industrial Research Organization (CSIRO) in 1970. The method was free rise and fall of a metal corner reflector through planes defined interferometrically. A value of 979,672.0 ±0.20 mgal was obtained for Sydney A.[6] Using the Soviet pendulum tie, Sydney-Moscow, the appropriate correction to the old Potsdam datum given by the above-mentioned determination is 13.79 ±0.21 mgal, which is in excellent agreement with other modern data.

Table 1. Determinations of gravity at Sydney A on basis of old Potsdam datum (*Milligals*)

1. Adopted by BMR[a], 1957	979,684.9
2. BMR revised value, 1962	979,685.7
3. BMR, May 1965, isogal value	979,685.74
4. BMR provisional value, 1970	979,685.80
5. OVM pendulum value	979,685.79 ± 0.06

[a] Bureau of Mineral Resources.

The adoption of the International Gravity Standardization Network by the International Association of Geodesy resulted in less importance being attached to the particular value of gravity assigned to just one datum point in the network. Nevertheless, the absolute determination of gravity at Sydney ensures its importance as one of the key stations in the IGSN 71, which adopts a value of 979,671.85 mgal for Sydney A.

Determination of scale

The precise determination of the calibration factors of all gravity meters to a common scale is of the utmost importance in the establishment of networks and the compilation of data from various surveys. The establishment of Australian calibration standards which are compatible with international milligal standards poses many difficulties. Measurements by BMR over the past few years and by a joint Australian-Soviet survey party in 1973 are expected to resolve many of these difficulties.

The first Australian gravity standard was set by the results (with magnetic correction) of the 1950–1951 Cambridge pendulum measurements at 59 stations in Australia.[7] Gravity-meter measurements between five of these pendulum stations in south-east Australia were used to calibrate the meters in terms of the Cambridge pendulum milligal, but only over a limited range of observed gravity. The meters were then used to measure the gravity interval over a gravity-meter calibration range of about 50 mgal near Melbourne. An essential by-product of the 1962 adjustment of the Australian gravity network was revision of the gravity interval over this calibration range in the light of more extensive comparisons between gravity-meter and pendulum intervals.[8] Subsequent work has indicated that the revised interval is compatible with other calibration standards to about one part in 3,000, and this short-range calibration standard has been retained unchanged.

Eight other short gravity-meter calibration ranges have been established near various cities throughout Australia.[9] The intervals on these ranges have been measured in terms of the Melbourne range to facilitate

[2] J. C. Dooley and others, *Pendulum Measurements of Gravity in Australia, 1950–51*, bulletin No. 46 (Australia, Bureau of Mineral Resources, 1961).

[3] A. H. Cook, *Comparisons Between Gravity Measurements with the Cambridge Pendulum Apparatus and Worden Gravity Meters in North America, South Africa, Australia, New Zealand and Great Britain*, monograph of the National Royal Astronomical Society, Geophysical supplement No. 7 (1957), p. 228.

[4] J. C. Dooley, *Australian Gravity Network Adjustment, 1962*, report No. 72 (Australia, Bureau of Mineral Resources, 1965); B. C. Barlow, "National report on gravity in Australia, July 1965 to June 1970", record 1970/72 of the Australian Bureau of Mineral Resources, 1970 (unpublished).

[5] N. A. Gusev, "Determination of gravity acceleration at Sydney with pendulum apparatus", Central Research Institute of Geodesy, Aerial Survey and Cartography; Chief Administration of Geodesy and Cartography; The Council of Ministers of the USSR, 1973 (unpublished).

[6] G. A. Bell, D. L. H. Gibbings and J. B. Patterson, "An absolute determination of the gravitational acceleration at Sydney, Australia", *Metrologia*, April 1973.

[7] Dooley and others, op. cit.

[8] Dooley, op. cit.

[9] B. C. Barlow, *Gravity Meter Calibration Ranges in Australia*, report No. 122 (Australia, Bureau of Mineral Resources, 1967).

the calibration of all gravity meters against a common standard.

A chain of gravity base stations at cities along the east coast of Australia was selected to form the Australian calibration line to facilitate calibration of geodetic gravity meters over substantial gravity intervals. As at first proposed, the calibration line ran from Melbourne to Cairns, spanning a gravity interval of some 1,500 mgal. The line was later extended to Hobart in the south and to Laiagam in the north, so that it currently spans nearly 3,000 mgal (see figure 52)

The 1962 values at Melbourne, Cairns and Darwin were considered to be particularly reliable, being based on several pendulum measurements as well as on gravity-meter ties. The mean milligal defined by the average given by the two intervals, Melbourne-Cairns and Melbourne-Darwin, was accepted as the "mean Australian milligal".

Subsequent comparisons between gravity-meter measurements on the national network with results of the 1950–1951 pendulum measurements show that the mean Australian milligal, as defined above, is compatible with the mean milligal defined by 47 of the 59 Cambridge pendulum measurements.

In 1965, the United States Air Force made international gravity measurements along the western Pacific Calibration Line (see figure 53); and, in co-operation with BMR, also made measurements between Cairns and Melbourne along the Australian Calibration line.[10] Values for the intervals Melbourne-Darwin and Melbourne-Cairns were calculated using the manufacturer's calibration tables. The mean intervals from the five LaCoste and Romberg gravity meters required a correction factor of 0.9997 to give the best fit to the intervals expressed in mean Australian milligals. Intervals for the Australian Calibration Line were then determined from the observations of the United States Air Force and BMR, using this correction factor. The results obtained by the United States Air Force on the western Pacific and Australian calibration lines are a major contribution to IGSN 71 and permit a comparison to be made between the milligal standards used on those calibration lines.

In 1969, BMR made observations along the western Pacific and Japanese calibration lines (see figure 53), using four LaCoste and Romberg geodetic gravity meters.[11] In 1970, three of these meters were used over the full length of the Australian calibration line (see figure 52), together with six quartz-type exploration gravity meters (four Wordens and two Scintrex CG2).[12] The fourth LaCoste meter previously used on the western Pacific Calibration Line was used over the Australian Calibration Line in 1972. These measurements by BMR supplement the earlier work by the United States Air Force and similar measurements made by the Dominion Observatory of Canada. The BMR measurements indicate that the scales of the Japanese and Australian calibration lines are very similar. Gravity-meter ties between Japan and Australia, together with pendulum ties by the Geographical Survey Institute of Japan, have already shown that the national datums are compatible.

A joint project of Australia and the USSR, to refine gravity values along the Australian Calibration Line, was undertaken during 1973; it was arranged by the Soviet Geophysical Committee of the Academy of Sciences of the USSR and by BMR. The objectives of this work were to measure the intervals along the Australian Calibration Line using a group of Soviet geodetic gravity meters, type GAG2, and to compare the results of these meters with results from LaCoste and Romberg geodetic gravity meters and Worden exploration meters. Because of the inherently lower accuracy at single stations of all sets of pendulum apparatus previously used in Australia, heavy reliance has been placed on the results from groups of geodetic LaCoste and Romberg gravity meters. The possibility of systematic errors in this type of meter should not be overlooked. The Soviet gravity meters operate on a different principle, having a Worden-type quartz movement which is nulled by tilting the instrument. It is claimed that the results of this instrument are absolute so that it does not require calibration against intervals fixed by absolute or pendulum apparatus. Results obtained in the USSR against intervals determined by the Soviet OVM pendulum apparatus give credence to this claim.

The survey party comprised six Soviet personnel making observations on nine Soviet GAG2 meters and five Australian personnel making observations on four LaCoste and five Worden meters. A chartered DC3 aircraft was used to transport the party between base stations of the Australian Calibration Line, drift control of the type ABAB being obtained for all intervals. During the seven-week period available for this survey, it was not possible to observe all stations, eight of which were overflown.

The results of this work are expected to improve significantly the accuracy of the values along the Australian Calibration Line, particularly values for the southern and northern ends.

Australian National Gravity Network

A gravity reference network was established in 1950–1951, when the Cambridge pendulums were used to set up 59 base stations throughout the continent.[13] In 1962, a comprehensive adjustment of the gravity values of these 59 stations was made, taking into account all gravity-meter and pendulum ties by both local and overseas observers.[14]

The Australian national gravity network was considerably extended and strengthened by a series of surveys, mainly in 1964 and 1967. Those surveys, now referred to collectively as the "Isogal project",[15] established a series of base stations with at least three dissimilar gravity meters at intervals of 150–250 km along 12 east-west lines of approximately equal observed gravity across Australia. Aircraft were used for transport, and drift control of the ABAB type was maintained for successive intervals. The east-west traverses are linked by three north-south traverses, of which the most easterly is the Australian Calibration Line. All but two of the

[10] C. T. Whalen, *The West Pacific Calibration Line Survey, 1964–65*, United States Air Force APCS OPLAN 503, Phase report No 3 (United States Air Force, 1966)

[11] R. J. S. Cooke, "Gravity meter measurements on the Western Pacific, Japanese and Australian calibration lines 1969/70", *Geophysical Journal of the Royal Astronomical Society* (1973).

[12] *Ibid.*

[13] Dooley and others, op. cit.

[14] Dooley, op. cit.

[15] Barlow, op. cit.

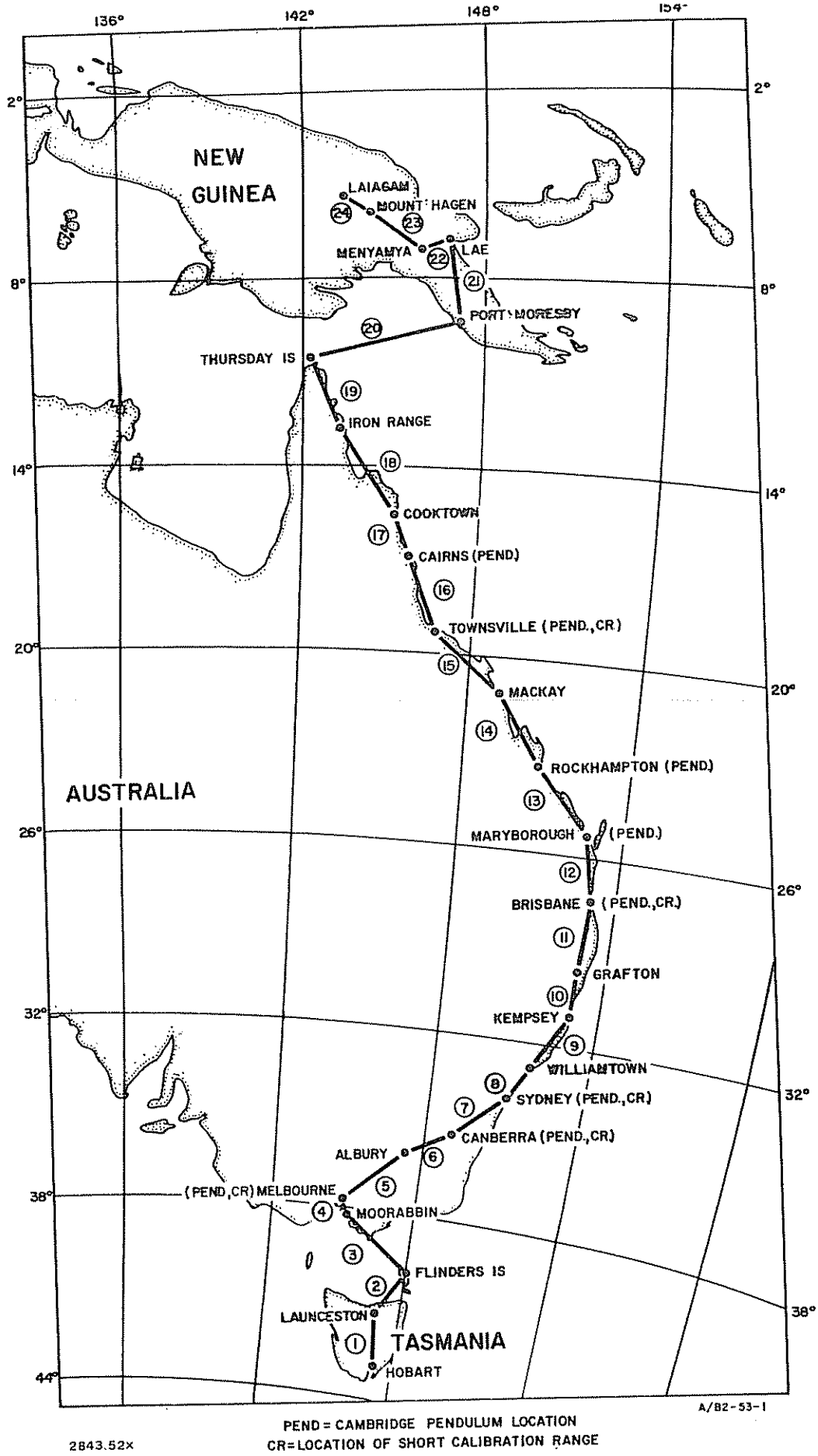


Figure 52. Australia: locations of Australian Calibration Line stations and key to tie numbers

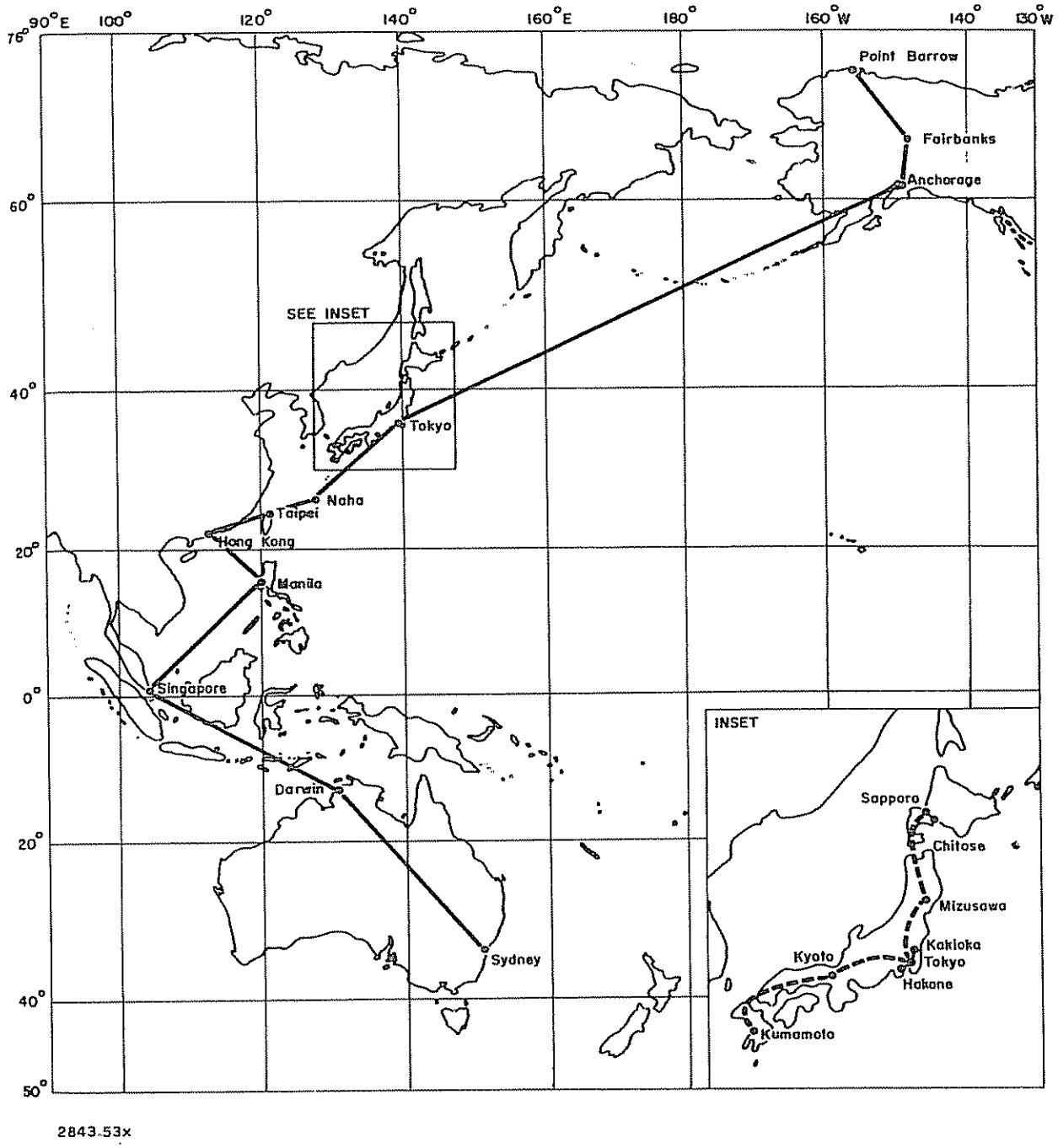


Figure 53. Australia: gravity-meter measurements on the western Pacific Calibration Line, 1969

950–1951 Cambridge pendulum stations are currently ncluded in the new network, which is shown in figure 54.

The design of the Australian national gravity network s such that the network as a whole can be readily djusted to fit any improved values which may be letermined for the Australian Calibration Line. It is roposed to adopt shortly revised values for all stations f the national gravity network, taking into account the GSN 71 values and all recent measurements to determine best values for datum and scale. The new values vill be expressed in micrometers/second^2.

Integration of existing data

Since 1950, nearly all gravity surveys have been tied to base stations of the Australian national gravity network so that compatible observed gravity values can be calculated for virtually all gravity stations in Australia. Similarly, nearly all stations have elevations tied to the Australian height datum network and horizontal positions known in relation to the Australian geodetic survey. It is therefore possible to recompute most Australian gravity surveys to modern standards of observed



2843.54x

Figure 54. Australia. isogal regional survey, 1964–1970

gravity, elevation and horizontal co-ordinates. This work has commenced, but it will take several years as over 500,000 gravity stations are involved.

Over the last two decades, BMR has compiled, without recomputation, all available gravity data in Australia and published these in the form of Bouguer anomaly maps to guide mineral exploration activities and regional structural investigations. Of these maps, the best known are the successive editions of the gravity map of Australia on the scale of 1 inch = 40 miles or 1:2,534,400, which show 5 mgal Bouguer anomaly contours over an increasingly large portion of Australia. The most recent edition shows coverage over 90 per cent of the Australian continent.

This map contains many discontinuities, which are due to datum shifts in the raw values of observed gravity and similar discrepancies, and, in particular, to changes in the assumed Bouguer density from area to area. In order to use the gravity data for geodetic purposes, mean free air anomalies were computed, and it was found

essary to apply approximate corrections for datum fts, area by area, before the data were sufficiently npatible to give accurate gravimetric solutions for the oid.[16] The recomputation and integration of existing vity data will permit more accurate gravimetric solu-ns

Extension of existing coverage

Reconnaissance or more detailed gravity surveys rrently cover 90 per cent of the Australian continent. The greatest contribution to the broad reconnaissance verage of the continent has been the data obtained ring successive BMR reconnaissance gravity surveys using helicopter transport. The survey establishes gravity stations with minimum station density of one per 130 km² with adequate accuracy for geodetic purposes. BMR will complete the coverage of the remaining areas in the south-east quadrant of Australia by the end of 1974.

During 1970–1973, BMR obtained reconaissance marine gravity coverage over the whole of the continental shelf and slope. These data will be available in a form suited for geodetic purposes by the end of 1974.

The extension of the gravity coverage of Australia will permit more accurate gravimetric solutions to be made over a wider area. The marine data will be particularly useful in minimizing edge effects, which have been particularly troublesome in earlier solutions.

[16] Mather, Barlow and Fryer, op. cit.

GEODETIC ACTIVITIES IN AUSTRALIA TO 1973*

Paper presented by Australia

Geodetic surveys in Australia, on a nation-wide scale, gan relatively late. However, Australian surveyors ve been able to make use of some important innova-ons which became available in Australia in 1956, mely, the introduction of the Tellurometer, automatic velling instruments and electronic computers, as well the availability of commercial helicopters.

The use of these new instruments and the co-operation f all concerned, under the general direction of the ational Mapping Council, has brought about homo-eneous national surveys for both horizontal and verti-l positions.

Many survey authorities in Australia have contributed the successful completion of these surveys together ith a number of private surveyors, who were engaged in velling and astronomical surveys financed by the Com-nonwealth of Australia.[1]

Horizontal control[2]

Early trigonometrical surveys in Australia began in New South Wales in 1828, and subsequently were ndertaken in other states. Most of these surveys were ot connected to one another. During the period 930–1945, the Royal Australian Survey Corps concen-rated on the co-ordination of existing triangulation in Victoria and New South Wales. By the end of the Second World War, only a small part of Australia was covered ith horizontal control surveys of currently acceptable tandard. In 1945, the National Mapping Council of Australia was formed and adopted a basic scheme of a national geodetic survey.

With the introduction of portable electronic distance-measuring equipment, mainly the Tellurometer in 1956, it was possible for the National Mapping Council to approve of, and sponsor, gradually extending geodetic survey operations that eventually covered the whole country. Only a further 10 years were required in order to complete a network of geodetic survey over the whole of the Australian continent and Papua New Guinea. At the beginning of this period, the computation of various parts of the existing survey, old and new, was based on 20 different geodetic datums using four different figures of the earth. In March 1966, the whole survey of 58 loops, containing 2,506 firmly marked geodetic stations including 533 astro-geodetic stations and over 50,000 km of Tellurometer traverses, was adjusted by programme VARYCORD, using the method of least squares by variation of co-ordinates on the spheroid. The Australian geodetic survey is particularly strong in azimuth due to the great number of Laplace stations along the traverse network.

Australian geodetic datum

This adjustment resulted in the formation of the Australian geodetic datum, which is a homogeneous system of latitudes and longitudes covering the whole of Australia and Papua New Guinea.

The latitude and longitude of the origin of the Australian geodetic datum, the Johnston Geodetic Station, was determined from a comparison of astronomical and geodetic co-ordinates at 155 survey stations, well distributed over the whole of Australia. This had the desired effect of placing the spheroid very close to the geoid in Australia. The value of the separation of the geoid was everywhere assumed to be zero, and all distances in the adjustment were reduced using trig heights based on mean sea level datums.[3]

New surveys are continually being added by adjusting them to points of the original 1966 adjustment. Over 11,000 geodetic stations are by now computed on the Australian geodetic datum. Figure 55 shows the network of geodetic control on the Australian geodetic datum as at 31 December 1972.

* The original text of this paper, prepared by the Division of National Mapping, Department of Minerals and Energy, Australia, appeared as document E/CONF.62/L.37.

[1] "Geodetic surveying in Australia", *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.72.I.20), pp. 145–147.

[2] "The geodetic survey of Australia", *Fifth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Proceedings of the Conference and Technical Papers* (United Nations publication, Sales No. E.68.I.14), pp. 126–131.

[3] "Adjustment of horizontal control surveys", *Fifth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Proceedings of the Conference and Technical Papers*, pp. 111–114.

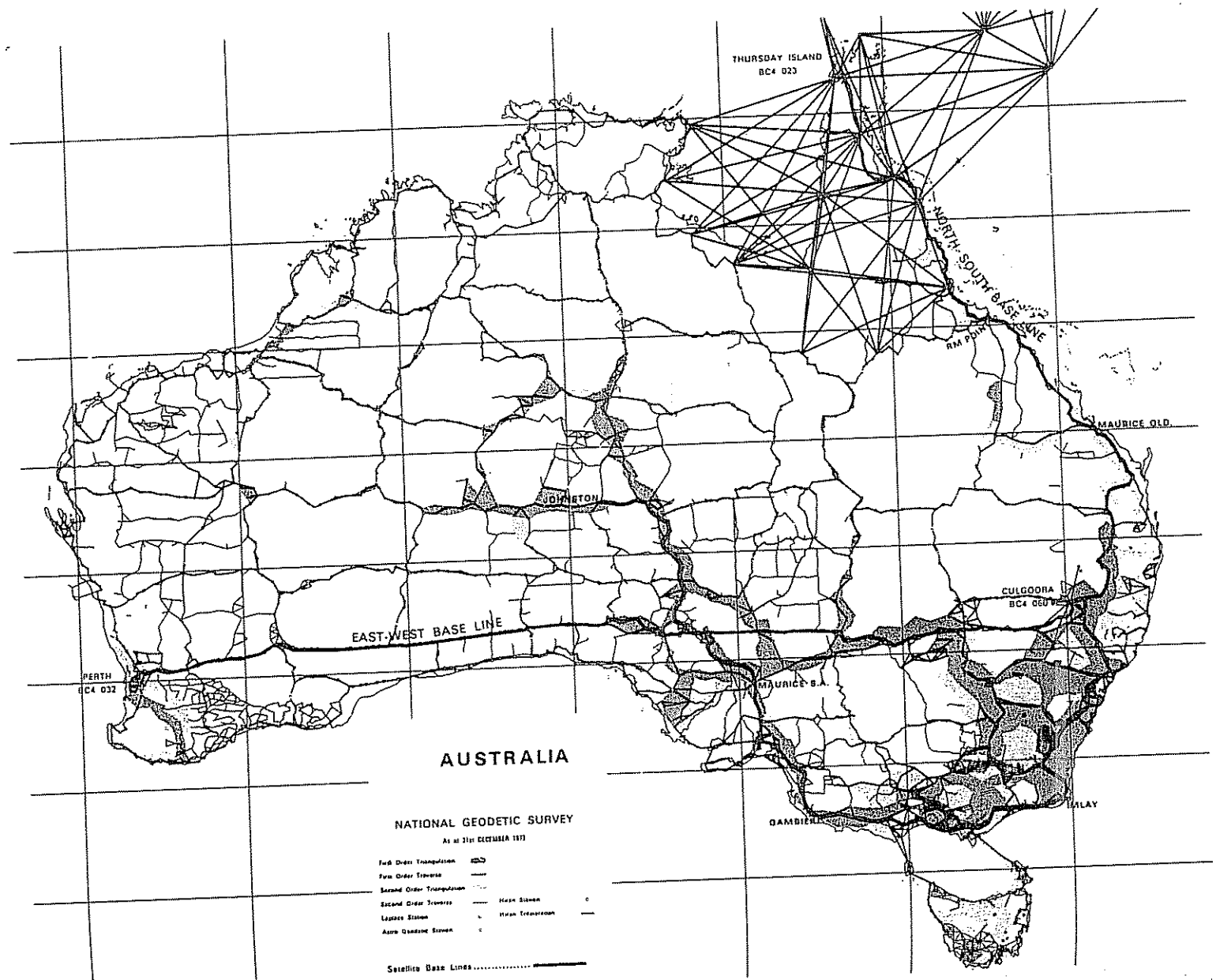


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Figure 55. Australia: national geodetic survey

Precision traversing

A network of precision traverses has been measured by the Division of National Mapping. It links all Australian capitals except Hobart with the Johnston origin and contains the two satellite base-lines. Except for a section of 500 km in New South Wales, the traverses follow existing geodetic work observed during the period 1957–1965 with Tellurometer models 1 and 2.

On these traverses, measurements were made as described in the section concerning satellite base-lines. Almost all stations on these traverses are astro-geodetic stations.

After the completion of the two base-lines, most distances along the traverses, begun in 1970, have been measured with model 8 laser Geodimeters and a few with MRA4 Tellurometers. Lines of up to 70 km in length have been measured with the model 8 Geodimeter employing up to 42 prisms. Smoke, dust particles in the atmosphere, shimmer and hazy conditions have at times restricted the use of the laser Geodimeter, while high humidity in coastal regions limited the range of MRA4 Tellurometers.

This network of precision traverses is included in the formation of the geodetic model of Australia, described below.

Satellite geodesy

During the past decade, Australian surveyors have become increasingly involved with satellite geodesy. The field-work has included the survey of two long base-lines in Australia between satellite camera stations and observations at three BC4 camera sites for the world-wide Passive Geodetic Earth Orbiting Satellite (PAGEOS) triangulation, the geodetic connexions to 51 satellite tracking facilities at 24 tracking sites and the assistance given to observation teams of PAGEOS, the Sequential Collection of Ranges (SECOR) and the tracking network (TRANET).

One satellite base-line between Perth and Culgoora in New South Wales is 3,200 km; the other between Thursday Island and Culgoora is 2,300 km.[4] The two base-lines follow traverses and triangulation which are part of the 1966 adjustment. The Division of National Mapping remeasured all distances along the two traverses connecting the base terminals, mainly with MRA4 Tellurometers and in part with model 8 laser Geodimeters. It observed astronomical azimuths simultaneously from both ends of a line on two nights along every line in pure traverse and every second line in triangulation. Almost every station along the two base-line traverses is an astro-geodetic station. The Royal Australian Survey Corps co-operated with authorities of the United States of America in the making of BC4 observations at Perth, Culgoora and Thursday Island.

Observations along both base-lines were reduced to the spheroid using Australian height datum heights and spheroid-geoid separations, N, from the 1971 geoid determination and were then adjusted by programme VARYCORD, holding the common terminal at Culgoora fixed.

Geodetic information sheets for all satellite tracking stations and radio telescopes in Australia have been prepared by the Division of National Mapping and are available upon request.

[4] Australia, Division of National Mapping, "Two Australian base-lines for the Pageos world triangulation", technical report 11.

Vertical control[5]

Levelling of geodetic standard with permanent marks placed at adequate intervals began slowly in Australia. Before 1956, about 5,000 km of geodetic control levelling had been completed in three of the six states of the Commonwealth of Australia. Between 1956 and 1960, an additional 16,000 km were levelled; and at the end of 1970, a total of over 150,000 km had been completed to provide nation-wide coverage.

The completion of this programme was made possible only by the adoption of third-order levelling techniques; and the letting of contracts, for marking and levelling, to private surveyors under the supervision of the states Surveyors-General. A total of 232 such contracts, worth about $2 million, were arranged during the period 1961–1970.

As part of the Australia mapping programme, the Division of National Mapping, on behalf of the National Mapping Council, and with the help of various state and other authorities, organized a programme of tidal readings at 33 tide-gauge stations around the coastline of Australia. The objective of this programme was to obtain simultaneous recordings at all stations on a continuous basis for a common period of one year in order to compute mean sea level at those stations pertaining to the same epoch.

The Division of National Mapping sent a survey team to visit each tide-gauge. The team's job was to calibrate the tide-gauge recorder against a standard instrument, to establish additional permanent marks so that there were at least three permanent marks near every tide-gauge and to determine the difference in height between the gauge zero and the permanent marks, as well as to take photographs of all important fixtures of the tide station.

The adjustment of selected loops of the continental net took place in May 1971. Observed orthometric differences based on theoretical gravity were used.

Australian height datum

The datum surface resulting from the adjustment of the Australian levelling net with minor modification in two metropolitan areas has been termed the Australian height datum and adopted by the National Mapping Council as the datum to which all vertical control for mapping is to be referred. The datum surface is that which passes through mean sea level at the 30 tide-gauges and through points at zero Australian height datum height vertically below the other 467 primary junction points.[6]

Figure 56 shows the Australian Levelling Survey on the AHD as of 31 December 1972.

One phenomenon evident from the Australian levelling network is the rise of mean sea level, along the north-east coast of Australia between Brisbane and Cape York,

[5] "The levelling survey of Australia", *Fifth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Proceedings of the Conference and Technical Papers*, pp. 114–115; Australia, Division of National Mapping, "The adjustment of the Australian levelling survey 1970–1971", technical report 12.

[6] "The adjustment of the Australian levelling survey 1970–1971"; Australia, National Mapping Council, "The Australian height datum", special publication No. 8.

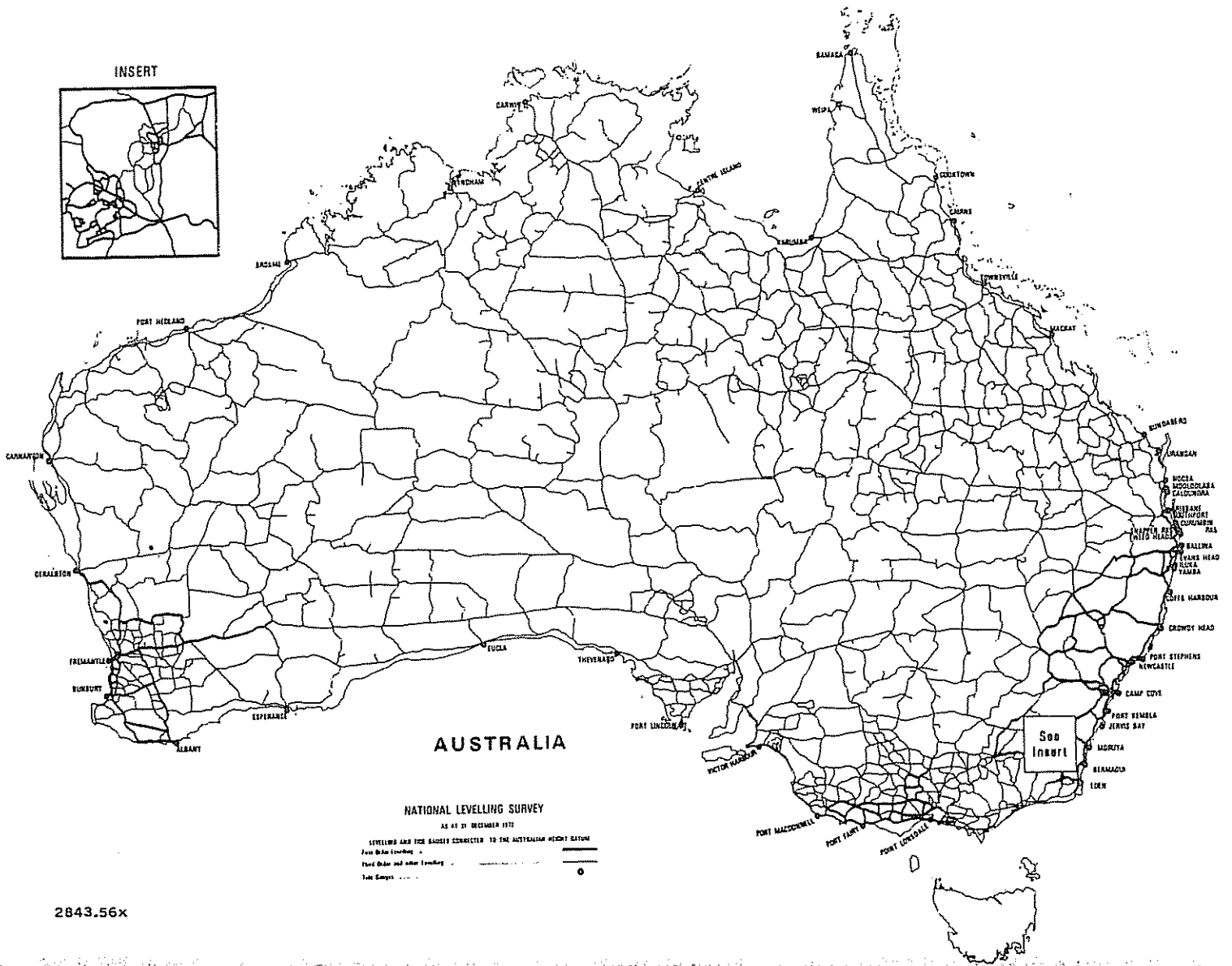

Figure 56. Australia: national levelling survey

1.5 m. A number of theories have been put forward to account for this rise along part of a theoretical equipotential surface. The presence of the coral reef, prevailing ocean currents, the temperature and salinity of the water, and the shallowness of the water have been considered. None gives a satisfactory explanation.

Adjustment of trigonometrical heights

Immediately after the completion of the levelling adjustment, trigonometrical heights of horizontal control stations were adjusted to the Australian height datum. To date, heights of all the stations included in the 1966 adjustment, which contributed to the establishment of the Australian geodetic datum, have been computed in terms of the Australian height datum, as well as heights of stations in many supplementary horizontal control sections.

The geoid in Australia

A preliminary geoid for Australia was determined in 1966 by Irene Fisher of the United States Army Topographic Service. About 550 astro-geodetic stations on the Australian height datum were available for this determination.

In 1971, a new geoid in relation to the Australian geodetic datum was determined. The first stage of that project was the computation of sections of primary geoidal profiles along traverses where the spacing of astro-geodetic stations was generally less than 35 km. Those sections formed large loops which were broken up by geoidal profiles along traverses where the spacing of astro-geodetic stations was often in excess of 50 km. A weighted-squares adjustment provided values of N for 1,133 astro-geodetic stations.

Values of N and the deflections of the vertical were computed from gravity data at 51 geodetic stations and at 1,679 points on a half-degree grid inside the loops formed by the geoidal profiles. The gravimetrically computed values were adjusted, loop by loop, into the system defined by the adjusted values of N at the astro-geodetic stations on the loop perimeter.

The results of the geoid adjustment were used to plot a geoid contour map of Australia based on the Australian geodetic datum. The range of the geoidal heights is about 22 m.

Diagrams showing contours of the components of the deflection of the vertical have also been plotted, as well as a diagram showing the deviation of the plumb-line. Deviations of up to 20 inches occur in Australia.

Precision control networks

The advent of integrated surveys and the availability of modern electronic distance-measurement equipment have given rise to a demand for precision survey networks in areas of intense development and high land prices. Part of these new precision control networks are coincident with previously adjusted networks; and, where practical, it is proposed to seek National Mapping Council approval to local modifications of the Australian geodetic datum to absorb the new precision networks.

Networks of this kind are being surveyed and adjusted in New South Wales, South Australia and Western Australia.

Geodetic model of Australia

Preparations are currently in hand to readjust all the geodetic surveys in Australia to form the geodetic model of Australia, making use of all modern surveys completed since 1966. The resultant data will be used for scientific purposes only and are not intended to supplant the data of the Australian geodetic datum for general survey and mapping purposes.

The input data will be adjusted by programme VARUDEL, which is identical to programme VARYCORD, with the following exceptions:

(*a*) It uses Rudoe's formula instead of Robbins' in the computation of azimuth and distance between co-ordinates of points and vice versa;

(*b*) It computes the parameters of relative error ellipses of adjusted points;

(*c*) The maximum number of variable points is 200 instead of 100;

(*d*) The differences between parameters of the geodetic model of Australia and the Australian geodetic datum are:

(i) The flattening of the spheroid will be changed to that of the reference ellipsoid of 1967, i.e., from $1/f = 298.25$ to $1/f = 298.247$;

(ii) The minor axis of the spheroid will be rigorously defined to be parallel to the pole of the Conventional International Origin (CIO).

The data for the adjustment based on the geodetic model of Australia will have all astronomical latitudes, longitudes and azimuths reduced to the CIO pole and all observed distances reduced to the spheroid using Australian height datum heights and 1971 N values. Laplace azimuths between the three PAGEOS triangulation stations at the ends of the two Australian satellite base-lines, determined from satellite observations, will be included.

The adjustment will result in co-ordinates of the geodetic model of Australia of the 140 odd junction points of the geodetic network in the first instance. Thereafter, only selected survey stations, such as radio telescopes, satellite tracking stations and other important stations, will have their co-ordinates computed in terms of the model.

Comparison of earth-centred geodetic datums with the Australian geodetic datum

A number of such comparisons have been made at single stations and groups of stations, for which co-ordinates on the Australian geodetic datum and on earth-centred geodetic datums are available. This is a continuous process with more comparisons becoming available and more up-to-date earth-centred datums being determined.

The best that can be said about these comparisons at the moment is that they present a most confusing picture. However, there are indications that the work currently being done by agencies of the United States of America on development of a world geodetic datum will clarify the issue.

A considerable effort has been put into the local testing of the United States Navy Navigational Satellite System (NNSS) for geodetic positioning. Although observations at various stations have, in themselves

given acceptable consistencies over a period of from three to four weeks, there have been marked differences between results obtained from receiving equipment of different manufacture when used at different time periods.

Possible explanations are differing software procedures or periodical changes in the location of the geocentre by the monitoring authorities.

Positional Astronomy Section of Division of National Mapping

The Division of National Mapping took over the Positional Astronomy Section of the Mount Stromlo Observatory in September 1971. This section, equipped with a photo zenith and with modern time-keeping equipment, including three atomic clocks, determines variations in the rotation of the earth and the position of the earth's pole in conjunction with similar observatories in other parts of the world. Photo-zenith observations can also be used to determine the movement of the earth's crust between observatories.

Similar results can be obtained by making laser rangings to reflectors left on the moon and to artificial satellites equipped with reflectors.

A lunar laser-ranging system has been made available to the Division of National Mapping by the National Aeronautics and Space Administration of the United States of America (NASA). The system will be set up near Canberra, A.C.T., and is expected to be operational in April 1974.

Crustal movement surveys

In August 1973, the Division of National Mapping planned to observe a network of triangles formed by six concrete pillars 2–15 km apart, in the Markham Valley of Papua New Guinea. Re-observation is planned in 1975 and at five-year intervals thereafter.

The site of the survey and the exact location of the firmly placed observation pillars on either side of the geological fault have been selected by the Bureau of Mineral Resources, Geology and Geophysics, which expects the survey to disclose mainly vertical movements of the crust on either side of the fault.

Observations to detect vertical movement will be carried out by first-order levelling, and for horizontal movements by angular and laser geodimeter measurements.

A second site for a crustal movement survey in Papua New Guinea is across the St. George's Channel between New Britain and New Ireland. Trial observations with laser Geodimeters of distances up to 62 km across the Channel and final selection of the pillar sites are scheduled for September 1973. If practicable, the initial survey of this crustal movement survey network is planned for 1975.

Conclusion

Australia is fortunate indeed in being one of very few large countries having homogeneous geodetic control systems, both horizontal and vertical, surveyed with modern instruments during a short span of time.

These systems form the base for all future mapping in Australia. Looking forward, they provide a firm base for national reference and retrieval systems without which full efficiency in all future automated thematic, resources, topographic, aeronautical and marine mapping and charting cannot be achieved.

NOTES ON AIRBORNE CONTROL SURVEYS, 1970–1973*

Paper presented by Australia

This paper deals with the development and application of three airborne methods used by the Division of National Mapping of the Department of Minerals and Energy, to extend horizontal and vertical control from the national geodetic survey and the national levelling survey, respectively. The objective is to provide a closer framework of survey control, suited for topographic mapping at 1:100,000 scale.

Supplementary developments in airborne profiling

Laser terrain profiling equipment

Since the Sixth United Nations Regional Cartographic Conference for Asia and the Far East was held at Teheran, Iran, the airborne laser terrain profiler has been operating successfully throughout Australia on 1:100,000 scale mapping projects.[1]

Commencing in early 1971, several modifications have been made to the measuring and operational techniques of the profiling system, the more important of which are:

(*a*) A second modulation frequency in the laser profiler;

(*b*) Installation of a Bendix B3 gyroscopically controlled drift-sight;

(*c*) Installation of a second barometric reference unit;

(*d*) A gyroscope to measure lateral roll;

(*e*) Aircraft operation under a Bendix M4C type of auto-pilot.

The second modulation frequency in the laser profiler is 500 kHz, which provides a full-scale deflection of 300 m, to be switched in as required. This feature overcomes any loss of ground reference after passing over an isolated cloud patch or terrain with almost vertical cliffs. It also allows profiles to be independent of any requirement to carry ground heights as chart output from datum points to sections of profiles.

The Bendix B3 drift-sight permits full ahead sighting of the proposed flight line under gyroscopic control which means that profiles can be navigated much mor

*The original text of this paper, prepared by the Division of National Mapping of the Department of Minerals and Energy, Australia, appeared as document E/CONF.62/L.38.

[1] "Developments in airborne profiling: laser terrain profiling equipment", *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.72.I.20), pp. 275–282.

accurately, usually within 200 m along the required flight line. Drifts can also be more confidently determined, as they can be read without interference by minor rolling or pitching of the aircraft.

The provision of two different barometric reference units makes possible a double monitoring of the aircraft height in relation to the selected isobaric surface. Since this height is not as rigidly measured as the laser distance, it was decided that two different measurements of the pressure height were warranted. The units are a Wild RST2 recording statoscope and a barometric reference unit, especially designed by the Scientific Services of the Department of Supply.

The lateral roll of the aircraft is measured by a pick-off modification of the gyroscope in the B3 drift-sight, which permits small corrections to be made to the height of the profile as recorded on the chart output.

Lastly, a Bendix M4C auto-pilot was installed to control the aircraft movements while on profiling operations. This auto-pilot has provided a vast improvement to the profile data, as under normal flying conditions, the aircraft excursions from the required attitudes are kept to a minimum.

Operational techniques

The techniques of profiling have improved to the extent that the north-south laser tie-lines in a survey area are flown almost directly over vertical ground control. The datum differences are transferred photogrametrically to these tie-lines from the ground control, which, in turn, are used to control the datum values of the intersecting series of east-west laser profiles in the survey area.

Operational results

The laser terrain-profiling output since March 1971 for vertical control, for 20-m contouring, of 1:100,000 scale mapping is as follows (see also figure 57):

(a) *1971.* In a nine-month field-season, 29 map areas at 1:250,000 scale (equivalent to 174 at 1:100,000 scale) were profiled, covering an area of 480,000 km^2. A total of 55,000 km was measured on all laser profiling projects;

(b) *1972.* In an eight-month field-season, 37 map areas at 1:250,000 scale (equivalent to 222 at 1:100,000 scale) were profiled, covering an area of 615,000 km^2. A total of 58,000 km was measured on all laser profiling projects.

In eight 1:250,000 scale map areas, representing a wide variety of terrain from flat to mountainous country, photogrammetric checks were applied to 451 laser points. These checks were obtained by levelling photogrammetric models, containing published Australian height datum ground control, solely on laser points, then reading the differences to the ground control within the models.

The results of these checks are as follows: 63 per cent are within 1 m; 86 per cent are within 2 m; 95 per cent are within 3 m; 99 per cent are within 4 m; 100 per cent are within 5 m.

In assessing these results, it should be noted that pointing accuracy in restitution instruments for 1:80,000 scale aerial photography is of the order 1.5–2.0 m.

Uses other than topographic mapping

In addition to profiling for mapping at 1:100,000 scale, several special project surveys were profiled by the laser terrain profiler. One such project was to check 1:100,000 scale (20-cm contour interval) orthophoto maps which had been compiled using radar terrain profiling for height control; that check examined 24 contour crossings on the orthophoto maps, over a flight length of 36 km; the standard deviation between the orthophoto and laser profile heights was 2.6 m, with a maximum deviation of 4.4 m, which indicated compatibility between radar and laser derived heights for mapping projects at 1:100,000 scale.

Another project was a tree-height study of forests in a mountainous area; and a comparison of the ground profile of the same area, as determined by the laser profiler, with 1:9,600 mapping. A comparison of 16 ground profile points between the laser profiler and the map over a length of 8 km of part of the flight line indicated a standard deviation of 2.8 m and a maximum deviation of 6 m. The laser profile, when plotted against the profile derived from the map contours, illustrated a very close agreement between the respective profiles, even where the terrain was very steep and covered with timber.

Further modifications

Recently, two further modifications were completed and both were scheduled to be used for the first time in profiling operations during 1973. One of these modifications is the development of a sealed laser unit, which does not require a continuous replenishment of gas. Consequently, the vacuum and argon flow supply units have been removed from the system, as they are no longer required; while another advantage is that one sealed laser unit will last between 700 and 1,000 hours of "on time", which is sufficient for one whole field-season.

The other modification is that the 70-mm film strip camera lens now has a focal length of 88.9 mm instead of 177.8 mm. This focal length will provide a photograph scale of approximately 1:25,000 from an altitude of 2,500 m, which will facilitate the transfer of laser profile points from the strip photograph to the mapping photograph of approximately 1:80,000 scale. Another advantage is that a wider strip of terrain will be photographed by the modified camera, which will assist in terrain interpretation and transfer of profile points.

A proposed modification is the provision of a gyroscope two-directional tilt read-out, which will record the simultaneous longitudinal and lateral tilts of the aircraft, while profiling is in progress. This facility will permit the determination of more precise profile heights for special profiling requirements.

Further development of profiling systems

In addition to the laser terrain profiler, described above, a second generation system has been recently developed, again by the Scientific Services of the Department of Supply. This system employs a pulse laser capable of operation in a Porter Pilatus type aircraft up to 5,000 m above terrain and 8,000 m above sea level. Some of the system details of this laser are as follows:

(*a*) The laser is a Q-switched Neodynium frequency doubled YAG type with an output pulse of 20 nanoseconds duration at 530 nanoseconds wave-length. The

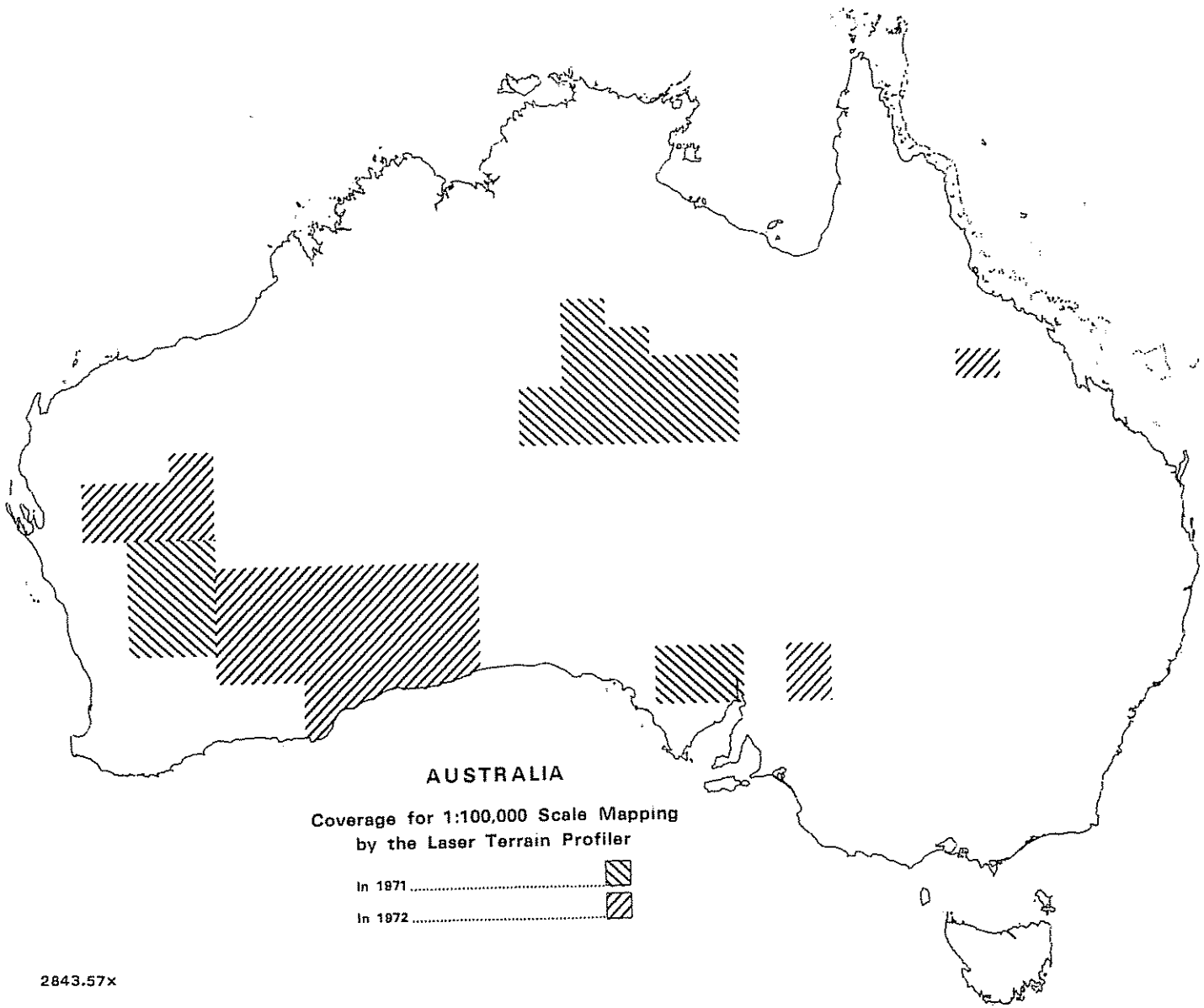

Figure 57. Australia: coverage for 1:100,000 scale mapping by laser terrain profiler

er diameter at the aircraft is 9 cm with a beam ergence of 5×10^{-4} radians;

b) The optical receiver has a focal length of 1.27 m, aperture of 0.1 m and an angular field of 1×10^{-3} lians;

c) The camera has a focal length of 0.1 m providing a otograph scale of 1:30,000 at 3,000 m above terrain, a 70-mm continuous-strip film.

(*d*) The barometric reference unit is a stage II version the Scientific Services of the Department of Supply of e specially developed barometric unit, with an in-eased stability factor;

(*e*) The data are recorded on magnetic tape and as a sual display on chart paper, to include profile height ither in 0–100 m or 0–600 m mode), barometric ference, lateral roll angle and timing code;

(*f*) The profiling equipment is mounted so that it can manually levelled in pitch attitude, while the rack and atform are separately anti-vibration mounted. The tal weight of the equipment is 137 kg.[2]

Aerial spot photography of control stations

Control station identification

As survey control stations are invariably established s a basis for photogrammetric mapping operations, it is ssential that their positions are accurately identified on erial photographs. For photogrammetric purposes, an ncorrect identification can nullify the value of the most recisely established ground control station.

Theoretically, the ideal way to achieve accurate identi-ication is to premark the control with a signal of a uitable size prior to the taking of the systematic map-ping photography.

However, this idea presupposes that this mapping photography can be organized to follow immediately the establishment of the ground control points—a situation which has very wide variation in practice, particularly in the more distant regions of the country. Unless it does follow almost immediately, a considerable problem arises in that the stations must be revisited on the ground and the markers checked. Another frequent situation is that the mapping photography is completed prior to the control survey work.

In the latter case, a visual ground identification can be made. This procedure cannot guarantee 100 per cent accuracy due to human errors and, except for a revisit to the station, cannot be checked.

Spot photography identification technique

In view of these problems, it is currently standard practice to use aerial spot photography for the identifica-tion of control stations for mapping work.

The technique involves the photography of the sta-tion, usually with a small format camera, first from a low altitude where the station itself is clearly visible; and then from successively higher altitudes so that the identifica-tion can be transferred from one photograph to the other; and, lastly, to the mapping photography.

[2]Australia, Department of Supply. Weapons Research Establish-ment, Defence Scientific Service, "An airborne laser terrain profiler", Technical note OSD 116. June 1970

Aircraft type requirements

It is normal to charter local aircraft in the area of operation, which means that various types are used, though whenever possible, a high-winged single-engine aircraft is used. The ideal situation is where an aircraft, suitably modified to accept a vertical camera, is avail-able. An increasing number of such aircraft are available around Australia. Where a modified aircraft is not available, it is necessary to use an aircraft with a window which can be opened in flight, so that photographs as nearly vertical as possible are obtained by the use of a camera held out of the window of the banked aircraft.

Station marking

Where a station is monumented with a standard survey cairn or beacon, no further marking is necessary, although it is usual to supplement the spot photography with low-level oblique colour photos to assist in the initial identification of the station. A zoom lens is used for this purpose to eliminate unnecessary low flying.

The situation frequently occurs where the station is established by another survey organization; but where it is established by the Division, e.g., an Aerodist station, the actual point is premarked with circular trenches or crosses made from white painted stone, panels of plastic sheeting, etc., depending upon the nature of the back-ground terrain.

Aerial cameras and film types

For a number of years, 35-mm cameras were used for spot photography, but the recent development in motor-ized 70-mm cameras has meant that better quality, larger format spot photos can now be achieved.

The camera most commonly used is the Hasselblad 500 EL fitted with a 40-mm wide-angle lens. This camera can be fitted in a simple mount or used hand-held with ease and comfort. Its built-in power-supply is an impor-tant feature. Kodak XX aerographic film in preloaded cassettes is normally used. The 70-shot magazines are easily changed and reloaded in the air. A good-quality reflex 35-mm camera fitted with a zoom lens (43–86 mm) and loaded with colour transparency film is used for any colour oblique photography required.

Aerial photography techniques

The Division requires that spot photographs be ob-tained at three heights above the terrain so that an initial positive identification and suitable scale relationships for transfer to the mapping photographs are obtained. These heights are approximately 250, 500 and 1,000 m. At least two photographs at each level are obtained so that a stereo-image is produced. Oblique 35-mm photos are taken at the low altitude where two pictures are exposed, one with the minimum (43 mm) focal length and the other at the maximum (86 mm) focal length setting.

Photo runs are made in an east or west direction so that the photos are from the same aspect as the mapping photography. It is an added advantage to take photo-graphs away from the sun so that the target is in full sun with the shadows falling away. This factor is especially important with colour obliques. A careful flight plan is necessary for locating control stations, and it is found easier if the aircraft arrives at a station at the lowest photograph level and then climbs to the next level before

departing for the next station on a descending path. By this manoeuvre, the station can often be located as a silhouette against the skyline. The initial visual sighting of a ground station is often difficult at flying heights about 1,000 m above ground level. Exposure settings for the camera are calculated using the Kodak aerial computer and an aerial exposure index for the film, chosen to give a gamma of 1.0.

Station identification transfer

After the film is developed, each frame is annotated before prints are ordered. The largest scale pictures and the colour obliques are used to identify the target which is normally visible on the smallest scale print. By means of a differential stereoscope, Bausch and Lomb zoom 95, with an accommodation ratio of 4:1, the control point is positively transferred to the RC9 mapping photo. Apart from the accuracy of the transfer, there is recorded evidence of the original identification which is always available for further reference and independent checking.

This procedure is commendable for speed of field operation, particularly where adequate signals exist, and for accuracy of control point transfer.

Aerodist operations in Western Australia in 1972

During 1972, the Division carried out field surveys to establish horizontal control for topographic mapping at 1:100,000 scale throughout the Great Sandy, Great Victoria, Gibson and Nullarbor desert areas of Western Australia.

Having an average elevation of 400 m and comprising lightly vegetated sand ridges, gravel rises and mulga plains, the country was suited to survey by airborne electronic distance-measuring techniques. However, the remoteness and undeveloped nature of the area usually restricted vehicular traffic to the few existing tracks, movement across country being slow and thus uneconomical.

To cope with these conditions, operations were programmed around a Grand Commander 680 FL fixed-wing aircraft carrying the three-channel master Aerodist system, with two Hughes 500 helicopters to move the four "remote" mobile ground transponders. These, in turn, were supported by 10 four-wheel-drive motor vehicles, ranging from Landrovers to 3-ton Bedfords.

A total of 20 men were involved, including three pilots and a helicopter maintenance engineer from the contractors supplying the aircraft.

Eight airstrips, located throughout the area, were used as fixed-wing aircraft bases during the measuring programme. As the endurance of the aircraft was limited to 7 hours and the ferry time from the nearest base to the measuring zone often exceeded 1½ hours, it was important to have as many line combinations as possible available for measurement while the aircraft was in the area.

The use of two helicopters permitted the movement of two ground parties simultaneously, reducing the time between control station occupation and increasing the number of lines available for measurement within a given period. Furthermore, in the event of a helicopter breakdown, it permitted the immediate recovery of personnel occupying ground transponder stations, which reduced the necessity to carry excess emergency water and rations, allowing more economical utilization of the helicopters.

Operations commenced on 1 April 1972 and concluded on 30 November 1972. During that eight-month period, sufficient field data were gathered to permit the co-ordinates of 80 new control stations to be determined. Control was established at 1° latitude and 1° longitude intervals over an area of 950,000 km^2; 530 lines were measured, varying in length from 25 km to 155 km. Each line was measured using the Aerodist "line-crossing" technique, and a minimum of seven crossings constituted one "line measurement". For identification and point transfer purposes, 120 previously established and new control stations were photographed vertically in 70 mm from heights of 200, 450 and 900 m above terrain. In the course of the survey, 790 fixed-wing and 670 helicopter hours were flown; the ratio of lines measured to aircraft hours to helicopter hours was 1:1.5:1.3. Figure 58 shows a representation of the Australian Aerodist network and delineates the area surveyed during 1972.

Much of the field data obtained during 1972 are yet to be reduced and computed; however, three areas, comprising 123 lines, contained within geodetic loops, have been adjusted by the least-squares method and the results indicate an average modulus residual value of 1.4 m.

Methods of improving the performance of the Aerodist equipment are continually being tested; and the standard Aerodist measuring system has been modified in a number of ways to improve ease of field servicing, quality of output and operating range. The major modifications incorporated in the system are:

(*a*) Relay and co-axial switching to permit utilization of any two combinations of the three master channels on two antennae;

(*b*) Two fixed 30-cm diameter flat-plate antennae with standard dipoles mounted on each side of the aircraft fuselage and connected to the master unit by minimal length low-loss cable. This type of antenna reduces drag in flight, increasing manoeuvrability, speed and range. The flat plates are suited for lines up to approximately 160 km in length, when the line-crossing technique is used;

(*c*) Three single-frequency remote transponder units, modified to incorporate interchangeable "backs" which permit operation on any of the three master frequencies;

(*d*) The introduction of standard fibre glass printed circuit-boards for the master units and modifications to master and remote units to allow the utilization of 95 per cent locally available parts.

Static tests have been undertaken using a 30-cm diameter parabolic dish in place of the flat-plate reflectors currently mounted in the rotatable "pods", the intention being to increase the measuring range for simultaneous three channel operation. Tests are also being carried out to gauge the effect of increasing the remote parabolic reflector diameter from 0.6 m to 1 m.

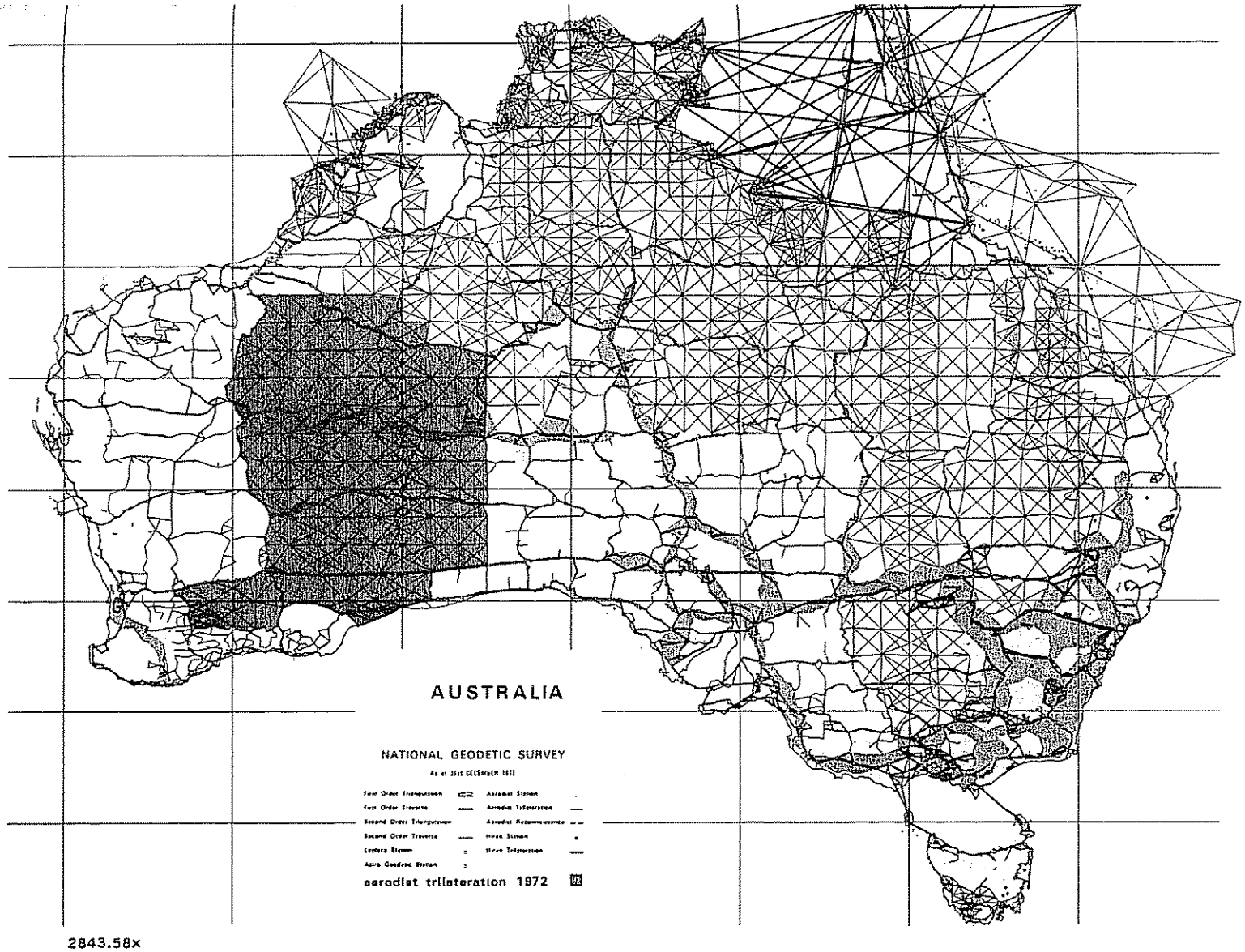

Figure 58. Australia: national geodetic survey, Aerodist trilateration. 1972

A SINGLE DATUM FOR ASIA AND THE FAR EAST*

Paper presented by the United States of America

Over the past years, extensive survey work has been completed in Asia and the Far East. A network of interconnected primary triangulation covers India, Burma, Thailand, Cambodia, Laos, the Republic of Viet-Nam, and Malaysia. This network of primary control, however, is inadequately tied to the primary control networks of Indonesia, the Philippines, Australia, New Zealand, China and Japan. Reflecting this lack of unification, the mapping control of this vast area is positioned on several datums.

The main thrusts for the unification of control into a single datum comes from two sources—the scientific interest in the exact size and shape of the earth and the practical need for accurate maps based on homogeneous control beyond political boundaries. The practical needs for control to support cadastral mapping, property delineation, engineering projects and long-range planning can be satisfied by strengthening and unifying the control networks in each country. The Australian geodetic datum is an example of the development of a single, well-fitting datum for a vast area. The unification of the control in Asia and the Far East on a single geodetic datum is a goal worthy of a planned and co-ordinated international effort.

This paper describes the Doppler system of satellite geodesy and strongly recommends its use for the strengthening, densification and unification of the control networks of the countries of Asia and the Far East. The all-weather portable Doppler receiver can be used to establish geodetic positions rapidly, accurately and economically. It has greatly altered the traditional concepts of the establishment of geodetic control.

The significance of a single well-fitting datum on the establishment of a unified accurate control system, is succinctly expressed by Fischer as follows: "The difference between a good and a poor fit of a geodetic datum can thus be expressed in very practical terms. The complicated correction procedures for distortions caused by an ill-fitting datum are unnecessary in a well-fitting datum. The latter is not unique, as any datum with small geoidal separations in the area of interest would serve its practical purpose".[1]

EFFORTS FOR UNIFICATION

The primary control in Asia and the Far East consists of triangulation, traverses and HIRAN trilateration (figure 59). Shown also in figure 59 are satellite tracking stations related to several systems. These are the optical systems (BC-4 and Baker-Nunn); the ranging system, which is the Sequential Collection of Ranges (SECOR); and the range-rate system (Doppler). An inspection of figures 59 and 60 will indicate how inadequate these data are in tying together the existing control, which is on many different datums (figure 60).

Over the past years, efforts to unify the control have commenced from Australia, India and Japan.

Efforts to unify the control in Asia and the Far East were initiated by the sequential adjustments of the primary triangulation of India, Burma, Thailand, Cambodia, Laos and the Republic of Viet-Nam into the Indian datum. The extension of this datum, however, produced very large separations between the geoid and the Everest spheroid oriented at Kalianpur.

At the eleventh General Assembly of the International Association of Geodesy (IAG), held at Toronto in 1957, a commission was formed to undertake the adjustment of the triangulation networks of south Asia. The object of this adjustment was to obtain a unified system of geodetic positions for scientific and mapping purposes in south Asia. The commission was composed of representatives from Burma, India, Malaysia, Pakistan and Thailand. Brigadier G. Bomford was the chairman.

The Commission derived the south Asia datum by selecting the Fischer spheroid constants,[2] determining the orientation,[3] and developing the equations for converting the control in India and Burma to the new datum.[4] The south Asia datum was extended into southern Burma, Thailand, Cambodia, Laos, the Republic of Viet-Nam and Malaysia by readjusting the primary triangulation in these areas. Before readjustment, the primary triangulation was strengthened by the introduction of Tellurometer traverses, additional Laplace azimuths and Geodimeter lengths. The results of the commission's work were reported to the IAG meeting at Berkeley in 1963.[5] In 1964, at the Fourth United Nations Regional Cartographic Conference for Asia and the Far East, Bomford[6] proposed the adoption of the south Asia datum. The south Asia datum, however, was not adopted by any of the countries concerned.

Efforts to unify the control in the south-west Pacific were initiated with the extension of the Australian geodetic datum into the eastern part of New Guinea by using HIRAN methods. The Australian control is now tied to the control in Indonesia and South-East Asia.

The Tokyo datum has been extended to the Republic of Korea and Manchuria by triangulation and to South East Asia by HIRAN trilateration. Large separations between the geoid and the Bessel ellipsoid are produced by the extension of the Tokyo datum into these areas. None of these surveys in the Far East are adequately tied to the control in the vast areas of China and Siberia.

*The original text of this paper, prepared by Archie Carlson, Chief, Asia-Pacific Section; and James Walker, Chief, Data Reduction Section, both of the Department of Geodesy, Defense Mapping Agency Topographic Center, United States of America, appeared as document E/CONF.62/L.58.

[1] "Constructing a geodetic datum that fits a continent", paper prepared by I. Fischer, *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.72.I.20), p. 126.

[2] I. Fischer, "The present extent of the astrogeodetic geoid and the geodetic world datum derived from it", paper presented to the meeting of the International Union of Geodesy and Geophysics, Helsinki, Finland, 1960.

[3] G. Bomford, "The junction of the Indian and European triangulation systems", *Bulletin Geodesique*, No. 56, new series (1960); pp. 177-189.

[4] G. Bomford, "Adjustment of south Asia triangulation, 1963, and possible use", *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Proceedings of the Conference and Technical Papers* (United Nations publication, Sales No. 66.I.2), pp. 204-261.

[5] *Ibid.*

[6] *Ibid.*

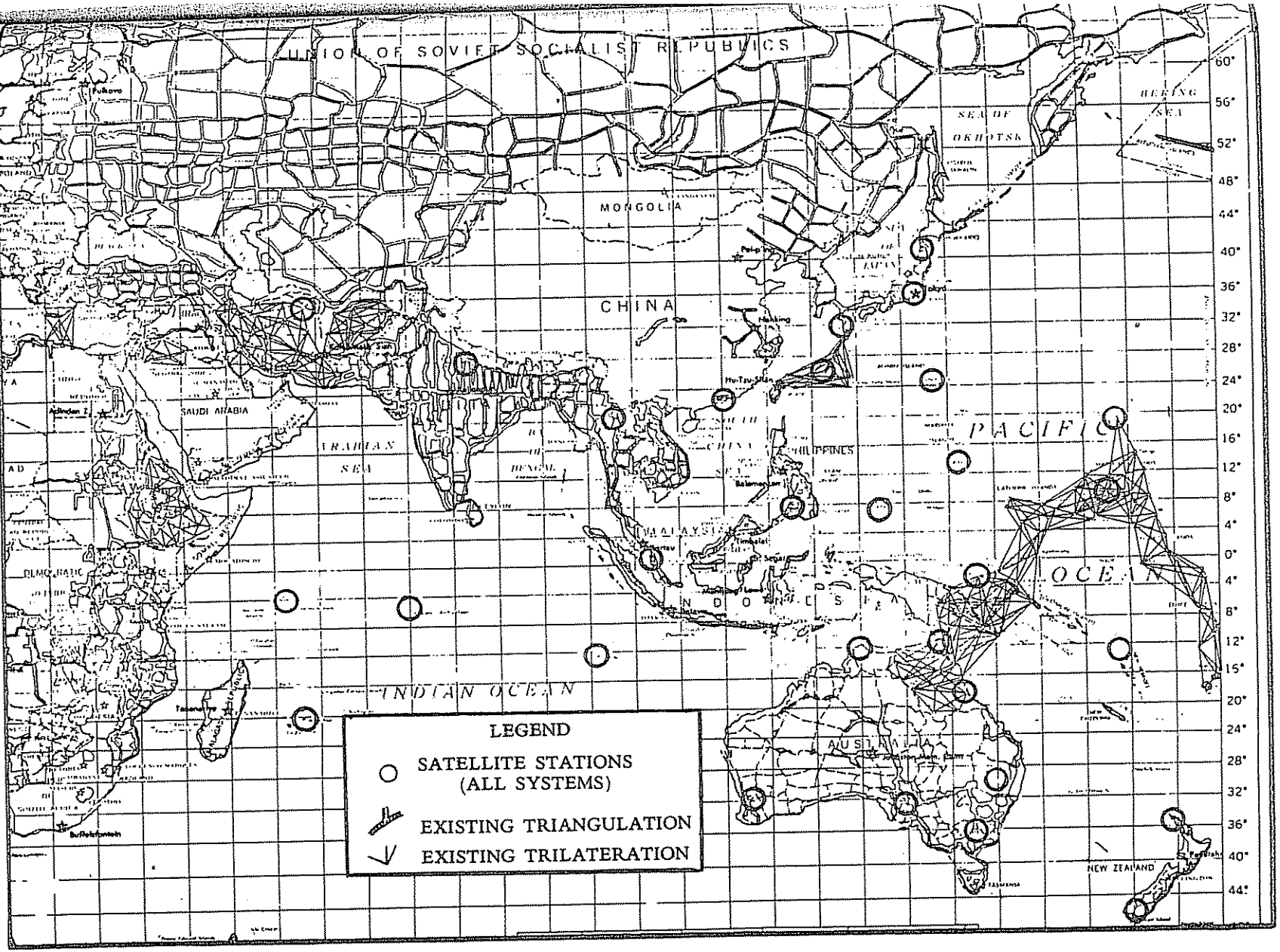

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Figure 59. United States of America: primary control in Asia and the Far East

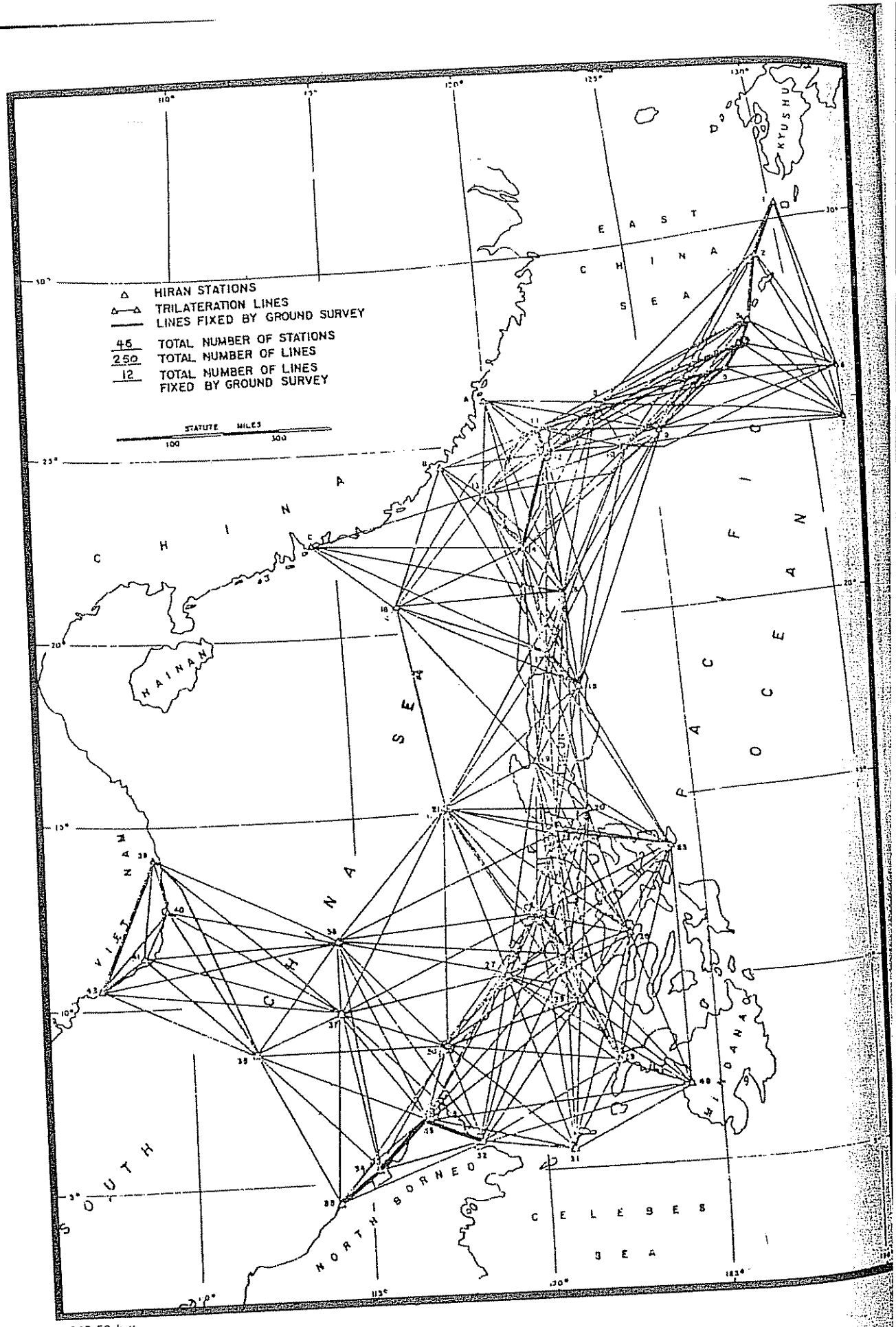

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Figure 59 (continued)

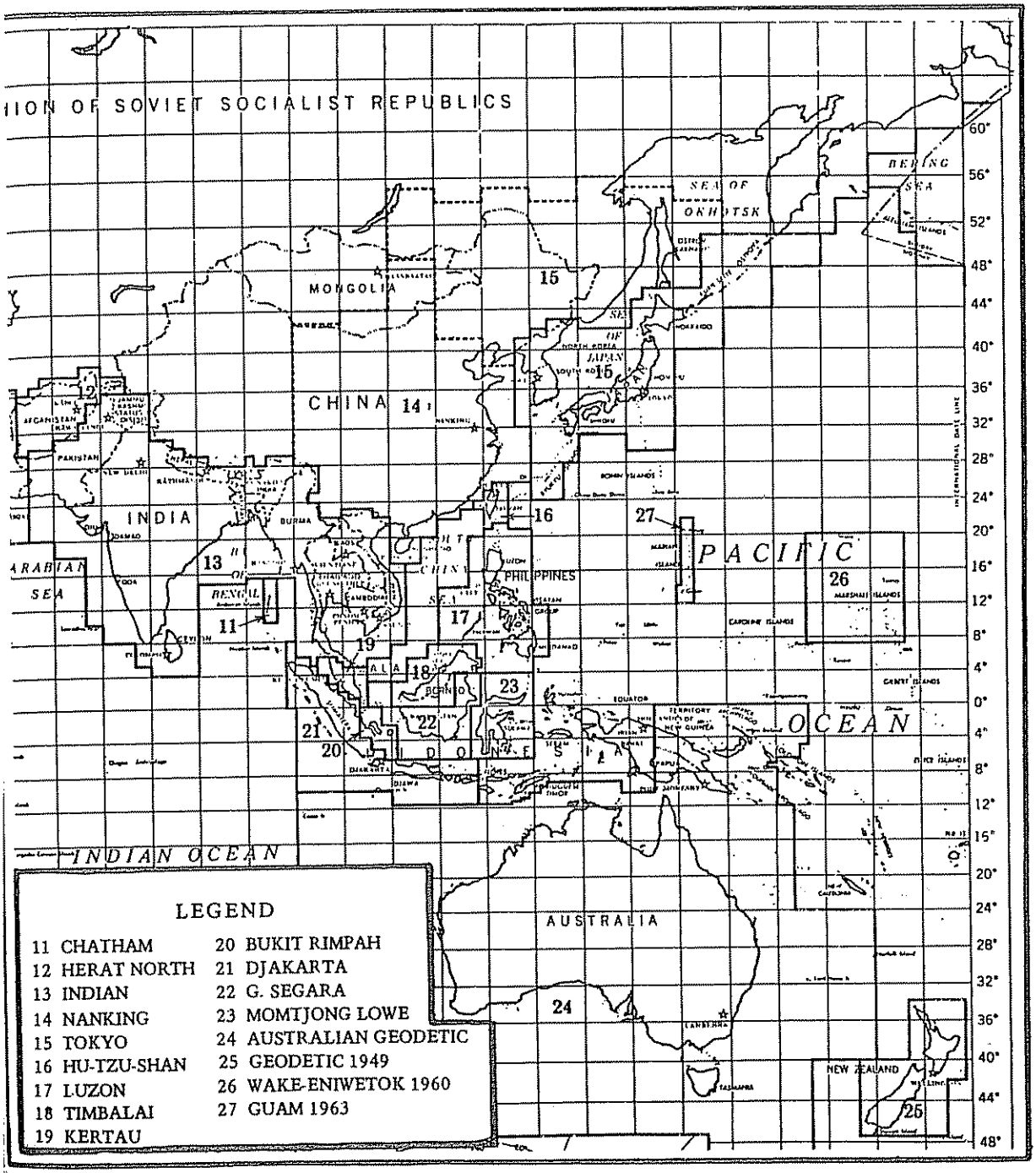

Figure 60. United States of America: mapping datums in Asia and the Far East

The establishment of satellite tracking stations represents the current effort to unify control. As indicated in figure 59, however, the combined networks of BC-4, SECOR, Baker-Nunn and Doppler satellite tracking stations do not provide enough stations to unify and strengthen the control in Asia and the Far East. For example, there are no tracking stations in Burma, Indonesia, Laos and the Republic of Viet-Nam. Only one tracking station is located in each of the following countries: India, Malaysia, and Thailand. The networks of satellite tracking stations, moreover, have not been combined to form a unified network of control on a single datum. These limitations of the past geodetic satellite programme can be remedied by the new Doppler methods discussed below. The key factor in these new methods is the portable Doppler equipment, the Geoceiver. Geoceivers are operational and plans for their use in various parts of the world have been initiated. The Australian National Survey, for example, is developing the capability of using the new Geoceiver. In the Philippines, moreover, the United States Naval Oceanographic Office, acting on a request from the Government of the Philippines, has established six Geoceiver stations.

General background relating to development of Doppler geodetic programmes[7]

The scientific work that led to the development of dynamic satellite geodesy was the measurement of the Doppler shift in the radio transmissions from the satellite launched in 1957 by the Union of Soviet Socialist Republics, Alpha (Sputnik I), at the Applied Physics Laboratory at Johns Hopkins University. The Doppler shift is generated by the relative motion between satellite and observer; it is a direct measurement of the rate of change of distance between the two. Consequently, if a Doppler-equipped satellite is tracked from a network of known ground-station positions, then the measured Doppler shifts—in combination with an adequate knowledge of the earth's gravity field—can be used to determine the satellite orbit. Conversely, if a Doppler-equipped satellite is tracked from unknown ground-station positions, then the measured Doppler shifts—in combination with the known satellite orbits—can be used to determine the unknown tracking-station positions. Based on these concepts, the Tracking Network (TRANET) system used by the United States Navy was developed by the Applied Physics Laboratory.

The TRANET system comprises a world-wide network of Doppler tracking stations. The TRANET system was originally designed for positioning and navigation of ships at sea. It has evolved into a system for precise determination of orbits which are, in turn, suited for the determination of highly accurate geodetic positions.

The TRANET Doppler receiver is an all-weather system. It is a relatively inexpensive geodetic tool in terms of the mapping and surveying budget because, fortunately, the navigation programme of the United States Navy pays for the fabrication and launch of the satellites.

The TRANET Doppler equipment required for each station weighed approximately 13,000 pounds. The weight factor stimulated the development and manufacture of several miniaturized Doppler receivers that weigh only a small fraction of the TRANET equipment.

In recent years, the United States Department of Defense (DoD) contracted for the purchase of miniaturized Doppler systems, called "Geoceivers" (Geodetic Doppler receivers). The Geoceiver is designed specifically to determine geodetic positions. It consists of an antenna, a receiver, a paper-tape recorder and a power source. Whenever power is not commercially available, a portable generator is required. The entire unit weighs about 100 pounds. Compared with the tons of equipment that were previously required for Doppler, this reduction in weight is a tremendous advantage in field deployment.

Geoceiver test[8]

During the period from October to December 1971, the United States military agencies that are now a part of the Defense Mapping Agency (DMA), participated in a co-operative test of the Geoceiver. The test was conducted in two phases, each lasting approximately one month (figures 61 and 62). Approximately 10,000 satellite passes were observed from 20 distinct stations.

The accomplishments of the Geoceiver test were as follows:

(*a*) The extended use of the Geoceiver in the field established the operational capabilities of the receiver under various conditions;

(*b*) The substantial amounts of observed data were used to investigate and validate the reduction procedures—point-positioning, translocations, short-arc;

(*c*) The comparison of Geoceiver station solutions with the precise Geodimeter traverse, observed and adjusted by the United States National Ocean Survey (NOS), verified the capability of the Geoceiver as a geodetic tool.

The Geoceiver test results for each mode of data reduction are given in tables 1–6 in the annex. The results consist of station solution, station comparisons and station accuracies.

The specifications for point-positioning accuracy were as follows:

(*a*) *Accuracy*: 1.5 m in each co-ordinate;

(*b*) *Consistency*: 1.0–1.5 m in each co-ordinate;

(*c*) *Limitations*: United States Navy satellite ephemeris; 35 or more passes; balanced data set; elevation angles of 10° or less deleted; 3σ residual deletion gate applied iteratively; Geoceiver local clock read-out;

(*d*) *Source*: Geoceiver test positions compared with NOS precise traverse positions.

The specifications for translocation accuracy were as follows:

(*a*) *Accuracy*: 0.5 m plus 2 parts per million of the distance in each co-ordinate difference;

(*b*) *Consistency*: 0.5 m plus 1.5 parts per million of the distance in each co-ordinate difference;

(*c*) *Limitations*: United States Navy satellite ephemeris; 20 or more passes; balanced data set; elevation angles 10° or less deleted; 3σ residual deletion gate applied iteratively; Geoceiver local clock read-out;

(*d*) *Source*: Geoceiver test positions compared with NOS precise traverse positions.

Geoceiver modes of operation[9]

The distinctive characteristics of the point-positioning mode (figure 63) of Geoceiver operation are as follows:

(*a*) Each tracking station observes satellite passes independently from other tracking stations;

(*b*) Satellite ephemeris is held fixed in the adjustment;

(*c*) Adjustment involves the solution of one station position in terms of the co-ordinate system of the satellite ephemeris;

(*d*) Accuracy depends upon the cancellation of satellite ephemeris errors by observing multiple passes of the satellite.

The distinctive characteristics of the Geoceiver translocation (figure 64) mode of operation are as follows:

(*a*) Two tracking stations observe each pass of the satellite simultaneously;

(*b*) Satellite ephemeris is held fixed in the adjustment;

[7] "A unified datum for Africa", (E/CN.14/CART/311) paper prepared by E. H. Rutscheidt and presented to the Third United Nations Regional Cartographic Conference for Africa, Addis Ababa, 30 October-10 November 1972.

[8] United States of America, Department of Defense, Defense Mapping Agency, *Report of the DoD Geoceiver Test Program*, DMA report 0001 (Washington, D.C., July 1972).

[9] *Ibid.*

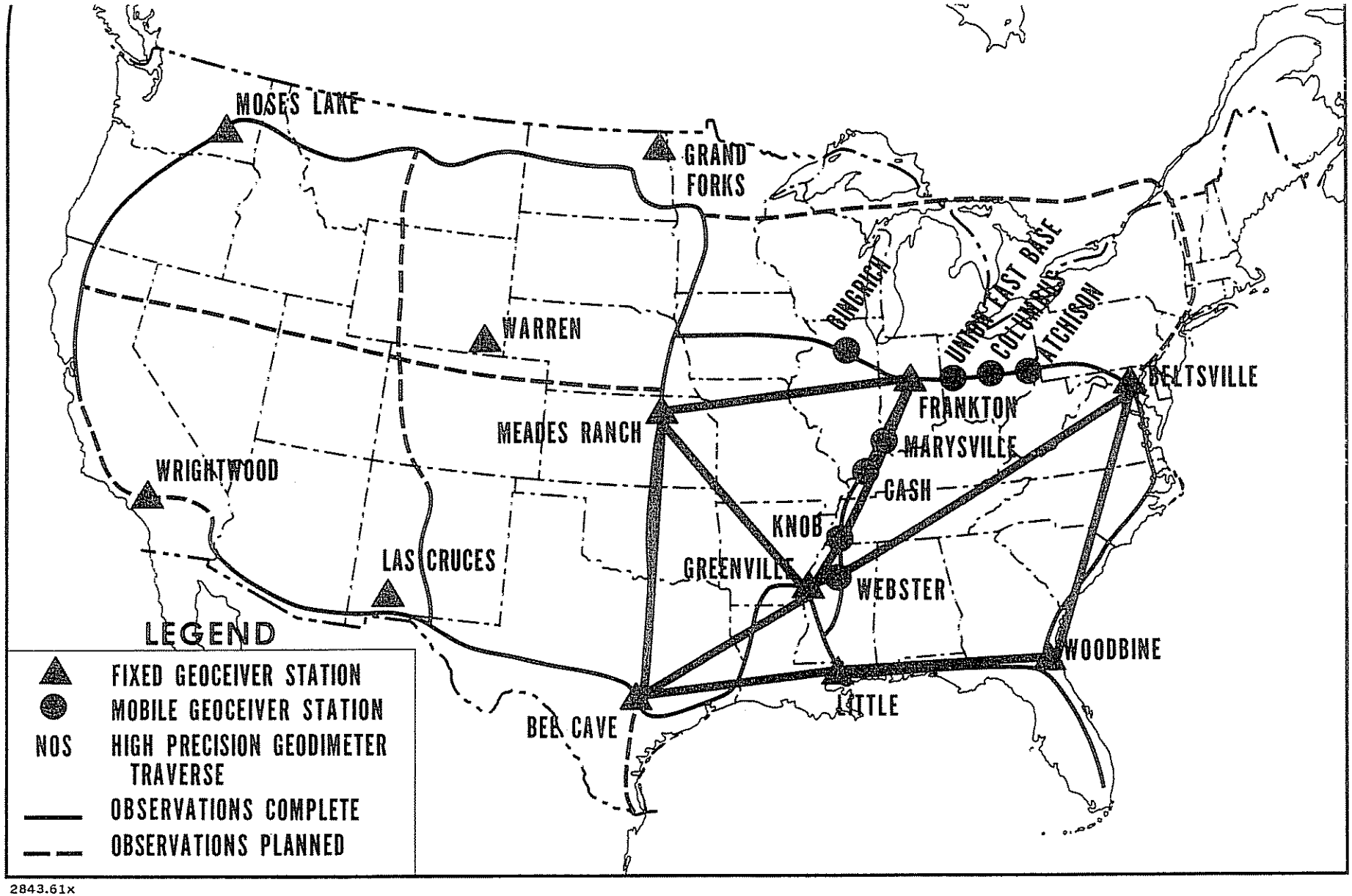

Figure 61. United States of America: Department of Defense Geoceiver test, phase I network

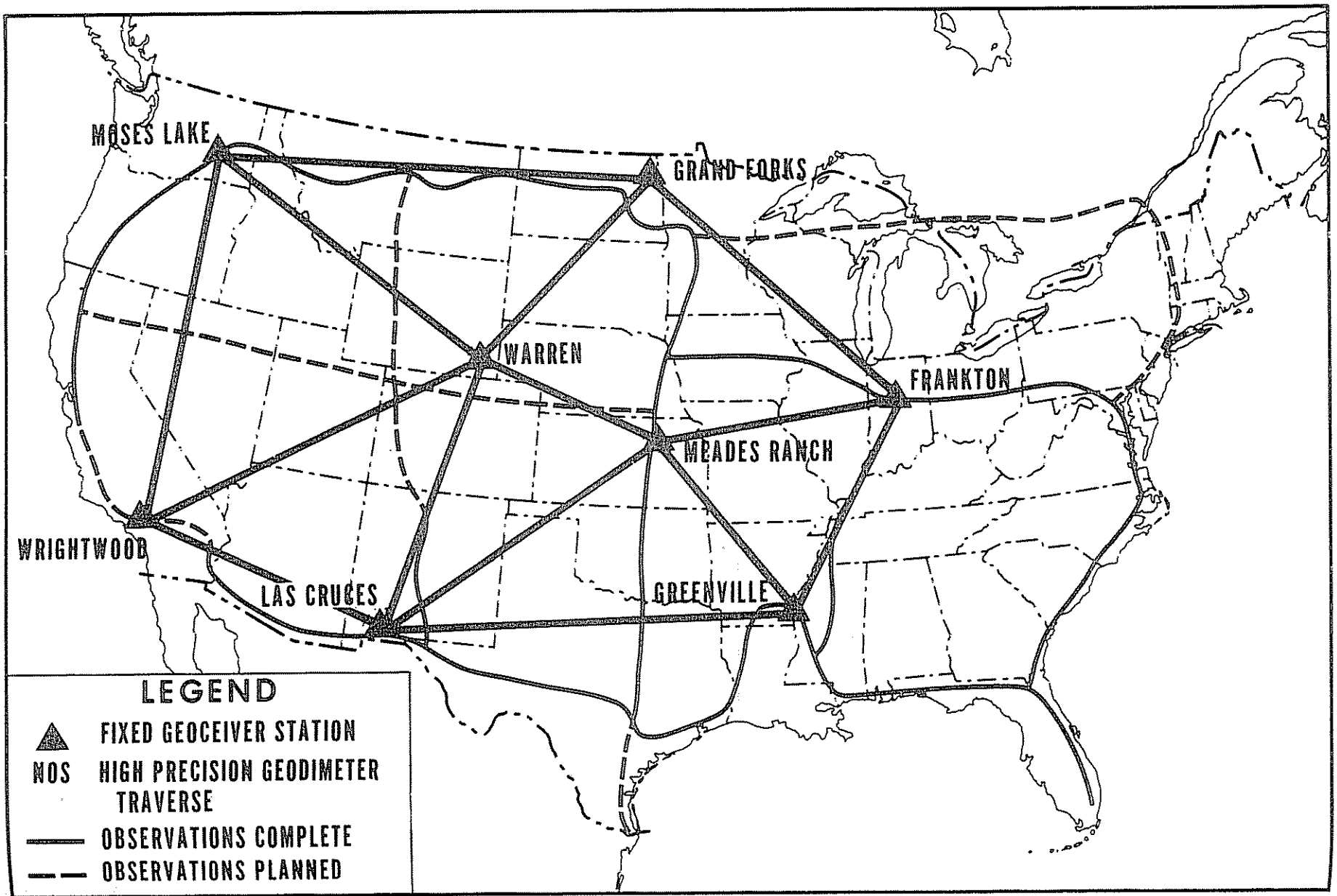

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Figure 62: United States of America: Department of Defense Geoceiver test, phase II network

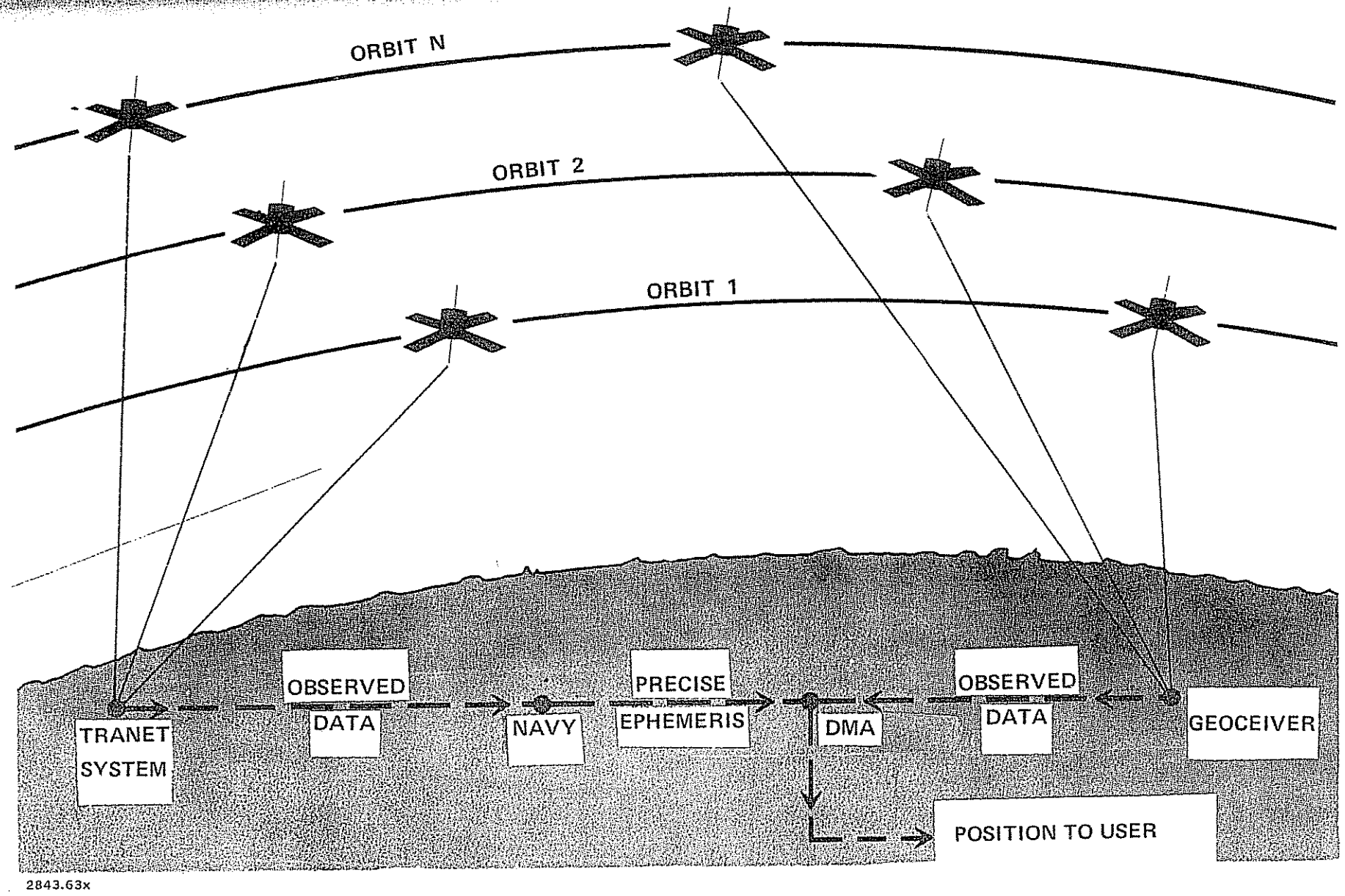


Figure 63. United States of America: single point positioning

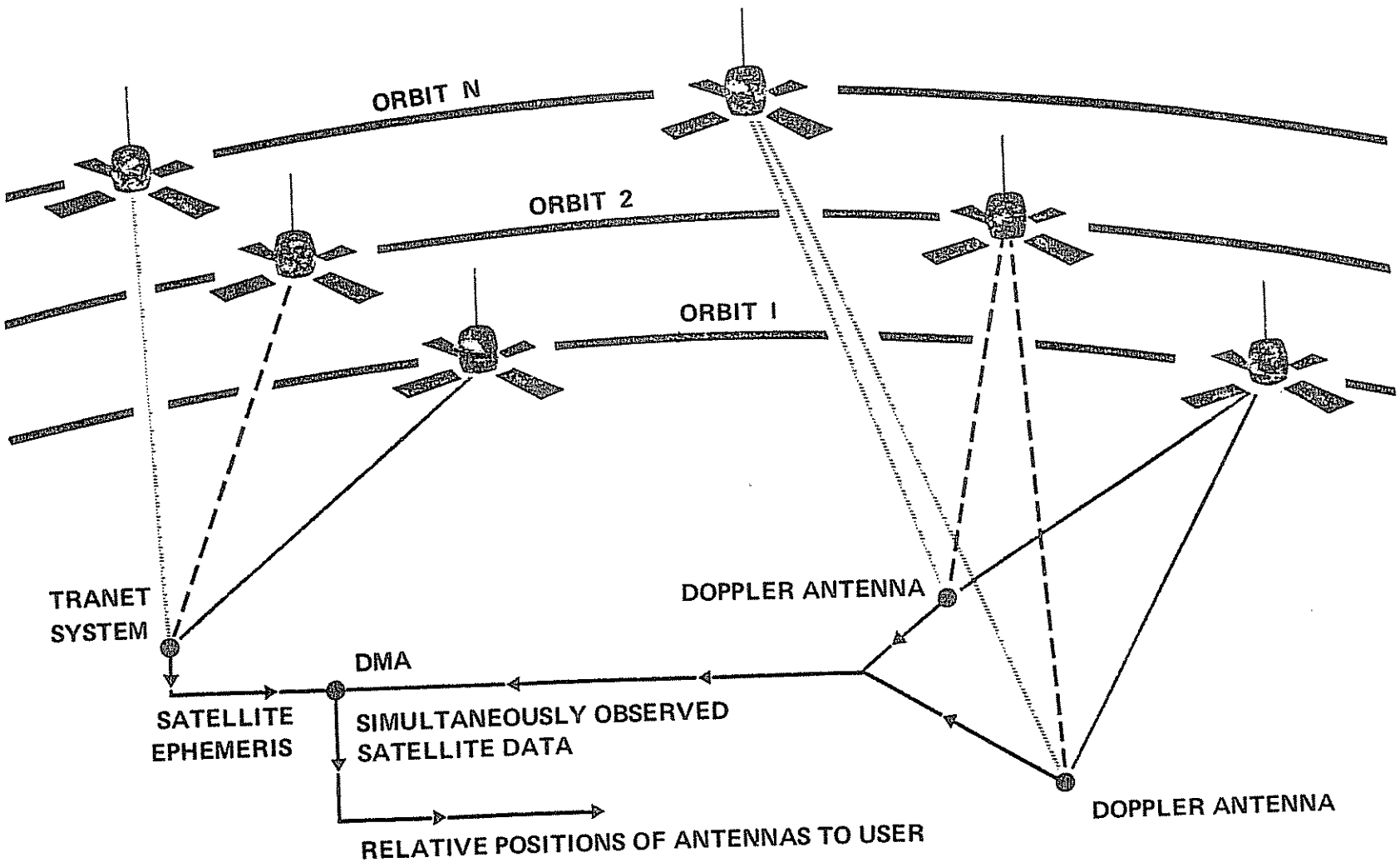


Figure 64. United States of America: translocation

) Adjustment involves the solution of the relative tions of two tracking stations;

') Accuracy depends upon the cancellation of satel- ephemeris errors by solving for relative station posi- s.

he distinctive characteristics of the Geoceiver short- mode of operations (figure 65) are as follows:

a) Six or more tracking stations are in operation ing the same time period;

b) Each pass of the satellite must be observed by four king stations;

c) Satellite ephemeris is not held fixed;

d) Co-ordinate system is introduced in the solution constraining the initial co-ordinates of some or all of tracking stations;

e) Adjustment involves the solution for satellite emeris corrections and for tracking station correc- is to the initial values;

f) Accuracy depends upon the constraints applied to initial tracking-station co-ordinates and the geome- of the network.

Based on the results of the Geoceiver test in the United ites, it is considered that the point-positioning mode lds the greatest benefit for the effort expended. Yet, in ne cases, the translocation mode is more desirable. e deciding factor is, of course, the number of portable ppler receivers that are available at one time. Man- g a single Doppler unit does not impose great diffi- lties since a minimum of two persons, or preferably ee, can man a single station. The training of personnel the use of the Doppler equipment imposes some initial nstraints in getting a programme started, but this can accomplished during the planning phase of the pro- amme.

Geoceiver data processing[10]

The processing of Geoceiver data at the Defense lapping Agency involves six basic steps: predictions for acking teams; conversion of Geoceiver punched paper- pe to punched cards; preprocessing; preliminary multi- ss solutions for point positions; final multipass solu- ons for point position; translocation or short-arc olutions, as appropriate.

Before a tracking team is deployed to a specific sta- on, it is provided with satellite alerts for the entire perational period. When the Geoceiver output punched paper-tape) is received from the field, the tapes re immediately converted into punched cards. These ards are then used as input to a preprocessing computer rogramme which produces Doppler observational data the format required by the multipass point- positioning and short-arc solution programmes. Follow- ng these basic steps, the data (with minor changes) also an be used for the translocation and short-arc solutions.

The preprocessing of data for a single station, nor- ally consisting of approximately 45 observed satellite sses, requires a minimum of eight man-hours. In ddition, 15 minutes of computer time on a large mputer, such as a UNIVAC 1108, are required. A ultipass point-position solution with 35–40 passes quires approximately 3 minutes of computer time, hile a translocation solution requires approximately 5 minutes. In the programmes at the Defense Mapping Agency Topographic Center (DMATC), the format has been standardized, and, therefore, the same data for a number of stations can be computed in a short-arc solution. A typical short-arc solution using 16 passes from six stations requires 6 minutes of computer time.

The processing and data reduction system developed at DMA was begun approximately two and one-half years ago, and modifications of the system are still in progress. The computer programmes for the point-position, translocation or short-arc solutions all have been validated by comparison with one another. Small differences in the methods used by the programmes to represent the satellite orbit, to compute the effect of tropospheric refraction and to perform data filtering appear to cause changes of several metres in the final station co-ordinates. These small differences are being studied in greater detail, and the resolution of these small differences may further improve the accuracy of Doppler positioning.

Suggested uses for Doppler positioning[11]

Considering the existing control in Asia and the Far East, the possible applications of the portable Doppler equipment are as follows:

(*a*) The establishment of point positions on existing control networks for the purpose of deriving datum transformations between independent networks and/or for readjusting and possibly improving upon the accuracy of the existing control networks;

(*b*) The establishment of point positions in remote areas for future control extensions by conventional methods;

(*c*) The establishment of point positions in support of mapping;

(*d*) The establishment of point positions on existing astronomical positions for obtaining deflections of the vertical;

(*e*) The establishment of point positions on existing sea-level vertical control to determine the geoidal height directly.[12]

In the list of applications, the direct measurement of geoidal height will make a significant contribution to the determination of a single well-fitting datum for each country in Asia and the Far East and/or for the entire region. The vertical co-ordinate obtained from Doppler observations consists of the elevation of the point above some adopted ellipsoid. If the orthometric height of the point is known also from spirit levelling, then the elevation of the geoid above the adopted ellipsoid is obtained directly by a simple subtraction. The main reason that satellite observations for the direct determination of geoid heights have not been discussed seriously in the past is that there simply have not been enough satellite tracking stations whose co-ordinates were determined with sufficiently high accuracy.

Tests conducted in the United States indicate that the vertical co-ordinate determined from the reduction of Doppler data is as accurate as the horizontal co-ordinate

[11] Rutscheidt, op cit.

[12] C.R. Schwarz, "Direct determination of geoid undulations with the Geoceiver", paper presented to the International Symposium on Earth Gravity Models, St. Louis, Missouri, August 1972.

[10] Ibid.

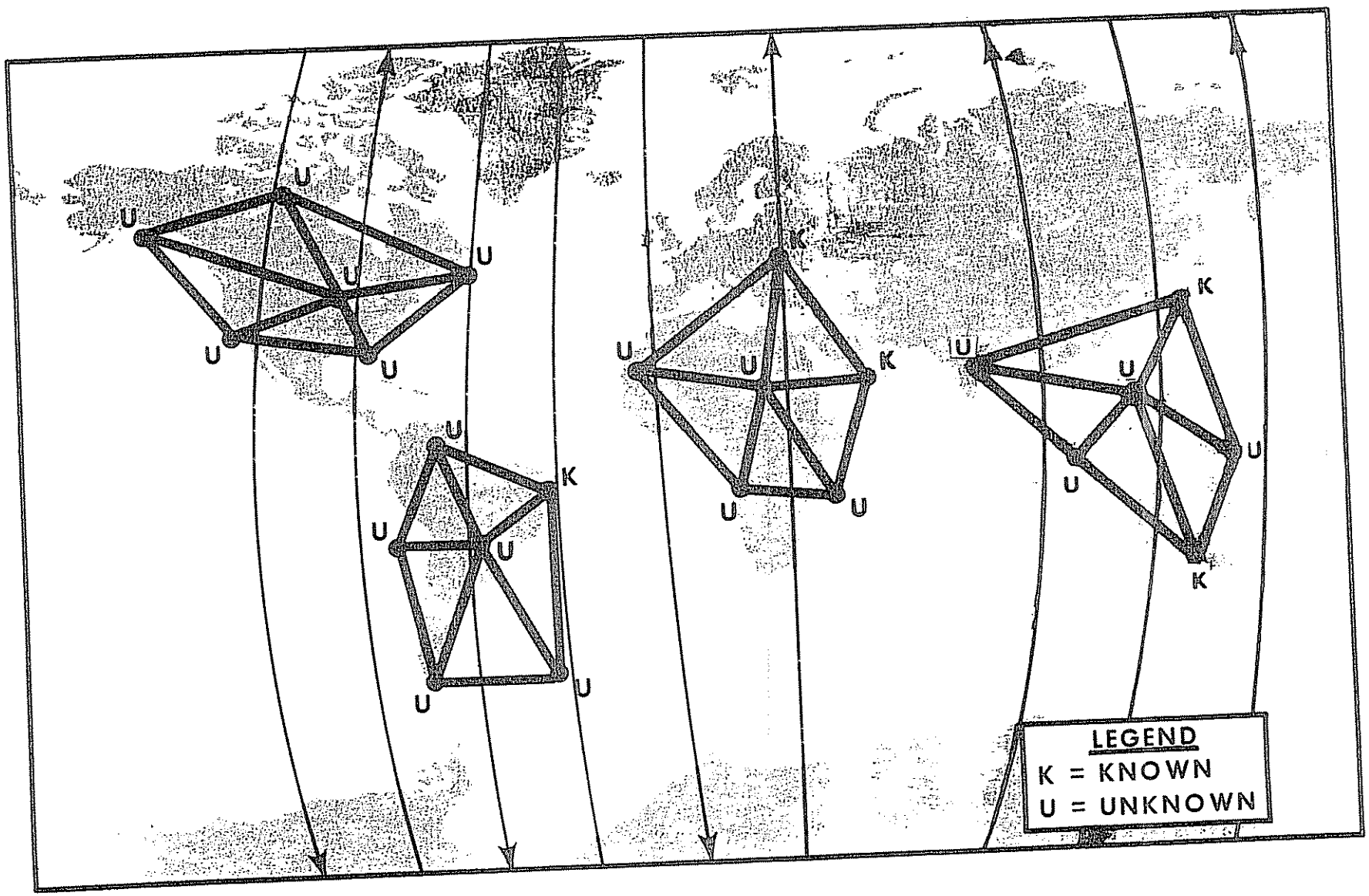


Figure 65. United States of America: possible geometrics for Doppler positioning by the short-arc method

Table 1. Phase 1 point position solutions, satellites 59 and 60
Co-ordinate system: United States Navy 9C ephemeris

ION	NAME	LATITUDE	LONGITUDE	HEIGHT	σ_ϕ	σ_λ	σ_h	NO. PASSES
003	GREENVILLE	33°28' 42".803	268° 59' 50".349	6.82m	0.10m	0.16m	0.10m	169
006	MEADES RANCH	39 13 26.646	261 27 27.512	565.73	0.19	0.30	0.18	63
018	BALDY	30 26 48.898	262 01 15.690	292.72	0.11	0.18	0.11	135
019	FRANKTON	40 14 7.030	274 10 26.545	222.40	0.11	0.17	0.10	172
020	MARYSVILLE	38 35 20.951	274 21 7.152	176.15	0.16	0.24	0.15	56
021	CASH	37 33 6.950	273 55 0.761	228.74	0.19	0.29	0.17	40
022	KNOB	34 47 15.800	271 45 29.412	211.78	0.26	0.41	0.22	36
023	WEBSTER	33 33 55.013	270 50 3.498	102.33	0.20	0.30	0.18	45
001	BELTSVILLE	39 01 39.814	283 10 27.104	4.36	0.12	0.20	0.12	196
015	WOODBINE	30 56 55.695	278 19 7.737	−25.01	0.25*	0.42*	0.24*	176
016	COLUMBIA	31 12 45.099	270 16 27.059	77.34	0.12	0.18	0.11	174
025	ATCHISON	40 05 11.784	278 15 39.474	322.46	0.16	0.24	0.15	91
026	COLUMBUS	40 00 27.799	276 57 29.862	203.94	0.17	0.26	0.16	62
027	UNION EAST BASE	40 09 51.465	275 23 26.296	277.30	0.22	0.36	0.21	37
028	GINGRICH	40 49 20.412	270 42 39.572	212.88	0.18	0.32	0.19	50

*MS residual at Woodbine is significantly higher than at other stations, probably owing to trees restricting station horizon.

Table 2. Phase 1 point position solutions, satellites 59 and 60
(Geoceiver positions minus precise traverse positions (NOS))

STATION	$\Delta\phi$(M)	$\Delta\lambda$(M)	ΔH(M)
10003	0.24	1.42	−2.11
10006	1.77	0.09	−2.29
10018	1.48	−1.49	−2.43
10019	0.27	0.26	−0.75
10020	0.81	0.94	−0.60
10021	0.22	0.78	−0.61
10022	0.14	1.44	−2.58
10023	0.08	0.20	−1.62
20001	1.40	0.53	−0.23
20015	−1.34	1.48	1.05
20016	−0.59	0.47	0.01
30025	1.31	−0.32	−1.29
30026	0.64	0.81	0.02
30027	0.94	0.45	0.16
30028	1.19	0.14	−0.96

Note: National Ocean Survey (NOS) positions were shifted to United States Navy 9C datum before comparison

Table 3. Comparison of relative positions determined by Geoceiver and by precise traverse (National Ocean Survey)

PART A

FROM	TO	DIST (km)	POINT POSITION—TRAVERSE			TRANSLOCATION—TRAVERSE		
			$\Delta\phi$(m)	$\Delta\lambda$(m)	Δh(m)	$\Delta\phi$(m)	$\Delta\lambda$(m)	Δh(m)
GREENVILLE, OHIO	FRANKTON, IND	104	-0.19	-0.68	0.91	0.64	0.02	-0.29
COLUMBIA, MISS	MATHISON, MISS	266	0.70	-0.27	-1.60	0.25	0.05	-1.81
COLUMBIA, MISS	GREENVILLE, MISS	278	0.85	0.97	-2.08	1.11	1.08	-1.64
FRANKTON, IND	METAMORA, ILL	301	-0.08	0.91	-0.20	0.04	0.07	-0.46
COLUMBIA, MISS	IUKA, MISS	420	0.76	1.01	-2.56	1.02	0.84	-2.01
FRANKTON, IND	IUKA, MISS	641	-0.08	1.25	-1.80	0.86	0.16	-2.14
WOODBINE, GA	COLUMBIA, MISS	768	0.66	-1.24	-0.85	0.67	-0.81	0.99
COLUMBIA, MISS	SUMMIT, KY	779	0.85	0.34	-0.57	0.81	0.13	-0.50
FRANKTON, IND	BELTSVILLE, MD	783	1.20	0.16	0.49	0.41	1.03	-0.10
COLUMBIA, MISS	JONESTOWN, TEX	793	2.10	-2.07	-2.39	2.01	-2.02	-1.94

PART B

FROM	TO	DIST (km)	POINT POSITION—TRAVERSE			TRANSLOCATION—TRAVERSE		
			$\Delta\phi$(m)	$\Delta\lambda$(m)	Δh(m)	$\Delta\phi$(m)	$\Delta\lambda$(m)	Δh(m)
GREENVILLE, MISS	FRANKTON, IND	879	-0.11	-1.35	1.21	0.32	-0.83	1.21
COLUMBIA, MISS	MARYSVILLE, IND	899	1.47	0.51	-0.55	1.52	-0.21	-0.04
GREENVILLE, MISS	MEADES RANCH, KAN	929	1.26	-1.11	-0.08	1.56	-2.16	0.59
BELTSVILLE, MD	WOODBINE, GA	998	-2.79	1.06	1.51	-2.77	1.86	1.59
COLUMBIA, MISS	FRANKTON, IND	1060	0.91	-0.19	-0.68	1.35	-0.04	-0.18
METAMORA, ILL	BELTSVILLE, MD	1082	0.29	0.08	0.72	0.36	0.58	0.13
MEADES RANCH, KAN	FRANKTON, IND	1093	-1.52	-0.46	1.44	-0.48	2.67	1.00
WOODBINE, GA	FRANKTON, IND	1095	1.75	-1.36	-1.48	2.62	-1.99	-0.75
JONESTOWN, TEX	FRANKTON, IND	1523	-1.80	1.18	1.59	-1.50	3.13	2.20
MEADES RANCH, KAN	BELTSVILLE, MD	1867	-0.23	-0.62	1.89	-1.04	4.25	1.30

Table 4. Comparison of distances between stations determined by Geoceiver and by precise traverse (National Ocean Survey)

PART A

FROM	TO	DIST (km)	SATELLITE DERIVED DISTANCE - TRAVERSE (M)				
			POINT POSITION	PASSES		TRANSLOCATION	PASSES
GREENVILLE, OHIO	FRANKTON, IND	104	0.13	37	172	-0.07	16
COLUMBIA, MISS	MATHISON, MISS	266	0.56	174	45	0.22	26
COLUMBIA, MISS	GREENVILLE, MISS	278	0.28	174	169	0.49	122
FRANKTON, IND	METAMORA, ILL	301	0.25	172	50	-0.09	28
COLUMBIA, MISS	IUKA, MISS	420	0.95	174	36	1.18	23
FRANKTON, IND	IUKA, MISS	641	-0.42	172	36	-0.98	24
WOODBINE, GA	COLUMBIA, MISS	768	0.48	176	174	0.75	96
COLUMBIA, MISS	SUMMIT, KY	779	0.87	174	40	0.76	26
FRANKTON, IND	BELTSVILLE, MD	783	-0.08	172	196	0.91	87
COLUMBIA, MISS	JONESTOWN, TEX	793	1.60	174	135	1.59	73

PART B

FROM	TO	DIST (km)	SATELLITE DERIVED DISTANCE - TRAVERSE (M)				
			POINT POSITION	PASSES		TRANSLOCATION	PASSES
GREENVILLE, MISS	FRANKTON, IND	879	-0.75	169	172	-0.10	118
COLUMBIA, MISS	MARYSVILLE, IND	899	1.48	174	56	1.27	36
GREENVILLE, MISS	MEADES RANCH, KAN	929	1.64	169	63	2.69	39
BELTSVILLE, MD	WOODBINE, GA	998	2.20	196	176	1.87	122
COLUMBIA, MISS	FRANKTON, IND	1060	0.73	174	172	1.24	93
METAMORA, ILL	BELTSVILLE, MD	1082	0.06	50	196	0.48	28
MEADES RANCH, KAN	FRANKTON, IND	1093	-0.37	63	172	2.73	30
WOODBINE, GA	FRANKTON, IND	1095	1.99	176	172	3.09	101
JONESTOWN, TEX	FRANKTON, IND	1523	-0.09	135	172	1.65	78
MEADES RANCH, KAN	BELTSVILLE, MD	1867	-0.30	63	196	4.49	24

Table 5. Phase I short-arc solutions
(Geoceiver positions minus precise traverse positions (NOS))

STA	NAME	$\Delta\phi$ (m)	$\Delta\lambda$ (m)	Δh (m)	PASSES
10003	GREENVILLE	0.00	0.00	0.00	12
10006	MEADES RANCH	4.14	3.74	0.62	12
10018	JONESTOWN	4.52	1.45	−6.01	10
10019	FRANKTON	−1.01	−5.88	3.59	11
10020	MARYSVILLE	−2.21	−5.21	2.48	15
20001	BELTSVILLE	−2.23	−14.98	−7.87	11
20015	WOODBINE	−5.64	−7.68	−4.18	10
20016	COLUMBIA	−1.05	0.38	0.68	11
30028	GINGRICH	0.16	−2.39	3.31	13

Notes:
1. National Ocean Survey (NOS) positions were adjusted to United States Navy 9C datum before comparison.
2. In the short-arc solution, one station position, one azimuth and one vertical angle are constrained

Table 6. Phase I modified short-arc solutions
(Geoceiver positions minus precise traverse positions (NOS))

STA	NAME	$\Delta\phi$ (m)	$\Delta\lambda$ (m)	Δh (m)	PASSES
10003	GREENVILLE	0.98	1.81	−1.54	12
10006	MEADES RANCH	1.97	−0.23	−2.41	12
10018	JONESTOWN	2.18	−0.10	−2.23	10
10019	FRANKTON	1.60	−0.20	0.34	11
10020	MARYSVILLE	0.42	0.51	0.08	15
20001	BELTSVILLE	1.24	0.21	0.44	11
20015	WOODBINE	−1.74	1.64	0.74	10
20016	COLUMBIA	0.53	3.43	0.39	11
30028	GINGRICH	2.11	0.20	0.093	13

Notes:
1. National Ocean Survey (NOS) positions were adjusted to United States Navy 9C datum before comparison.
2. In the modified short-arc solution, four station positions were constrained.

pproximately ±1.5 m).[13] Allowing another ±1.5 m for rrors in orthometric height, the accuracy of the geoidal eight determined by use of Doppler observations is pproximately ±2 m. This value was, in fact, verified in omparisons with astrogeodetic profiles in the United tates.[14]

In Asia and the Far East, a geoid map with an ccuracy of 6 m could be produced from a grid of atellite points with a spacing of about 300 km. Although it would not contain the detail of a geoid map stablished by astrogeodetic means, such a map would ontain much more detail than is contained in current atellite geoids based on spherical harmonic expansions f the gravity field. A geoid map with an accuracy of 6 m is sufficient to reduce precise electronic measured ngths to the datum spheroid and to maintain the ccuracy of the measured lengths to one part per million.

Conclusion

A considerable co-operative effort among the countries involved is required for the determination of a ingle datum for Asia and the Far East. An accurate etwork of unified control stations must be established n sufficient number and distribution to tie together the old control and to strengthen the readjustment of the old control on a single datum. Astronomical co-ordinates and sea-level heights for additional stations must be obtained in sufficient quantity and distribution to establish the geoid. Obviously, an optimum supply of these kinds of data will lead to the best-fitting datum.

There are several possible approaches to obtaining the constants for a single datum. Some or all of the constants could be selected from a number of datums; for example, south Asia datum, Australian geodetic datum, or Smithsonian Standard Earth II. The most exact method involves the derivation of the constants from an astrogeodetic adjustment of a uniform network of data covering the entire area.

To establish an accurate unified control network, it is suggested that the involved countries in Asia and the Far East consider the use of the Geoceiver as a major tool. The Geoceivers are operational and plans for their use in various parts of the world have been initiated. Geoceiver stations, for example, have been established in South-East Asia and the Philippines.

The prospects and applications of the Geoceiver are numerous. Most important, however, is the consideration that this new tool provides the way and means to fulfil the goal—a single well-fitting datum for Asia and the Far East.

[13] United States of America, Defense Mapping Agency, op. cit.
[14] Schwarz, op. cit.

[*Note:* Annexes appear on pages 181, 182, 183 and 184]

SURVEYING THE MOON: PHOTOGRAMMETRIC GEODESY FROM APOLLO*

Paper presented by the United States of America

The moon goddess of ancient Greece, Selene, was a huntress who gave her name to the study of the moon's ize and shape—selenodesy. Since Selene, man's knowldge of the moon has progressed through the centuries eaching a new era with the Apollo programme.

In July 1969, the Apollo 11 made the first landing on he moon. Apollo missions 11–14 carried high-resolution ilm return cameras to add information about the landng sites, but the cameras were not yet a cartographic ystem. On 26 July 1971, however, Apollo 15 marked a iew era in space exploration by carrying a cartographic amera system which was designed for surveying and napping the moon. Thus, Apollo missions 15, 16 and 17 re the culmination of centuries of man's progress in elenodesy to survey the earth's closest celestial neighbour. The emphasis of this paper is to describe these istory-making missions from a photogrammetrist's iewpoint. Details are given about the camera and data ensors, and the work being done at the Defense Mapping Agency (DMA) to exploit the data to produce a nodern network of control points on the lunar surface.

Apollo 15, 16 and 17 missions and objectives

In 1965 and 1967, the United States National Aeronautics and Space Administration (NASA) convened Conferences on Lunar Exploration and Science,[1] at which distinguished scientists from the disciplines of geology, geophysics and geodesy/cartography recommended scientific objectives and a mapping programme which could be addressed by an orbital metric mapping camera system. These scientific objectives were to:

(*a*) Refine the lunar ephemeris describing the position of the moon's centre of mass with respect to the earth;

(*b*) Refine the physical librations of the moon about its centre of mass;

(*c*) Define a mathematical reference surface and co-ordinate system with origin at the centre of mass and axes aligned with the principal axes of inertia;

(*d*) Determine a co-ordinate network of photo-identifiable control points on the lunar surface with an accuracy of 10–15 m;

(*e*) Provide a mathematical expression for the spatial variations in the moon's gravity field.

In addition, several map series were recommended to support geological planning, mission operation and post-mission analysis. The effects of budget cuts in the Apollo programme may prolong the accomplishment of some of these objectives. The mapping programme consists of topographic line and orthophoto maps and mosaics ranging in scale from 1:25,000 to 1:500,000. The

*The original text of this paper, prepared by Donald L. Light, cting Technical Director, Defense Mapping School, Defense Mapping Agency; and Raymond Helmering, Technical Director, Missile upport Department, Defense Mapping Agency Aerospace Center, epartment of Defense, United States of America, appeared as ocument E/CONF.62/L.61.

[1] United States of America, National Aeronautics and Space Administration, *NASA 1965 Summer Conference on Lunar Exploration and Science, July 1965*, SP-88 (Washington, D.C., Government Printing Office); *NASA 1967 Summer Study of Lunar Science and Exploration, July 31–August 13, 1967*. SP-157 (Washington, D.C., Government Printing Office).

main scales being made by this agency are 1:250,000 and 1:50,000 topographic orthophoto maps. Some investigators are interested in small-scale mosaics on the scale 1:1,000,000 for regional analysis. Emphasis is being placed on supporting the needs of the various principal investigators and their scientific experiments. This may require a total mapping effort. The United States of America and the Union of Soviet Socialist Republics are joining together to produce a 1:5,000,000 scale map. To pursue these objectives, in October 1969, NASA formed the Apollo Orbital Science Photographic Team to serve as scientific advisers for maximizing the scientific return from the remaining missions. The team chairman was Frederick J. Doyle, and the team was composed of twelve representatives from universities, industry, NASA and governmental mapping agencies. The team served as advisers to the orbital science and geodesy/cartography programmes for camera instrumentation design, mission planning, data reduction and analysis. The authors of this paper were members of the team. Their efforts culminated with the Apollo 17 mission. The landing sites and typical mapping photographic coverage for the three cartographic missions are illustrated in figure 66. For Apollo 15 (26 July 1971), the highest inclination mission was Hadley-Apennine. The site is about 3° west of the centre of the moon, approximately latitude 25° north or 465 miles north of the lunar equator. Mission 16 (16 April 1972) went to the Descartes area which is located about latitude 9° south and longitude 15.5° east. Appollo 17 was launched on 6 December 1972, and landed on the south-eastern rim of the Sea of Serenity, which is called Tauras-Littrow. The three missions were much the same except for inclination of the orbit and its corresponding photographic coverage.

Mapping camera system

With the 3-inch metric Mapping Camera System (MCS) aboard the Apollo spacecraft for Apollo missions 15, 16 and 17, photogrammetric geodesy took on an intriguing new dimension. The MCS, built by Fairchild, was mounted in the front shelf of the Scientific Instrument Module (SIM); figure 67 shows the SIM. The MCS is composed of a terrain camera with an associated stellar camera, laser altimeter and precise timing mechanism. The mapping camera photographed the lunar surface, while the stellar camera simultaneously looked to the side of the orbital plane and about 6° above the horizon for the purpose of providing starfield photos for reduction of the attitude angles of the stellar camera. The attitude angles of the stellar camera are subsequently related to the mapping camera, which provides orientation of the mapping camera with respect to the lunar surface based on the right ascension, declination system of the stars. The stellar camera recorded over 30 sixth-magnitude stars per frame. The laser altimeter is synchronized to fire simultaneously with the MCS and is aligned parallel with the optical axis of the MCS. The output is a measured distance from the spacecraft to the lunar ground for each photo given, with a precision of ±2 m. The altimeter was built by RCA. The time of each exposure is given to 1 millisecond. Film deformation can be minimized by virtue of the 10-mm reseau engraved on the glass focal-plane plate. For the nominal altitude of 111 km (60 nautical miles) with Kodak 3400 film, the resolution ranges from 30 to 60 m per line pair, depending upon the solar altitude. Details of the system are well documented by Doyle[2] and are only summarized here for background to the applications. Figure 68 illustrates the total system as configured in orbit as a data collection system, and table I gives its characteristics.

Apollo optical bar panoramic camera

Another very important item in the SIM bay is the 24-inch optical bar panoramic camera built by Itek. It provides very high-resolution photographs of most of the surface covered by the frame camera. In general, it did not expose simultaneously with the mapping camera. From the nominal altitude of 111 km, the panoramic (pan) camera provided about 2 m surface resolution at the spacecraft nadir. The lunar module can be identified in the photography without enlargement. With enlargement, the Lunar Rover vehicle is depictable. In the stereo mode, as illustrated by figure 69, the pan camera rocked through the 25° convergence angle between each two exposures. The forward exposure from station 1 and the aft exposure from station 6 overlaps by 100 per cent, as shown by figure 70 to form a stereo model. Each succeeding stereo model overlaps the preceding one by 10 per cent. Doyle[3] gives further details of the pan camera. The total system integration into SIM was performed by North American Rockwell. The pan camera is for photo-interpretation, while the MCS is for surveying a control point network. Doppler tracking of the spacecraft by the NASA tracking network provides orbital elements and ephemeris position, and velocity vectors for each photo exposure. The nominal speed of the spacecraft was 1,627 m/sec based on the 111-km circular orbit. By virtue of the 0.001-second timing for each exposure, relative distances between exposures is known to ±2.3 m. Several factors contributed towards making this system much improved over previous lunar mapping systems. These factors include:

(*a*) Flight film returned to earth;

(*b*) Higher photograph resolution;

(*c*) Reseau in the camera to control film deformations;

(*d*) Attitude constraints for each photo obtained from stellar photography;

(*e*) Precise timing of exposure station positions related to orbital ephemeris data;

(*f*) Laser altimeter distance from spacecraft to ground for each photo.

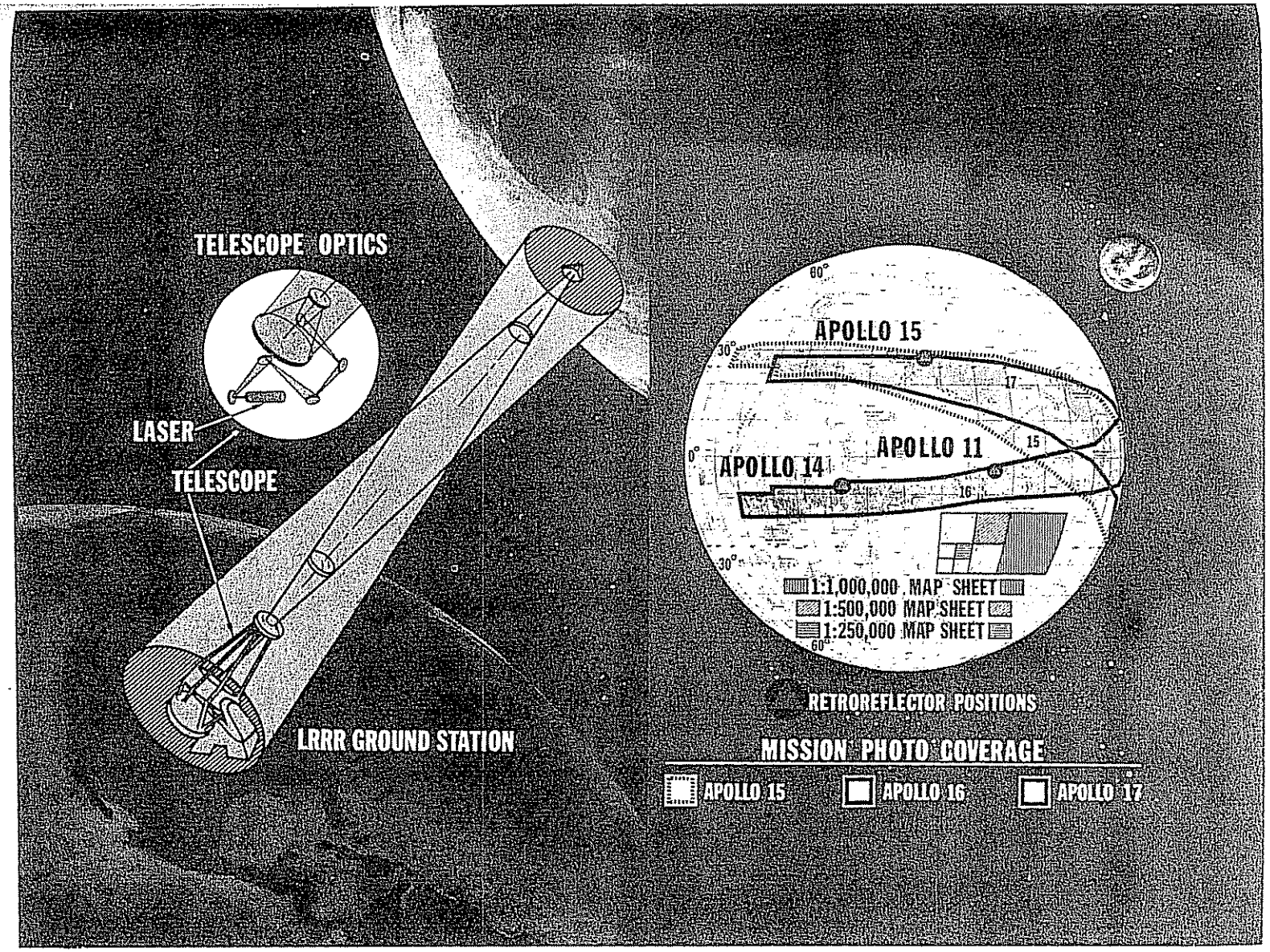
Methods of analytical triangulation

Several scientific applications have been initiated which plan to utilize the data collected with the Apollo data sensors. Esenwein, Roberson and Winterhalter of the NASA Lunar Exploration Office have described all of these.[4] The application of primary interest to many lunar scientists is the establishment of a lunar control-point reference system and its associated selenodetic constants. Establishing a well-documented and accurate reference system will provide a basis for a total mapping programme. The control-point triangulation problem is

[2] Frederick J. Doyle, "Photographic systems for Appollo", *Photogrammetric Engineering*, vol. XXXVI, No. 10 (1970), pp. 1039–1044.

[3] *Ibid.*

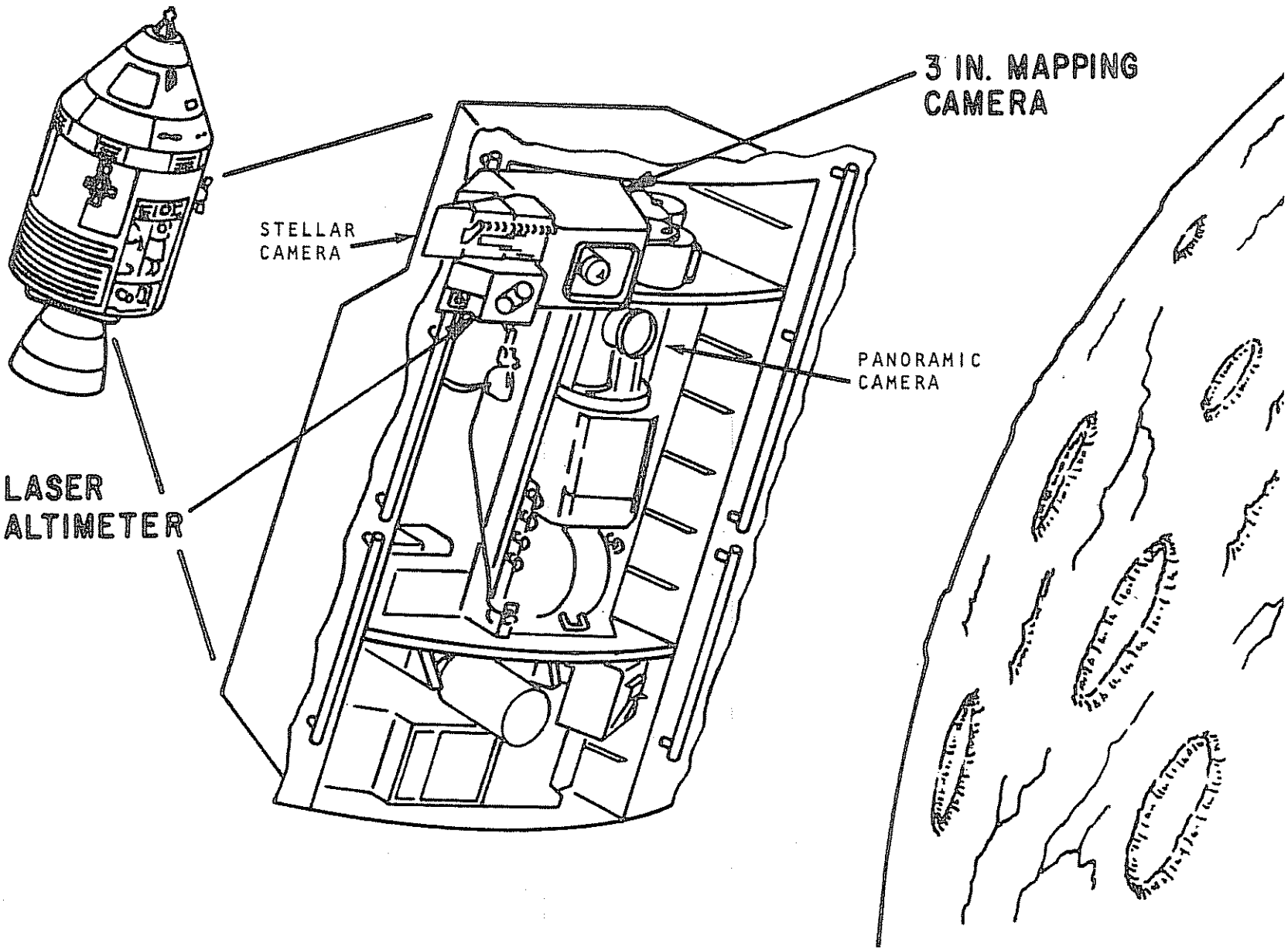
[4] George F. Esenwein, Floyd I. Roberson and David L. Winterhalter, "Apollo in lunar orbit", *Astronautics and Aeronautics*, April 1971, pp. 52–63.



2843.66x

Note: Landing sites and typical mapping photographic coverage for Apollo 15, 16 and 17 missions shown on right.

Figure 66. United States of America: laser-ranging retroflector experiment


3 IN. MAPPING CAMERA
STELLAR CAMERA
PANORAMIC CAMERA
LASER ALTIMETER

2843.67x

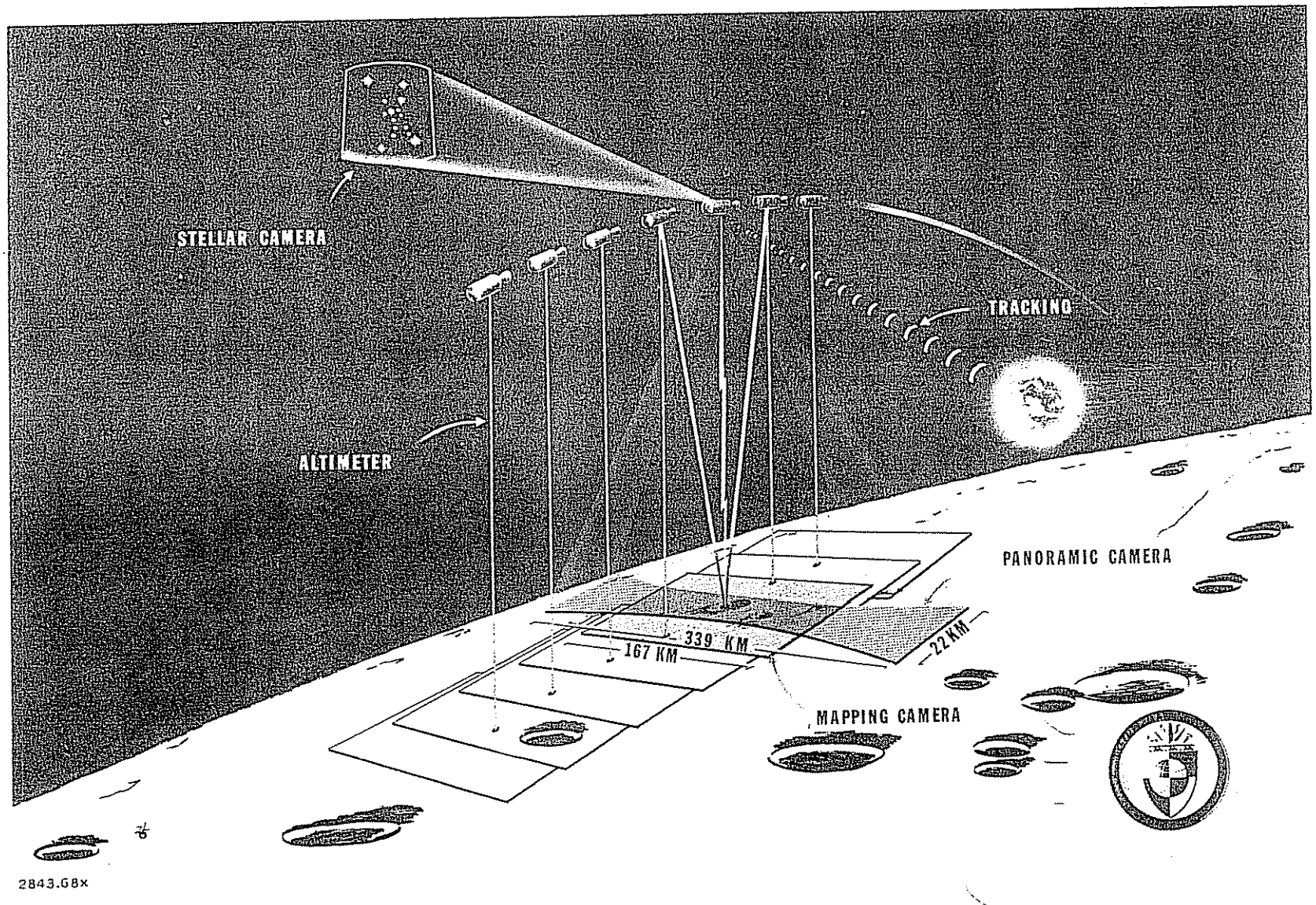
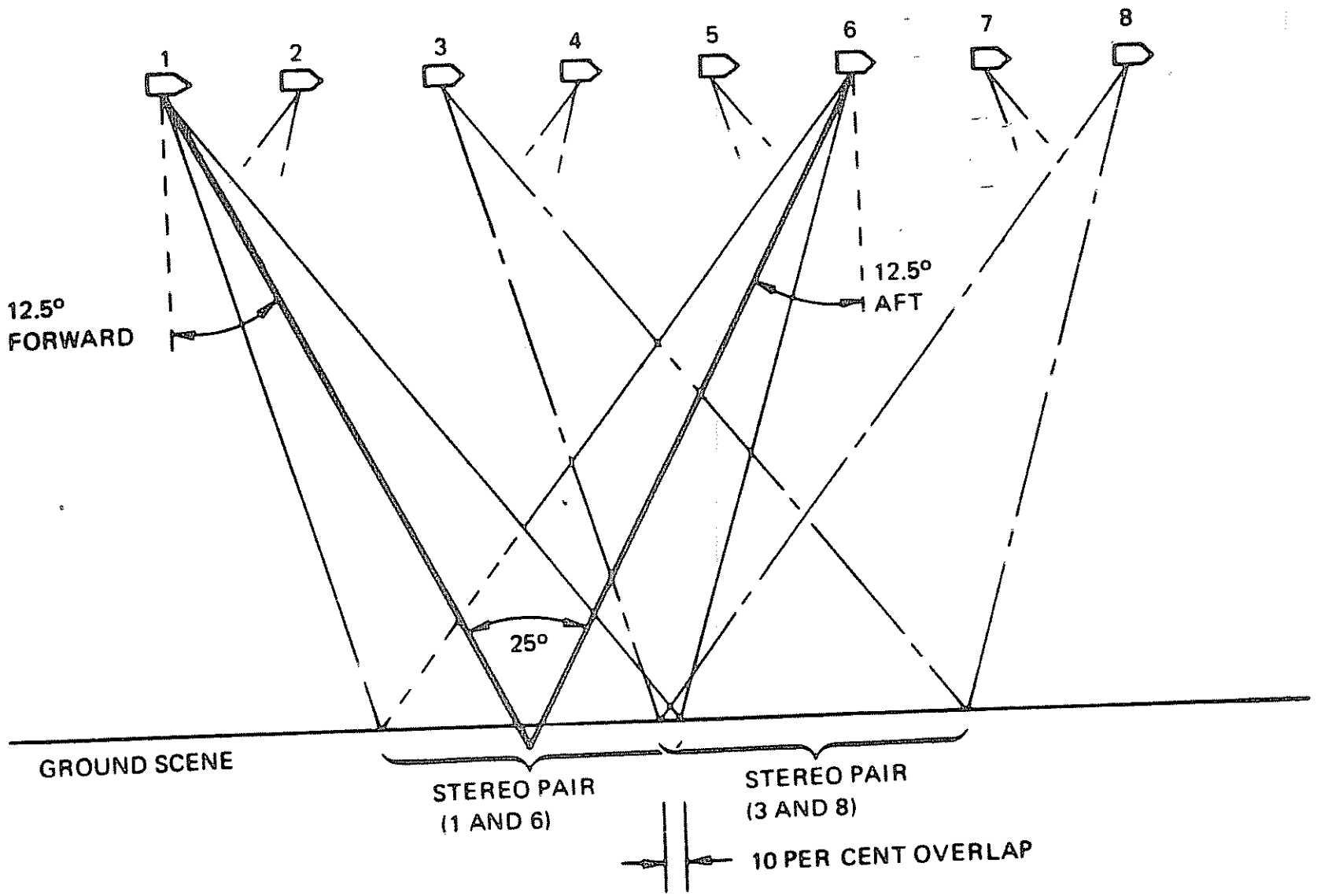


Figure 68. United States of America: Apollo mapping camera system



190

2843.69×

... 60. United States of America: stereo coverage

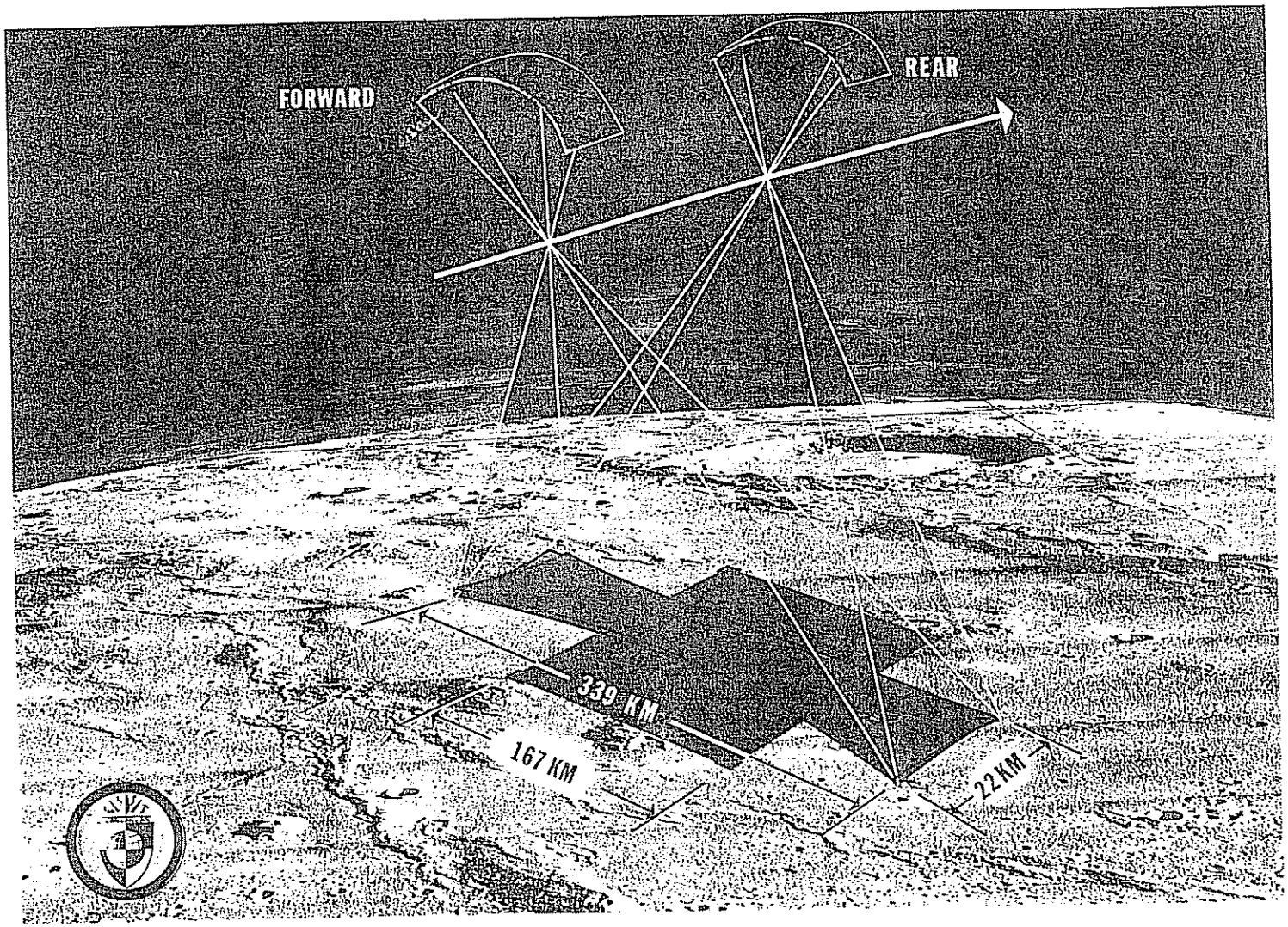


Figure 70. United States of America: panoramic stereo model

Table 1. Summary of Apollo SIM camera characteristics

Characteristics	Mapping camera system: Terrain	Mapping camera system: Stellar	Terrain analysis
Manufacturer	Fairchild Camera & Instrument Corp.	Fairchild Camera & Instrument Corp.	Itek-Optical Systems Division
Basic design	Frame	Frame	Panoramic
Focal length	3 inches (76.6 mm)	3 inches (76 mm)	24 inches (610 mm)
Lens angular coverage	74° × 74°	24° × 18°	10°46′ × 108°
Lens aperture	f/4.5	f/2.8	f/3.5
Lens distortion	<50μm	<10μm	—
Filter	None	None	None
Resolution lp/mm	@ 1.7:1, 58–70	To star magnitude 6	@ 2:1, 108–135
Reseau-interval	10-mm crosses (121)	5-mm crosses (22)	—
Illumination	Natural	Artificial	—
Fiducials—artificial	2 sets of 4	4	Marks
Natural	4	None	—
Shutter type	Between lens	Between lens	Focal plane—variable slit
Shutter speeds	1/15 to 1/240 sec.	1.5 sec/fixed	1/80–1/500 sec.
Format	4.5 × 4.5 in.	0.88 × 1.25 in.	4.5 × 45.25 in.
Transmission	44.3%	93%	55–78%
Film size and typical type	5 inches (127 mm), Type EK 3400 or EK 3414	1.38 inches (35 mm) (non-perf.), type 3401	5 inches (127 mm) type EK 341
Magazine	1,500 feet	510 feet	6,500 feet
Capacity	(3,600 frames)	(3,600 frames)	(1,617 frames)
Cycling rate	8.5–34 sec.	8.5–34 sec.	4.96–16.95 sec.
Motion compensation	10–40 M radians/sec.	None	10–20 M radians/sec.
Exposure control	16:1 Automatic	Fixed (1.5 sec.)	Automatic with variable slit
Weight	131 lb with film	Total	343 lb with film
Data recording	Data block	Time; serial no.	GMT; frame INCR; V h in MR sec.
Film flattening	Platen with movable pressure plate	Platen with movable pressure plate	Rollers
Convergence	—	—	= 12½° plus IMC

most interesting to a photogrammetric geodesist for it gives him an opportunity to exploit data heretofore unavailable. The triangulation problem is interrelated with each of the other selenodetic applications, besides being fundamental to a sound mapping programme. Rigorous, computational methods of analytical photogrammetry, as introduced in the United States of America by Schmid[5] and Brown,[6] are playing a major role. The MCS has provided a great deal of auxiliary information about the photogrammetric parameters, and it is necessary to incorporate these data into observation equations and then impose a least-squares criterion. The method is that the parameters and observations enter as constrained variables with appropriate statistical estimates of each parameter and observation to be used as weights. Appropriate geometric and dynamic constraints are imposed on the parameters and reduced in a simultaneous system.

To begin the photogrammetric triangulation, one needs a post-flight ephemeris as reduced primarily from the Doppler tracking data. This ephemeris is computed by NASA using the Houston Operations Predictor/Estimator (HOPE) programme,[7] which accepts, as input, the classical observations, including: range; X-, Y-angles; range rate; hour angle; azimuth; declination; elevation; Doppler.

In addition to the HOPE programme for tracking data reduction, there is a companion programme, the Apollo Photograph Evaluation (APE). Together, these two programmes produce initial estimates of the position history of the spacecraft for each exposure; rough estimates of the orientation of the frame, pan and stellar cameras; and the predicted star field in the field of view of the stellar camera, as well as a cursory reduction of the slant range of the altimeter. These parameters are invaluable as initial values to the follow-up triangulation work, which combines both the orbital elements and the laser altimeter distance in a simultaneous least-square adjustment.

Camera attitude orientation elements

The stellar camera is the sensor that links the mapping system to the celestial co-ordinate system. Attitude determination accurate to ±(4–30 sec of arc) for the three orientation angles is being obtained. The procedure is well documented in the *Manual of Photogrammetry*[8] but is mentioned here for completeness. The procedure for stellar camera orientation in a celestial co-ordinate system is as follows:

(*a*) Identify stars on film;

(*b*) Update star right ascension and declination co-ordinates;

[5] Hellmut Schmid, *A General Analytical Solution to the Problem of Photogrammetry*, report No. 1065 (Aberdeen, Maryland; Ballistic Research Laboratories, July 1959).

[6] Duane Brown, *A Treatment of Analytical Photogrammetry with Emphasis on Ballistic Camera Applications*, RCA Data Reduction technical report No. 39 (New York, August 1957).

[7] TRW Systems Group, *Houston Operations Predictor/Estimator (HOPE) Engineering Manual*, TRW note 70-FMT-792A (June 1970).

[8] Eldon D. Sewell, "Aerial cameras", in M. M. Thompson, *Manual of Photogrammetry*, (Falls Church, Virginia; American Society of Photogrammetry, 1966), vol. I, chap. IV, pp. 133–194.

(c) Measure star co-ordinates (x, y) on stellar camera ites.

ie relationship between the two co-ordinate systems is :n a 3-by-3 orthogonal rotation matrix.[9]

The moon's orientation $[M]$ in the celestial (earth-ntred) sphere and its relationship to the earth-based ›ollo trackers presents some interesting problems, in dition to providing the connecting link for attitude nstraints. Until improvements in the $[M]$ matrix are alized, the absolute position of the moon and its atures in space will have uncertainties on the order of 0 m. The NASA laser retroreflector experiment, rrently in progress, may be the means to improve the atrix.

Strip and block triangulation

The mapping camera has a capacity of 3,600 frames :r mission. Due to the 78 per cent forward overlap, ily every other photograph is required for the triangu-tion task. Two approaches are being utilized in data duction. One is purely geometrical and the other ›poses dynamic constraints. That is, the camera sta-ons are constrained to fit on the orbit as reduced from ie tracking data. The geometrical solution can be :complished by the well-known Multiple Station nalytical Triangulation Program (MUSAT)[10] (see quation 1), and the dynamic solution by an Apollo ersion of Lunar Orbiter Strip Block Triangulation[11] .OSAT/LOBAT) (see equation 3).

The basic relationship for the two photogrammetric rogrammes is the fundamental projective equations of nalytical photogrammetry. These equations are given y Schmid[12] and Brown[13] and can be functionally epresented as follows:

$$\begin{bmatrix} x \\ y \end{bmatrix} = F_1 [x_p, y_p, f, (\phi, \omega, \kappa), (X^c, Y^c, Z^c), (X, Y, Z)] \quad (1)$$

where

x, y = photo image space co-ordinates of the projected object space point from the lunar surface;

x_p, y_p = image space co-ordinates of the principal point;

f = principal distance or focal length of camera;

ϕ, ω, κ = orientation angles of photo in the selenocentric system;

X^c, Y^c, Z^c = object space co-ordinates of each photo on the orbit;

X, Y, Z = object space co-ordinates of the lunar ground object.

The photogrammetric equations (1) are independent of the nature of the motion of the Apollo vehicle. For example, the exposure station could, in principle, be completely randomly distributed in space. This is the geometrical mode as in MUSAT and is shown by equation (1).

However, in order to exploit the fact that the spacecraft proceeds along a free-flight orbital trajectory during each orbital pass and all photos lie on this orbital arc, orbital constraints must be introduced. From astrodynamics,[14] the camera stations X^c, Y^c, Z^c can be given as functions of the six Keplerian orbital elements (a, e, i, Ω, ω, t_i) or as position and velocity components (X, Y, Z, $\dot{X}$, $\dot{Y}$, $\dot{Z}$) at a given time, t_i. In other words, spacecraft position at some arbitrary epoch t_o may, in principle, be expressed as:

$$\begin{bmatrix} X^c \\ Y^c \\ Z^c \end{bmatrix} = g [X_o, Y_o, Z_o, \dot{X}_o, \dot{Y}_o, \dot{Z}_o, t, C_{nm}, S_{nm}, \text{other constants}] \quad (2)$$

Substituting equation (2) into equation (1), one obtains the basic condition equation for the Apollo LOSAT/LOBAT programme as:

$$\begin{bmatrix} x \\ y \end{bmatrix}_{i,j} = F_2 [\phi, \omega, \kappa, t)_i, (X_o, Y_o, Z_o, \dot{X}_o, \dot{Y}_o, \dot{Z}_o, C_{nm}, S_{nm}), (X, Y, Z)_j] \quad (3)$$

x_p, y_p, f are usually given as constants and are left out of (3) for simplicity. C_{nm}, S_{nm} are given coefficients of the lunar gravity potential function and are constants in LOSAT/LOBAT.

The laser altimeter distance is expected to contribute a strong scale constraint to the triangulation equations. Donald Light discusses the geometry of the altimeter distance in detail.[15] Previous lunar orbiters had either the altimeter or the stellar camera information. Since the altimeter and the metric camera are aligned and they expose simultaneously, the image co-ordinates of the spot to which the altitude is measured will be known. The ground position of this point will be computed in the photogrammetric solution, and the measured distance (D), provides a condition equation between that point and the corresponding camera station:

$$D = [(X^c - X^a)^2 + (Y^c - Y^a)^2 + (Z^c - Z^a)^2]^{1/2} \quad (4)$$

where

D = measured distance at time t;

(X^c, Y^c, Z^c) = co-ordinates of spacecraft at time t;

[9] For matrix relationships for relating the mapping camera to the moon, see Donald L. Light, "Photo geodesy from Apollo", *Photogrammetric Engineering*, vol. XXXVIII, No. 6 (1972), pp. 574–587.

[10] United States of America, United States Army Engineers, Geodesy, Intelligence, and Mapping Research Development Agency (GIMRADA), *Multiple Camera Analytical Triangulation Program* (Fort Belvoir, Virginia; United States Army Engineer Topographic Laboratories, December 1965).

[11] DBA Systems, Inc., *The Rigorous and Simultaneous Photogrammetric Adjustment of Lunar Orbiter Photography Considering Orbital Constraints*, RADE-TR-70-174 (Rome Air Development Center, December 1970).

[12] Schmid, op. cit.

[13] Brown, op. cit.

[14] Robert M. L. Baker and Maud W. Makemson, *An Introduction to Astrodynamics* (New York, Academic Press, 1960).

[15] Donald L. Light, "Altimeter distance observations for astrophotogrammetric triangulation with orbital constraints", *Photogrammetric Engineering*, vol. XXXVIII, No. 4 (1972), pp. 339–346.

(X^a, Y^a, Z^a) = co-ordinates of illuminated point on surface.

Figure 71 illustrates the usage of the terminus point of the altimeter as a constraint. Each altimeter terminus point on the surface will be viewed on the other eight photos surrounding the one of interest. For the moment, consider a group of nine photos as a unit with the eight conjugate image points being constrained to the centre picture distance, D. Then, expand the concept as is shown with the three units and 27 photographs. It is readily apparent that the altimeter provides vital scale constraint data. Its total contribution will be of interest to numerous experiments.

Now, having considered the contribution of each of the sensors as illustrated in figure 68, it seems appropriate to view these as a simultaneous system of observations ready for adjustment by the method of least squares. The data types are: photogrammetric equations; orientation angles and time; orbital parameters and C_{nm}, S_{nm}; object space co-ordinates; altimeter distance measurement.

Comparing equations (1) and (3), it is easy to see the difference in the concept of the geometrical MUSAT and the dynamic LOSAT/LOBAT systems. MUSAT does not impose orbital constraints.

These two programmes offer a unique capability for strip and block triangulations and the computation of a lunar control-point network given in ϕ, λ, h for each measured image on the photographs.

The logical approach to the unified network is to reduce each mission somewhat separately and then combine the three missions into one total network as a final phase.

To accomplish a complete job for global lunar geodesy, full photo coverage from different times, inclinations and altitudes is needed. This coverage is not possible with these three missions. In any case, considerable experimentation will be needed to determine how far the solution can be pressed so that computed results be meaningful.

Geometrical reference surface

After a dense, well-distributed set of lunar ground feature co-ordinates (X, Y, Z) is computed from the triangulation, a mathematical reference surface can be determined. A surface-fitting procedure could be employed to determine the reference surface for the moon. Either a sphere, spheroid, or triaxial ellipsoid could be fitted by minimizing the sum of squares of difference between the triangulated topographic points and the selected reference surface equations of the general form:

$$Q = \frac{X^2}{a^2} + \frac{Y^2}{b^2} + \frac{Z^2}{c^2} - 1 = 0$$

where

Q is an oblate spheroid if $a = b$;
Q is a sphere if $a = b = c$;
Q is an ellipsoid of $a \neq b \neq c$.

The best-fitting Q should be adopted. The reference survace X-, Y-plane would coincide with the moon's equator and its Z-axis would coincide with the axis of rotation. Its centre would be the centre of figure. It would be desirable to reduce the radius arbitrarily to make all topographic elevations positive and perhaps use one of the Apollo lunar modules now sitting on the moon as the moon's datum point. Figure 66 shows the laser retroreflector points that will form a triangle with very accurate absolute position co-ordinates eventually given for each point. This triangle could form the absolute datum for the reference surface. It should be noted also from figure 66 that the points are contained within ±26° latitude, which would degrade the validity of the reference surface at latitudes outside this area.

Up to this point, the Apollo era has been discussed from a system-and-technique point of view. The transition from the theory into practice is made below, and a review is given of the practical aspects of the reduction work being accomplished by the Defense Mapping Agency.

Apollo control development

NASA has assigned the data acquisition and reduction of MCS photography from Apollo missions 15, 16 and 17 to the Defense Mapping Agency. Figure 72 shows the photographic coverage acquired during each mission. The objectives of those assignments were to produce various types of precise photogrammetric data for the scientific community, and to combine reduced measurement data with other supporting information to compute co-ordinates of lunar surface features. The Defense Mapping Agency Aerospace Center (DMAAC) has been given the responsibility for the Apollo 15 reduction, and the DMA Topographic Center that for the Apollo 16 reduction. The Apollo 17 reduction, as well as the total control network development, has been assigned to DMAAC. For the total control network, it will be necessary to combine data from all three missions in one photogrammetric solution which will produce co-ordinates of selected lunar surface features with respect to the centre of mass of the moon. This planned system of lunar control co-ordinates, called the Apollo Selenodetic System, will cover approximately 20 per cent of the lunar surface and will be used as a basis for mapping and studies of selenodesy. The following sections of the paper describe the characteristics of each of the individual reductions associated with Apollo 15, 16 and 17 photography, and presents a discussion of the scheme envisioned for the generation of a single network of control.

Apollo 15 reduction

The Apollo 15 data reduction was initiated in October 1971 and completed in April 1973. The total area coverage amounts to approximately 4 million km^2. Photography covering this area was acquired during 14 orbital revolutions. After a photographic review and preliminary test and analysis, alternate photographs from each of those revolutions were selected. This process resulted in strips of photographs with 56 per cent forward lap, and sidelap between strips ranging from 50 per cent to 100 per cent. A total of 832 photographs was selected for the data reduction.

Stellar orientation computations

By utilizing the images of stars recorded on each stellar photograph and their corresponding star catalogue positions, the precise orientation of the stellar

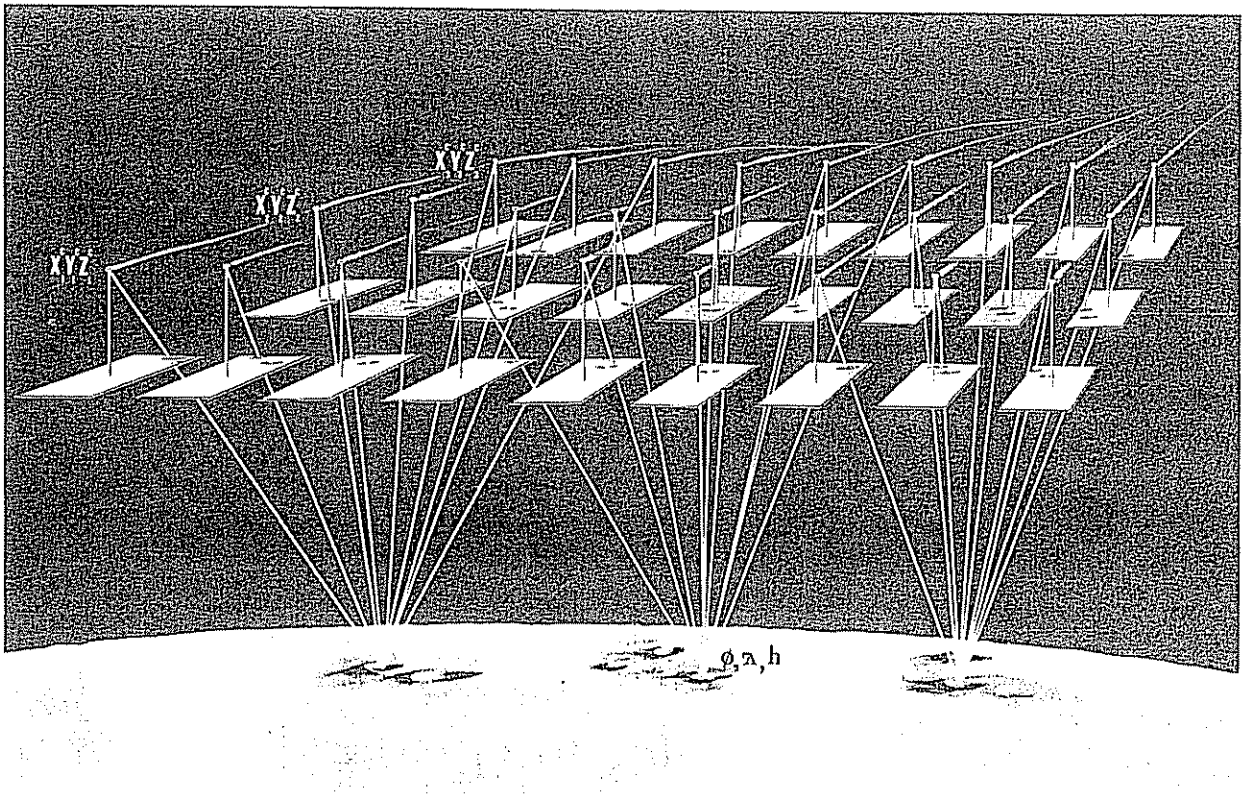


Figure 71. United States of America: multiphoto ray concept with altimeter constraints

camera with respect to the inertial reference frame was computed. The procedure involves the precise measurement of the star images on the photographs, correction of the measurements for known sources of systematic errors; and, lastly, a data reduction phase which resects the corrected measurements to their corresponding star catalogue positions and, thus, computes the orientation of the camera. Once this is known, the orientation elements of the mapping camera may be computed by means of the premission calibration of the interlocking angular relationship of the stellar and mapping cameras. Typical standard deviations of the derived mapping camera orientations are 3, 3 and 12 seconds of arc for the three angles which relate the camera system to the inertial reference system. The stellar-derived orientations for the mapping camera were utilized in subsequent analytical triangulation reductions.

Mapping photography reduction

On each photograph selected for reduction, the image co-ordinates of well-defined lunar features were selected and measured. The average number of image points mensurated on each photograph is 30. The measured co-ordinates were corrected for systematic effects, such as film distortion, lens distortion and forward motion compensation. Also measured was the photographic image of the spot on the lunar surface corresponding to the laser altimeter observation location. Measurement of the image co-ordinates of the altimeter observations allows the altimeter data to be included in the triangulation solution. Analysis of the quality of the mensurated image co-ordinates has shown their accuracy to be in the 5–10 micrometre range.

The input data for the triangulation solutions included the mapping camera orientation angles, the image measurements of lunar features and the positions of the mapping camera at the time of each exposure. These positions were furnished by NASA as part of the photo support data.

Strip triangulation solutions were performed for each of the 14 photographic revolutions. Analysis of initial solutions indicated that the *a priori* constraints applied to the data types were not consistent with the *a posteriori* results of the adjustment. Additional strip solutions were therefore undertaken with the standard deviations of the image measurements and orientation parameters unchanged, and the orbital positions relaxed in accordance with the observed changes from the initial strip solutions. The second solutions were satisfactory in a geometrical sense and deemed suited for a final block triangulation solution. Neither the changes to the orientation parameters nor the image measurement residuals were in excess of the *a priori* standard deviations. The altimeter observations were not considered to be constrained parameters in any of the strip solutions.

The final Apollo 15 control point network was developed by means of a simultaneous block analytical triangulation solution. A selection of photographs from the 14-strip solutions was made, eliminating those photos not required for a strong geometrical block configuration. It was found that 630 photographs from 10 strips would provide coverage of the maximum area available from the Apollo 15 materials. In the solution, the

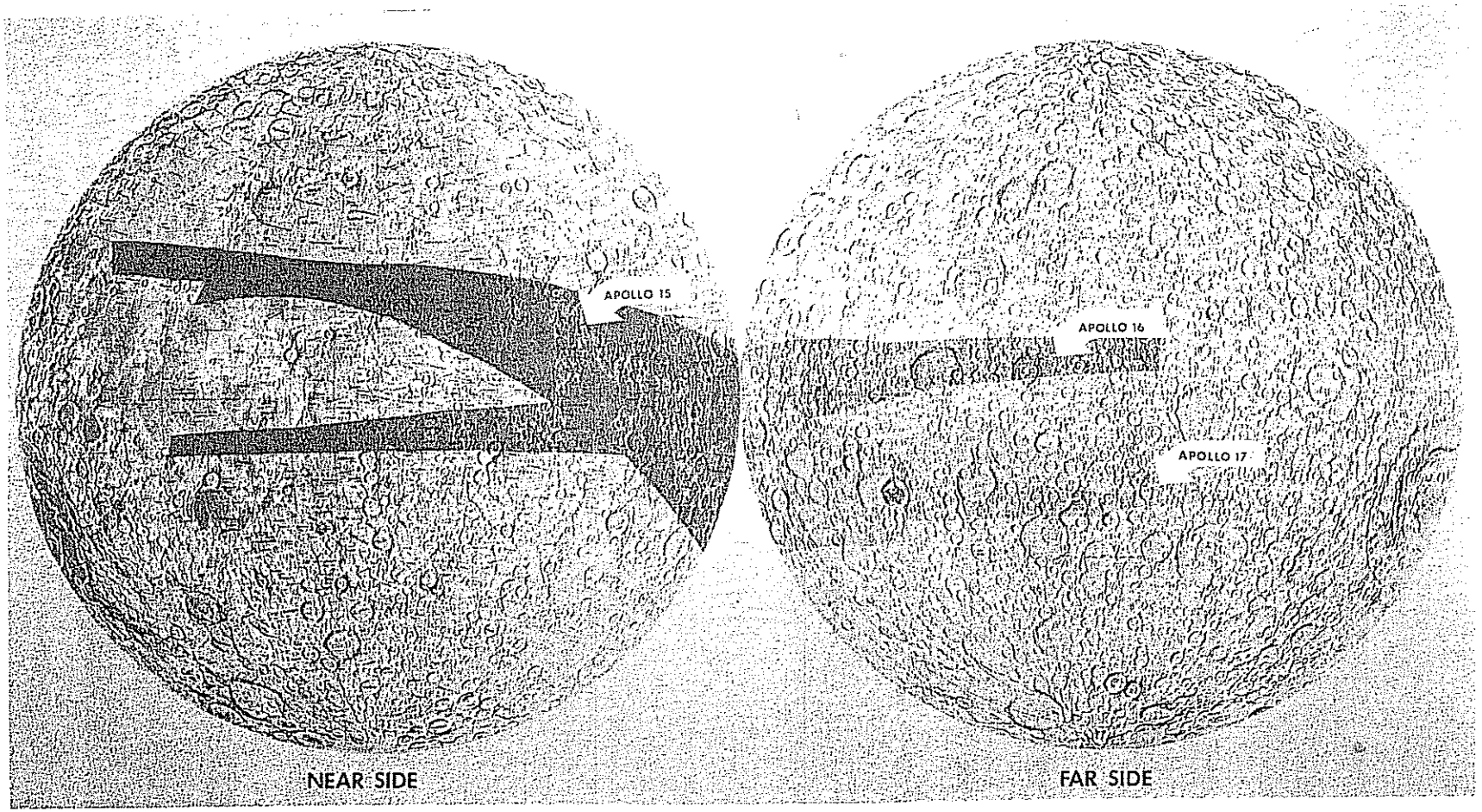


Figure 72. United States of America: photographic coverage by Apollo 15, 16 and 17

photography of one revolution was the constraining element. This strip was chosen because it exhibited the most favourable consistency of data types in its strip solution. All other strips were evaluated in the block solution in such a way that they could conform to the configuration of this strip. Analysis of this solution has shown that the standard deviations of triangulated lunar co-ordinates are approximately 25 m with respect to the datum established by the block triangulation.

Apollo 16 and 17 reductions

The Apollo 16 and 17 reduction assignments were begun in July 1972 and March 1973, respectively. The Apollo 16 reduction was completed in July 1973, and the Apollo 17 assignment is due to be completed in March 1974. The Apollo 16 coverage (figure 72) was acquired during nine orbital revolutions. Operational constraints during the mission provided a great deal of redundant photographic coverage. Planning for the data reduction of this mission followed the same principles outlined above for the Apollo 15 mission. For the triangulation reduction of the total Apollo 16 area, alternate photographs from four of the nine photographic revolutions were selected. A total of 248 photographs was included in the reduction.

Apollo 17 coverage of the lunar surface duplicated the Apollo 15 coverage to a great extent. In all, photography was acquired during 11 orbital revolutions. To provide the basic data for generating lunar co-ordinates in the area not covered by the previous two Apollo missions, 336 photographs from six orbital revolutions were selected.

The principles of basic data production for the Apollo 16 and 17 assignments were similar to those described for the Apollo 15 work. The over-all quality of the resulting data was in agreement with the accuracies quoted for the Apollo 15 data types. The maximum number of image points possible were selected for the Apollo 15 reduction and were also identified and measured for both the Apollo 16 and 17 reductions. This will allow all three missions to be combined in the final solution to generate the Apollo selenodetic system.

Apollo selenodetic system

The planning and completion of the Apollo selenodetic system are affected by two general areas of endeavour, concurrently in work. The first is the individual Apollo 15, 16 and 17 data reduction assignments which will provide the data for the total control network development. As part of this, an analysis is being made of additional photographic coverage with which it is planned to improve the non-contiguous coverage of the Apollo missions. The second area is concerned with pertinent results from other independent lunar investigations which may lead to improved selenodetic parameters and precise co-ordinates of photo-identifiable lunar features.

Data from Apollo 15 and 16 reductions are currently being prepared for the final solution. Apollo 17 will be added shortly. A final decision on the techniques to be used for the total Apollo triangulation will be made as soon as the data from all missions have been completed.

DMA is also considering the possibility of significantly extending the Apollo selenodetic system by employing oblique photography taken with the mapping camera during each of the Apollo missions. Figure 73 shows the basic Apollo vertical coverage, as well as the additional area where control co-ordinates could be established by means of the oblique photography. Consideration is also being given to other types of lunar photography which could be used to provide control co-ordinates of lesser accuracy in the regions of non-continuous Apollo coverage. It is expected that extensions to the Apollo network will be computed as part of the final reductions by exploiting these types of photography.

The second area of endeavour is the responsibility of numerous investigators employed by NASA. Research projects which could effect the absolute reliability of the Apollo selenodetic system are concerned with the fields of subsatellite experiments, laser-ranging, very long base-line interferometry (VLBI) positioning techniques, lunar sounder and altimetry profiling data. The results of these experiments will be utilized in the computation of new Apollo ephemerides or in the definition of co-ordinates of Apollo landing-site equipment. Data of this type may be accommodated in the photogrammetric solution to realize more fully the initial objective of the Apollo reduction, namely, the generation of lunar co-ordinates with respect to the centre of the mass of the moon.

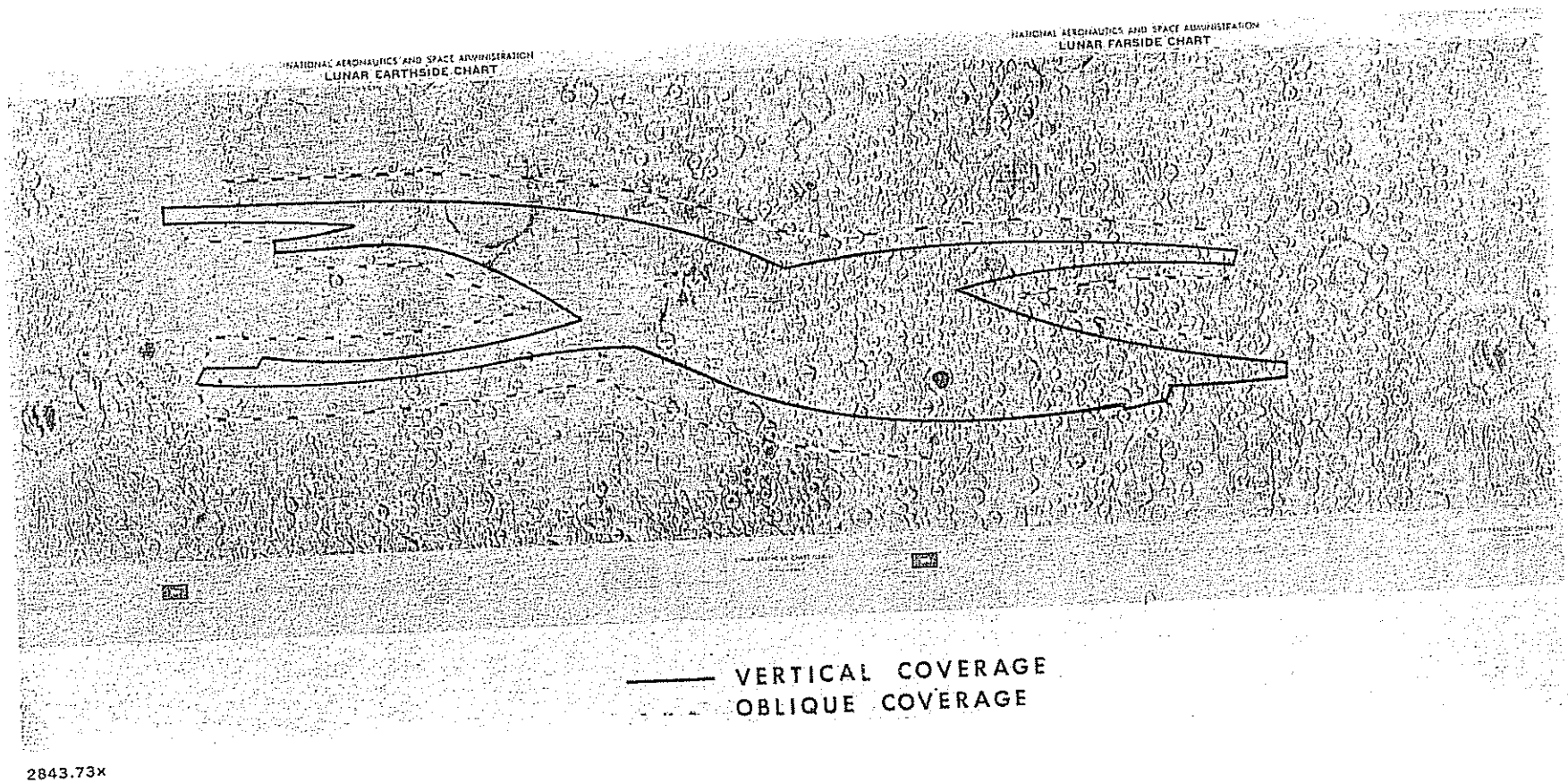


Figure 73. United States of America: Apollo metric coverage

SURVEYING-NAVIGATIONAL RESEARCH COMPLEX OF LUNOKHOD-1 AND LUNOKHOD-2*

Paper presented by the Union of Soviet Socialist Republics

The programme of scientific and technical investigations by the mobile moon vehicles of the Union of Soviet Socialist Republics, Lunokhod-1 and Lunokhod-2, included:

(*a*) Study of the topography of the moon's surface and spacing of topographic elements;

(*b*) Surveying and geodetic work required for the moon vehicles;

(*c*) Investigations of the system and methods to navigate the moon vehicles.

These problems were solved by means of measurements with navigational systems of the mobile vehicles, as well as by photogrammetric measurements of television imagery.

The navigational systems of the Lunokhods included: distance counter; gyro-semicompass; gyropendulum.

The readings of these instruments were telemetered to the earth.

Lunokhod-2 was built with an improved navigational system, which resulted in improved mobility of the vehicle and increased the accuracy of measurement of the distances covered.

The television systems of the Lunokhods are unified multipurpose complexes, designed to obtain:

(*a*) Imagery of the moon's surface, which is directly in front of the vehicle, with details and frequency of obtaining the images needed to drive the vehicle;

(*b*) Imagery of the moon's surface with high angular resolution and negligible geometrical and hue distortions, required for detailed study;

(*c*) Observations of the sun and the earth.

To perform these tasks in accordance with very specific working conditions, two cameras of electronic small-screen television and four panoramic-view cameras of optical-mechanical television were installed aboard the Lunokhods.

On the basis of the experience gained from the work of Lunokhod-1, some changes were made in the television system of Lunokhod-2. For example, the height of a small-screen television camera setting was increased, thus improving the interpretation of impediments and thereby increasing the speed of Lunokhod-2.

The television imagery registered on the earth, such as television panoramas and photographs, was measured photogrammetrically.

Common methodological principles, stipulated by interconnexion of navigational and photogrammetric measurements, were worked out for geodetic, photogrammetric and navigational processing of the telemetric information. An example of this interconnexion is the use of results of photogrammetric processing of television panoramas for navigational measurements.

An operative photogrammetric processing of television panoramas and shots with images of the sun, the earth and fixed remote local landmarks and shadows from the co-ordinated details of the vehicles permitted the regular determination of their astronomical course. These very determinations provided the structural redundancy of the navigational systems of the Lunokhods, made them composite and thus increased the stability of the system against hindrances.

Photogrammetric processing of television panoramas and shots for driving the vehicles was carried out not only for orientation, but for obtaining the necessary survey information on the surface. Such information, processed into operative topographic schemes and plans, was used to plan the scientific exploratory routes to survey craters, stone piles, tectonic faults and settings of the Lunokhods for laser fix or for location from the earth and for recharge of the sun batteries.

To ascertain the optimum driving routes while the Lunokhods were working under difficult conditions, a panoramic television survey of the moon's surface was carried out with reiterated overlaps, and operative topographic plans with relief were compiled (see figures 73 and 74).

The estimations of the position of the vehicles from navigational calculations of their way and course were used for both operative and detailed processing of the television panoramas as preliminary information on the co-ordinates and orientation of the Lunokhods.

The navigational measurements that were intended to determine the co-ordinates of the Lunokhods are actually linear-angular geodetic measurements. For that reason, in the processing of the navigational telemetric information, rather modified algorithms of geodetic processing of traversing were used. These algorithms were applied for processing navigational and photogrammetric measurements to test the system and the methods of navigating the mobile vehicles. Thus, the course of Lunokhod-1 was charted so as to make several closed polygons of different lengths to carry out these tests.

For this purpose Lunokhod-2 covered the same 1.5-km leg of its route three times. An estimation of navigational accuracy was made with respect to the co-ordinate closures appearing in the closed polygons.

The algorithms of statistical processing of the results of photogrammetric and navigational measurements were based on the recommended generalized least-squares method.

All the above mentioned circumstances predestined the unification of topographic studies and navigational researches into a single surveying-navigational complex.

The objective of the survey of the moon's surface, performed by Lunokhod-1 and Lunokhod-2, was to obtain the quantitative characteristics of the main topographic features within the explored area. The choice of the task of studying the moon's surface was predetermined by the potentials inherent in the vehicles of the Lunokhods as surveying apparatus carriers and by technical parameters of the television apparatus, as well as by peculiarities of the moon's landscape in the area explored.

Mezzo- and micro-relief of the flat surface of the Sea of Rain, where Lunokhod-1 explored the area, form a complicated composition of craters that are quite differ-

*The original text of this paper appeared as document E/CONF.62/L.107

ent in size and shape. The same type of surface is found in the bottom of Lemonier crater, which is inundated by basalt clinkers. Here, the explorations were done by Lunokhod-2.

Stereo-photogrammetric survey was carried out to obtain a quantitative estimation of relief forms. Both Lunokhods made a stereo-photogrammetric survey of craters up to 400 m in size, rock piles and a tectonic fault in the Lemonier crater, as well as a survey of the slopes of the mainland hills surrounding the crater.

About 300 television panoramas of the moon's surface were obtained by the Lunokhods.

Photogrammetric processing of the data obtained from the survey made it possible to compile topographic plans of the surface along the routes of the Lunokhods. Figure 74 shows the topographic plans of such areas, while figure 75 shows the television panoramas of those areas.

The study of such topographic plans of craters of different morphological types, in combination with the results of the physical and chemical studies of the moon's surface, provided the means of improving the existing theory of impact crater formation and of ascertaining the quantitative representation data concerning the evolution of the moon's surface due to horizontal shift of the lunar material.

In the course of processing of the television panoramas for compilation of the topographic plans, the interpretational signs of craters of different shapes were ascertained. These signs were used for photogrammetric processing of separate television panoramas and shots.

The processing of single panoramas and shots permitted the compilation of topographic schemes (see figure 76) of separate localities of the moon's surface without relief representation, i.e., planimetric schemes.

Such schemes, used in combination with schemes of the routes of the mobile vehicles, which were based on the navigational-telemetric information, in addition to single television photographs of the moon's surface, permitted the study of the statistical regularities of spacing of topographic elements. Furthermore, the topographic schemes were used to locate the places of scientific research. The scheme of scientific research tasks performed by Lunokhod-2 is an example of such a location.

The use of such a scheme in combination with results of research experiments made it possible to follow the variations of the physical and mechanical properties of the moon's surface along the routes of the Lunokhods. Such research is most important for study of key areas of the moon's surface, such as the transitional zone "sea-continent" explored by Lunokhod-2. The results of surveying-navigational research carried out by the Soviet fully automatic mobile vehicles, the Lunokhods, allow the planning of their effective use in subsequent expeditions to the moon.

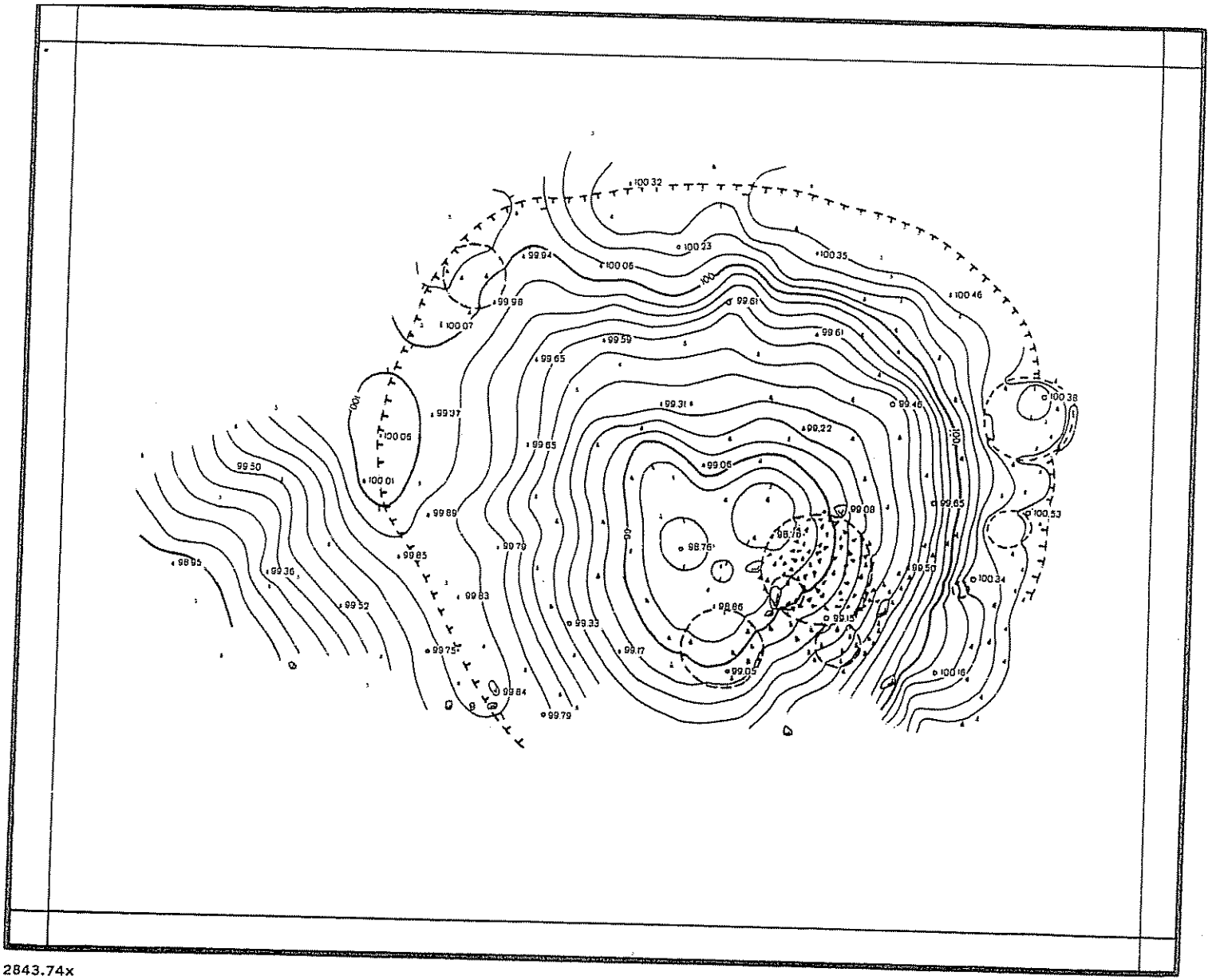


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Figure 74. Union of Soviet Socialist Republics: topographic plans of surface along routes of the Lunokhods

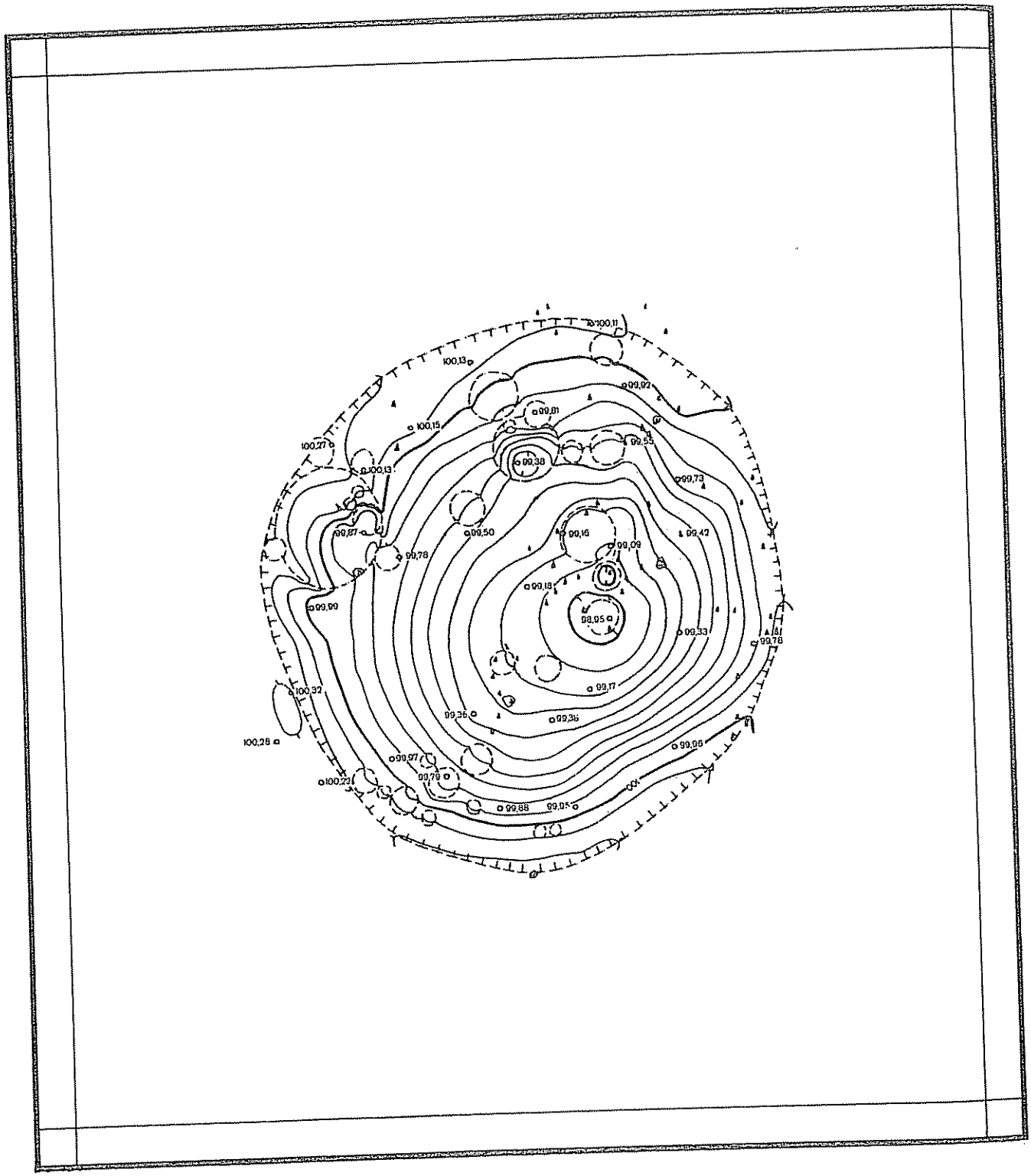

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Figure 74 (continued)

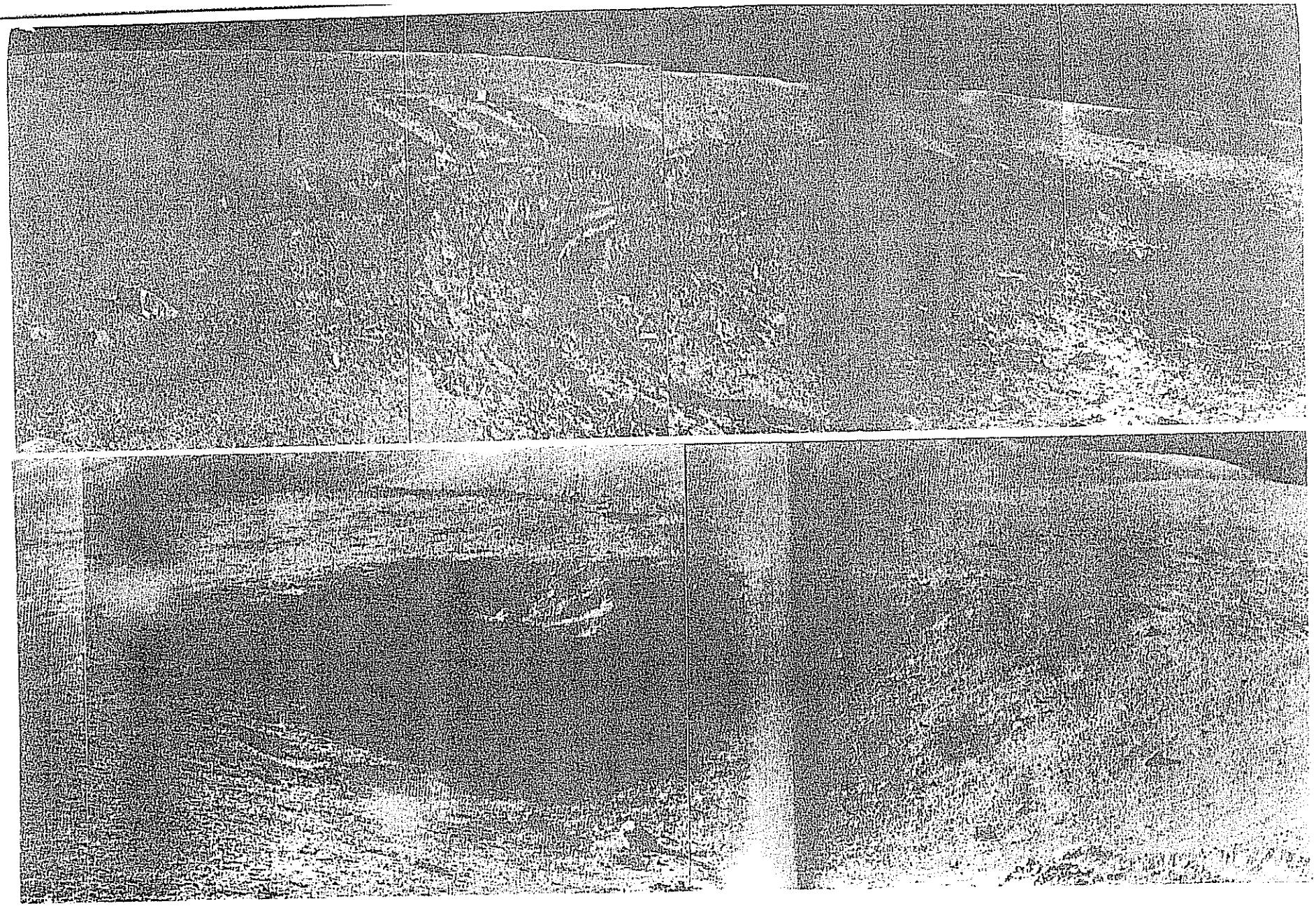


Figure 75. Union of Soviet Socialist Republics: television panoramas along routes of the Lunokhods

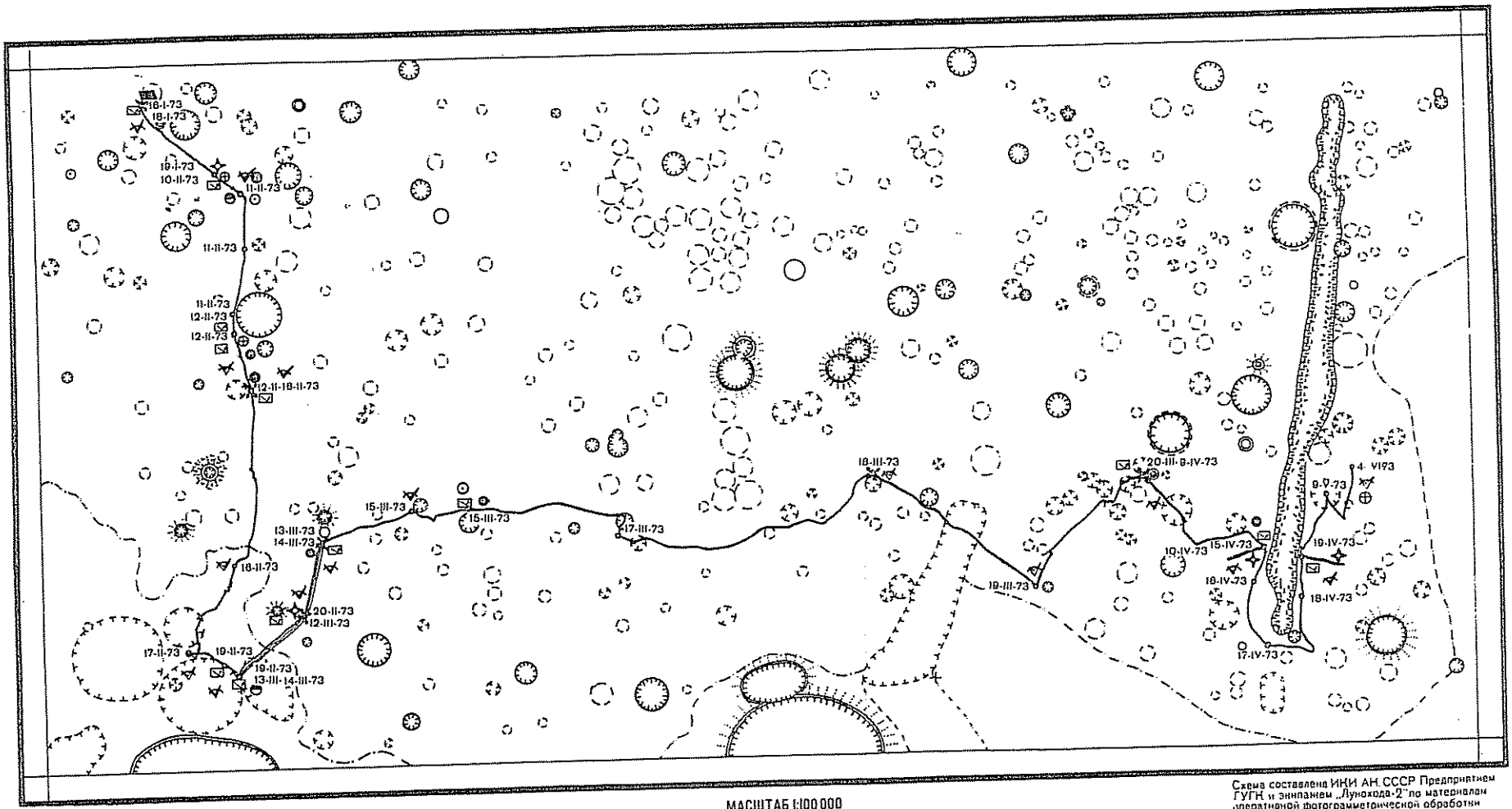


Figure 76. Union of Soviet Socialist Republics: topographic schemes performed by Lunokhod-2

ELABORATION OF THE MAP OF RECENT VERTICAL CRUSTAL MOVEMENTS ON THE SCALE 1:2,500,000 FOR EASTERN EUROPE*

Paper presented by the Union of Soviet Socialist Republics

In 1973, the general map of recent vertical crustal movements on the scale 1:2,500,000 of the territory of Eastern Europe was published in the Union of Soviet Socialist Republics.

The commencement of combined operations for compiling the map was decided upon in 1961 at the meeting at Moscow, in which the representatives of Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary, Poland, Romania, the USSR and Yugoslavia participated. When compiling the map, the member States regularly exchanged corresponding information. More than 50 scientists from many countries and in various disciplines, such as geodesy, oceanography, geology, geomorphology and geophysics, participated actively in the elaboration of the map.

The map was compiled by means of the combined utilization of relevelling data and long-term registrations of the tide-gauge, as well as geological and geomorphological investigations of levelling lines and bench-marks.

A total of 124,000 km² of relevelling lines was used for compilation of the general map. The lines form 223 loops, with the perimeter length ranging from 64 to 3,700 km. The perimeter length of 138 loops is less than 600 km and that of seven loops is in excess of 2,000 km. About 17,000 bench-marks of different types are established along the levelling lines. Some figures characterizing the relevelling nets of individual countries are given below.

Relevelling nets in Eastern European countries

Country	*Total length of relevelling lines (thousands of kilometres)*	*Number of bench-marks*	*Average time interval between repeated levellings (years)*
Bulgaria	5.6	735	20
Czechoslovakia	5.6	880	22.5
German Democratic Republic	6.2	1,100	25
Hungary	4.9	1,200	25
Poland	7.2	780	40
Romania	6.0	750	30
USSR	80.0	9,100	20
Yugoslavia	8.7	1,788	40

The first- and second-order levelling lines have been used as the geodetic control for the general map. Only in very rare cases have some short third-order lines of high quality, with a large time interval between repeated levellings, been used for this purpose. The first levelling had been carried out in the period from 1872 to 1956, and the second one from 1939 to 1971. All the levelling is a two-way one. The rate values for the vertical recent crustal movements were computed from the formula:

$$\Delta V = \frac{h_2 - h_1}{t}$$

where ΔV is the average rate value in millimetres per annum for the time interval Δt; h_1, h_2 are the height differences obtained by the first and the second levelling correspondingly; Δt is the time interval between the first and the second levellings in years.

To compute the "absolute" rates, registrations of the tide-gauges were used. The 34 tide-gauges, the movement rates of which had been determined with errors not exceeding ±0.3 mm per annum, were taken into adjustment as initial data. The geographical distribution of the "initial" tide-gauges is as follows: Barents Sea, 1; White Sea, 1; Baltic Sea, 13; Adriatic Sea, 2; Black Sea, 10; Sea of Azov, 5; Caspian Sea, 2. In addition, the observations of 118 sea-gauges and lake-gauges not connected with the geodetic control were used for plotting the isobases.

As soon as the formation of the joint relevelling net was completed, the net was adjusted on a computer. Through the adjustment, the most probable values of the absolute rates of vertical crustal movements for the 226 knot and common stations were obtained. The absolute rates of the 34 initial tide-gauges were considered to be true values during the adjustment. The errors of rates of 226 stations were computed by means of the covariance matrix formed in the joint adjustment. On the basis of these values, the accuracy diagram of the movement rate determinations was constructed.

The absolute rates of all the intermediate stations which lie on the lines connecting the knot stations with the initial ones, as well as on the lines not included in the general adjustment, were computed directly by individual member States for their corresponding national territories. The obtained values were used by each member State for plotting isolines (isobases) on the maps of its territory, which were subsequently brought into accordance with the others.

When compiling the national maps, special field geological and geomorphological investigations of the main relevelling lines and bench-marks, as well as of the tide-gauges, were carried out to ascertain their representability. Some characteristics were estimated: the technical condition of a bench-mark or that of the construction in which a bench-mark is installed; engineering, geological and geomorphological soil conditions; specific regional effects, e.g. seismic activity; dynamic load of the urban areas; reservoirs; and traffic.

As a result of the investigations and the analysis of geodetic and oceanograhic data, the external effects on the movement rates of some bench-marks and tide-gauges could, to a certain degree, be ascertained and separated. According to the degree of stability, all the stations were classified into three categories: stable; relatively stable; and non-stable. The map was based, as a rule solely on the stable stations. The data of the relatively stable stations were used only when they did not contradict those of the stable ones. Special geomorphological area investigations were carried out to secure more reliable and well-founded plotting of the isobase inside the loops and on the sea-coasts. Geological and geomorphological data have been utilized by different countries to a different extent.

All the relevelling bench-marks and tide-gauges (with their "absolute" movement rates), as well as the relevelling lines, were plotted on the map on the scale

*The original text of this paper appeared as document E/CONF.62/L.109.

1:2,500,000 and used for constructing the isobases of movement rates with the principal interval of 2 mm per annum and the auxiliary one of 1 mm per annum on the general map. The "absolute" rates of an overwhelming majority of stations did not exceed 3 mm per annum. The rates considerably exceeding this value in the territory of the USSR are characteristic for the Caucasus and Krivoy Rog area (uplift), as well as for a part of the Urals, Kotlas and Kasan areas (subsidence). Some areas in Bulgaria, Romania and Yugoslavia have movement rates of 3–4 mm per annum.

The map of recent vertical crustal movements Eastern Europe permits the estimation in the first a proximation of some quantitative characteristics recent vertical movements over a territory of about million km². The work on the map demonstrated t importance of the complex investigations of rec crustal movements and confirmed the great scient significance of high-precision levelling.

AGENDA ITEM 8

Aerial photography and photogrammetry

PLANNING OF PHOTOGRAMMETRIC MAPPING SYSTEMS*

Paper presented by the Federal Republic of Germany

TASK OF ECONOMIC SURVEYING AND MAPPING

Surveying and mapping of the earth's surface is the objective of geodetic work. The required representation of the earth's surface has to fulfil some general requirements, such as type and quality. Using photogrammetry[1] as an economic technical method for this work, all the different possibilities of the photogrammetric technique must be taken into consideration (see figure 77).

The objective and the method show a mutual dependency. For a certain task, a suitable and economic procedure has to be set up, selecting those techniques, methods and operations which will give an optimal solution of the problem.

For this purpose, the structures of the photogrammetric procedures are analysed in this paper. Special attention should be paid to those peculiarities which characterize the photogrammetric method and strongly influence the method of aerial surveying.

STRUCTURES OF PHOTOGRAMMETRIC PROCEDURES

Structure elements

For production of representations of the earth's surface, there are three general methods, as shown in figure 78:

(1) Optic-photographic transformation (rectifier, orthoprojector);

(2) Mechanic-analogue projection (analogue plotting instruments);

(3) Analytical transformation (computational analytical methods).

The technique of exploiting aerial photographs can be effected in three ways:

(1) By photographic means (without actual plotting);

(2) By graphical plotting (lines, contours);

(3) By digital plotting (co-ordinates).

Photogrammetry also allows three final modes of representation:

(1) Photographic representation (aerial photographs, orthophotos);

(2) Graphical maps;

(3) Numerical forms (co-ordinate lists, digital terrain models).

Structure relations

The combination of the different possibilities of transformation, of plotting technique and of final representation permit very different procedures of aerial surveying. For instance, if a map is required, three entirely dissimilar procedures (see figure 79) can be adopted to fulfil this task:

(1) Optic-photographic transformation to obtain rectified and geometrically correct photos: digital plotting and subsequent automatic plotting;

(2) Mechanical projection of the aerial photographs in normal stereoplotting machines and conventional graphical plotting;

(3) Measurement and registration of image co-ordinates on unoriented photos: analytical transformation into ground co-ordinates and subsequent automatic plotting.

Special characteristics of the photogrammetric process

Three special characteristic attributes of the photogrammetric process typify the whole procedure and cause special difficulties:

(1) Normal aerial photos are unoriented and have to be set in a correct position and oriented;

(2) They need a projective correction of their central projection at least for hilly country;

(3) To obtain spatial information, two different photographs are necessary; and the formation of a stereoscopic model is indispensable.

However, the entire system of photogrammetric processing possibilities becomes a more detailed representation if the steps are indicated in which these problems are solved (see figure 80).

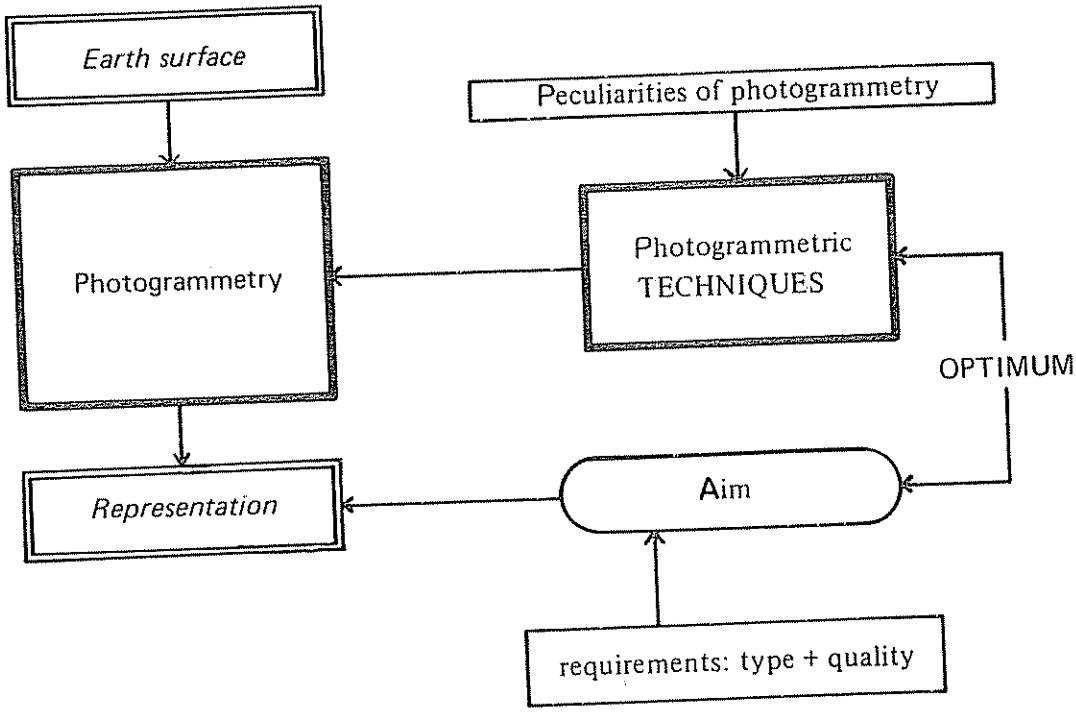
Orientation can be carried out by:

(*a*) Enlargement only;

(*b*) Optical rectification before the photographic process;

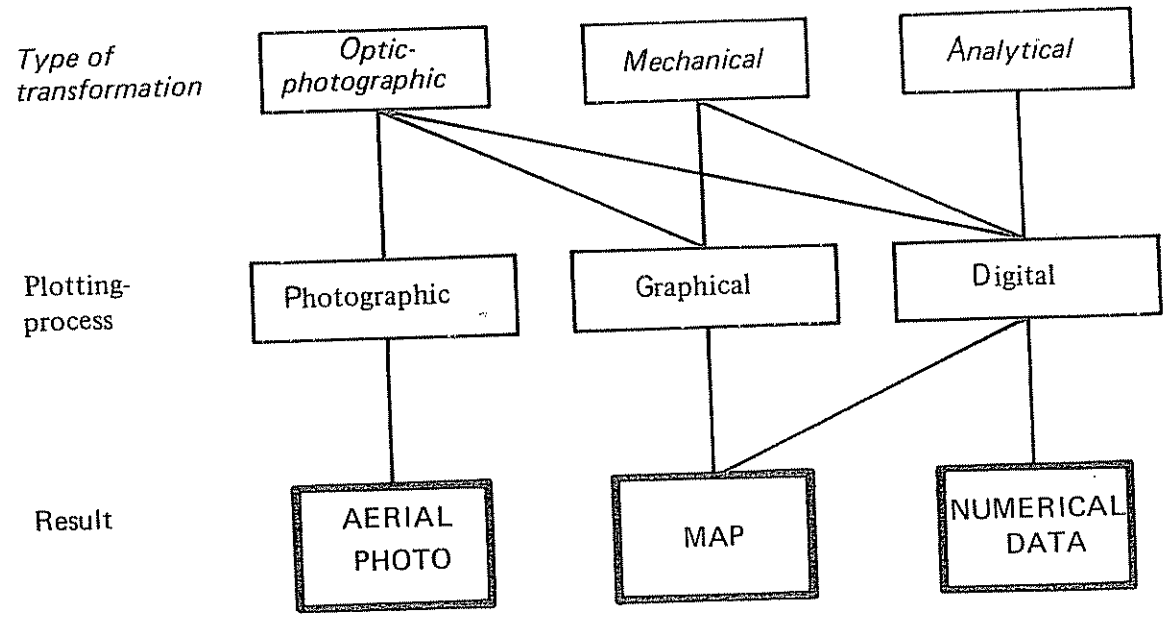
*The original text of this paper, prepared by W. Brindopke, Nds. Landesverwaltungsamt, Hanover, appeared as document E/CONF. 62/L.7.

[1] For detailed planning of photogrammetric projects, see H. J. Jerie, "Planning of photogrammetric projects", invited paper, Congress of the International Society of Photogrammetry (ISP), Commission IV, Enschede, 1972; B. Makarovic, "The application of automated equipment in photogrammetry", paper presented to the Congress of ISP, Commission II, Enschede, 1972.



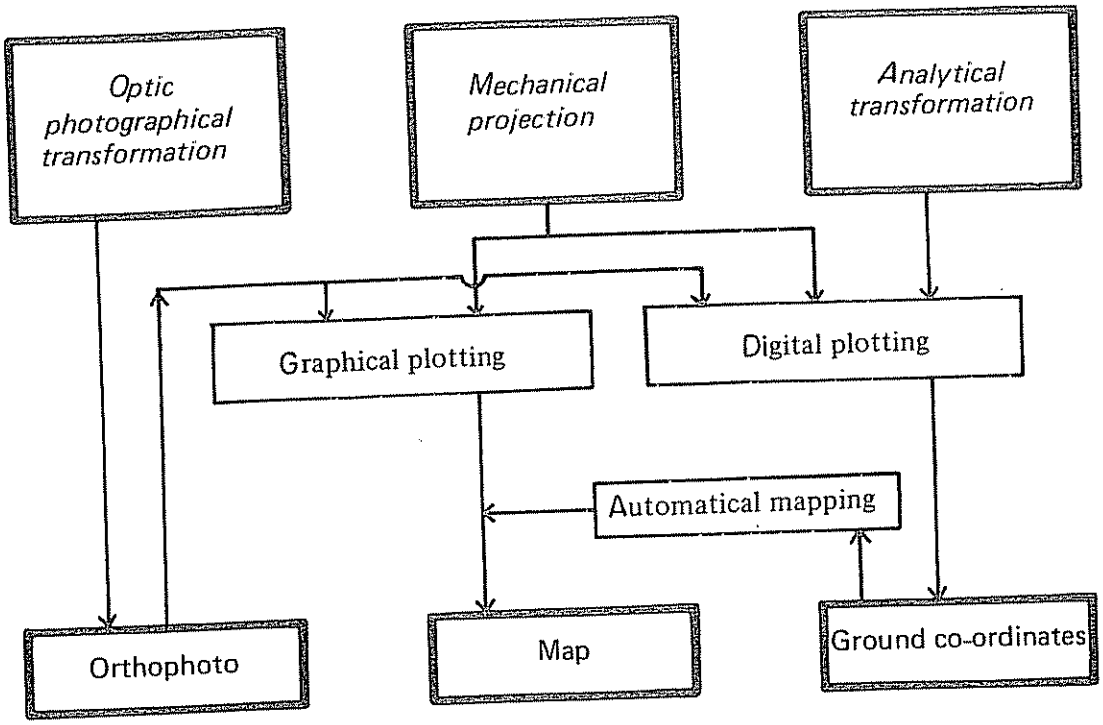
2843.77×

Figure 77. Federal Republic of Germany: possibilities of photogrammetric techniques



2843.78×

Figure 78. Federal Republic of Germany: possible procedures of photogrammetric plotting



2843.79x

Figure 79. Federal Republic of Germany: structures of photogrammetric plotting procedures

(*c*) Mechanical orientation in a mechanical stereoplotter before the complex graphical plotting;

(*d*) Computational transformation of the digital plotting after relative orientation and model formation;

(*e*) Mere analytical transformation after measuring coordinates in the unoriented photographs.

Orthoprojection derived from the central perspective entails:

(*a*) No correction in flat terrain and, to the extent possible, using longer principal distances;

(*b*) Optical orthoprojection;

(*c*) Stero restitution.

The third dimension:

(*a*) Can be neglected in flat terrain, using rectifications or orthophotos for tracing the planimetry;

(*b*) Can be produced by stereo-orthophotos:[2] stereoplotting takes place after optical orientation and elimination of central perspective influences;

(*c*) Can be done by mechanical-analogue models, stereoplotting simultaneously due to mechanical-analogue steering in stereoplotting machines;

(*d*) Can be done by analytical models, in which two-dimensional image information is spatially transformated into orthogonal results.

[2] T. J. Blachut, "Methods and instruments for production and processing of orthophotos", invited paper, Congress of the International Society of Photogrammetry, Commission II, Enschede, 1972

Discussion of the different photogrammetric procedures

Summarizing all the geometrical and technical aspects of the photogrammetric process, one can derive the different methods, which are discussed and assessed below:

(a) *Optic-photographic transformation to produce rectified photos.* This method is without actual plotting. Rectifiers in flat and orthoprojectors in hilly terrain produce orthophotos (single photographs); orthocartographs (Blachut) produce stereo-orthophotos which combine the advantages of orthophotos with the necessity of spatial plotting-out of two aerial photos. This method leaves the interpretation, planimetric or height measurement to the user of the orthophotos; therefore, few personnel are needed; further kind of treatment is flexible; financial expense is small, but automation of the orthoprojection by correlators is possible;

(b) *Optic-photographic transformation with subsequent graphical representation.* This method involves graphical plotting of rectified photos; tracing of rectified photos or orthophotos, graphical treatment of drope lines from orthophotos, stereoscopic plotting of planimetry and heights from stereo-orthophotos after orientation and projective transformation. Instrumental investment: none for tracing, simple stereocompilers for stereoscopic plotting. Operators do not need special qualifications for orientation, only for stereoscopic viewing and cartographic tracing. This method favours a very

broad decentralization of all processing steps; it is the simplest and most economical mapping procedure with average accuracy.

(c) *Optic-photographic transformation with subsequent digital plotting*. This procedure involves digital plotting of rectified photos and digital plotting of single points. There is increased accuracy and accelerated procedure. Higher hardware and software investments are required for computational treatment of digital output (subparagraph (g) below);

(d) *Mechanical analogue stereoplotting with graphical output*. This has been the conventional method of stereo-photogrammetric mapping for 40 years. Expensive, "complex" instruments and very highly qualified operators are necessary. The procedure cannot be decentralized (on-line). It has good graphical accuracy, but limited suitability for automation;

(e) *Mechanical analogue stereoplotting with digital output*. In this method, the accuracy is increased by digital plotting of single points. The saving of the absolute orientation and a point-by-point plotting simplify the whole process. Increased investments include a digitizer, a computer and the programme. As long as numerical output is not used for automatic plotting (see subparagraph (h)), this method is useful only for numerical determination of single points and for digital terrain models;

(f) *Analytical procedures with numerical result*. This method has the highest accuracy of individual points. It requires simple instruments, probably monocomparators; but expensive programmes and computers are necessary. Less qualified operators only are needed. Off-line procedure can be decentralized. It is a very economical and highly efficient method if there are not too many points. The procedures with numerical output can be continued by following automatic plotting of points and lines. These methods take on a "hybrid" character. The acutal objective is the conventional graphical map;

(g) *Optical-photographic transformation with digital plotting and automatic mapping*. The method described in subparagraph (c) with additional graphical output appears to be very complicated. Apart from the instruments mentioned in subparagraphs (b) and (c), programmes and automatic plotters are required. However, many advantages can be seen: simple plotting machines; simple plotting procedures; averagely qualified operators; very strongly decentralized operations; all-round usable results of the whole process;

(h) *Mechanical stereoplotting with digital output and automatic mapping*. This method is conventional plotting with high automation and high precision; however, it calls for high investments. Qualified operators are needed, good circumstances for decentralization and further automation. It is relatively expensive, but it is an automatized procedure with high efficiency for graphical and numerical results;[3]

(j) *Analytical method with graphical output*. This method offers two possibilities. One is off-line; it is the method mentioned in subparagraph (f) followed by automatic plotting. It entails a high investment and quality; and is economical for limited number of points. The other is on-line; this system is equivalent to the analytical plotter AP/C, a very versatile and highly accurate, but most expensive solution for a mapping system. It is not very suited for mass production.

Choice of optimal photogrammetric procedures

Aspects for choice of procedures

For the choice of a suitable and optimal procedure, the points of view are given in the form of the following alternatives:

(a) *High precision*: numerical procedures, or production in a minimum of time; only photographic procedures;

(b) *High level of automation*: numerical procedures using computers, automatic plotters and perhaps correlators; or processes with a high engagement of personnel, typified by a broad decentralization of simple photographic methods for mass production;

(c) *Form of representation*: photographic representations allow nearly any further adaptation; digital plotting requires computers, but makes high-precision work possible; graphical plotting is a conventional way, but not a very rationalized one;

(d) *Decentralized work*: offers a division of labour (orthophoto and digital techniques); conventional stereoplotting is suitable only with a central organization;

(e) *Less qualified personnel*: orientation of stereo models, for example will be avoided or automatically done; conventional stereoplotting machines need qualified operators;

(f) *Plotting*: if plotting is restricted on planimetry (e.g. cadastral projects), conventional plotting of models may be avoided; in any case, height plotting necessitates rigorous model formation;

(g) *Small-scale mapping*: can be restricted to simple procedures (mosaics, rectification, tracing) increasing map scales will lead to procedures with a higher intensity, which means to more numerical methods and to more automatic procedures.

Choice of the aerial triangulation method

Block triangulation methods with rigorous adjustments are the most economic procedures for the determination of contropoints.[4] For the choice of an optimal method, the following points of view are important:

(*a*) Pure analytical methods (bundle adjustments) have advantages:

(i) Where numerical results with highest precision are needed (survey control points, height control points, cadastral surveying);[5]

(ii) Where the actual process of mapping does not need the conventional stereo restitution, for instance, in mechanical plotting machines, that is, where mapping can make use of the various methods of optic-photographic projection;

[3] H. Bauer and J. Müller, "Height accuracy of blocks and bundled justment with additional parameters", invited paper, Congress of the ternational Society of Photogrammetry, Commission III, Enschede, 72

[4] F. Ackermann, Numerische Photogrammetrie Nachrichten Kartenu Vermessungswesen, Reihe I, Hft 53 (Frankfurt am Main, Institut für Angewandte Geodäsie, 1971)

[5] Bauer and Müller, op. cit.

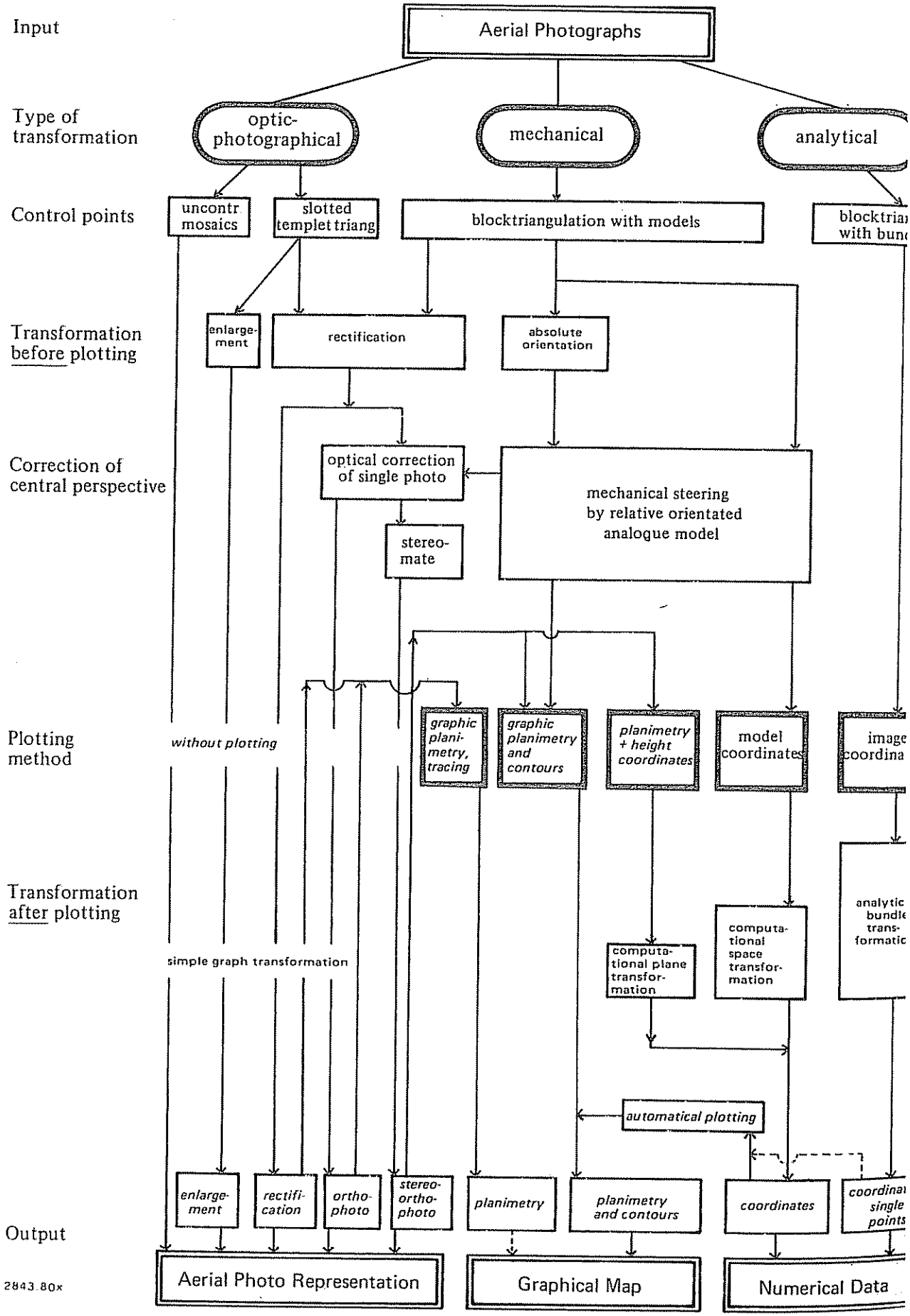


Figure 80. Federal Republic of Germany: system of photogrammetric plotting operations

(b) Block triangulation with models fulfils all those conditions which are set up by normal conventional plotting in conventional plotting instruments as long as less than optimal precision is required.

A photogrammetric system built up gradually

In many cases, different factors prevent or hinder a rapid complete or high quality survey of the whole map area. Therefore, step-by-step development is the only possible way. It is of great importance that each step has a maximum of validity and simultaneously allows a further development to a higher level. Planning these steps may have the following arrangement:

(*a*) Photo flight with not too small a photo scale;

(*b*) Block triangulation with the highest possi accuracy (5–10 m);

(*c*) Production of orthophoto maps out of rectifi tions, orthophotos or stereo-orthophotos;

(*d*) Production of overlays in addition to the ortl photo maps with the objective of further interpretat of the orthophotos;

(*e*) Possibly, drafting of the orthophotos;

(*f*) Digital plotting of the orthophotos, if necessary conventional models in stereoplotting instruments;

(*g*) Organization of numerical data registers, toget with results of the block triangulation.

Examples of optimal choice of photogramme procedures for significant projects in surveying a mapping are given below.

Photogrammetric procedures for significant projects

Type of project and proposed procedure	*Arguments for selection of procedures*	*Output and quality*
1. Topographic survey map 1:250,000 1. Photo flight for planimetry: M = 1:25–40,000, f = 30 cm statoscope-stabilized for exact photo scale [6] 2. Uncontrolled mosaics 1:25–40,000 3. Tracing and subsequent reducing to 1:250,000 4. Photo flight for height: simultaneously to planimetry flight: f = 8.5 cm = M = 1:80–1:140,000 5. Orthoprojection, adjustment to planimetry 1:250,000, drop lines	The large scale allows free play of about 1 cm (a) for the uncontrolled mosaics, (b) for nonrectified projection-influences. Due to f = 30 cm height-differences in terrain below 250 m are not significant A rough orthoprojection of super-wide-angle photos will produce height accuracy of 0.5% flying height	1. Reduced mosaics 2. Tracing 1:25,000 reduced to 1:250,000 3. Accuracy: planimetry = about 250 m height = about 50 m
2. Topographic surveying 1:50,000 1. Using photo flight material from above or new flight M = 1:40,000, f = 15 cm, h = 6,000 m 2. Block triangulation 3. Orthoprojection with drop lines or production of stereo orthophotos [3], orthophoto scale = 1:15,000 4. Tracing of orthophotos for planimetry and of drop lines or plotting of stereo orthophotos	Block triangulation will fulfil all requirements of control points (planimetry and height). If planimetry is wanted only in flat terrain (height differences below 20 m), rectified photos may replace orthophotos. Drop lines from orthoprojection will give a height accuracy of 0.05% flying height, or 0.1% using correlators for automatic orthoprojection	1. Photo maps 1:50,000 2. Maps with accuracy: planimetry = 20 m height = 5–10 m
3. Topographic surveying 1:10,000 1. Photo flight: M = 1:18,000, f = 15 cm 2. Analytical block triangulation 3. Orthophotos (4 per map) for photo maps and stereo orthophotos 1:10,000 4. Tracing planimetry or plotting planimetry and contours 5. Digitizing of stereo photos	Analytical block triangulation will fulfil all requirements of control points and is of special economy if there is no conventional stereoplotting Required height accuracy determines method for height plotting: plotting from orthophotos/stereo orthophotos graphical or digital	1. Photo maps 1:10,000 2. Maps with accuracy: planimetry = 5 m height = 1 m

Photogrammetric procedures for significant projects (*continued*)

Type of project and proposed procedure	*Arguments for selection of procedures*	*Output and quality*
4. Topographic maps 1:1,000–1:2,000		
1. (a) Photo flight M = 1:4,000, f = 15 cm (b) Analytical block triangulation (c) Stereo photos 1:1,000, 1:2,000 (d) Plotting planimetry and contours 2. (a) Photo flight M = 1:6–8,000, f = 15 cm (b) Block triangulation with models (c) Plotting in conventional stereoplotters graphical or digital	Alternative: 1. Procedure for decentralized operations and averagely qualified operators 2. Intensive procedure, well-trained operators; centralized work with computational method. Orthophotos not required	1. Photo maps (method 1) 2. Maps with accuracy: planimetry = 0.3 m height = 0.2 m
5. Cadastral surveying 1:10,000		
1. Photo flight M = 1:15,000, f = 30 cm 2. Analytical block triangulation with simultaneous determination of survey points 3. Orthophotos or stereo orthophotos 1:4,000 4. Tracing of topographic boundaries	Cadastral projects in relatively small scales need a high numerical accuracy for the network and a relatively mean accuracy for graphically fixed objects. Combination of analytical and photographic procedures will be optimal	1. Co-ordinates of survey points with accuracy of 5–10 cm 2. Maps with planimetric accuracy of 1 m 3. Photo maps 1:4,000
6. Cadastral surveying 1:1,000		
1. Photo flight M = 1:3–8,000 2. Block triangulation with models, simultaneous determination of survey points 3. Conventional stereoplotting with graphical or numerical output 4. Automatic plotting if plotting has been done digitally	Highly intensive working procedure. If there is a large number of cadastral points, conventional plotting with, perhaps, digital output will be most economical	1. Co-ordinates of survey and cadastral points with accuracy of 3.5 cm 2. Maps with accuracy of boundaries = graphical topographic planimetry = 0.3 m heights = 0.2 m
7. Survey control points		
Photogrammetric determination of further control points in an existing network of I., II. or III. order (condensation). Photo flight in large scales (1:5–10,000), f = 30 cm with additional strips of 60% lateral overlap. Analytical procedures only	Analytical procedures guarantee utmost accuracy in determination of single points; they are the most economical methods for blocks with a relative large number of models and a small number of points	Co-ordinates of survey control points with accuracy of 3–5 cm

EXPERIENCE WITH THE PRODUCTION OF PHOTO MAPS 1:5,000 IN NORDRHEIN-WESTPHALIA*

Paper presented by the Federal Republic of Germany

After 1945, a programme was commenced to produce a topographic map of large areas of the Federal Republic of Germany on the scale 1:5,000. Each sheet covers an area of 2 × 2 km with a format 40 × 40 cm.

By 1968, this topographic map, the GermanBasic Map 1:5,000 (Deutsche Grundkarte), was partially completed in the State of Nordrhein-Westphalia, in the most densely populated part of the Federal Republic of Germany, with 14 per cent having contours and 52 per cent in preliminary edition wih planimetry without spot heights. Urgent tasks of various users made it imperative to produce maps on the scale 1:5,000 for the remaining area within a few years.

WORK PLAN

The difficult task of producing more than 3,000 mapsheets on the scale 1:5,000 within the shortest possible time could not be accomplished with previous conventional mapping methods, including even stereo photogrammetry. Photo maps, as they had been produced annually, were not suitable, as they did not possess the

* The original text of this paper, prepared by G. Krauss and E Pape, appeared as E/CONF 62/L 9

required planimetric accuracy due to elevation differences and their displacements

Orthophoto projection seemed to be the most obvious solution. Within a few years, differential rectification of aerial photographs has acquired a world-wide reputation, and its importance in producing maps quickly and inexpensively in both the developed and the developing countries is increasing.

In applying this method, all efforts are being coordinated so that the orthophoto map at 1:5,000 scale becomes a special edition of the German Basic Map 1:5,000.[1] It has the same scale, the same limits and the same format. It also has to correspond to the relatively high accuracy requirements that have been set for positions and elevations in the German Basic Map, as follows:

(*a*) Standard deviations for uniquely definable points:

$m_p = \pm$ 3 m—position error;

$m_{H_1} = \pm 0.2$ m—elevation error in flat terrain;

$m_{H_2} = \pm 0.3$ m—elevation error in hilly terrain;

(*b*) Standard deviations for contours:

$m_{h_1} = \pm 0.3$ m in flat terrain;

$m_{h_2} = \pm(0.4 + 3\ tgd)$ m in hilly terrain.

For stereo-photogrammetric plotting procedures during the past years, the following elevation accuracies have been achieved:

(*a*) $m_H = \pm 0.18$ m for uniquely identifiable points;

(*b*) $m_h = \pm (0.2 + 2.5\ tgd)$ m for contours.

The same accuracy was also achieved for terrestrial mapping procedures used for producing the German Basic Map before and after the Second World War.[2] This accuracy guarantees that this map does, in fact, constitute a genuine base map; further, the terrain cannot be defined more accurately in general. Thus, the German Basic Map can be the basis for technical planning for very different requirements.

Equipment

A Zeiss, Oberkochen SEG V rectifier was already available for classical rectification of aerial photographs. For stereo-photogrammetric restitution of the profile-strips for orthophoto projection, an available C8 stereoplanigraph was used. At first, Zeiss, Oberkochen GZ1 orthoprojector was directly connected to the instrument. It was very soon realized that it would be more advantageous, for technical and economic reasons, to work off-line rather than on-line. During off-line operation (contrary to on-line operation), one can adjust the profiling speed according to the difficulties of the terrain; thus, it becomes possible to raise accuracy. The orthoprojector, if it is controlled by a reading unit, can operate three times as fast, as compared with on-line operation, which means that three photo maps, instead of one, can be exposed within a work period of from seven to eight hours. If there is an annual work-load of 500–600 photo maps, for one work-shift per annum the purchase costs for a storage and a reading unit can be written off within about two years.

Therefore, an SG1 storage unit and an LG1 reac unit were soon acquired. The storage device stores evaluated profiles in analogue form on glass plates. reading device automatically reads the stored pro and controls the orthoprojector in that manner. O copying devices and facilities, which can be usec develop, to raster and to copy the exposed film are course, part of the equipment.

Methods of operation

Disposition of aerial photography

The photography and method used in producing photo map on the scale 1:5,000 depends upon respective terrain. If the elevation differences with map-sheet are smaller than ±10 m, single-image recti tion can be carried out. For elevation differences gre than ±35 m, the photo map will be produced by or projection in any instance. If the elevation differenc between ±10 m to ±35 m, one has to determin connexion with the adjacent sheets which method sh be applied. To reach the required position accu these sheets also are mostly produced by orthopr tion; one may choose during profile scanning and tially during the exposure the larger profile w because of this ability the procedure can be carriec fairly rapidly.

For flat areas, the photography is flown with a nc angle camera (30/23), on the photo scale 1:12,00(with a flying height of 3,600 m in such a manner each photo covers the area of a map-sheet of the Ge Basic Map. The longitudinal and the lateral ove amount to about 27 per cent. A longitudinal overl 90 per cent is selected only if the photos require st scopic coverage in order to carry out aerial triangul

For hilly terrain, the photography is flown w wide-angle camera (15/23) on the scale 1:13,00(with a flying height of 1,950 m; the longitudinal ov is 90 per cent and the lateral overlap, 32 per cent photographs can, therefore, be selected in such a m that two stereo-models each will cover a complete sheet of the German Basic Map during ortho restitution.

Determination of control

In areas for which the German Basic Map is ava as a line map with sufficient accuracy, one can about the determination of control. In such case single-image rectification or the orthophoto-mode tution is carried out utilizing the planimetric detail German Basic Map. Frequently, the following di ies occur:

(*a*) Despite the use of stable base materials f map originals, the planimetry is more or less dist Regular and irregular distortions must therefc considered;

(*b*) Identification of identical points betwee aerial photo and the map is often very difficult. difficulties are brought about by the fact that German Basic Map, property boundaries are depi favour of topographic boundaries;

(*c*) A map-sheet of the German Basic Map c considerably smaller area than an aerial photo mentioned image scales. As a result, the points u rectification or model orientation often are situa close to the centre of the images or the models

[1] G. Krauss, "Die Herstellung von Luftbildkarten", *Bildmessung und Luftbildwesen* (1970), pp. 209–216; E. Pape, "Die Deutsche Grundkarte 1:5,000 als Luftbildkarte", *Bildmessung und Luftbildwesen* (1971), pp. 194–198.

[2] G. Krauss, "Das Deutsche Grundkartenwerk 1:5,000", *Vermessungs-technische Rundschau*, No. 3 (1968).

When using available line maps as a basis for restitution, errors are easily made which exceed the tolerances for the German Basic Map. Especially frequent are the errors in scale, which show gaps with the neighbouring sheets when they are assembled. To avoid such errors, it is necessary to consider a number of aspects and to distinguish between single-image rectification and orthoprojection.

For single-image rectification, the dimensions of the line map are checked by comparison with a grid plate on glass before rectification. A regular distortion is compensated after the rectification process by an appropriate scale correction. In case of an irregular distortion, the line map is transformed photographically on to the correct dimensions before rectification. For this procedure, at least two photographs are necessary with a repro-camera. Although principally all the detail of the line map is used for the rectification process, identical objects in the photo corners are particularly important in order to avoid extrapolations. Thus, if identical objects cannot be found in the corners for an individual case, the planimetric detail in the adjacent map-sheets must be included in the rectification process. For this purpose, copies of the adjacent parts of neighbouring map-sheets are mounted together on special base sheets.

Orthoprojection models are, as a rule, oriented numerically to the co-ordinates of control points. Maps are used for the restitution of models, and one selects and graphically determines from the grid-line co-ordinates of clearly identifiable points in the model corners. In this way, both regular and irregular distortions are eliminated from the map base. In order to obtain a check for the identity of the points, it is always advisable to select several points in a model corner. It is best to select a point in each adjacent map-sheet; the orientation of adjacent models may then be carried out by the aid of the same points selected. To the extent that it is not possible to select points in the model corners, it is advisable to arrange the procedure in such a way that at these locations auxiliary points may be determined for the restitution.

To level the models by known elevations, the elevation detail given on an available map-sheet of the German Basic Map is always sufficient. If necessary, one may also use the elevation details given in the topographic map on the scale 1:25,000, which, in general, possess an accuracy of $m_h = \pm (0.8 + 10\ tgd)$ m.

When the outlined aspects are taken into account, the use of available maps on the scale 1:5,000 as a restitution base becomes possible within the permissible tolerances along the sheet corners.

If map bases are not available, control points must be determined for single-image rectification, as well as for orthophoto projection. This procedure is done at the Landesvermessungsamt Nordrhein-Westfalen almost exclusively by means of aerial triangulation, using block triangulation with independent models. As triangulation equipment, a Wild A7 autograph with an EK 5a co-ordinate recording device, Zuse Z25 electronic computer and a complete programme package are available, by which not only the co-ordinates of the transfer points, but the settings for the exterior orientation elements of the models can be determined.

For single-image rectification, aerial photography is flown with a 30-cm camera. As this principal distance cannot be introduced in the Wild A7, autograph, the images are restituted in an affined manner with a principal distance of 21 cm. As far as height control is concerned, all new points are given the same arbitrary height. The resulting errors from both sources are kept well within the differences due to the small elevation differences of the terrain. For each model, four artificial transfer points are marked into the diapositives with a PUG 3 point-transfer device. As far as possible, one uses original negatives in the subsequent rectification process and where the artificial points are not available, one has to determine additional clearly definable natural points in the corners of the images. For computations, programmes for planimetric and spatial block adjustments are available. Despite the longer computation time for spatial block adjustment, this method is preferred because it results in more complete information.

For orthoprojection, the control points are determined in the same manner. The approximations justifiable for single-image rectification cannot, however, be upheld. But this factor does not cause difficulties. The principal distance can be introduced exactly; and for stabilization of heights in the block, one can always use an elevation control determined from the 1:25,000 topographic map. In many instances, ground control is available for subsequent stereo-elevation restitution. For each model, from four to six elevation control points are used. Thus, one can omit the determination of perspective centres in the instruments, a step which is provided for in the programme but which is time-consuming. Four artificial points are used per model, in subsequent restitutions as control points. The settings for the exterior orientation elements are always computed, especially for orthophoto production.[3]

Single-image rectification

It is particularly economical to begin with the original negatives in the single-image rectification process to screen the rectified image and to cover the edges of the German Basic Map format at the same time. It is, therefore, necessary to orient an exterior frame after rectification and to fix the position on the rectifier easel. The rectification base is then exchanged with the unexposed film on to which a 70 magenta contact screen is placed. Both are covered with the exterior frame, and a vacuum frame table is required to keep all materials flat. The subsequent exposure and development immediately gives an upright, screened and formatted diapositive of the image planimetry.

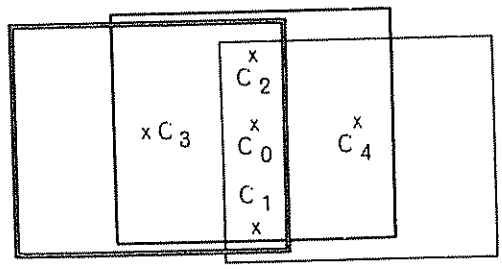
In this procedure, only limited possibilities exist for adjusting the variable volume of contrast present in the negative; and it does not produce as a by-product a half-tone negative, which is desired by some users. For this reason, diapositives are preferred as a source for producing single-image rectifications as well as orthophoto projections.

Orthophoto projection

In orthophoto production, one always begins with projection diapositives, which are produced as carefully as those for single-image rectifications. In addition, one map-sheet requires two diapositives for profiling plus one diapositive for printing.

[3] "Die photogrammetrischen Rechenprogramme des Landesvermessungsamtes Nordrhein-Westfalen für die Zuse Z-25", *Nachrichten aus dem öffenlichen Vermessungsdienst Nordrhein-Westfalen*. No 4 (1971)

For the measurement of profiles and for the exposure of orthophotos, a method developed by the Institut für Angewandte Geodäsie at Frankfurt is used. This method is especially applicable as it selects and marks five check-points in the central diapositive (the middle one of the three required to cover the two models) with a PUG 3 point-transfer device,[4] as shown in figure 81.



2843.81×

Figure 81. Federal Republic of Germany: location of check points

In figure 81, points given at locations C_1 and C_2 by preceding aerial triangulations can be used. If exterior orientation settings are given, the orientation can be carried out without problems. This procedure requires only a short time, including the necessary checking and corrections. In order to prove an errorless and sufficiently accurate orientation, the model co-ordinates of the control points are measured and recorded. In doing so, the differences between the actual co-ordinate values are marked down; they should not exceed 0.1 m on the model scale 1:10,000. In addition, the model co-ordinates of the C points are measured and recorded. They are transformed by computation into the system of the orthoprojector, where they are used for an external check of the proper settings of the orthoprojector. At the same time, the model co-ordinates offer a possibility for transferring the C points into new imagery of subsequent flights, as a prerequisite of later use of the stored profile information plates.

As a model scale, 1:10,000 or 1:15,000 may be used; the large scale, 1:5,000, is selected only when drop lines are to be recorded in order to generate contours.

The profile width is chosen according to the topographic map on the scale 1:25,000 for each photo map. For the terrain conditions of Nordrhein-Westphalia, the use of a larger profile width has proved to be sufficient. The current tendency is to measure profiles more accurately at a wider width than to measure them more rapidly at a smaller width. For all such cases, there are the possibilities for electronic interpolation of profile heights.

For the first exposure, the central diapositive used for measurement, into which the C points have been marked, is placed into the orthoprojector. After introducing the rectifier settings, known from stereo planigraph profiling, one can make the final check using the C points. The model co-ordinates, retransformed into the system of the orthoprojector and set on the orthophoto device by a ring mark in place of the sli have to coincide with the marked and projected points. Discrepancies greater than 0.2 mm are nc tolerated. After the check, the profile storage plate brought into relation with the diapositive used fc measurement through the aid of the C points; th measurement diapositive is then exchanged with th projection diapositive and an unexposed film is inserte The exposure begins with the light-marking of th sheet edges according to precalculated instrument c ordinates. The subsequent exposure process is general automatic. As a result, one obtains a mirror-reverse negative of the orthophoto, which has the same chara teristics as that of the recent single-image rectification For the various major applications, the production tim for profiling are listed in table 1 and those for printing table 2.

Reproduction, editing and duplication of the photo m

It will seldom be economically feasible to print photo map at 1:5,000 scale in one edition. On the oth hand, it is not satisfactory to reproduce the photo ma photographically one by one, because the production photo copies is too time-consuming and too costly. F this reason, it was necessary to select a less expens duplicating procedure which was more susceptible ease of operation and to reproduction in a relativ small number of copies; only ozalid copying is apj cable. A prerequisite of its application is screening of details. The loss of detail associated with it has to accepted; it remains within tolerable limits if one use fine dot raster, but there still remains the possibility special tasks to produce photo prints from the half-t negative.

In order to avoid further loss of detail, cartograp editing is reduced to a minimum. In each case, one a the map title, map information and names. The m important cartographic editing, however, consists adding the height information. It was found in tests t white lettering is usually more easily read on the ima and that black contour lines least disturb the readab of the photo map. A colour editing process is applicable for photo maps to be reproduced by oz printing.

The total reproduction process, which is schematic shown in figure 82, has been standardized. This pr dure was designed, in principle, in such a way that s deviations of the standard in one step can still compensated in the subsequent steps. Thus, it is gua teed to a large extent, that all results, despite different quality of the original aerial photos, will the same appearance and that they will be of the s quality for reproduction.

As previously stressed, one should begin with diap tives, whether one uses single-image rectificatio orthoprojection. When producing these diaposit through use of an electronic dodging device one b their density range, that is, the difference between mal and maximal density, always into the same ran the density scale of the diapositive (the density ran always 0.5–1.1 of the logarithm to the base o reciprocal value of the transparency). Each diaposit densitometrically checked and visually compared w sample; it is marked as a projection diapositive and not be used for other tasks (e.g., aerial triangulatic

When processing is carried out further as a resu single-image rectification or of orthophoto proje

[4] *Verfahrensanleitung zur Herstellung von Orthophotoplänen aus einem Stereogramm oder aus 2 Stereogrammen mit dem Orthoprojektor GZ 1 im Speicherbetrieb* Frankfurt am Main Institut für Angewandte Geodäsie).

Table 1. Production times for profile measurement
(*Hours*)

Model scale	*1:10,000*				*1:5,000*	
x-step (C-8)	*2 mm*		*4 mm*		*4 mm*	
Orientation settings available	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
(*a*) Model orientation, recording of transfer and control points	4.5	2.0	4.5	2.0	4.5	2.0
(*b*) Fitting of SG 1	0.5	0.5	0.5	0.5	0.5	0.5
(*c*) Profile measurement and storage	3.0	3.0	1.5	1.5	5.0	5.0
(*d*) Preparation and additional work	1.0	1.0	1.0	1.0	1.0	1.0
TOTAL EFFORT	9.0	6.5	7.5	5.0	11.0	8.5

Table 2. Production times for exposure
(*Hours*)

Scale ratio	*1:2*				*1:1*	
x-step (C-8)	*2 mm*		*4 mm*		*4 mm*	
Interpolation	*1*	*1/2*	*1*	*1/2*	*1*	*1/2*
(*a*) Setting of the GZ-1 fitting of the LG-1, scale and elevation check, exposure of edges	1.5	1.5	1.5	1.5	1.5	1.5
(*b*) Exposure	1.5	3.0	0.8	1.5	1.5	3.0
(*c*) Preparation and additional work	0.5	0.5	0.5	0.5	0.5	0.5
TOTAL EFFORT	3.5	5.0	2.8	3.5	3.5	5.0

mirror-reversed half-tone negatives, which should be within the desired density range of 0.3–0.4, these half-tone negatives are screened on to high-contrast film with the aid of a magenta contact screen (70 lines per centimetre or 175 lines per inch) (1). The exposure with yellow and blue light is controlled by a Gevarex instrument in such a manner that the resulting screened diapositives show 5 per cent coverage in the lightest image parts and 90 per cent in the darkest parts. During the same stage, an appropriately placed edge mask ensures the formatting of the photo-map image. The proper registration of the edge mask with respect to the image is ensured by punch holes and studs. The result is an upright, screened and formatted diapositive which always has the same density range (3).

During the next step, the screened image has to be combined with the edge data information and the inside lettering. The map edges of the photo map are identical with those of the corresponding line map. In the photo map, one only tries to avoid small letters, which would have poor legibility in the image, and the use of designations which would be difficult to recognize in the photo map. Therefore, it is easily possible to extract the edge and name information from the same sheet of an existing line map of the German Basic Map. A foil is used which is placed over the line map; and with a brush cover, in black, all information required is transferred on to the photo map (4). This process does not need to be very exact. An ozalid copy is then produced on foil. This copy is then superimposed with the line map and another copy on foil is made (5). In doing so, registration is ensured by punch holes and studs. The developed foil shows the information of the line map to the extent to which it has previously been covered. Where unwanted fragments of the line map appear on the foil, these can be scratched away with an erasing tool. In this manner, it would also be possible to transfer the map grid from the line map with the information on grid lines of the 3° UTM system used; but in most cases, the required dimensions would not be shown due to the shrinkage of the material, and it would therefore not harmonize with the geometrically correct image information. For this reason, only the place names are generally transferred; the super position with an accurate standard frame is carried out in a second stage by eliminating the lettering in the interior of the photo map in order to avoid difficulties (9) (10).

If a line map does not exist, the edge data and place name foil can be generated in the usual manner by setting and assembly of the lettering (6) (7). Lastly, in either case, a contact negative of the positives with the lettering information (5) and (7) is produced by photographic means; in this step, the entire edge data text is blacked out (11) (12). Through use of the intermediate originals (3) (10) and (12), the image with the frame and the lettering can easily be combined using ozalid printing. Two exposures are required (13). The photo-image is printed during the second exposure in contact, while the frame and lettering foil is overlayed. Because the foils are very thin (0.1 mm), this step does not affect the quality of the final result. The registration of the various originals is ensured by punch holes and studs. The result of this combination is a mirror-reversed original of the photo map, of which ozalid prints can be produced on contact. Where a large number of copies are required, this original may be used to produce prints on art reproduction paper.

It is possible to provide the user with second copy originals, so that he will be in the position to produce ozalid prints according to his own requirements.

A combination of the photo map with elevation information is no longer considered practical, as some users prefer the photo map without elevation informa-

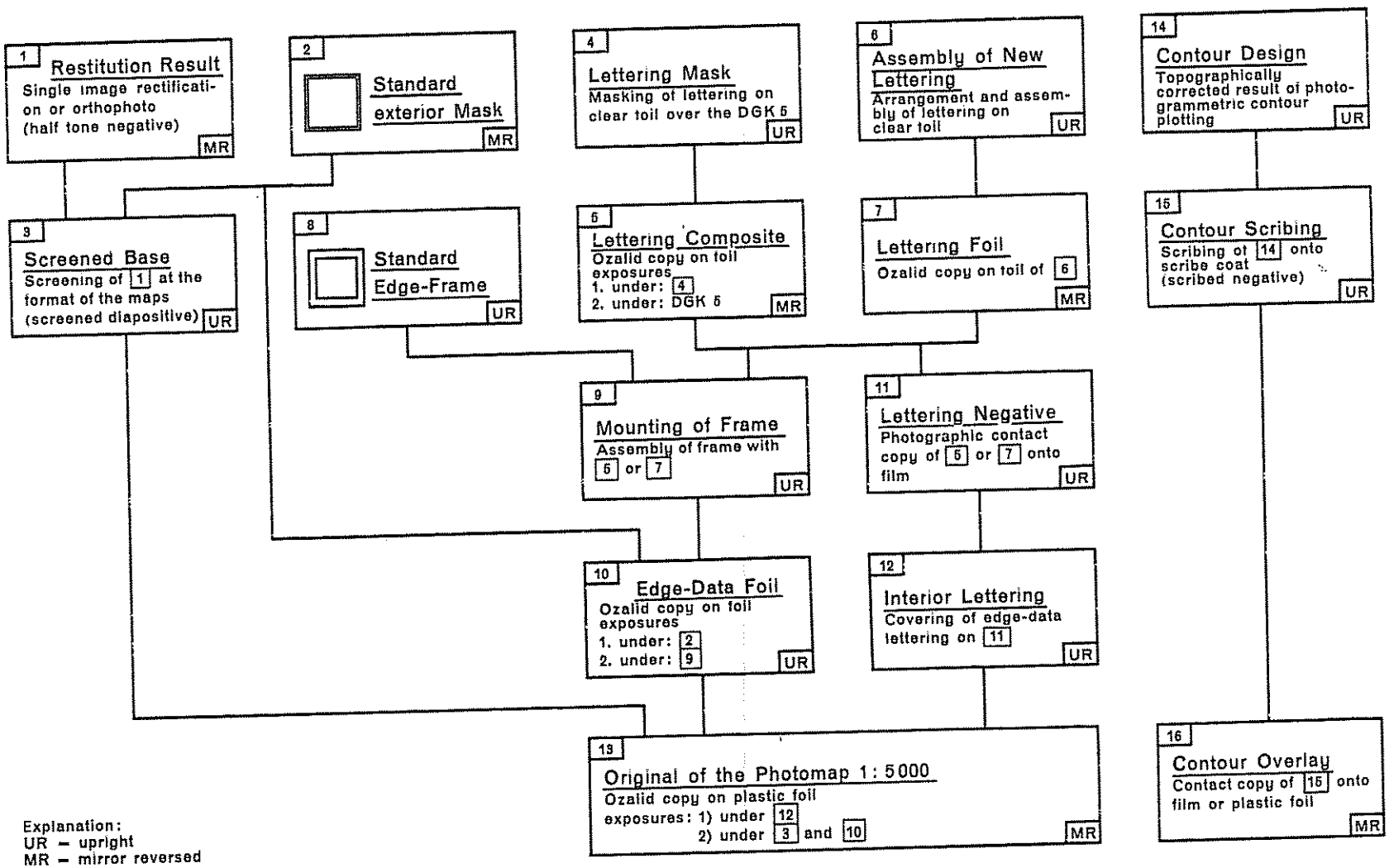


Figure 82. Federal Republic of Germany: reproduction process for the photo map at 1:5,000 scale

tion. If necessary, the elevation information foil (16), which is identical with that of the line map, can easily be combined by ozalid copying with the planimetry original (13).

Elevation restitution

The GZ 1 orthoprojector can be equipped with a device for photographic output of drop lines. The end points of the drop lines describe points of equal elevation, and lines joining these end points constitute contours.

In most areas where, during the past years, photo maps on the scale 1:5,000 had to be produced with high priority, previous elevation surveys were not available on that scale; and an attempt was made to derive the contours from drop lines, but this procedure was stopped for the following reasons:

(*a*) For derivation of the contours, an experienced draftsman needs about two thirds of the time required for exact photogrammetric contour plotting;

(*b*) The achievable accuracy of contours derived from drop lines, approximately $m_h = \pm (0.8 + 3\ tgd)$ m, does not satisfy the tolerances for the German Basic Map. A greater number of elevation control points cannot be used to directly improve the restitution; this is contrary to the situation in stereoplotting;

(*c*) Numerous morphological details are neglected;

(*d*) Heights of special terrain points, such as the top of hills, the bottom of ditches and saddles, and the extent of man-made slopes, are not especially expressed, as it is generally impossible to supplement contour information by selecting a number of additional spot heights.

In order to attain the necessary accuracy, all height information is obtained by stereoplotting, regardless of whether this information is to be used to complete a photo map or to be part of a normal line map. It is currently impossible to compile the height information for all sheets produced; therefore, a great number of photo maps are produced without contours. Since, when applying orthoprojection the aerial flight and the determination of control points are so arranged that the requirements are equally satisfactory for stereomapping, one can, in urgent cases, proceed simultaneously to compile heights at the time of the orthophoto projection, or one can generally follow up with plotting of the heights at a subsequent convenient time.

Only for a relatively small part of the photo maps is it currently possible to produce in combination with a final elevation overlay of the German Basic Map a relatively small number of photo maps, in which the photogrammetrically compiled heights were supplemented by local measurements. In most cases, the photo maps are combined solely with the photogrammetric plotting result, which is permissible because the plotting accuracy is checked by a number of superfluous elevation control points. In areas in which the operator was not able to guide the floating mark with certainty, the contours are marked as uncertain by dashed lines.

In countries where such high requirements for the accuracy of elevations are not maintained, the contours gained by drop lines or by automatic contour plotting along the profiles by interpolation constitute a valuable by-product of orthoprojection.

Time requirements and cost

The time requirements and the costs for producing a photo map on the scale 1:5,000 by single-image rectification (2) are given in table 3. The sums listed under (*a*) in the table are valid for the case that the German Basic Map is available in planimetry as basis for rectification and for deduction of the edge data and the lettering foil; (*b*), includes the necessity of retransforming the German Basic Map to scale before using it as a rectification base; lastly, (*c*) provides the necessity to determine position control as a basis for rectification and to compile the frame and place name information from scratch. The time and cost effort is considerably different for the three cases.

Table 3. Time and cost effort for producing a photo map on the scale 1:5,000 by single-image rectification

No.	*Work stage*	*Time effort (days)*	*Costs (Deutsche-marks)*
1	Aerial flight with planning and checking of specifications	0.3	110
2	Retransformation of the DGK to proper scale	0.2	70
3	Determination of position control points by aerial triangulation	1.5	400
4	Production of edge data plus place names from DGK	0.3	60
5	Setting and mounting of edge data frame plus lettering	1.0	140
6	Rectification with screening combination with frame and lettering	0.2	110
	(*a*) Sum of 1, 4 and 6	0.8	280
	(*b*) Sum of 1, 2, 4 and 6	1.0	350
	(*c*) Sum of 1, 3, 5 and 6	3.0	760

Table 4 shows the corresponding data for producing a photo map at 1:5,000 scale by orthoprojection. Here, (*a*), (*b*) and (*c*) do not constitute differences in the prerequisites, but in the results: (*a*) refers to the production of a photo map without elevation information; (*b*), the elevation information was gained with drop lines; and (*c*) with stereoplotting. Again, large differences can be found in time and cost effort. Furthermore, the effort for (*a*), for which the result is comparable with that of table 3, is very much higher for orthophoto restitution; but even then, the time and cost effort for orthophoto projection is also within favourable limits. In comparison with these figures, the production of the German Basic Map by stereoplotting would require an over-all time effort of 75 working days and a cost effort DM 18,000. When compared with (*c*) of table 4 as the most expensive situation, the time effort is 4.3 times and the cost effort 3.5 times more favourable. This result makes apparent how costly the effort is to produce line maps despite the use of photogrammetry. On the other hand, the use of the orthoprojection method constitutes a high gain, and the results are available more quickly.

Revision

As mentioned above, the photo map on the large scale 1:5,000 is edited only to a limited extent in order to avoid loss of detail. This method, of course, also facilitates

Table 4. Time and cost effort for producing a photo map on the scale 1:5,000 by orthoprojection

No.	Work stage	Time effort (days)	Costs (Deutsche-marks)
1	Aerial photography with planning and checking of specifications	0.3	130
2	Control point determination by aerial triangulation:		
	(*a*) Position	1.5	400
	(*b*) Position and height	2.5	800
3	Terrestrial elevation control determination	5.0	1500
4	Orthoprojection; model scale 1:10,000, $\Delta \times = 2$ mm, without orientation settings:		
	Profiling	1.0	450
	Exposure (interpolation 1)	0.4	250
5	Orthoprojection and drop-line recording; model scale 1:5,000, $\Delta \times = 4$ mm, without orientation settings:		
	Profiling	1.2	650
	Exposure (interpolation 1)	0.4	280
6	Setting and assembly of frame and lettering	1.0	140
7	Derivation of contours from height profiles	4.0	500
8	Stereoplotting of contours	4.0	1600
9	Scribing of elevation foil	4.0	500
10	Copying and registration	0.3	120
	(*a*) Sum of 1, 2b, 4, 6, 10	5.5	1890
	(*b*) Sum of 1, 2b, 5, 6, 7, 9, 10	13.7	3120
	(*c*) Sum of 1, 2a, 3, 4, 6, 8, 9, 10	17.5	5090

revision of the photo map, because the frame will rarely be subjected to any changes and because the lettering and the height information will be only slightly changed. During revision, therefore, only the photo-image will have to be renewed. As the first photo maps were produced only a few years ago, experience in revising the photo-image, except for the results of some tests, is limited. For all sheets, where elevation profiles were stored on glass plates and for which new aerial flights had been carried out, it is not necessary to determine new control points and to remeasure the elevation profiles. The stored profiles can be reused for the projection of new photo-images. For this process, at least one of the C points, which has been marked in position on the storage plate, has to be transferred into the new photographic material. This step is particularly simple if the C points refer to permanent, natural image details which can be identified with certainty and accuracy in the new photography. On the other hand, it is possible to transfer the C points into the photos according to model co-ordinates determined during the first restitution of the model. For this procedure, it is necessary for each map to orient a model of the new photography in the plotter.

During the tests carried out to date, it has always been possible to reuse the stored profile plates; and from the point of view of accuracy, the results were satisfactory.

Use of photo maps

As the photo map is geometrically accurate, other geometric data, such as contours or results of planning data, can be properly related to it. Thus, there are ma possible uses for the photo map.[5]

The production of the photo map at 1:5,000 scale v begun on the initiative of the highway administration the time when it began to set up a highway-data bank the administration of the wide road network. The ph map serves as a data base and it is used further to ded important details. The photo map, supplemented w elevation information, can be used for the planning new roads and for the enlargement of existing roads

The main application of the photo map, howe rests with the local planning authorities, even if the li map edition of the German Basic Map is available the planning district, as the photo map contains m additional information which is important for planni The photo map is usually never older than the line m Planners use the photo map with advantage in t negotiations with various groups because a layn usually finds it easier to orient himself on the photo n than on the more abstract line map. Therefore, lc planning authorities quite often offer to the Landes messungsamt funds to produce a photo map e though the line map is already available.

Regional planning authorities use the photo map v advantage in order to determine land use and the siz certain areas. For this purpose, the photo map proba offers the best conditions because it depicts the act land use of a large area geometrically correct at a cer time.

The Forest Service can use the photo map as a b for its management plans, in which the boundaries of individual forest divisions are transcribed into the ph map in the field; the areas of these divisions are sul quently determined on the map. In this way, exten survey work in the field and in the office can be sa During the computations and during subsequent eva tions, automation may be used to a great extent.[6]

For the purpose of securing property owners Nordrhein-Westphalia has large-scale cadastral m for which high accuracy requirements exist becaus the high property values. Photo maps, even on sc larger than 1:5,000, would not satisfy these requ ments. For countries with low property values, wl currently do not yet possess geometric documentatio ownership of properties or which have only lim information of this type, photo maps may be use advantage for this purpose; they may serve as a suit base for a property register.

Lastly, the photo map on the scale 1:5,000 ma used for a faster and more economical production o line map at 1:5,000 scale and for faster updatin topographic maps at smaller scales.

In Nordrhein-Westphalia, a greater number of p metric bases for the German Basic Map at 1:5,000 s have been derived from the photo map. Whether, the exception of city areas, in purely rural areas, maps and photo maps will exist side by side will de upon future needs.

[5] G. Krauss, "Utilization of the 1:5,000 photo map in Nord Westfalen", paper presented at the Colloque international s orthophotocartes, Paris, 1971.

[6] F. Voss, "Anwendungsmöglichkeiten von Luftbildkarten f Forstwirschaft in Nordrhein-Westfalen, *Bildmessung and Lu wesen* (1969), pp. 203–208

Altogether the major advantages of the photo map are the ability to produce it rapidly and economically, to be able to update it just as easily and to evaluate it in various ways. Therefore, the photo map has, in a very short time, become a valuable tool; and, in some cases, an indispensable tool for many tasks.

SOME ASPECTS OF PHOTOGRAMMETRY*

Paper presented by Australia

This paper deals with two aspects of computerized photogrammetry used in the Division of National Mapping, as well as with the reproduction of orthophoto maps.

SEMI-ANALYTICAL BLOCK TRIANGULATION

The Division has commenced block triangulation in Australia by the method of independent models.

The cameras used are the Wild super-wide-angle type, and the diapositives are printed on film using a Wild U4A printer which removes the effects of earth curvature and atmospheric refraction on the assumption that the flying height is 7,000 m above ground. The photographic scale is about 1:80,000.

Triangulation points are customarily signalized and photographed from an aircraft at two or three different altitudes. Transfer to the diapositives is effected using a Bausch and Lomb differential stereoscope to make a model from a spot photograph of the triangulation point and survey flight diapositive. Elevation control points are either identified in the field and transferred to the diapositives by mirror stereoscopes with binoculars or identified from bench-mark descriptions where possible. Airborne control for height is also largely used.

Diapositive marking, both of ground control and minor control, is done using specially designed Letraset rub-on markers. They consist of a central point of 0.1-mm diameter surrounded by a 3-mm diameter circle, and they are quicker to use than specially designed point transfer devices.

Observations are made on Kern PG 2 instruments fitted with X, Y guide-rails; and encoders supply X, Y and Z co-ordinates to 10 microns accuracy. The instruments are also fitted with the autocollimator and bridging microscope accessories. The method of observation used is the customary one of independent models.

The co-ordinates are displayed on a digitizer, and recording is currently made on magnetic tape for off-line tape to card conversion. This method has not been very satisfactory due to instances of parity errors and misrecording of data. The firm of W. E. Beveridge & Associates, based at Adelaide, is now building, to the Division's specification, a new digitizing equipment which will include recording on punched cards and typewriter listing, and will also permit the use of alphabetical characters and special symbols. The card punch will automatically interpret the cards, which will simplify their arrangement for the computer programme.

The programme being used is one originally written in 1966 by C. W. B. King.[1] It treats the block as composed of models considered to be invariable units, each with seven degrees of freedom. The resulting $7n$ equations (where n is the number of models) are simultaneously solved by the method of least squares. The $7n$ parameters so obtained are then used to transform all models to the ground system, at the same time averaging values of points occurring on more than one model. The conditions used in forming the equations are:

(*a*) That the transformed values of observations of ground control should as nearly as possible equal the supplied ground values;

(*b*) That the transformed values of observations of points on more than one model should as nearly as possible be identical.

The programme contains sorting routines so that no preclassification of points is necessary, and they may be numbered in any way.

The equations are solved by least squares for the parameters, representing the scales, rotations and displacements of each model; and the values found are subsequently applied to the models to bring them nearer to level and to a preset scale. Since the equations that are solved are linear, and therefore approximations, the process must be repeated. Because a limited number of iterations are necessary, a semi-iterative method of solving the equations is used. Within each strip, the parameters are solved directly, but the sets of strip solutions are iterated in a Gauss-Seidel fashion. In this way, a mean is struck between the large storage requirements of a full direct solution and the large number of iterations normally required for a full iterative adjustment.

It is found that three or four iterations suffice for a strip. For a block, the number varies from seven or eight with a lot of control to 30 or more with minimum control.

The block adjustments provide minor control for compilations of 1:100,000 scale maps, of which there are six to a 1:250,000 sheet, which is the unit used for photographic missions. Such a unit contains about 170 models or 220 models if tie strips are available. Blocks are generally composed of one or two such units. It is intended to increase them to four units where ground control is scarce, but further enlargement would seem inadvisable because of the larger costs of re-runs of the adjustments to eliminate the last remaining small errors.

For all blocks so far computed, the mean-square error of unit weight of an observation computed from the adjustment has been about 20 microns or 1.6 m on the ground (at 1:80,000 scale).

*The original text of this paper, prepared by the Division of National Mapping, Department of Minerals and Energy, Australia, appeared as document E/CONF.62/L.39.

[1] For further details, see "A method of block adjustment", *Photogrammetric record*, No. 29 (1967); and "Programming considerations for adjustment of aerial triangulation". *Photogrammetria*, No. 23 (1968).

Contouring from digitized models

The Division of National Mapping has been using digitized terrain model data (obtained simultaneously with the production of orthophotos from Wild B8 Stereomat equipment) for the automatic plotting of contours

Data formation

The data are derived from a stereoscopic model set up in the Stereomat equipment. X, Y and Z co-ordinates of fine grid points on the model are supplied by encoders attached to the three axes of the machine, displayed visually on a digitizer and recorded on magnetic tape.

The equipment in operation systematically scans the model in the X direction, in a 2-mm strip in the Y direction of the end of the scan and then repeats the process in the reverse direction. During each scan, the X, Y and Z co-ordinates are recorded at 2-mm intervals. In this way, the entire model is scanned automatically; and the result is, in fact, a record of co-ordinates for points on a 2-mm grid over the model. There is overlap of this grid between consecutive models.

Data plotting

The data is processed using an IBM system 360 model 44 computer with peripheral typewriter, line-printer, card-reader, disc and tape unit attachments; and plotted using either an EAI 430/200 or Gerber 522 plotter.

There is a capability to plot contours for single models only, or to plot contours for a 1:100,000 sheet area, i.e., 30′ × 30′, containing approximately 40 models.

Single-model contours

The processing technique for plotting of a single model involves four phases:

(1) The incoming data are examined and a detailed report of each model is produced. At this stage, any errors are detected, examined and corrected if necessary; the data are then compacted on to a master tape;

(2) The compacted output is analysed; and a polynomial interpolation procedure is applied to the scans to form a 1.5-mm mesh, which is then written to disc for future processing. The control points are extracted and written to a control point file. During the analysis, individual scans may be deleted, individual point co-ordinates in the scans may be deleted and control points may be extracted from the tape;

(3) The data are filtered two-dimensionally to eliminate any correlation lag of the Stereomat equipment in areas of steep gradient;

(4) The contour lines and control points are plotted. All the plotting work is performed remote from the programme which generates the plot data. Plot images are recorded on magnetic tape, which is then used to control the plotter as a separate task to that of plot tape generation. Plotter 430/20 is independently supervised by an off-line controller. Plotter 522 is supervised by a multiprogramming task of the processor independently of other processing tasks. The plotter used by any programme is defined at run time; and, consequently, each plotter can be used interchangeably, thus providing back-up facilities should system failures occur with any particular plotter.

Area contour plotting

The plotting of contours for a 1:100,000 sheet area quite obviously requires greater processing time. The process is similar to that carried out for single models, but the models are joined at the selection stage. Each individual model is transformed by Helmert transformation to fit the observed model control co-ordinates to true co-ordinate values which are supplied in two forms:

(1) *Analytical block adjusted co-ordinates:* X, Y and Z co-ordinates are supplied; hence, a three-dimensional transformation is carried out;

(2) *Graphically derived co-ordinates:* a base sheet, on which the sheet corners and adjusted control points are marked, is supplied and digitized prior to model joining. On digitization, the X and Y co-ordinates are available; and, hence, a two-dimensional transformation can be carried out. There is no transformation required for the Z co-ordinates, as the observed Z value is set to the true ground value by levelling the model to the adjusted Z ground values.

For all models transformed, the Z co-ordinate values of the points in the common overlap areas are examined, and an averaging process is applied to derive Z values to which the model grids are adjusted.

The data are then formed into a grid for the whole area, and the filtering and plotting process proceeds as for a single model. Ground control points are not plotted on the contour sheet, but the sheet corners and the 15′ graticule intersections are plotted.

As the data are in a grid form in a ground-based system, there is a capability for plotting contours at any required interval and at any scale consistent with the scale and density of original data.

It is intended in the future to incorporate into the programme software, mathematical corrections for earth curvature, refraction and lens distortion that will permit the use of contact (uncorrected) diapositives in the Stereomat equipment. It is expected that these changes will improve the quality of the orthophotos.

As an interim measure, the processing and plotting are done under commercial contract from data supplied by the Division, while internal capacity is being expanded.

Reproduction of orthophoto maps at 1:100,000 scale

The Division is currently producing orthophoto maps at 1:100,000 scale on 1:100,000 sheet lines as a step in the line compilation process, in general for those areas set down for 1:100,000 compilation and 1:250,000 publication, but also as a final map product.

Orthophotos from Zeiss Topocarts, Wild B8 Stereomats and rectified photographs are being assembled to 1:100,000 sheet lines, and contour overlays are being prepared at 1:100,000 scale for photography with the assembled orthophotos.

The flow chart (see figure 83) shows processing from receipt of the orthophoto map and overlays to the preparation of guide images for scribing of the 1:250,000 map.

Edition 1 can then be issued as an unenhanced orthophoto map with contours and is available for production of a line compilation by marking a transparent overlay to the orthophoto map while viewing it stereoscopically using the orthophoto map and original photographs, through a differential stereoscope.

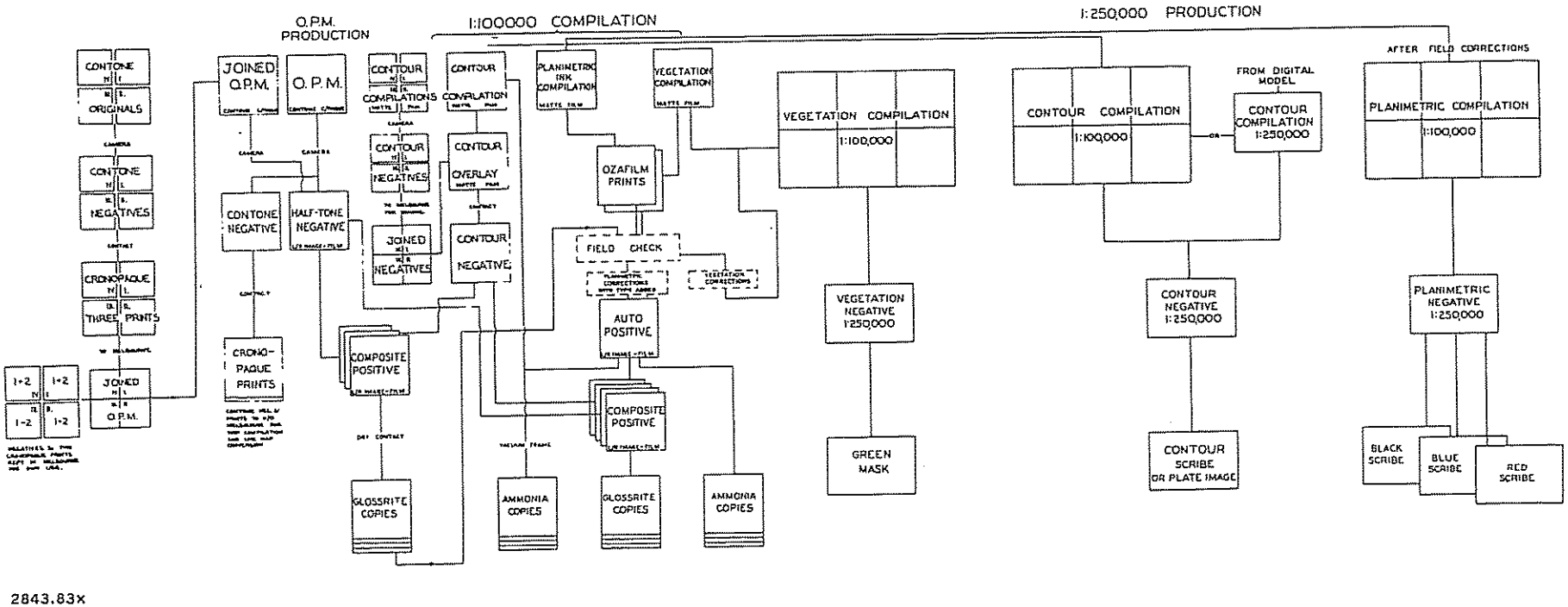


Figure 83. Australia: flow chart for orthophoto map at 1:100,000 scale

The line weights and symbol sizes on the compilation are drawn with mechanical pens on matte film and are suited for reproduction both on the scale 1:100,000 and on the reduced scale 1:250,000, for guide-image purposes. The compiling draftsman does not include names on the line overlays at this stage, although the grid reference, graticule values and contour values do appear in pencil.

When automatic typesetting of the 1:250,000 gazetteer of feature names has been finalized, existing names will then be available on self-adhesive stripping film, for placement on the compilation. Prints of the orthophoto map and line compilation are next used for field completion of map detail; and, subsequently, edition 2 can be made available with contours in black and linework in white, on glossy dye-line paper as shown in figure 84.

Prints of the line compilation only, or the orthophoto map only, can be supplied, if required.

7843 84×

Figure 84. Australia: orthophoto-map print

BLOCK ADJUSTMENT IN AUSTRALIA, 1973*

Paper presented by Australia

As permanent marks and other ground control points are relatively scarce in Australia, it is clear that aerotriangulation and adjustment form an essential part of mapping projects. This paper examines the various approaches followed by the Government and private enterprise and tries to draw general conclusions from the replies to a short questionnaire. Analytical photogrammetry, now firmly established in Australia, relies exclusively on stereocomparator measurements, and programmes for data processing are most frequently based on polynomial adjustment. However, a need is expressed for more rigorous forms of adjustment, to supply data sufficiently accurate for direct use on the ground.

Aerotriangulation is an essential part of a mapping programme. In the context of topographic mapping, few objections could be raised to this general statement. Problems arise, however, if an attempt is made to be more specific. For instance, let it be desired to qualify the statement by the insertion of the word "only". Two places come to mind, either at the very beginning or at the very end of the sentence. The former would be facetious. Surely there are many other essential parts in a mapping programme, although, judging from the extraordinary number of papers published on the subject, aerotriangulation seems to catch much of the limelight. The alternative of placing the word "only" at the end of the statement would belittle the status of aerotriangulation; it can no longer be said that applications are found only in the field of mapping.

The purpose of aerotriangulation is the same as that of classical triangulation in plane and geodetic surveying: the determination of the relative position of points on a surface. It has been a long time since the measurement of angles was the only form of triangulation. Likewise, in plane surveying, techniques have moved away from the direct measurement of sides and angles to determine relative position by means of geometrical elements. Co-ordinates are ultimately the most convenient means of expressing (relative) position, and a much better understanding of the aims of surveying is achieved by regarding all observations in this field as indirect measurements for the purpose of co-ordinate determination.

In the same manner, photogrammetry has progressed far beyond the stage where aerotriangulation meant the construction of minor control points on a map-sheet to constrain subsequent graphical compilation of map detail. Aerotriangulation from aerial photographs is simply a technique of providing X, Y, Z co-ordinates on the ground. Yet, so much of the old tradition still lingers on that one tends to think almost exclusively in terms of mapping control. A map is merely a graphical document, albeit a sophisticated one. As a consequence, even if the ambiguity of conventional symbols as concerns position is discounted, the location of an extremely well-defined point has a precision no better than 0.1 mm. On the map scale 1:100,000, this amounts to 10 m on the ground, and co-ordinates established by aerotriangulation need not have any greater precision.

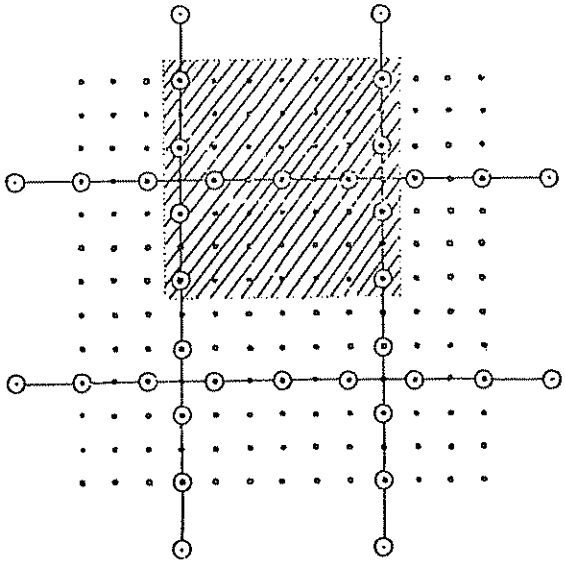
The mistake in the foregoing deliberations, as in many others of a similar nature, is that statements and conclusions are made in terms of map accuracy. Numerical photogrammetry is well capable of producing numbers for co-ordinates without going first through a graphical stage and subsequently digitizing data. Average figures quoted for a single measurement of position and height in a stereo model appear to hover around one part in 5,000 of the flying height (h/5,000), equivalent to 30 microns at picture scale for a wide-angle camera with a focal length of 150 mm. At a minimum flying height of 500 m, a positional precision of 0.1 m is obtained on the ground, a figure that will interest surveyors.

The question arises whether photogrammetry can still be further improved. Recent publications are claiming precisions in the order of 2 microns at picture scale, and it is interesting to find out how these are being achieved. Once more, reference must be made to the power exercised by the traditional approach to aerotriangulation. Aerial photographs are normally used with a 60 per cent forward overlap, only because this is the way in which they are employed for mapping. It may be true that the photographs at first overlapped each other by 80 per cent; but then it is common procedure to select only every second photograph as necessary to achieve adequate coverage. In this way, most points measured stereoscopically appear only in two photographs. Some points will occur in the triple overlap between three adjacent pictures, which means that they will be measured three times; and a very small proportion of points actually occur on the sidelap between adjacent runs, they may be measured five or six times at the most. It is well known that the strongest and most reliable fixes are obtained in the sidelap between runs—so one may ask why the idea of multiple measurements should not be extended to all other points.

The number of measurements of the same point may be increased by using multiple-overlapping photos viewing the point from many different angles. This idea was introduced by D. C. Brown in 1971.[1] Figure 85 gives a typical example of the disposition of ground points and camera stations in a small block. All ground points are premarked, and the photographs are measured in a comparator. Co-ordinates of ground points are calculated using the conditions of perspective geometry created by central projection. A proper and rigorous treatment by least squares also permits the calculation of the precision of derived quantities. In his paper, Brown arrives at a round figure of one part in 150,000 of the flying height (h/150,000), which means that a precision of 0.03 m (0.1 ft) can be achieved from a flying height of 4,500 m. However, it should be pointed out that a special camera was used, including image motion compensation (IMC); and that the camera must be subjected to a very exhaustive calibration. Sophisticated equipment and refined techniques undoubtedly give greater performance, but one must ask at what cost. Being the head of a commercial organization, Brown naturally has not left

*The original text of this paper, prepared by S. G. Bervoets, University of Melbourne, Australia, appeared as document E/CONF 62/L.40.

[1] D. C. Brown, "Analytical aerotriangulation v. ground surveying", paper submitted to the Symposium on Computational Photogrammetry, sponsored by the American Society of Photogrammetry, 1971.



O exposure station
⊙ target
Hachured: area of one photograph

2843.85x

SOURCE: D. C. Brown, "Analytical aerotriangulation *v.* ground surveying", paper submitted to the Symposium on Computational Photogrammetry, sponsored by the American Society of Photogrammetry, 1971.

Figure 85.
Australia: example of multiple-overlapping photographs

his aspect uncovered. If one is to believe him, the cost is far less than a conventional ground survey; and considering that his proposed method requires less primary control than conventional ground surveys, he finds that this saving actually pays for the photogrammetry, with the result that the photogrammetric cost is nil. Such arithmetic may be valid from an over-all national point of view; but an organization wishing to establish co-ordinated points on the ground will always be involved in direct cost. The inference that may be drawn from Brown's paper is that at about the same cost it would be possible to determine ground co-ordinates by photogrammetry with a precision of the same order as ground surveying. Following Brown's investigations, it is clear that aerotriangulation would be capable of much more than providing control for mapping only.

Bearing in mind the vast amount of work that faces Australia in connexion with the introduction of integrated surveys on the basis of co-ordinates, it will be worth while to follow the developments of high-precision aerotriangulation.

QUESTIONNAIRE

To collect information on the practice of aerotriangulation and block adjustment in Australia, a short questionnaire was sent to both government agencies and private organizations. Surveys of this kind are the order of the day; and if not already over-stuffed, one is certainly running the risk of indigestion when trying to absorb all the facts. Therefore, a decision had to be reached as to which information to seek and not become involved in an unmanageable task.

It would be interesting to find out about the amount of aerotriangulation being done, the rate of production and the accuracy delivered. However, with respect to accuracy, scarcely anything new could be added. As long as all procedures continue to be based on the standard overlap of 60 per cent in the flight direction and 30 per cent across, it is unlikely that the precision can be improved beyond, say, 10 microns at picture scale. Thus, in view of the fact that aerotriangulation appears to be used exclusively for mapping, there is even little need in Australia to go beyond that precision, at least not for the time being.

With respect to rates of production, the general conclusion appear to be that analytical photogrammetry yields the greatest benefits. Because of the simple instrumental procedures on a comparator, a much larger number of models can be processed during a given time than when using an analogue instrument. Most government organizations use stereocomparators of the conventional type, i.e., operator-driven; one Commonwealth government agency and one private consulting firm use a Nistri AP/C analytical instrument.

Australia is a vast country, and much work is yet to be done in surveying and mapping. Rather than quibbling about who turns out most models per day, one finds a sense of urgency to get on with the job. At this stage, it appears more important to maintain production while satisfying the current standards of accuracy than to improve on these standards. For this reason, it was decided to limit the questionnaire to production methods and to inquire about the work to which aerotriangulation is applied.

Questions relating to the following subjects were asked:

(1) Purpose of aerotriangulation;
(2) Photographic data;
(3) Density of new control required;
(4) Distribution of ground control used;
(5) Methods;
(6) Equipment;
(7) Programmes for electronic computing;
(8) Procedures of electronic data processing (EDP);
(9) Problems encountered;
(10) General comments on the system adopted.

The remainder of this paper attempts to bring together the diversity of replies received from all but two of the 13 organizations receiving the circular.

PURPOSE

One may ask what the purpose of aerotriangulation is and why it is used. Apart from the obvious answer (that of providing control for mapping), quite a few other interesting aspects emerged from the replies to the questionnaire. They may be loosely placed in the following groups:

(*a*) Establishment of pass points for the absolute orientation of individual models during map compilation; subdivided into: three-dimensional control; and horizontal pass points only;

(*b*) Provision of control, at first for mapping at 1:100,000 scale and to be readjusted later for 1:50,000

mapping without repeating the aerotriangulation observations;

(*c*) Checking of the quality of field surveys;

(*d*) Setting-up of a framework of reference points ensuring homogeneity between a large number of map-sheets (scale 1:500);

(*e*) Provision of pass points for orthophoto maps and cadastral compilations;

(*f*) Establishment of co-ordinated permanent marks for survey integration;

(*g*) Determination of cadastral boundaries for land title registration

Concerning category (*a*), it is interesting to note that a fair amount of horizontal triangulation and block adjustment is still being done, mainly for large-scale projects requiring good vertical accuracy. In those cases, it is considered desirable to establish many more vertical points than for topographic mapping; and as spirit-levelling is commonly used, covering the terrain in long sweeping courses almost throughout the block, one may as well establish a vertical control point at the corners of each model. It adds very little to the cost of field-work; and one avoids the aerotriangulation for the vertical dimension, which is still the weakest form of photogrammetric co-ordination. This aspect may have prompted the Division of National Mapping to establish vertical control by non-photogrammetric methods. A special laser airborne profile recorder was developed for this purpose, and one instrument is capable of measuring at least 1,500–2,000 km of profiles every week. Coupled to this, the Division of National Mapping employs the technique of slotted templet assemblies to control equally vast areas in the horizontal sense. The most recent lay-down covered roughly 800,000 km^2, comprising 4,000 models and 110 map-sheets at 1:100,000 scale. Slotted templets are not everybody's forte (many refinements have been incorporated by the Division); but at this stage, not many programmes are available that are capable of handling such a vast amount of data on a computer.

It is clear from category (*b*) that the large mapping organizations in this country are operating on the basis of long-term planning. Though aerotriangulation provides control at a much more reasonable cost than ground surveying, one will not dismiss lightly the opportunity to use the same data for more than one purpose. Of course, the density of pass points required for 1:50,000 is twice as high as that for 1:100,000, which is possibly the reason that analytical photogrammetry is used so often because it is a more convenient method of handling increased amounts of data. On the other hand, comparator measurements do permit the end-results to be used at a larger scale than the photographs, which would, perhaps, not be the case with slotted templet assemblies.

Many surveyors will frown at the third purpose being mentioned for aerotriangulation, i.e., checking field data. One may ask if photogrammetry does not depend upon field surveys, how then can their quality be checked. Perhaps too much reliance is placed on field data; i.e., often the amount of redundant information is reduced to the bare minimum. If there is any mistake in the provision, or use, of field control, it will not be found in those circumstances; and the photogrammetric data will be stretched to accommodate the mistake. Being aware of this, many will put in more ground control than strictly required; but, strangely enough, it reverses the roles. Photogrammetry has an awkward way of showing up inconsistencies (without necessarily being able to resolve them), and blunders in the field data just cannot be passed. Question 9 of the questionnaire refers to problems encountered in the whole system of aerotriangulation and block adjustment by EDP. It was somewhat surprising to discover that problems do not seem to bother the respondents to the questionnaire very much. Some admitted to having no problems—other than occasionally with field data. Two replies frankly stated that the error incidence with respect to control was as high as 10 per cent. It may console some people to know that the majority of the mistakes can be traced back to the transcription of field notes during data processing. There is no intention here to perpetuate the mild animosity between field and office staff often centred around field control, and surely photogrammetrists make as many mistakes as surveyors. One would have thought that more conscious effort would be devoted to their detection and elimination.

Categories (*d*) and (*e*) refer to the provision of a network of pass points on the photo to control other map or plan units at a larger scale. In project work, the photographs are often enlarged so many times in the stereoplotter that the overlap cannot be fitted on the plotting-table. It has to be broken up into smaller sections, as shown in figure 86 and to ensure there shall be continuity along the edges of the sections, they must be fitted to common pass points. This is true also for orthophoto maps, which are often controlled by smaller scale photography.

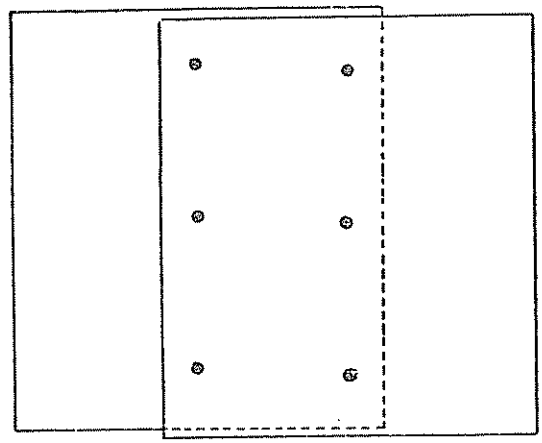


Figure 86. Australia: normal density of pass points

The last two categories herald a new application o photogrammetry in Australia: the determination o ground co-ordinates for survey integration and registra tion of ownership. Current techniques of aerotriangula tion have proved sufficiently accurate for the definitio of mining leases in remote areas.[2] A considerabl amount of developmental work will have to be done both legally and technically, before definition of prc

[2] P. M. Byrne and J. G. Roberts, "Photogrammetric survey c mineral leases in the Hamersley Range, Western Australia", *Th Australian Surveyor*, vol. 23, No. 7 (1971), pp. 426–471.

perty is possible by photogrammetry in urban areas. On the technical side, there is quite a promise in the multiple overlaps mentioned above. A summary of applications of aerotriangulation is given below in table 1.

Photography, control and applications

Questions 2, 3 and 4 of the questionnaire sought information on the end-product of aerotriangulation and the source materials from which it is derived. The basic and most common pattern of co-ordinate points produced by photogrammetric triangulation is shown in figure 86, obviously for the control of stereo models for map compilation. No replies were received concerning the use of aerotriangulation for the determination of a multiplicity of points on the ground directly from the photography used for triangulation (as proposed by Brown in 1971). Where photogrammetry is indeed employed for co-ordination on the ground, the basic pattern of pass points remains the same as in figure 86. They are subsequently used for the control of larger scale photography from which the ground co-ordinates are finally derived. Source materials comprise aerial photography and control. Both Wild and Zeiss aerial cameras are used in Australia, predominantly with a format of 230 × 230 mm and focal lengths of 85–89 and 150–152 mm. Photographic coverage, when arranged in blocks, is normally flown east-west in areas of 1° latitude × 1½° longitude, or multiples or fractions thereof as related to map-sheet boundaries.

Concerning ground control, most mapping agencies prefer using features selected after aerial photography. In the rather featureless outback of Australia, the selected points are often identified by means of large-scale spot photography from low altitudes. A Polaroid camera giving an instant picture is considered by many to be ideal for the purpose, there being no risk of drawing a blank film after development at the head office much later. Targetted control, premarked before aerial photography, is also used; in one organization, it is the only way of providing control.

With respect to the number of ground control points, the following observations may be made. First, a great many more vertical control points are needed than horizontal points, owing to the difference in accuracy between vertical and horizontal block adjustment. For many years, blocks have been adjusted on nine horizontal control points spaced regularly throughout the block; but the current tendency is to have perimeter control. Vertical control continues to be provided in bands at right angles to the flight line, as shown in figure 87, which gives a typical example of photographic coverage and ground control used. For large-scale mapping, there is still a preference for fully controlled models (four points) in the vertical dimension, with XY control established by horizontal block adjustment. Table 1 gives a sample of the kind of work to which aerotriangulation is applied in Australia.

Methods and equipment

Analytical aerotriangulation with the aid of stereocomparators is well established in Australia. A rapid count from the returns to the questionnaire gives three Hilger and Watts comparators, five Stecometers, two Nistri AP/C analytical instruments, one Zeiss PSK comparator and a few other assorted pieces of equip-

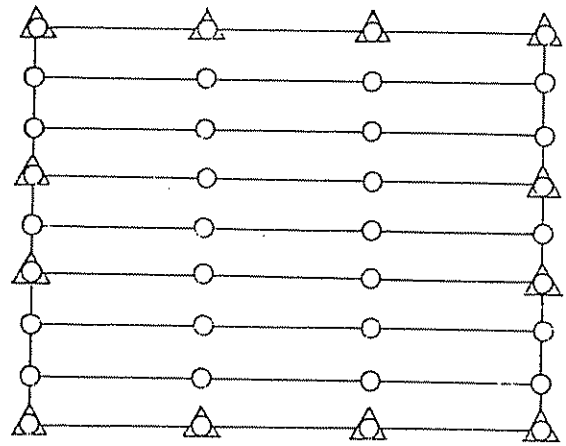


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Figure 87. Australia: normal control pattern

ment. The Hilger and Watts instruments are being phased out as they are no longer manufactured. A Stecometer is probably the cheapest of the stereocomparators for which good service and maintenance are available in Australia. Most people report that if there is any trouble with the instrument, it is usually in the (mechanical) co-ordinate registration device; and it is therefore interesting to note that, recently, the first delivery took place of a Stecometer interfaced with a solid-state electronic digitizer (Dell Foster from the United States of America). The rather awkward manner of introducing the photo/base in the Stecometer has led to the omission of the measurement of the fiducial marks on the photographs. Some cameras in use do not even have point marks for the fiducials, so that reliable measurements cannot be made in any case.

A major advantage of the systems currently in use derives from the fact that a human operator is involved only in controlling the movements of the comparator and setting the floating mark. Thus, observational and clerical mistakes are avoided in data recording which is completely automatic. An additional advantage of the Nistri AP/C analytical plotter, by the way, is that the control of the instrument (i.e., the operation of guiding the instrument to the various points to be measured) is also automatic; and, as a result, an enormous output can be claimed (20 models per day).

Data recording is predominantly by means of punched cards—a few instances are quoted of the use of punched paper-tape, but it appears to be declining as a direct form of data input to a computer. To err is human; hence, some improvement can be expected from the use of automatic data-recorders. However, these instruments seem to err as well; and much time can be lost by data errors, particularly when cards have to be taken elsewhere to be batch-processed on a computer. One organization reports it is considering putting the comparator on line to the computer so that data can be checked in real time (i.e., next-to-no-time while measurements are in progress).

A certain amount of analogue triangulation is still being done; but only where smaller organizations, not in possession of comparators, wish to do their own triangu-

Table 1. Representative sample of applications of aerotriangulation

Application	*Topographic maps*	*Topographic maps*	*Topographic maps*	*Base maps*	*Project*	*Topographic maps*	*Topographic maps*	*Topographic maps*	*Cadastral maps*	*Project*
Map scale	1:100,000	1:50,000	1:25,000	1:4,000	1:2,000	1:100,000	1:50,000	1:10,000	1:2,500	1:500
Contour interval (metres)	20	20	10	2	1	10	10	5	2	0.5
Flying height (metres) .	7,000	7,000	8,400	2,400	1,200	7,000	7,250	5,175	2,500	650
Photo scale	1:80,000	1:80,000	1:55,000	1:16,000	1:8,000	1:80,000	1:85,000	1:60,000	1:16,000	1:4,000
Camera	SWA(88)	SWA(88)	WA(152)	WA(152)	WA(152)	SWA(88)	SWA(85)	SWA(85)	WA(150)	WA(150)
Block size:										
Runs × models	4,000 models	8 × 20	6 × 20	6 runs	Irregular 10. – 60 models	8 × 20 models	8 × 20	8 × 20	4 × 4	Mostly strips
Latitude × Longitude	5° × 6°		½° × 1°	5 × 6 km		1° × 1½°				
Control:										
Number of horizontal points	Perimeter, ½° interval 16 (perim.) Internal, 1° interval		16	16	Irregular	11 (perimeter)	16 (perimeter)	16 (perimeter)	Perimeter	Every five models
Number of vertical points	Profiles	4 × 9	20–40 (irregular)	Fully controlled	Fully controlled	4 × 9	5 × 9	5 × 9	Fully controlled	
Aerotriangulation	*XY* (templets)	*XYZ*	*XYZ*	*XY*	*XY*	*XYZ*	*XYZ*	*XYZ*	*XY*	*XYZ*

lation in instruments that actually reconstruct the geometry of stereo overlaps. Some years ago, there was much discussion of aerotriangulation by independent models, which permits owners of instruments basically designed for plotting (Kern PG2, Wild A8, Zeiss Stereometrograph) to do their own aerotriangulation without having to invest in special equipment for the purpose. Very little has come of it. Only one agency reports on its current use (with a Stereometrograph), while another government instrumentality is proposing to introduce it, using Kern PG2 with automatic data-recording.

In the context of this discussion, another mention must be made of templets. With various improvements incorporated in the technique of slotted templet laydowns, the one organization still using it claims an accuracy of pass points of ± 0.15 mm at photo scale. Some users of analytical photogrammetry report limited computer capacity as one of their problems; and this difficulty, of course, is overcome by large slotted templet assemblies. It is noteworthy to see the Jerie analogue computer still being used for height as a mechanical device giving an immediate and visible display of the interaction between overlapping runs during adjustment.

Data processing

Programmes selected for the processing of comparator measurements follow the same pattern in almost all cases, and one can distinguish the following stages:

(*a*) Reduction of comparator measurements to fiducial axes of photographs;

(*b*) Model and strip formation (usually in one operation) at the scale and orientation of the first photograph;

(*c*) Strip adjustment or simultaneous strip adjustment (block adjustment).

From the returns to the questionnaire, it was not clear to what extent image co-ordinate refinement is applied to the first stage (i.e., making allowance for camera distortion, refraction, etc.). With respect to the third phase, one finds in Australia a predominance of polynomial strip adjustments, most of them derived directly or indirectly from programmes written by G. H. Schut and published by the National Research Council of Canada. Another programme in use adjusts the horizontal co-ordinates by subjecting all stereo models to a simultaneous linear co-ordinate transformation.[3] It is basically a digital form of Jerie's analogue computer, and it has been employed successfully in connexion with large-scale projects where heights are supplied by spirit-levelling.

To put a system of data processing into operation requires a large amount of planning, effort and perseverance. It was noted that all organizations carrying out aerotriangulation have written their own programmes for the computer installations available to them, and no programme packages appear to have changed hands. The reason for this situation may be found in the fact that a considerable amount of work is still necessary to adapt a programme to a particular computer, even though a ready-made programme that operates on a different system may be purchased. Schut's programmes were readily available without charge, which explains why they are found so frequently in Australia. The basic mathematics had been worked out, and the users were able to amend the programmes to suit their own particular needs.

Although accuracy was not the primary object of this paper, a summary is given here of the references made to accuracy in the replies to the questionnaire. Some "remedial arithmetic" has been applied, in order to give the reader a general impression only of the order of magnitude of precisions reached. The figures represent averages and have been rounded off to the nearest 10 micrometres.

In Australia, there is currently a great deal of interest in a more rigorous approach to the adjustment of aerotriangulation. Motivation is twofold: first, there is a need to improve upon the order of accuracy, evident from table 2; and, secondly, some users are looking for a more objective method of isolating data errors than is possible from visual inspection of residuals produced by polynomial transformations. It appears that a series of programmes developed by what was formerly the United States Coast and Geodetic Survey will be used eventually, again because they are readily available without charge. However, their adaption to other computers proves to be quite a problem because of their complexity.

Table 2. Average accuracy of adjustments
(Micrometres at picture scale)

Category	*Mean square error (μn at picture scale)*	*Tolerance (μm) used for rejection of measurements*
1. Comparator measurements		10
2. Residual y-parallax in relative orientation	10	20
3. Co-ordinate differences between adjacent models	20	40
4. Residuals after horizontal polynomial block adjustment	70	
5. Residuals on vertical control points after polynomial strip adjustment	30	
6. Residuals horizontal block adjustment (model adjustment)	30	

Problems encountered in data processing

A specific question on the subject of problems encountered in data processing met only with a moderate response in the replies to the questionnaire. Difficulties in EDP seem to arise mainly from errors in: (*a*) source material (both field control and photogrammetric observations); and (*b*) data input media.

For some time in the past, it was believed that automatic data-recording would solve all the problems of mistakes and blunders caused by humans. As it has been found that machines also have lapses in their performance, data checks are absolutely necessary throughout the whole process of calculation. Some organizations rely mostly on visual inspection of intermediate results, while others are building more and more error routines into their programmes to detect and reject data errors. It is a subject that still bears much research. Lastly, a common problem concerning EDP

[3] S. G. Bervocts, "Horizontal block adjustment", *The Australian Surveyor*, vol. 23, No 5 (1971), pp 304–317.

seems to be the limited capacity of computers currently in use. Either the super-computer or the clever programme seems to be sure of a job in the future.

Conclusion

The last question asked concerned the reason the current systems adopted by the various organizations appeared to be the most suited to meet their requirements. Before summing up, one observation can be made in connexion with what appears to be a tacit agreement: high precision is not the first objective of aerotriangulation and block adjustment; instead, one wishes to obtain reliable results. It is fortunate that the reliability of results can be improved by better and more advanced programming; but to increase the precision, it will be necessary to improve the quality of source data.

Most frequently, the reason for adopting a particular system referred to the fact that the programmes had been built up over the years by the organizations themselves on the basis of their experience. Another reason often supplied was that the work of surveying and mapping the country simply had to be set in motion, so one could not waste too much time in deliberating for years on what would be the best system. Lastly, some argued that, although they felt the need for introducing more powerful systems, there was simply no time for experimentation because too many target dates had to be met.

THE PROGRESS OF PHOTOGRAMMETRY AS A MEANS OF GEODETIC POINT-POSITIONING*

Paper presented by the United States of America

Early history of photogrammetry

In retrospect, photogrammetry, as a method of point positioning, has progressed considerably from the days when it was referred to as fence-post geodesy. Truly, it had a humble beginning with photographs taken by Laussedat from a balloon in 1858. However, it is no one's fault that Niepce invented the photograph 81 years before the Wright brothers launched their flying machine at Kitty Hawk, North Carolina. At least, during that intervening period, the geometry of the photograph was worked out. The facts—that tilt in the photograph and changes in elevation in object space due to the central projection required certain transformations to yield an orthographic projection of object space—became understood.

The early photogrammetrist realized that efficiently to take advantage of these geometric relationships, one must cover as large an area as possible in a single photograph. Further, the principle of double-point resection had been developed, and the concept that one could bridge control by relating the geometry of one photograph to the adjoining one through the information contained in the area common to each became apparent. Despite the arduous task of computing with logarithms, the first photogrammetric extension was reduced by Pulfrich in 1920.[1] This analytical approach was necessary because Pulfrich had designed the stereocomparator, while the Zeiss C4 stereoplanigraph, with base-in, base-out capability which was required for tying models together, was 10 years from being; however, the possibility was already foreseen in 1924 when the model C2 was designed.[2] Pulfrich's project involved the mapping of several islands and a stretch of the coastline of the Netherlands from oblique photos. The results were unsatisfactory, with errors in scale up to 10 per cent and in azimuth up to 7°; however, Doyle notes that the amount of control used was inadequate even by current standards.[3] One may wonder why the stereocomparator had been developed, since the analytical photogrammetric problem, in which the positions and orientations of the aerial photographs had to be determined, was impractical. However, the intersection of a point in space (the other part of the problem) is a fairly simple computation and was commonly used with terrestrial photogrammetry, where the positions and orientations of the photo-theodolite were first obtained by conventional survey methods.

With the development of universal stereoplotting instruments, such as the C4 stereoplanigraph, the analytical photogrammetric approach was abandoned as a practical method of extending control. Although the theory and technology for photogrammetrically extending control was at hand, the process had accuracy limitations which restricted its use. Even with wide-angle cameras, the photogeometry hampered the accuracy of vertical measurements; while, at the same time, the vertical map accuracy requirement was always more stringent than the horizontal requirement. As a result, bridging to establish horizontal control was frequently used, while the vertical control with four or five points per model was established in the field. This procedure also made sense vertically, because the establishing of vertical control was approximately 20 per cent as costly as horizontal control in those days. Currently, however, where fourth-order accuracy is required, both horizontal and vertical control may be run concurrently. During the 1940s and 1950s, when bridging with the universal first-order instruments was at its peak of popularity, a vertical accuracy of 1:5,000 of the flight altitude could be expected for the first-order instrument, camera, and film combination. Photography for large-scale military mapping was flown at altitudes of 10,000–20,000 ft above mean terrain and at 30,000 ft for medium-scale mapping. The flight altitudes were always dictated by the contour interval required and by the double-projection type of instruments available for stereoplotting.

The usual method of extending control involved tying successive models together for a strip of photography and then adjusting the strip of model co-ordinates to the

*The original text of this paper, prepared by Car J. Born, Chief, Geodetic Control Division, Defense Mapping Agency Topographic Center, United States of America, appeared as document E/CONF.62/L.57.

[1] Frederick J. Doyle, "The historical development of analytical photogrammetry", *Photogrammetric Engineering*, vol. XXX, No. 2 (March 1964); Carl Pulfrich, *Ueber Photogrammetrie aus Luftfahrzeugen und die ihr dienenden Instrument* (Jena, Gustav Fischer, 1919) (original reference).

[2] O. von Gruber, *Photogrammetry, Collected Lectures and Essays* (Boston, Massachusetts, American Photographic Publishing Co., 1942).

[3] Doyle, op. cit.

field-established control. Besides the systematic error propagated from the imperfect compensation of camera distortions in the stereoplotting instrument, the results were also plagued by the unfavourable propagation of accidental error. The principle involved is known as double summation. Consider an error which affects the slope of the first stereo model in the direction of flight. This affects the second model and, due to the slope and distance, causes an error in elevation of twice that of a point in the same relative position in the first model. In the *n*th model, the error in elevation is *n* times that in the first. The same thing occurs in the second model; that is, it has an error of its own which also linearly propagates through the extension. As a result, instead of the error propagating as the square root of the number of models bridged, the errors propagate with the three halves power of the number of models. This is a condition which in the past has encouraged the use of two scales of photography, one for bridging and one for plotting. Here one is comparing the loss of ground resolution as a linear function of scale, but gaining as a function of the three halves power of the (fewer) number of models bridged.

With the capability for rapid computations available through the use of electronic computers, interest quickly shifted towards the application of analytical photogrammetry. It is interesting to recall von Gruber's comment on the application of analytical photogrammetric methods, "The calculation of resecting in space either by the direct or the differential method, is merely a waste of time and is of minor practical importance".[4] Even Church, who introduced his own system of analytical photogrammetry, thought of it as a tool for teaching theory rather than as a practical production method. Despite such early thinking, from a practical standpoint, the advantages envisioned in the use of analytical methods lie in the refinements of mensuration, distortion corrections, refraction corrections and camera parameters. When the early programmes had been debugged and comparison tests were made between analogical triangulation (stereoplotter) and analytical triangulation, the small improvement resulting from the analytical methods was rather disappointing. However, the limited improvement in accuracy is not surprising when one considers the methods used. The adjustment procedures were the same as with the analogical triangulation, except that the three-dimensional stereo model had been replaced by its mathematical representation. Obviously, the stereoplotter instruments were capable of retaining most of the geometric fidelity and resolution in the imagery recorded through the aerial camera. At that time, the simultaneous adjustment of large blocks of photographs was more conceptual than practical, for such adjustments taxed even the large computers of the late 1950s.

The work of Schmid, Brown and Herget[5] in the late 1950s led to the development of the programmes for the simultaneous adjustment of large numbers of photographs. Schmid's objective was towards the plotting of missile trajectories by photogrammetric methods, while Brown's purpose was for geodetic positioning by flare triangulation. It is interesting to note that only the work of Herget was originally designed specifically for aerotriangulation. The importance of their work is that their concepts for the simultaneous adjustment of large blocks were later incorporated into usable programmes exclusively intended for aerotriangulation. Of particular concern is the impact that these programmes have had on the flexibility of using auxiliary data and the accuracy attainable. Auxiliary data could be used as weighted constraints on the unknowns.[6] Recent tests using simulated data have shown that the technique of employing the simultaneous adjustment of bundles of rays, which is the principle of the Schmid and Brown methods, yielded reductions in errors of 26–68 per cent for planimetry and 20–42 per cent for heights. This compares with the sequential procedures; that is, where models are tied sequentially into strips and the strips are then adjusted sequentially into blocks, using polynomial approximations to compensate for systematic errors. Apparently, the unfavourable effects of error propagation (double summation), previously mentioned, are minimized in the simultaneous adjustment of photographs.[7]

Although the simultaneous adjustment had been emphasized as making a major contribution to the accuracy currently attainable in point positioning, there were other significant contributing factors, such as improved film, camera resolution, camera calibration procedures, and measuring equipment precision. These factors all influence the accuracy with which object space can be measured from the photographic imagery. Stable base aerial films with a resolution of 50 lines or more per millimetre at a contact ratio of 1:1.6 are currently used. The cameras also have a resolution (Area Weighted Average Resolution, or AWAR) of about 50 lines per millimetre, and their interior orientation parameters are determined with a precision that is from 10 to 20 times better than it was 20 years ago. Sophisticated analytical calibration systems are used, employing the simultaneous reduction of a large number of exposures to ensure complete coverage of the camera format with star images as targets. Even tangential distortion, which in the past was measured, but ignored, is now expressed with a mathematical function and corrections applied numerically as part of the analytical triangulation solution. Thus, with the current state of technology, one can expect the accuracy of the processed film, including camera errors, to be in the range of from ±4 to ±7 micrometres.[8] In considering the simultaneous analytical solution with aerial photographs of high quality, one is combining a solution which minimizes the effect of error propagation with photographs having very little inherent distortion. No wonder, then, that vertical accuracies of 1:24,000 and horizontal accuracies of 1:20,000 of the flying height have been attributed to such a solution.[9] If, despite all the refinements described above, a systematic pattern of error is still observed, a further refinement

[4] Von Gruber, op. cit.

[5] H. Schmid, *A General Analytical Solution to the Problems of Photogrammetry*, report No. 1065 (Aberdeen, Maryland; Ballistic Research Laboratories, July 1959); D. Brown, *A Solution to the General Problems of Multiple Station Analytical Photogrammetry*, RCA Data Reduction technical report No. 43 (New York, 1958); R. Matos, "Analytical triangulation with large and small computers", *Photogrammetric Engineering*, vol. XXIX, No. 2 (1963)

[6] J. Case, "The utilization of constraints in analytical photogrammetry", *Photogrammetric Engineering*, vol. XXVII, No. 5 (1961)

[7] J. M. Anderson, *Summary of Working Group Reports*, International Society of Photogrammetry; Commission III, Aerotriangulation (Ottawa, Canada, 1972)

[8] M. Ahrend, "Analysis of photogrammetric errors", paper submitted at the 30th Programmetric Weeks. Karlsruhe, Federal Republic of Germany, 1966.

[9] G. C. Tewinkel, "Block analytical triangulation", *Photogrammetric Engineering*, vol. XXXII, No. 6 (1966)

may be introduced through the application of linear least-squares interpolation—a concept originally devised by Moritz for smoothing gravimetric observations and later applied to photogrammetric problems by Kraus.[10]

Modern applications

After recounting the improvements which have taken place over the past 20 years, the question is whether full advantage is being taken of these improvements and, if not, how it can be. If the accuracy requirements have not changed, then it obviously should be possible to use smaller scale photography and still obtain the same accuracy. The benefits should cascade; the accuracy of the block solution leads to fewer models and the efficiency of the analytical reduction will increase, because of the fewer photographs which have to be measured and computationally processed. Furthermore, the amount of field control required will be reduced, and the pattern in which it should be distributed will facilitate the work of establishing it. The overwhelming advantage of horizontal control around the perimeter of the project has been demonstrated through simulations and actual practice.[11] In addition, the use of 60 per cent sidelap between strips of photographs, instead of 20 per cent, increases the vertical accuracy from 1.4 to 2.0 or even more.[12]

As a practical example, taken from a military application, the increased accuracy from smaller scale photography has led to the production of so-called "point-positioning data bases". A base consists of an orderly array (block) of photographs and their corresponding positions and orientations, as derived from an analytical block triangulation. These photographs are used in the field, with appropriate equipment, for determining the geodetic positions and elevations. When one considers that comparators are portable, small electronic calculators are fast and powerful, and the photogrammetric intersection problem, even with associated transformations, is straightforward and comparatively simple, the use of photographs in the field seems realistic. It is recognized that such a system cannot be carried in a soldier's hip pocket like a map. However, in comparison with a map as a means for point positioning, the data base is more cost-effective to produce and requires less elapsed time for preparation. It is also, in practice, more accurate, because the inherent accuracy of the photograph is not degraded through the compilation, scribing and reproduction processes which affect the map. Furthermore, the data base provides for the identifying and positioning of more features, since with a map one is capable of accurately scaling positions of only those features which have been symbolized. The practicality of the idea rests with the use of small-scale photography. This becomes apparent in recognizing that a single model of wide-angle photography on the scale 1:140,000 will cover 80 per cent of the area of a 1:50,000 scale map and that even greater coverage is attainable from super-wide-angle photography from lower flight altitudes. This example is not unrealistic when one considers that the United States Geological Survey has used photography flown at 69,000 ft for preparing an experimental orthophoto map on the scale 1:50,000—obviously, the resolution must be exceedingly good to permit an approximate three-time enlargement and still have detail interpretable to the unaided eye. In comparing the point-positioning data base to conventional survey methods, it is obvious that the data base technique will save considerable time and cost compared with extending control by field methods.

The following example illustrates the inherent accuracy attainable in a block adjustment using photography on the scale 1:102,000 obtained with a super-wide-angle camera. The project area was rectangle with dimensions of approximately 60 × 115 miles. Only perimeter horizontal control was used. However, five bands of vertical control were used as the photography was flown with 20 per cent sidelap and control was already available. One of the advantages of block solutions with small-scale photography is that, frequently, sole dependence can be placed on existing control because of the large area covered by a single photograph. Of course, the control must be photo-identifiable; but when it is not, ties to identifiable features can be made with less expense than extensive surveys. In this project, none of the control, whether used for the solution or as check-points, was panelled; and only those points which were obviously misidentified were discarded. The accuracy of the results based on withheld control points (not used in the solution) was $\sigma_N = \sigma_E = 16$ ft, and $\sigma_h = 19$ ft. If one considers the horizontal error in the centre of the project area with respect to the nearest horizontal control point, or, in other words, a distance of half the project width, then the relative accuracy is 1:10,000 of the distance. It may be argued that the error in the centre of the adjusted block is not representative of the standard error; but theoretical studies previously mentioned, which show the insignificant contribution of horizontal control in the centre of the block, would refute such an argument.

Although the project described above was designed for testing the point-positioning data base concept for military use, the same principle would apply if the project had been designed for such civil uses as cadastral mapping, dam-site planning and other economic development projects. Such applications, of course, are not new; but emphasis is placed on the more efficient use that can be made of generating control by photogrammetric methods. Such areas as, swamps or jungles, which are not readily accessible on the ground for running surveys, can be skirted by using perimeter control and still be mapped.

Future trends

In looking to the future, it might be interesting to speculate on what advancements one might expect. Auxiliary data for determining the position and attitude of the camera at time of exposure and for obtaining model scale have been useful in the past, particularly for bridging very large areas, but usually only where horizontal accuracy requirements greater than 20 m and vertical requirements of 15 m or less would suffice. The current state of the art is well covered by Zarzycki.[13] This

[10] K. Kraus, "Film deformation correction with least-squares interpolation", *Photogrammetric Engineering*, vol. XXXVIII, No. 5 (1972); K. Kraus and E. Mikhail, "Linear least-squares interpolation", *Photogrammetric Engineering*, vol XXXVIII, No. 6 (1972)

[11] B. Kunji, "The accuracy of spatially adjusted blocks", paper presented to the International Society of Photogrammetry, Commission III, Lausanne, Switzerland, 1968.

[12] H. Ebner, "Theoretical accuracy of models for block triangulation", invited paper, International Society of Photogrammetry, Commission III, Ottawa, Canada, 1972

[13] J. M. Zarzycki, "The use of auxiliary data in aerial triangulation", invited paper, International Society of Photogrammetry, Commission III, Ottawa, Canada, 1972

is a fertile field for improvement. The Terrain Profile Recorder (TPR) as an elevation determining system, for example, is restricted by the knowledge of the slope of the isobaric surface, although the camera-to-ground distance can be accurately measured by a laser beam. If it is not possible to improve the knowledge of the barometric pressure gradient, then, perhaps, an accurate instrument for attitude determination at time of exposure would be better. Much work has already gone into the development of such systems. A greater motivation for perfection may come from the application of coherent radar and infra-red sensors, where the geometric fidelity of the imagery is highly dependent upon how well the exterior orientation of the sensor is known.[14] Aerodist has performed well as a distance-measuring system with an accuracy of x and y co-ordinates of the camera stations in the order of ±5 m and is probably the most accurate system currently in extensive use. The long-range position-determining system, currently under development and testing by the United States Army Engineer Topographic Laboratories, could be modified to provide air-station positions. These positions currently constitute an intermediate step in the process of positioning a point on the ground. They are discarded in the reduction process that has been designed for the system. When the long-range system becomes operational, it could, with minor modification, provide the Army with a capability for positioning a photographic aircraft—an application for which the system was not originally intended. The technical feasibility of using the Doppler principle with the beacon in the aircraft and Geoceivers for tracking purposes has been theoretically demonstrated. The desirability of such a system rests in the simplicity and portability of the equipment.

Certainly, the flight altitudes will increase for the reasons previously mentioned. The cameras may be calibrated in flight using the artificial star field.[15] Such a calibration would assure correction for any changes in the interior orientation elements attributable to the in-flight conditions. The pantoric camera, developed by Scripto Inc., with toroidal optics shows promise for the future. Its favourable characteristics are high. It combines the advantageous features of the panoramic camera with the stable geometry of the cartographic camera; that is, the field of view is 20 per cent (half-angle) in line of flight and 150 per cent cross-flight, with a resolution (AWAR) of 40 lines per millimetre for a nominal 3-inch focal length. A revolutionary change in aerial cameras could result from the use of electro-optical imagery (charge-coupled device). This technology has been developed by Fairchild Camera and Instrument Corp. If the film with its emulsion were replaced by a highly compacted array of photo-sensor elements, the imagery could then be recorded digitally, which would permit, in effect, automating the marking and measuring phases of analytical triangulation or, in other words automating the entire process.

The purpose of this paper has been to provide a rapid review of the progress made over the past 25 years in the use of photogrammetry as a technique for point positioning. Many improvements in instruments and technology have been made which, in turn, have contributed to current capability. One tends, at times, to lose sight of these advances and their implications. It is hoped that through this compendium of changes one will become aware of the progress which has taken place.

[14] G. Konecny, "Geometrical aspects of remote sensing", and F. Leberl, "Evaluation of single strips of side-looking radar imagery", invited papers, International Society of Photogrammetry, Commission IV, Ottawa, Canada, 1972

[15] J. Voggenthaler, "An artificial star field camera calibrator", paper presented to the International Society of Photogrammetry, Commission I, Ottawa, Canada, 1972

BLOCK ADJUSTMENT OF INDEPENDENT MODELS FOR 1:50,000 MAPPING IN CANADA*

Paper presented by Canada

The 1:50,000 map is very important to Canada as it is considered to be the working scale for the exploration and development of natural resources and serves a multitude of other purposes. It is the largest scale, most detailed mapping that exists for a large part of the country; and, in the foreseeable future, except for areas of residential, commercial or economic development, it is the largest that will exist on a regional basis.

Canada has been completely mapped at 1:250,000 scale since 1970; however, of the 13,150 sheets required to cover the country at 1:50,000 scale, only 4,200, or 40 per cent (figure 88) have been published. All the populated areas in the southern part of the country are covered so that one can say that 99 per cent of all Canadians live in areas covered by 1:50,000 mapping. Further, many areas of the north which are of economic or defence interest have been covered. For example, the most recent mapping activity in the north is in the Mackenzie River Valley in the Northwest Territories, which is currently of intense economic interest as a transportation corridor for oil and natural gas. The remaining 60 per cent consists of the Arctic Islands, the Northwest Territories and large areas to the south and east of Hudson Bay. This area, covers approximately 6 million km², which, except for small settlements scattered all over the north, are devoid of man-made features.

AERIAL PHOTOGRAPHY

The climate of northern Canada is one of the most severe in the world. The mean annual number of days with snow cover varies between 160 in the most southern parts to 280 in the Arctic Islands. Consequently, the photography season does not last more than three months (June, July and August) and is often much shorter. An average of 50 hours per season of weather suited for high-altitude photography is an optimistic estimate. In spite of this, an extensive inventory of aerial photography has been obtained. Most of the north is

*The original text of this paper, prepared by Topographical Survey Directorate, Surveys and Mapping Branch, Department of Energy, Mines and Resources, appeared as document E/CONF.62/L.99.

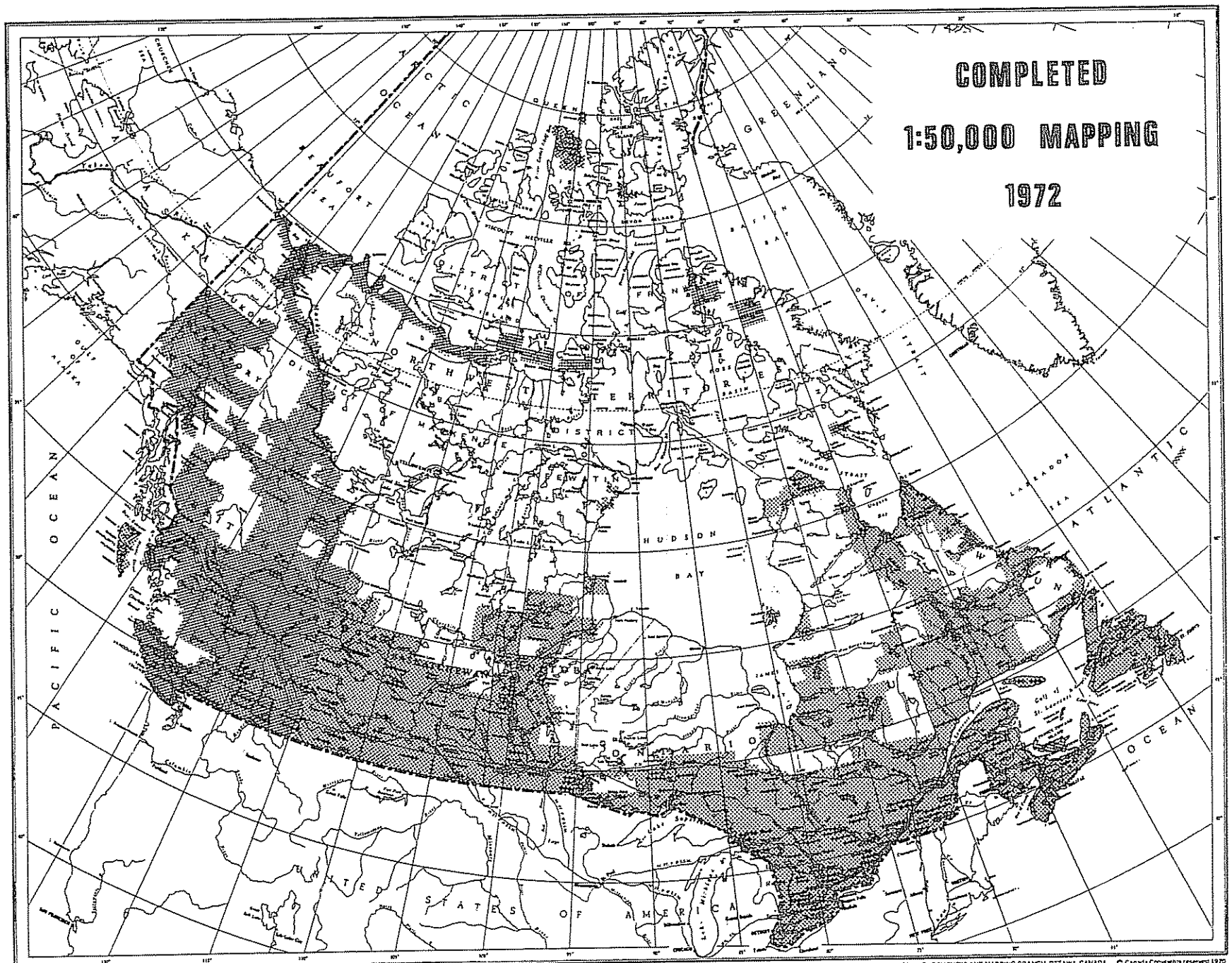


Figure 88. Canada: completed mapping at 1:50,000 scale, 1972

covered with good photography on the scale 1:60.000. This coverage was obtained for the 1:250,000 mapping programme; and even though some of the coverage is almost 20 years old, it is still up to date as the north is largely undeveloped.

Horizontal control

Since 1945, horizontal control surveys have been extended over most of Canada. These consist mainly of third-order Tellurometer traverses tied to a first-order geodetic net established by SHORAN. These traverses have been run around the parameter of the Arctic Islands and around large blocks of sheets on the mainland. Since the surveys and aerial photography were not done at the same time, the targets on the points do not appear on the photography. Photogrammetric identification is established by photographing the targetted point with a reconnaissance camera from a light aircraft or helicopter and transferring the point stereoscopically to the mapping photography, using a point transfer device with differential zoom optics.

The heavily forested and tundra regions of the northwest are flat, and terrain access and intervisibility are difficult. Since lines of sight are short, control traverses must be conducted with towers and thus are generally uneconomical. Consequently, Aerodist-controlled photography has been used. An aircraft flying a line of photography at approximately 1:20,000 scale (figure 89) is continuously ranged from three ground stations giving the position for each exposure station. These models are tied to the mapping photography by differential scale transfer of tie points; and as a block adjustment of independent models is used, the perspective centres of each Aerodist model then become horizontal control points.

Vertical control

On the Arctic Islands, vertical control has been established by Airborne Profile Recorder (APR) traverses run from sea level to sea level across the flight lines of the mapping photography on an average spacing of eight models. On the mainland, far from the sea, helicopter-borne barometer traverses have been run between spirit-level lines set out over the frozen tundra during winter or along drainage systems in both winter and summer. In general, this control has an accuracy of 3–4 m, which on the 6–8 model spacing in the existing photography is adequate for 20-m contours. In flat terrain, where 10-m contours are required or where control spacing is greater, additional traverses must be run.

Block adjustment

The data are generally suited for 1:50,000 mapping and form the input to the programme, therefore, with few exceptions, all the required information is readily available to produce 1:50,000 maps anywhere in northern Canada. Photogrammetric planning was based on large blocks of photography for 1:250,000 mapping, using slotted templet adjustments; and, subsequently, as computer technology developed, multiplex block of section adjustment and then adjustment of blocks of strips by polynomial transformations, using the well-known programmes formulated by Schut. Rectangular blocks of 50 or 60 map-sheets, from 150 to 200 km on the sides and having from 800 to 1,500 models are the normal case.

Photogrammetric data are derived by measuring independent stereo models in either the Wild A7 or A10 with the co-ordinates of the perspective centres being derived by the resection method using a calibrated grid plate. Two Wild STK-1 stereocomparators also are used, with the independent models being computed analytically.

Because of the need to adjust these large blocks having only perimeter horizontal control, a research project was initiated in 1968 to develop a computer programme for the adjustment of large blocks of independent models. At the same time, a similar project was initiated by the Institute for Photogrammetry at Stuttgart University under the direction of F. Ackermann.[1] Two years ago, on determining that the Institute was considerably further advanced, it was decided to purchase their Program Package for Aerial Triangulation with Independent Models (PAT-M) as the capability to adjust very large blocks was urgently required. The programme has been in operational use in the Surveys and Mapping Branch for more than a year and has proved to be a very efficient tool for the adjustment of these large blocks.

A complete report of the experience of the Directorate with two horizontal test blocks has been published.[2] The conclusions drawn in this report with respect to the stability of the adjustment, the theoretically unlimited block size, the accuracy of the results and expected savings have been realized in practice. With respect to cost, table 1 gives the cost per model for a number of adjustments which have recently been completed. These are the costs for one run of the programme for a complete adjustment and do not include the previous runs which were used to remove blunders and other data errors. Moreover, they are not necessarily representative of commercial rates as they were done on the CDC 6400 computer operated by the Department of Energy, Mines and Resources.

Table 1. Computer costs for PAT-M

Number of models	*Cost per model*
40	0.34
138	0.38
291	0.55
787	0.77

One of the significant advantages of the Stuttgart programme is its generality, which allows the incorporation into the adjustment of cross-flights in the block. This feature is particularly advantageous in the use of the Aerodist-controlled models previously mentioned. This feature has also been found advantageous in tying together blocks flown on different azimuths to follow a proposed transportation route down a large river valley.

In so far as accuracy is concerned, it has been found that the standard error of unit weight both for the horizontal and for the vertical block adjustment is of the

[1] F. Ackermann, "Experience with block triangulation by independent models", paper presented at the Convention of the American Society of Photogrammetry and the American Congress of Surveying and Mapping, March 1972.

[2] J. R. R. Gauthier, J. H. O'Donnell and B. A. Low, "The planimetric adjustment of very large blocks of models: its application to topographical mapping in Canada", *The Canadian Surveyor*, vol. 27, No. 2 (1973).

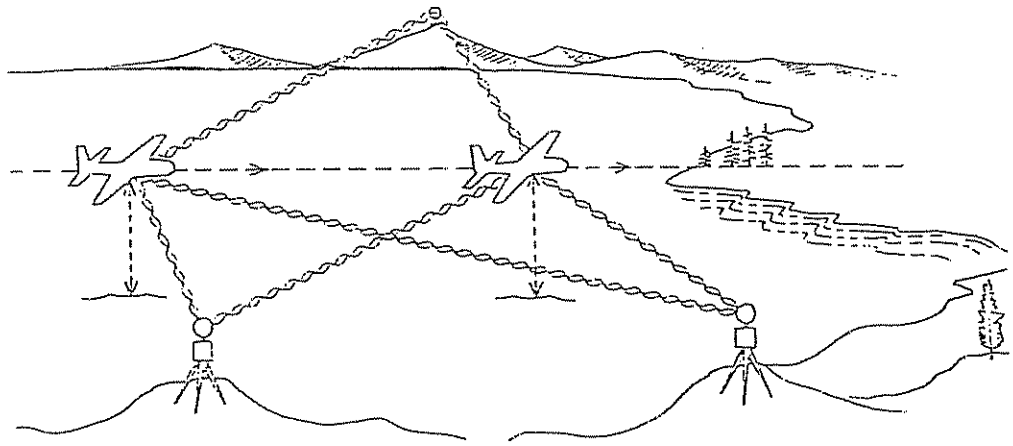


Figure 89. Canada: Aerodist simultaneously ranging on three ground stations

order of 20 microns, or 1.2 m at ground scale for 1:60,000 scale photography. As an example, the results of the adjustment for a block of 850 models of 1:60,000 scale photography covering 40 map-sheets are given in table 2. These are the root mean-square deviations in metres at ground scale on tie points, perspective centres and control points. It can be seen that results are more than sufficient for mapping at 1:50,000 scale.

Table 2. PAT-M block adjustment results, Somerset Island block

	RMS values of residuals (metres)			*Number of points*
	X	Y	Z	
Tie points	.59	.52	.76	6,500
Perspective centres	1.62	1.96	1.08	1,064
Horizontal control	2.04	2.18		31
Vertical control			1.22	543

Standard error of unit weight, horizontal = .90 m
Standard error of unit weight, vertical = 1.27 m

In spite of the fact that the Stuttgart programme was purchased, the Branch continued the project under the direction of J. A. R. Blais. The first operational version of the programme has just been completed. It is called the Spatial Photogrammetric Adjustment for Control Extension using Independent Models (SPACE-M). This programme differs from PAT-M in that it is a simultaneous seven-parameter adjustment of planimetry and height rather than an iterative four-parameter adjustment for planimetry and three-parameter adjustment for height. A complete formulation of the programme is the subject of a forthcoming report from the Branch. In the first version, it is not as general or flexible as the Stuttgart programme; but, nevertheless, it has proved to give equally good results both horizontally and vertically.

Vertical block adjustment test results

Extensive tests on a vertical test block have been conducted with both programmes. The block, which consists of 142 models of wide-angle photography at 1:27,500 scale, is shown in figure 90. There are nine lines of 15–16 models each.

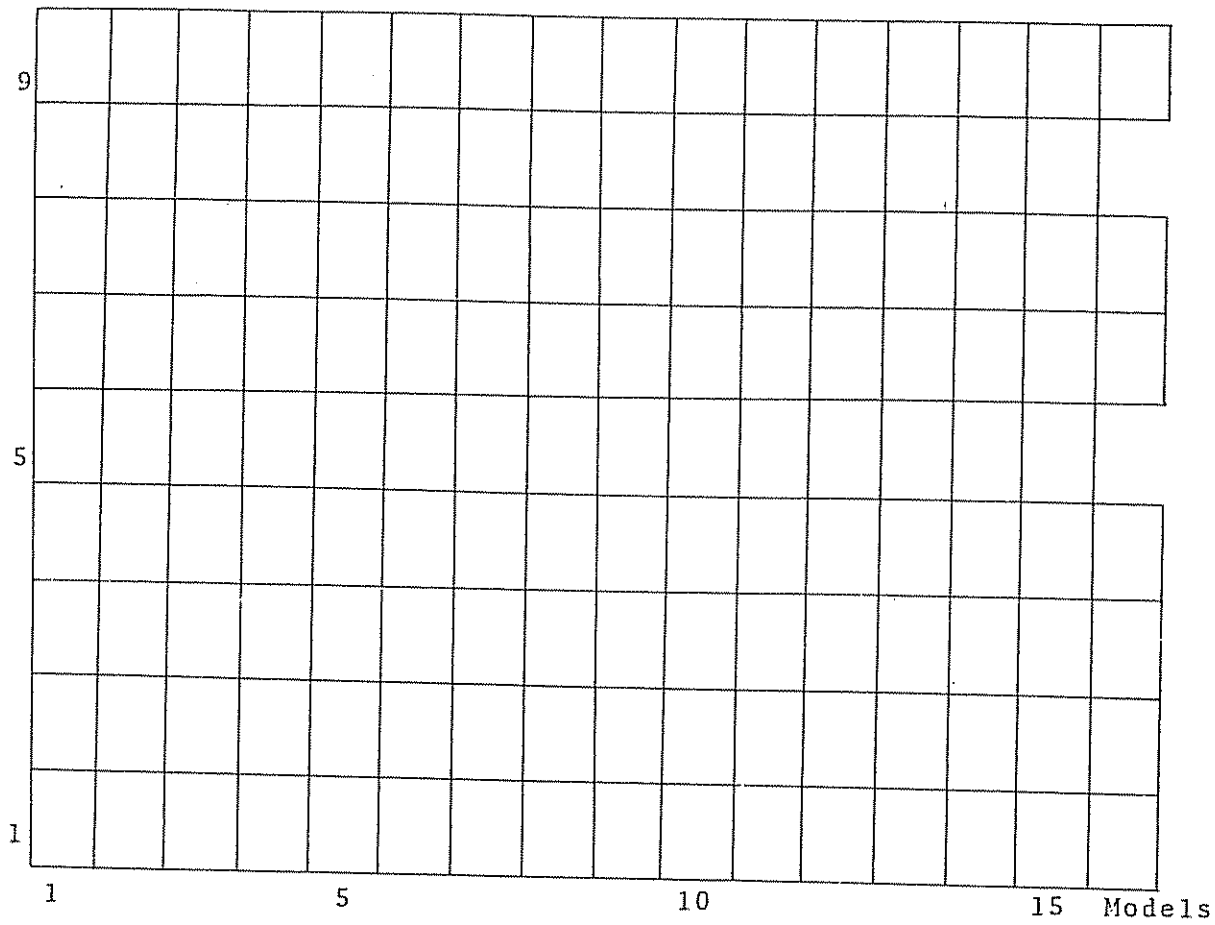
Measurements were made on the Wild STK-1 stereocomparator, and independent models were formed analytically. There are 19 horizontal control points and 376 vertical control points evenly distributed throughout the block. A number of different vertical control configurations were used with the points not contributing to the adjustment being used as check points. The results of block adjustments with each programme with all the control points contributing to the adjustment are given in table 3. The results of three adjustments using four, and three cross-chains of vertical control are given in figures 91 and 92, respectively. It should be noted that in the cases of three cross-chains, in two instances, there are two adjacent strips that do not contain any vertical control points. In practice, this situation is unacceptable unless the tie points between the two strips are laterally staggered as there is no condition to control the lateral tilt in each strip. The fact that the results are good in this case is due to the presence of this condition plus small tilts in the photography.

Table 3. Calgary test block, adjustment to all control points (*RMS values of residuals in microns at photo scale*)

SPACE-M	*X*	*Y*	*Z*
Tie points	14	14	12
Control points	43	50	19
C.P. time 326 seconds			
PAT-M43	*X*	*Y*	*Z*
Tie points	8	10	10
Control points	51	64	12
C.P. time 338 seconds			

The data used in these tests are typical data used for production purposes in Canada, and it is considered that the results are representative of those which would be realized in practice. In the experience of the Branch, the predictions of Ackermann[3] and Ebner[4] with respect to

[3] Ackermann, op. cit.
[4] H. Ebner, "Theoretical accuracy models for block triangulation", invited paper, International Society of Photogrammetry Congress, Commission III, Ottawa, 1972.



SCALE	1:27,500
MODELS	142
HORIZONTAL CONTROL	19
VERTICAL CONTROL	376

2843.90x

Figure 90. Canada: Calgary test block

the accuracy, generality and efficienty of block adjustment of independent models have been borne out.

Future development

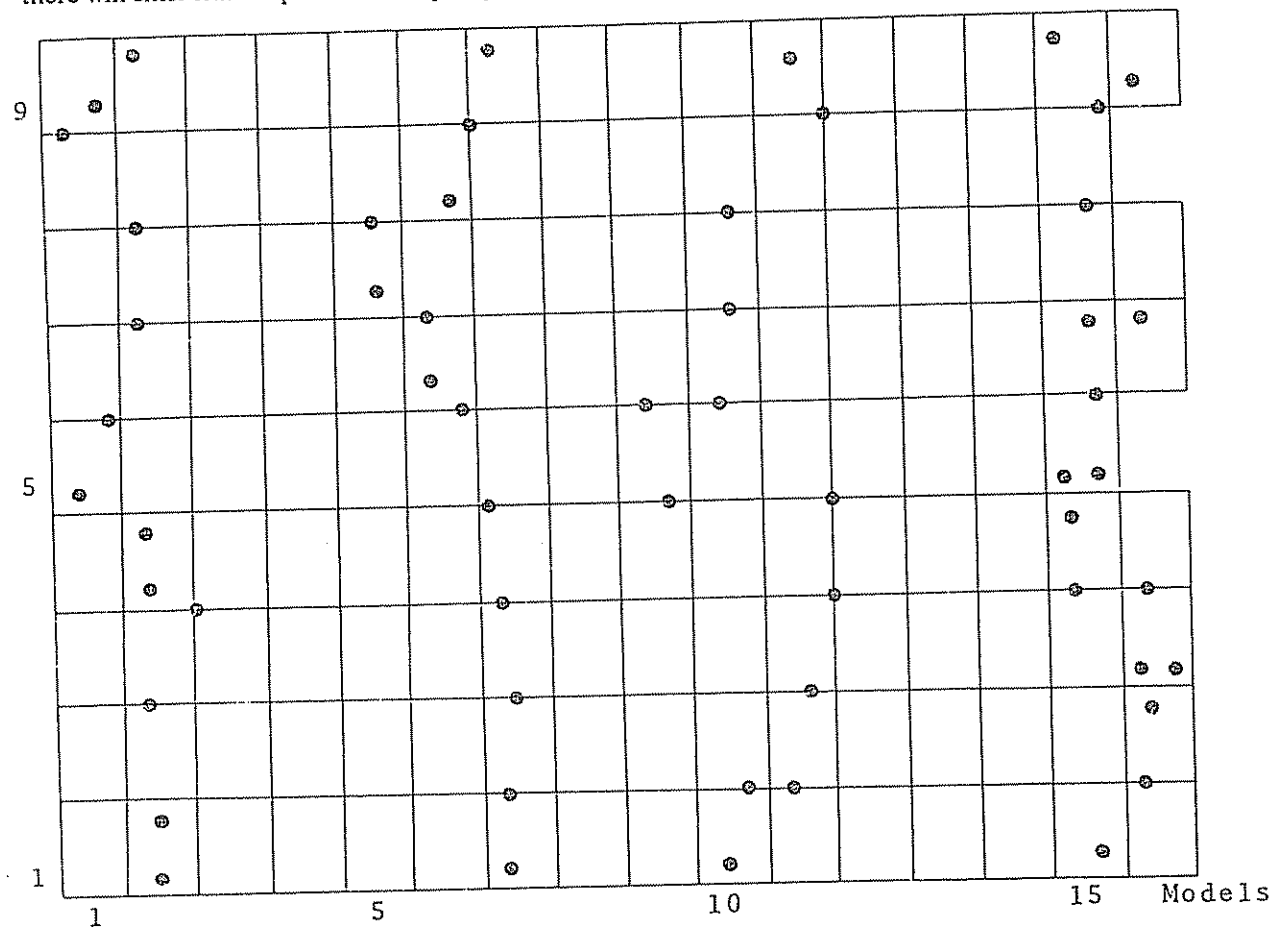
Currently being developed by Stuttgart University is a combined block adjustment of APR data and independent models.[5] Also to be included in this programme is the capability to use lake surfaces of unknown elevation as a model levelling constraint. This latter feature will also be incorporated in SPACE-M. It is expected that these features will allow a substantial reduction in the vertical control requirement due to the increased accuracy of the control and the large number of suitable lakes in most blocks in northern Canada.

Data Base

At current rates of production, it will take another 20 years or more to cover Canada with 1:50,000 scale mapping. This rate is incompatible with the current situation in the north, where, areas are being explored for oil, mineral, hydroelectric and transportation route development. These activities give rise to urgent demands which are difficult to satisfy when the shortest possible elapsed time to produce a provisional map is 18 months. If the user is to be satisfied, the Branch must anticipate his future requirements as much as possible

[5] F. Ackermann, H. Ebner and H. Klein, "Combined block adjustment of APR data and independent photogrammetric models", *The Canadian Surveyor*, vol. 26, No. 4 (1972)

and also develop a rapid response system. Publishing various map expedients reduces response time; however, photogrammetric blocks are necessarily large and take a long time to process through aerial triangulation. Thus, there is a considerable delay from the statement of requirement to the beginning of actual map compilation. In order to avoid this delay, the Branch has commenced a programme to establish a data base of adjusted photogrammetric blocks so that anywhere in Canada there will exist either a published map or photogrammetric data ready for immediate compilation into a map which will meet standard accuracies. This programme will increase the effectiveness of the 1:50,000 mapping programme in that the Branch will be able to satisfy urgent demands with standard products without unreasonable interruption to programmed mapping activities and revision. Furthermore, these data can be used to provide control for new photography for larger scale mapping at specific locations or along proposed transportation routes.



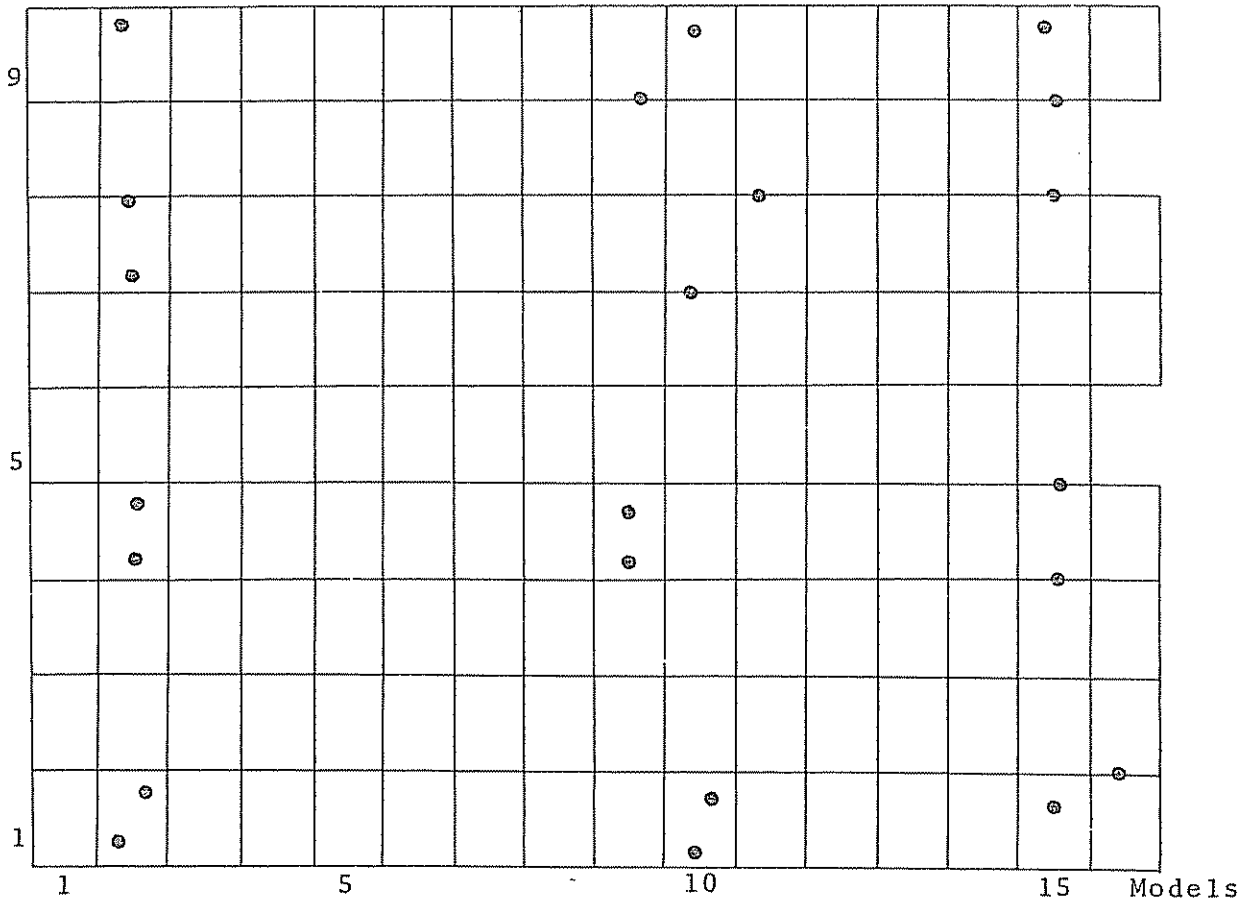
SCALE 1:27,500

VERTICAL CHECK POINT RESIDUALS

	RMS GROUND	RMS PHOTO
SPACE-M	.85 m	.031 mm
PAT-M	.85 m	.031 mm
CONTROL POINTS	56	
CHECK POINTS	320	

2843.91x

Figure 91. Canada: Calgary test block, four bands of vertical control



SCALE 1:27,500

VERTICAL CHECK POINT RESIDUALS

	RMS GROUND	RMS PHOTO
SPACE M	1.08 m	.039 mm
PAT M	1.13 m	.041 mm
CONTROL POINTS	22	
CHECK POINTS	354	

2843.92x

Figure 92. Canada: Calgary test block, three bands of vertical control

Block adjustment of independent models has proved in practice to be an efficient and accurate procedure for the adjustment of very large blocks for medium- and small-scale mapping. Considerable savings in ground control costs are realized since perimeter control only is required. In fact, with a rectangular block, good results can be obtained with only one point in each corner.

While the method is theoretically not as accurate as a bundle adjustment, results obtained are more than adequate for all mapping requirements. Therefore, the only justification for using the more expensive and complex bundle adjustment is the flexibility allowed in incorporating auxiliary data in the adjustment in a rigorous manner in order to realize greater savings in ground control.

AERIAL PHOTOGRAPHY USING LONG-DISTANCE FOCAL LENGTH LENSES*

Paper presented by France

The continually increasing interest shown everywhere in aerial photography and its applications has encouraged the Institut géographique national (IGN) to acquire: (*a*) a range of orthophoto equipment for accurately correcting the perspective deformations of aerial photographs and transforming them into metric documents even for the mountainous areas; and (*b*) long-distance focal length cameras which extend somewhat the limits of usefulness of simple rectification procedures to make good-quality photo maps of hilly regions.

IGN uses Zeiss RMK 610-mm focal length cameras, and their utility has been considerably increased since the arrival of the IGN Jet Falcon Mystère 20 aircraft, specially transformed for photographic work.

It is currently possible to obtain aerial photographs at 1:15,000 scale with these cameras by flying at 9,000 m; and to go easily to 1:20,000 scale by working at 12,000 m, an altitude slightly less than the ceiling of 12,500–13,000 m, thus allowing one to fly over regions with elevations of 500–1,000 m and still conserve the photographic scale 1:20,000.

As the Mystère 20 has two ports, one can combine surveys at the above-mentioned scale with another using a 152-mm (or 88-mm) camera, which, for those altitudes, would give surveys on the scales 1:60,000 and 1:80,000 (or 1:100,000 and 1:135,000).

The high climbing rate and cruising speed of the Mystère 20 allows one to photograph large areas at very attractive prices.

The use of very rapid emulsions, e.g., 250° ASA, enables one to reduce the exposure time to very short intervals of the order of 2.5 millisec., which eliminates even at large scales all trace of image movement on the photograph despite the high speed of the Mystère 20, which is of the order of 800 km/h.

One can thus enlarge the photographs three or four times, like those taken with 152-mm cameras, without visible loss of resolution.

The percentage of fine-weather days suited for high-altitude photography is obviously less than that at low altitude due to the greater thickness of atmosphere traversed and the increased probability of large clouds. It is difficult to give a precise rule because the meteorological conditions vary with each country and from one year to another. It should be noted that as cameras with long focal length have a smaller field of view, the illumination of the frame is more homogeneous as the side rays are absorbed less than in wide-angle and super-wide-angle cameras.

The high-altitude flight stability is comparable to that encountered in the lower layer, i.e., about 1°, so the regularity of the coverage and the overlapping take place in good conditions.

One can also correct for non-verticality effects in 610-mm camera photographs by rectification procedures similar to those used with other focal length cameras. Even if the offsetting calculator of the rectifying equipment was not constructed for 610-mm cameras, one can use an iterative process by first levelling the models without offsetting; and then use inclination angle values taken from the rectifier to compute by hand the corresponding offsetting, which is then introduced into the apparatus. It is usually not necessary to repeat the cycle as a single operation suffices. One might also develop a programme to process photographs taken far out of the vertical and requiring several iterations.

One can advantageously use the rectified photographs for producing photo maps which conserve all the details and resolution of the original photograph without showing large planimetric deformations in hilly regions.

For example, with photographs taken at 12,000 m on the scale 1:20,000, one can produce photo maps at 1:5,000 scale without having planimetric position errors greater than 1 mm for all identifiable features, so long as the ground elevation changes are not more than ±30 m within the same photograph. With a 152-mm camera, the tolerance would be only a quarter of this value for the relief (i.e. ±7.5 m); or with identical relief, the photo map deformations would be quadrupled to ±4 mm. The use of orthophoto maps, which are much more expensive, is consequently not so imperative in such work.

In urban areas, the advantages of cameras with long focal length are particularly outstanding because they considerably reduce the dead angles and the perspective effects of façades. Consequently, buildings 30 m high are only distorted by 1 mm (maximum) anywhere on a 1:5,000 photo map. As built-up areas are, in general, not very hilly, the usefulness of 610-mm cameras is thus increased, so long as the transparency of the air allows one to photograph large towns under normal conditions.

From the foregoing discussions, it is evident that cameras with long focal length are going to have an increasing use in aerial photography, for they serve a variety of purposes at very reasonable prices and extend the range of services available to users.

*The original text of this paper, prepared by the Institut géographique national, France, appeared as document E/CONF.62/L.125.

AGENDA ITEM 9*

Medium-scale and large-scale surveying and mapping

(a) *Topographic mapping*

DYNAMIC METHODS IN THE PRODUCTION OF TOPOGRAPHIC MAPS ILLUSTRATED ON AN EXAMPLE OF A TOPOGRAPHIC MAP OF 1:100,000**

Paper presented by the Federal Republic of Germany

A good deal has been spoken and written on the question whether a map should be produced as quickly as possible; and, if necessary, at the cost of quality, or without flaws and thus more slowly. There is, however, no doubt that this question cannot be posed in this "either or" form. There are cartographic situations in which the quantitative requirement must be placed before the qualitative one. On the other hand, it cannot be contested that where cartography stands on a firm foundation, the speed with which maps are produced takes greater priority now than ever before. The quantitative urgency of map usage had given rise to this situation. It is emphasized most of all by the variety, extensive size and speed of planning and technical design in the field of topographic cartography. The planning can no longer wait until the desired cartographic data are available; the maps must always be at the disposal of the planning, when and wherever they are needed. Of course, other factors also affect the quantitative-qualitative problem of map production, such as, for example, the cartographic state of development, cost, personnel and technical conditions. Thus, it is not surprising that the recent development of topographic cartography has been accompanied by attempts to give more attention to cartographic presence. The hope of being able to solve this task by substituting an aerial photo map in the widest sense for the traditional topographic map has not been fulfilled; and, in the last analysis, will not be fulfilled. For it has been shown that the advantages of the topographic map are ideally suited to precisely the high demands of planning and development, whereas aerial photo maps leave much to be desired. In the face of this knowledge, the principle is gaining more and more weight that a map with defects is better than no map at all. Between quantity and quality, a compromise can be found consisting of the possibility of developing maps step by step from the aerial photo to the topographic map. The cartographic building-blocks of each stage are produced in such a way that they serve the next stage as the basis for further construction and the beginning of further developments. Such a procedure ensures an efficient and economical manner of work.

The Landesvermessungsamt at Baden-Württemberg has begun to concern itself with such production models at a time when all the technical possibilities of orthophotography are at its disposal. These models were realized, at least in part, when the production of the topographic map at 1:100,000 scale was to be completed within about four years.

Although it was possible to begin the development procedure at an advanced stage, which was built directly on the already existing topographic map at 1:50,000 scale, the following remarks concern the essential aspects of every possible phase of development. In this manner, it is possible to offer every cartographic situation an individually optimal solution. The stages of development in the production process are:

(*a*) Aerial photo maps (basis: affine-rectified aerial photos);

(*b*) Orthophoto maps (basis: aerial photos, rectified differentially and in strips);

(*c*) Topographic orthophoto maps (orthophoto maps with a topographic, especially relief plan);

(*d*) Preliminary topographic maps;

(*e*) Topographic maps.

The area in question encompasses about 36,000 km^2 with 17,400 residential areas and a population of about 8 million. Since a topographic map is to be the end-product of the cartographic undertaking, its form and its contents must be essentially outlined before work is begun. In other words, the analytical and analogous cartographic principles that are to distinguish this project must be substantially present. This requirement is fulfilled by a sample sheet or a cartographic instruction, or both together. In the case in point, the sample sheet was able to serve as the point of departure for the topographic map at 1:100,000 scale. This cartographic base can, however, also be established without difficulty, if only one of the topographic maps intended later, for instance, at 1:25,000 or 1:50,000 scale, is correspondingly

*The following papers relating to the present agenda item appear under the agenda item indicated: "Topography, geodesy and cartography in the USSR" (E/CONF.62/L.76); and "Progress report on cartographic activities in Thailand" (E/CONF.62/L.100), agenda item 6; "Experiences with the production of photo maps 1:5,000 in Nordrhein-Westphalia" (E/CONF.62/L.9), agenda item 8.

**The original text of this paper, prepared by W. Beck, Landesvermessungsamt, Baden-Württemberg, appeared as document E/CONF.62/L.3 and Add.1.

analysed. But if one were to do without this preliminary work, the continuity of development would be disrupted; unnecessary and unjustified additional work would make the success of the procedure impossible. Unfortunately, systematic cartographic planning is quite often dispensed with, and thus every opportunity of achieving some kind of satisfactory result is lost.

Cartographic stages of development in map production

Aerial photo map

The aerial photo, affine-rectified and provided with place names (geographical orientation), serves as the initial aid in the cartographic development of a State. Favourable terrain, little or sparse forestation and good external and internal photographic conditions assure considerable success. As these conditions are often not fulfilled, however, the aerial photo map (see plate 1 of figure 94[1]) can only provide temporary help at the beginning. The lack of a relief picture greatly restricts its possibilities of usage. As a rule, it will thus not be worth while to consider an intensive cartographic elaboration of such a picture, for example, through explanatory notes. The orthophotographic technique makes, moreover, such a procedure superfluous, for the conditions that this evaluation presents are materially only little removed from those that the affine-rectification presupposes. Thus, it is only used where flat terrain is portrayed.

In the case in question, that of terraced land, it is suited for the reproduction of the terrace faces. And like all cartographic productions from aerial photos, it ought to prove itself in large scale. This is borne out by the seven examples presented here. There are, however, fewer examples for those cases which have smaller scales, for instance, 1:100,000. In order to demonstrate the difficulties and possibilities offered by this scale range, the scale 1:100,000 has been given preference. This should, above all, show how difficult it is to read and interpret an aerial photo of such a scale and whether it is possible and desirable to perform certain cartographic operations in the form of pictorial generalizations.

Orthophoto map

While an aerial photo map provides quick temporary help, the orthophoto map (see plate 2), the aerial photo rectified differentially or in strips, is sufficient for the analytical cartographic principles under discussion. It offers by itself a profiled representation of four features: residential areas; road network; waters; and vegetation. The thing for which it is praised, its enormous density of information, remains, however, at first hidden to the normal map user because he has little experience in interpretation of aerial photos; and, moreover, is interested in only a few of the features and characteristics. Consequently, the orthophoto picture has to be supplemented in accordance with the future analogous principles of illustration and interpretation. The resulting density of information is appropriately carried only as far as the readability of the map permits. Since it is already hampered by the lack of generalization, the readability is yet further burdened by the fact that the cartographic picture is single-coloured. Whether or not it is worth while to increase the information given in the picture through the use of colours must be judged on the basis of each respective situation. In any case, the cartographic supplements are projected into the orthophoto picture in such a way that in the transition later to a purely linear picture, they only need to be supplemented and not redone.

Topographic orthophoto map

Normally the orthophoto-map stage can be omitted, as with the corresponding application of instruments, the relief picture is automatically produced as a representation of contours together with the orthophotographic rectification. However, this picture of the contour lines lacks the spot heights; and in forested areas, as a rule, the desired exactness of plotting. It must be judged individually whether in such cases photogrammetric analogous plotting is to be used. At any rate, the topographic orthophoto map (see plate 3) should be developed far enough to be distinguished from the linear topographic map picture only by the flat-surfaced, single-coloured, continuous-tone illustration of the feature outlines. For better optical differentiation of the continuous-tone pictures, which are first developed in only one colour from the aerial photo, a coloured overprint can, as already mentioned, improve readability.

Preliminary topographic map

If a modern map that is analytically and analogously satisfactory is already available in a different and larger scale, photogrammetric aids can be dispensed with without endangering the accelerated production of the map. In such a case, the temporary plan is based on reductions of the topographic map at 1:50,000 scale. Only the lettering (names and numbers) retains its original scale. This could be done quickly, economically and definitively with the help of photo-setting. On the other hand, the reductions from the scale 1:50,000 to the scale 1:100,000 appear to be futile with respect to the subsequent original scale adaptation. Yet, these reductions can provide the basis for the plans for the original adaptation of scale 1:100,000. The time involved in the production of the preliminary topographic map (see plate 4) can be broken down as follows:

	Hours	
Reproduction (reduction of eight colour plates)	16	
Draft (lettering)	270	
(*a*) Lettering, photo-setting	30	300
(*b*) Assembly	270	
Cartographic operations (cartographic frame and border assembly, retouching, colour plate red)	1,200	
Proof-sheets and inspections	110	

The generalization of the map plan can also be extended, of course, beyond the lettering plate to the outlines of whole feature pictures or parts thereof. This example shows that the next logical step would be to generalize the relief plan in order to express the geometry of the forms and of the terrain more clearly and distinctly. Yet, all of these operations must be subject to the same principle, namely, not to undertake anything in these cases that cannot be added unaltered to the final pictorial representation.

[1] Figure 94 appears in pocket at end of volume.

Topographic map

The problems that prompt the generalization of a map plan, in this case on the scale 1:100,000, cannot be elaborated here. They are, however, quite evident upon comparison of plates 4 and 5. The question of interest here is, above all, how much time is needed to complete such a map. In order to make a comparison with the previous outlay possible, the operations were broken down according to the same principle:

	Hours	
Reproduction (reductions to 1:100,000 of feature pictures at 1:50,000)	10	
Drafting operations	5,000	
(*a*) Lettering, photo-setting	30	350
(*b*) Assembly	320	
Engraving (original picture and assembly of vegetation)	5,150	
Proof-sheets and inspections	480	

The expenditure for the original scale adaptation of the map is thus about six times greater than that for the preliminary topographic map.

Map continuation and cartographic improvisations

As a rule, it is easier to produce a map than to keep it up to date. Revisions have to be repeated at short and regular intervals and require so much time that only three corrections amount to the production expenditure. Wherever economic growth causes intensive alteration of the landscape, the continuation very often begins to lag behind. And obsolete maps not only annoy the user; it is tedious work to bring them up to date, and to produce anew the sheets that are in arrears cannot be considered until automation can provide decisive help.

When a clear, multicolour differentiated plan is dispensed with, a topographic plan negative combined with an orthophoto which has been plotted on the basis of the most recent aerial photos can be considered a temporary measure in such cases (see plate 6). This procedure will be more successful in large than in small scale. The fact that this temporary solution can only be of short duration results from the contrasting cartographic design of the preliminary and the original map. And it is fully apparent as soon as several sheets have to be placed together to form a plan within the scope of map usage. In such cases, which are the rule in planning, these pictorial contrasts can scarcely be reconciled and cause even the expert map-user considerable difficulty.

Some final observations

To begin the development of a map or map series over the various stages is often the result of deficient capacity, lack of experience on the part of personnel, insufficient technical equipment and a slight cartographic basis. The following summary should provide orientation data for the compromise which must be made between what is cartographically desirable and economically possible:

	Hours
Aerial photo map	200
Orthophoto map	200
Topographic orthophoto map	250
Preliminary topographic map	1,900
Topographic map	11,000

It is logical to take advantage of the help that plotting automats offer for more rapid and economical production of maps. This automated aid could, first of all, be effectively designed to digitize and automatically plot in the map original certain pictorial elements from the orthophoto, for example, streets, roads, waters, vegetation limits, buildings or groups of buildings. This digitizing stage has been developed so far that automatic generalization is already being tested. If, however, the quality of the maps is not to be lessened by automatic operations in the production and continuation, considerable difficulties have to be overcome, which, among other things, are to be found in the limited qualitative performance of the automatic plotting-head. Nevertheless, all the procedures mentioned help to make the work of topographic cartography flexible. Thus, not only the quantitative, but the qualitative performance can clearly be improved.

THE AUTOMATIC PREPARATION AND REVISION OF TOPOGRAPHIC MAPS*

Paper presented by the Federal Republic of Germany

General remarks

Cartography is the art, science and technology of making maps, together with their study as scientific documents and works of art. In this context, the word "maps" includes all types of maps, plans, charts and sections, three-dimensional models and globes representing the earth or any heavenly body on any scale.[1] This definition has been established in the multilingual cartographic dictionary published by Commission II, Standardization of Technical Terms, of the International Cartographic Association (ICA).

Commission II also issued the following definition for the concept of "a map"; "a map is a conventional representation, normally to scale and usually on a flat medium, of a selection of material or abstract features on or in relation to the surface of the earth, of a heavenly body, or of space".[2]

A great variety of maps exists. In the following list, maps are classified according to the most recent state of knowledge and one must differentiate among them:

* The original text of this paper, prepared by H. Knorr, Director, Institut für Angewandte Geodäsie, Frankfurt am Main, appeared as document E/CONF 62/L 4 and Corr 1.

[1] International Cartographic Association, Commission II, *Multilingual Dictionary of Technical Terms in Cartography* (Wiesbaden, Franz Steiner Verlag GmbH, 1973).

[2] *Ibid*

1. *World maps*

(*a*) Survey maps (original maps or base maps):

(i) Cadastral maps (as well as town maps, forest maps, etc.);

(ii) Topographic maps;

(iii) Nautical charts, maps for internal waterways;

(iv) Oceanographic charts;

(v) Applied maps (hiking maps, road maps, aeronautical charts, etc.);

(vi) Thematic maps, classified by topics: geographical settlement maps, hydrological maps, soil maps; geomorphological maps (morphographic and morphogenetic maps); structural development and planning maps, geological maps, geophysical maps, weather and climate maps, geovegetational maps; population maps (maps of population distribution and population density); maps of races, religions, languages, peoples and nationalities; political, historical and geopolitical maps; geomedical maps and economic maps;

(*b*) Derived maps:

(i) Topographic maps, general topographic maps, index maps, maps of countries, maps of continents, map of the world;

(ii) Nautical charts, maps of internal waterways;

(iii) Oceanographic charts;

(iv) Applied maps (hiking maps, road maps, aeronautical charts, etc.);

(v) Thematic maps, classified by topics, as listed above in (*a*) (vi);

2. *Maps of other celestial bodies*

(*a*) Survey maps (topographic maps, thematic maps);

(*b*) Derived maps (topographic maps, thematic maps);

3. *Celestial maps*

The difference between survey maps (original maps or base maps) and derived maps is especially important. While survey maps are based directly on data obtained by measurement, derived maps are always prepared from other maps, mostly of larger scale.

A topographic map represents a part of the surface of the earth to scale and is geometrically correct. In addition, the representation should be true to nature, expedient, clear, comprehensible, easily legible and plastic. In order to reach this goal, many individual working steps are necessary. If the preparation and, subsequently, the revision of a topographic map is automated, one has to envisage an automation of these working steps. Thus, constant attention should be paid to the fact that, if possible, the quality of the maps is not reduced by automation, that the cartographic working process is rationalized, that map design and generalization are objective and that the content of the map is improved.

To realize this goal, cartographers are confronted with a very difficult task; and a practical solution for all the problems has not yet been found. Too many questions must still be clarified. There is no doubt that great efforts are being made all over the world to automate the preparation and revision of topographic and thematic maps, as has already been achieved in the preparation of cadastral maps, planning maps and technical maps. Automation poses problems in cartography, as well as in electronic data processing (EDP). In cartography, one is mainly concerned with problems of design, representation, regularities and standardization, whereas in EDP, one must deal with questions of automated systems, equipment, data banks and software.

Because of the very complicated working process, it is not yet possible to prepare and revise a topographic map in one operation. One has to apply the step-by-step building-stone method, and efforts have to be made first to assist the cartographer in mastering such work-intensive operations as drawing and scribing.

The procedure of automating cartographic working processes by means of EDP plants comprises data acquisition, data processing, data storage, data revision and data output.

Before the preparation of topographic maps and topographic map series, respectively, can be automated, detailed studies must be made on the elaboration of the maps, i.e., the harmonious representation of settlements, road nets, hydrography, relief, etc. There is a purely creative work and, to a certain extent, even a work of art which cannot be replaced by automation; but it may be possible to support this work by the variation of stored data. When doing this, the geometry of the single features must be maintained as far as possible. As to the selection of symbols, these should be adapted to fit the possibilities of automation and should be as simple and clear as possible. As to automation, it is rather a question of the equipment used; and a plotting table equipped with a drawing or scribing attachment is almost indispensable, but of less importance is a plotting table equipped with an optical exposure head.

Data acquisition

The map margin of a topographic map shows the designation of the map series, sheet name, sheet number, the extract of the legend consisting of the conventional signs used with the appertaining lettering, the linear scale; and some special indications, such as political boundaries, the sheet location diagram and the publication note. The map frame of such a map mostly consists of several lines, contains indications on the geographical latitude and longitude, the plane co-ordinates of the projection used, the adjoining sheets of the sheet in question and some other lettering. The topographic map content is composed of situation, relief and lettering. The basic graphic elements of situation and relief are, if one disregards hill shading, the dot, the line, the outlined area and the conventional signs (symbols). Automation should always be used reasonably. The data required for the map frame and for the geometric accuracy of the map content, such as projections and geodetic fundamentals, are available in the form of co-ordinates and can therefore be stored in a data bank as so-called "list data." They can at any time be plotted automatically and, in the case of need, be linked to each other, etc.

Lastly, the acquisition of the information required for the map content is of primary importance. In this connexion, it should be pointed out that a topographic map or an aerial photograph is already an excellent data storage bank with a limited range of application (by enlargement or by reduction). But this storage bank is not in digital-numerical or alpha-numerical form, as is required for automation, but in analogous form. The necessary digital data for boundaries, settlements, traffic networks, hydrography, features to be represented by individual topographic symbols, soil and vegetation, and

for relief can be obtained for a trichromate survey map by means of terrestrial or aero-photogrammetric measurements. With these measurements or plottings, the necessary generalization (selection, schematization, combination by groups) can be made.

Survey maps

The scale of the survey map or original map will probably range from 1:5,000 to 1:50,000, depending upon the type of country, i.e., whether it is an industrial country, an agrarian country or a developing country. The terrestrial surveying method applied is tacheometry, which has gained new importance through the development of new electronic recording tacheometers and has, in some cases, even entered into true competition with aerial photogrammetry.

Photogrammetric survey

In the automatic preparation of topographic maps by means of photogrammetric measurement, one must differentiate between: direct plotting of the map in stereoplotters; and production of the line map through use of a photo map by means of rectifiers. If the latter procedure is applied, the contour line representation can, in certain cases, be obtained as a by-product of the working process. If the first procedure is applied, the plotting instrument must be provided with additional equipment which furnishes the scanned dots and lines in digital numerical values and allows for identification of the individual features.

In the preparation of topographic original maps, by means of photo maps, one must differentiate between the derivation of photo maps from rectified single photographs, which is restricted to flat or nearly flat terrain, and the derivation of photo maps from differentially rectified aerial photographs with undulating terrain. If the first procedure is applied and one wants also to obtain indications of height, (e.g., in the form of contour lines), these data must be determined by terrestrial or by stereoplotter measurements. If the second procedure is applied, the heights are obtained during the working process proper: for differential rectification, one must measure the vertical profiles for the single strips in the stereoplotter.

The result is, in all cases, a photo map with contour lines. The primary advantage of a photo map consists in the abundance of information; but if such a photo map shall replace a topographic map, every user must interpret it, and, above all, interpret it correctly. Now it is possible to digitize the photo map in order to obtain digital values for the individual features. The subsequent automatic drawing or scribing will then furnish a line map.

The essential parts of a complete survey map are the classification of the traffic net and, above all, the lettering. If the map has been derived from aerial photographs, and if no other sources of information are available, the classification of the traffic net, the names of places and fields, etc. must be ascertained by subsequent field reconnaissance.

Map-lettering is composed of geographical place names. The acquisition of data for lettering has been arranged in such a manner that, in addition to an output in the form of lists (e.g., by means of a ball-head typewriter), a direct positioning of the names, etc. on the map will also be possible, provided a corresponding device is available.

In conclusion, the revision of the survey map must be done in the simplest manner, i.e., easy access to all digital values of the different map features and simple performance of the revision. It must be stressed repeatedly that, besides map preparation, map revision is the central problem; therefore one must pay special attention to it.

Derived maps

Derived maps are maps derived from survey maps and not directly based upon terrestrial and/or photogrammetric measurement. If, e.g., one has a survey map at 1:5,000 scale, and one derives from it maps at 1:25,000, 1:50,000, 1:100,000, 1:200,000, 1:500,000 and 1:1,000,000 scales, then these maps are called "derived maps". The change-over from the larger scale survey map to the derived map at a smaller scale entails various problems. As a smaller scale makes the representation of all features impossible, one must select from these objects with respect to quantity and quality; they must be schematized, combined to groups and, lastly, a great number of features must be displaced. This is the process of generalization which is, in addition to the creative work of map-designing, the most difficult task of topographic cartography. By introducing automation into topographic mapping, one wishes to reach, above all, objective generalization, i.e., that generalization shall in the future be considered under mathematical aspects and that it shall be freed from the hitherto subjective influence of the cartographer practising generalization. The first step in this direction has been made with Töpfer's "radical law":

$$n_F = n_A \sqrt{\frac{M\,a}{M\,f}}$$

which states that the number of the objects to be selected, or of the object flections or of the objects to be combined at the derived scale n_F is equal to the number of objects or object flections at the extraction scale n_A multiplied by the square root of the quotient of the scale number of the extraction scale M_A divided by the scale number of the derived scale M_F.[3] As the legend of the derived scale map is to be adapted corresponding to the legend of the extraction scale map, Töpfer's "radical law" also applies to this legend, viz.

$$s_F = s_A \sqrt{\frac{M\,A}{M\,F}}$$

The size of the symbol on the derived scale map s_F is equal to the size of the symbol of the extraction scale map s_A multiplied by the above-mentioned square root.[4,5]

Unless a generalization is mathematically determinable to the very last detail, the active display units described below can be of some assistance. This applies even more to the displacements to be performed in connexion with scale reduction, where the mathematical approach to generalization will lead, in many cases, to extensive programmes which, perhaps, are not justifiable for reasons of economy. As long as generalization rules

[3] F. Töpfer, "Gesetzmässige Generalisierung und Kartengestaltung", *Vermessungstechnik*, vol. 15, No. 2 (1967), pp. 65–71.

[4] *Ibid.*

[5] F. Töpfer, "Die Ausnutzung des Wurzelgesetzes bei der Darstellung und Generalisierung von Wasserläufen", *Petermanns Geographische Mitteilungen*, Jahrgang 111, No. 3 (1967).

and corresponding programmes do not exist, one only has the possibility of charging a cartographer with the preparation of a generalization design for the derived scale and having this design digitized.

Data-digitizing equipment

Digitizing is performed with instruments developed for that special purpose. There are different types of digitizers, i.e., manually operated digitizers for point read-out and semi-automatic line following, automatic line followers and scanning digitizers, the so-called "scanners". These fully electronic instruments are used for the acquisition of two-dimensional geometric data and the output of these data in digital form. A great variety of such equipment already exists. An example of manually operated digitizers is the Aristo/Bendix Aristogrid digitizer, which has been used in the Institut für Angewandte Geodäsie for tests. An example of automatic line-followers is the Aristo/AEG Aristometer/Geameter 3000, of which the measuring table can also be used as a drafting table (Aristomat/Geograph 3000). The line-follower is designed according to the co-ordinatograph principle and equipped with a photo-optics (selenium cell) with electronic control by means of which the points and lines are recognized, followed, registered at predetermined intervals and put out as co-ordinates or as sequences of co-ordinates. Connected with this unit is an AEG 60–10 process computer, which can be used at the same time for the control of the automatic drafting machine.

Unit digitizing by means of scanners is used at the Rome Air Development Center, Rome, New York, (United States of America). With this unit, the entire drawing, i.e., points, lines and areas (monochrome or polychrome) is scanned strip by strip in one co-ordinate direction with respect to drawing parts or blank spaces, i.e., black or white elements. Upon completion of the digitizing, the scanned drawing must be represented on a display unit or on a drafting table, so that the individual map features can be identified. This calls for the reconversion of the raster data into sequential line data by means of the computer.

For the acquisition of list data containing geodetic fundamentals, projections, place names, geographical names and other names, a punch-card perforator can be used, e.g., the IBM 029 perforator.

Equipment for graphic output of data and for printing of list data

The equipment for graphic output is used for the automatic drafting, scribing or light-spot drawing of line maps and area maps. Automatic drafting means the preparation of a drawing with a programme-controlled automatic drafting machine on the basis of numerical data. The data required for topographic maps may be measured data from national surveying, from analogous maps or from map designs.

On principle, one distinguishes, according to their mode of drafting, between the following drafting systems:

(*a*) Relatively inaccurate flat-bed or drum plotters which are connected with large computers and only serve for checking purposes;

(*b*) High-precision drafting machines which are built according to the co-ordinatograph principle;

(*c*) Raster plotters, which are a kind of inversion of the raster digitizers.

The main interest here is in plotters (high-precision drafting machines) with constant track control. As an example of the many plotters available on the market, one might mention the Contraves Corograph automatic drafting machine.

The raster plotter may be considered an inversion of the raster digitizer. It comprises an input unit, a control unit with integrated computer, a drum and a photo-exposure device. A film is mounted on the drum and exposed line by line of the drawing by means of a cathode or laser ray. Thus, the map is obtained.

For the output of list data, data terminals, such as the Nixdorf data terminal are used. By means of a ball-head typewriter connected with the data terminal, the list data can be printed in capital and in small letters, including all particular signs. The existing automatically controlled photo-composing machines are, in most cases, not equipped with cartographic type; but in this field also, a change is expected. The only automatic systems of which the author knows are operating at the Aeronautical Chart and Information Center, St. Louis, Missouri (United States of America); and at the United States Naval Oceanographic Office, Washington, D.C. They comprise phototyping, draft positioning and subsequent positioning on to the map original by means of photo exposure.

Data processing, computers and programmes

For processing the data of a cartographic system, the use of a small or medium-size computer[6] and a large computer[7] is recommended. For the process computers, a completely new operating system, adapted to the specific requirements of cartography, must be programmed. For the large computers, e.g., the TR 440, the operating system has already been programmed, so that tasks of cartography have to be subordinated to this operating system. As the programming calls for some additional remarks, the programmes for small or medium-size computers are first considered. They can be written in assembly language or Fortran and based on dialogue processing. The user poses partial problems and the computer furnishes the result. The user then decides which problems shall be solved next. The counterpart to dialogue processing is batch processing, a principle which is usually applied to large computers, e.g., the TR 440.

The following programmes have to be set up for small to medium-size computers:

(*a*) Listing of data;

(*b*) Automatic line-following;

(*c*) Conversion of digitizer data, survey data, photogrammetric data and list data to standard system data;

(*d*) Filtering of data;

(*e*) Rectification of data;

[6] Examples of small or medium-size computers are the AEG 60–10 process computer, the Contraves Cora II and the Telefunken TR 86 computer.

[7] Large computers include the TR 440 computers of the IBM series 360 and 370, Siemens 4004 and Control Data 6600. The TR 440, available at the German Computing Centre at Darmstadt, is used by the Institut für Angewandte Geodäsie.

(*f*) Joining of data of several map-sheets or digitizings;

(*g*) Conversion of a given projection into another projection;

(*h*) Merging of identifiers (usually called headers) with geometric data;

(*i*) Correction of data errors;

(*j*) Drawing, scribing and light-spot drawing;

(*k*) Positioning of signatures and lettering;

(*l*) Representation of data on a display unit, etc.

Approximately 50 per cent of the above-mentioned programmes are already available at the Experimental Cartography Unit of the Royal College of Art (London); and at the Rome Air Development Center of the United States Air Force (Rome, New York). The programmes prepared for digital equipment computers are mainly written in assembly language.

The programmes to be prepared for large computers should preferably be written as a post-processor in a cartographic guest language in Fortan IV, as has been suggested with Cartol. Appropriate examples already exist in geology and the machine-tool industry. The following programmes have to be set up for the large computer:

(*a*) Translation of language;

(*b*) Conversion of input data to standard system data;

(*c*) Listing of data;

(*d*) Conversion of a given projection into another projection;

(*e*) Reduction of data;

(*f*) Originalization (preparation of a map original without generalization);

(*g*) Generalization (this also applies when display units are used);

(*h*) Revision of digital data;

(*i*) Management of the data bank;

(*j*) Evaluation of the data bank, etc.

In addition, it should be mentioned that the manufacturer or the user of the equipment must determine the arrangement of the data on the data media, i.e., they must decide on the format of data. Mention is made here of only three formats: the digitizer format; the system format; and the international format. Further details of this subject cannot be discussed here.

Data bank

The data bank used for the storage of topographic data consists of two different component groups: (*a*) list data; and (*b*) digitized topographic data. In order to give an idea of the quantity of topographic data, the estimated quantity of data required for the German Basic Map (Deutsche Grundkarte) 1:5,000 are as follows: the map comprises 62,000 sheets; the estimated number of points are 1.9^9; this corresponds to approximately 30,700 points per sheet and approximately 20 points per square centimetre; the resulting total number of stored data amounts to about 11.4^9 bytes.

Storage media are interchangeable discs (no fixed discs), magnetic card storages and magnetic tapes.

In the system analysis of NC software, the following solution has been suggested for the field of cartography:

> "As a matter of principle the data are stored on magnetic tapes. This has the additional great advantage that within the entire system only one standard data format is required which is made obligatory, e.g., for the AEG Computer 60-10 as well as for all EDP plants involved.
>
> "For processing, the data of all tapes involved are read, one after the other into a large-capacity storage which, in pursuance of this concept, need not be exchangeable any more. After processing, the same storage is used for copying on new tapes. Thus, the problem is solved at the cost of the running time of the computer which is extended by the repeated copying".[8]

As concerns data storage, it is recommended that a data bank for each scale be established.

The automatic preparation of topographic maps, in general, has been undertaken with much energy; and, in consideration of the tremendous task to be performed, considerable progress has already been made.

[8] G. Horn, "Systemanalyse", *Nachrichten aus dem Karten und Vermessungswesen* (Frankfurt am Main) special publication, 1970

A PRESENT-DAY PROCEDURE OF TOPOGRAPHIC MAP REVISION*

Paper presented by the Federal Republic of Germany

At all times, civilized countries have tried to represent their living space on maps. The rapid change in the appearance of the earth's surface due to the increase in population, economic development and industrialization requires maps of the greatest accuracy. Thus, the importance of cartography is constantly increasing, especially for developing regions; for urban, national and physical planning; for traffic, for settlement and, last but not least, for tourism. In many countries, the weight has moved from the preparation of a new map series to the much more important problem of map revision in order to maintain up-to-date usability.

The impact of techniques on equipment and working methods has decisively influenced the design and depiction of maps. Therefore, cartographers have always aspired to make use of the most recent technical developments, in particular, with respect to their endeavours to simplify and facilitate manual work by modern techniques.

In the Bavarian State Survey Office, the procedure of map revision on glass by means of chemical engraving ("wash-out copy") for the remaining part of the map, combined with the procedure of manual coat-scribing for the corrections, has been applied with much success for over five years.[1] The term "chemical engraving"

* The original text of this paper, prepared by Ludwig Katzenberger, München, Federal Republic of Germany, appeared as document E/CONF.62/L.6 and Add.1.

[1] See figure 95 in pocket at end of volume.

means that a cartographic representation (negative), as far as possible resembling an engraving, is made from an existing transparent map original by chemical process. It is of special importance to apply this procedure without a loss in quality. The principle applied to the preparation of a multicoloured topographic map, namely, never to abandon the dimensionally stable carrier, is followed, e.g., with the topographic map at 1:50,000 scale by doing the work on glass. In map revision, too, this principle must be observed if the quality of the map is to be maintained, therefore applying the coat-scribing procedure. In this process, it is very important that the additions are in conformity with the map scale. The characteristic schematization in topographic map preparation must be maintained, and only the really new and essential features may be added.

The above-mentioned procedure of map revision of the topographic map at 1:50,000 scale includes the following:

(*a*) The topographic fundamentals for a revision, cartographically supplemented and illustrated to form the original pattern, the results of an aerial photograph evaluation or those of a field reconnaissance, are photographically reduced to the scale of the map to be revised, this scale being at the same time the drawing scale. Using the former map representation as a basis, these reductions are placed and mounted correspondingly. Then the elements to be scribed are applied on a dark guide-copy on to the coated glass plate, the so-called "working plate". Map revision also includes the updating of lettering, which also is copied on the working plate in a dark tone. As in the preparation of a new map, the map revision is done colour plate by colour plate; first, the planimetry (black plate); then hydrography (blue plate); and vegetation (green plate), etc. The masks for the different fillings for forest, hydrography and roads are matched by drawing. The representation of contour lines usually only calls for retouch work and only seldom will it be necessary to revise large areas;

(*b*) The revision of planimetry includes the deletion of obsolete or changed signs and symbols removed by scraping. From the revised planimetry plate, the chemical engraving (wash-out copy) is made on the working plate provided with a scribe coat; the resulting true-to-size representation looks like an engraving, i.e., negative, transparent. In this process, it is very important to maintain the original line width and the original sharpness of the contours of the former map.

(*c*) On the guide-copy, the changes are manually scribed and joined seamlessly to the existing transparent film containing the unchanged parts of the map. A time-consuming edge-matching, i.e., the combining of the old map parts with the newly scribed changes, is no longer necessary. The time saved resulting from the application of this procedure is considerable. It has already been mentioned that when scribing changes, the new map-lettering applied only as a guide in a dark tone is kept clear of the new elements to be scribed, and that at those places where the old lettering is eliminated or displaced, the representation of planimetry is completed again. This procedure also results in a considerable saving of time, as compared with a subsequently performed background removal of lettering. The result of this procedure combining chemical engraving and manual scribing is the updated planimetric original plate. Eventual corrections caused by map revision or other necessary changes can easily be performed on the working plate by masking or by scribing. The combining of the new planimetry with the lettering is done on glass;

(*d*) The water and the vegetation plates are revised analogically. First, the guide-copy of the already revised planimetry is applied in black, and the guide-copy of the previously mentioned mounting of the topographic base is then applied in a lighter shade on to the mirror-glass plates provided with a scribe coat. Subsequently, the chemical engraving of the remaining parts of the water and vegetation plates is performed, where the obsolete or changed parts of the plates have been previously removed;

(*e*) The precisely matching manual scribings of the changes in hydrography and vegetation complete the corresponding working plates directly. The combining of the revised water-plate with the changed or supplemented lettering of hydrography is done on glass, precisely matching the positive;

(*f*) The necessary revisions for forest, hydrography and roads on the planimetric, water and vegetation plates revised by scribing is also performed on glass by preparing translucent red copies. Subsequently, these copies are supplemented and matched by drawing on the respective blue copy.

The checking of map revision work is indispensable, as it is in map preparation. Thus far, the multicolour copying process on white or transparent Astralon has proved very useful; but the Dupont Cromalin process is currently applied with very great success. This procedure not only results in a considerable saving of time, but facilitates the revision of the multicoloured map due to its excellent and microscopically sharp representation.

The former map preparation techniques using stone and copper plates had developed very specific and expedient revision methods. When drawing on paper and subsequently on plastic foil, the objective was to facilitate very tedious work, particularly in the field of map revision. With the procedure of revision on glass by chemical engraving combined with manual scribing, a far-reaching perfection has been realized. However, efforts to simplify the revision of topographic maps must be continued. Above all, an effort must be made to reduce the period of time between the taking of the aerial photograph or the field reconnaissance and the printing of the map. In this endeavour, the application of automation may bring about considerable progress.

CARTOGRAPHIC CONFIGURATION OF PHOTO MAPS*

Paper presented by the Federal Republic of Germany

Cartographic representations, in particular maps, are an important basis of work and decisions for numerous tasks performed in the different fields of human activity. Maps in this sense are used in physical and regional planning, in environmental protection, in administration, in commerce, in air navigation and navigation at sea, in national defence, etc.

However, maps can only be considered a reliable basis of work and decisions if they indicate the most recent information, i.e., if they are prepared in the shortest possible time and revised at the shortest possible intervals. Currently, the preparation and revision (updating) of map series are essentially influenced by photogrammetry, its photographic and evaluation procedures being extremely efficient as far as the time factor is concerned.

LINE MAPS

It is generally known that in the preparation of line maps, photogrammetry is used to a great extent. Some unsolved problems with respect to the preparation and revision of line maps on the scales 1:10,000, 1:50,000 and 1:100,000 by means of photogrammetric procedures have been dealt with particularly by Commissions D and E of the Organisation Européenne d'Etudes Photogrammétriques Expérimentales (OEEPE). Experts of Austria, Belgium, the Federal Republic of Germany, Italy, the Netherlands and Switzerland have participated in these experimental investigations.[1]

CONTROLLED MOSAICS AND PHOTO MAPS

Aerial photographs are used not only to prepare and revise line maps; but, after corresponding transformation (rectification), as controlled mosaics or as a base for the preparation of photo maps. By "controlled mosaics" is meant one rectified section of an aerial photograph or several rectified sections, fitted together. As a rule, the controlled mosaic is limited according to sheet lines. If the rectification is performed according to the orthophoto method, the controlled mosaic is also called an "orthophoto plan". A "photo map" is understood to be a controlled mosaic provided with cartographic additions, such as names and designations, map grids and contour line representations. The high resolving power of the camera lenses and films currently in use allows ratios of aerial photograph scale m_b to map scale m_k up to approximately 6.0 to be applied with respect to these tasks. Whether the given ratios also apply to aerial photographs taken from great altitudes could not yet be clarified completely. The orthophoto plan at 1:24,000 scale (sheet "Mesa, Arizona") prepared by the United States Geological Survey is of particular interest in this connexion, as the aerial photographs used were taken in November 1970 by an aeroplane of the U-2 type from an altitude of approximately 21,300 m on the image scale of 1:138,000. Here, the scale ratio $mb/mk = 5.75$, and the (printed) controlled mosaic is still relatively legible. With the magnitude of the quotient mb/mk, the area of the territory covered by the aerial photograph is increased (with given m_k), and the number of control points required per unit of area and the orientation time used in the plotters are reduced. If the possibility marked by the quotient mb/mk is used optimally, then the procedures applied to the preparation of controlled mosaics (in particular, preparation of orthophotos) are extraordinarily efficient as far as the time factor is concerned. A review of the current possibilities of orthophoto preparation and use is, among others, given in the reports submitted to a number of meetings, as well as in some other publications.[2]

Cadastral photo maps

As a rule, cadastral maps are used to secure landed properties, in particular, private landed properties, and to register these properties with respect to taxation. In addition to these cadastral maps, many countries produce so-called "economic maps", which contain not only some cadastral data (e.g., property boundaries), but topographic data. They are, in particular, used by the economy (e.g., forestry, agriculture, industry) for planning purposes and other tasks. In countries in which the securing of private landed property only plays a subordinate role due to their social order, frequently only economic maps are produced.

For examples of cadastral maps, one may refer to the work supported by the Federal Republic of Germany in Thailand and Central America (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama) in establishing a cadastre. In Thailand, cadastral photo maps on the scales 1:2,000 and 1:4,000 are prepared for an area limited for the time being to 100,000 km². The sheet lines

*The original text of this paper, prepared by H. Schmidt-Falkenberg, Institut für Angewandte Geodäsie, Frankfurt am Main, appeared as document E/CONF.62/L.8 and Add.1.

[1] H. Knorr, "Die Europäische Organisation für experimentelle photogrammetrische Untersuchungen-OEEPE—in den Jahren 1962 bis 1970", *Nachrichten aus dem Karten und Vermessungswesen* (Frankfurt am Main), special publication, 1971; K. Neumaier, "Interpretationsversuch: Berichte den Zentren der Kommission E der OEEPE", *Nachrichten aus dem Karten und Vermessungswesen*, special publication, 1972; W. Beck, "Herstellung einer topographischen Karte 1:10,000 auf photographischem Wege", temporary report for Commission D (unpublished); K. Neumaier, "Versuch "Bedford" und "Waterbury"—Gemeinsamer Bericht aller Zentren der Kommission E der OEEPE" and "Versuch "Schweizer Block"—Gemeinsamer Berich aller Zentren der Kommission E der OEEPE", *Nachrichten aus dem Karten und Vermessungswesen*, special publication, 1966.

[2] "Proceedings of the International Symposium on Photo Maps and Orthophoto Maps, Ottawa, September 18–22, 1967", *The Canadian Surveyor*, vol. XXII, No. 1 (1968); "Report of the Orthophoto Workshop, January 18–21, 1971", American Congress on Surveying and Mapping, Washington, D.C.; *Communications du Colloque international sur les Orthophotographies et les Orthophotocartes*, Paris, 5–7 October 1971 (Paris, Imprimerie de l'Institut géographique national); general report of Commission IV, Twelfth Congress of the International Society for Photogrammetry, Ottawa, 1972; W. A. Brucklacher, "Rationalisierung der Kartenherstellung durch Umstellung auf Photokarten", *Kartographische Nachrichten* (Gütersloh), vol. 17 (1967); H. Schmidt-Falkenberg, *Das Orthophotoverfahren unter besonderer Berücksichtigung der Arbeiten des Instituts für Angewandte Geodäsie*, report on the activities of the Institus für Angewandte Geodäsie in 1970 (Frankfurt am Main, 1971); R. Förstner and J. Hothmer, "Luftbildkarten zur Einrichtung eines Katasters in Entwicklungsländern", figure XIII, Sonderdruck, paper prepared for the Internationaler Kongress der Vermessungsingenieure, Wiesbaden, 1–10 September 1971; J. Visser and others, "Performance and applications of orthophotomaps", paper presented at the Twelfth Congress of the International Society of Photogrammetry, Ottawa, 1972.

are 50 × 50 cm. The scale ratios are 4.25 and 3.75, respectively.[3] Recently, in El Salvador, cadastral photo maps have also been prepared, the scale being 1:5,000 and in less valuable regions, 1:10,000; sheet lines according to the graticule lines of 1'15" latitude × 1'15" longitude (5.2 km²); and 2.5' latitude × 2.5' longitude (20.8 km²), respectively. Here, the scale ratio *mb/mk* is approximately 3.0.[4]

One might also mention the production of cadastral photo maps in Canada and Japan.[5] Canada plans to produce cadastral maps for all larger towns; some of these maps are prepared as cadastral photo maps on the scale 1:1,000, 1:2,500 or 1:5,000. Japan envisages, within the scope of its 10-year plan for surveying and mapping, the production of 1,990 sheets for an area of 101,670 km².

Although cadastral maps on scales ranging from 1:500 to 1:3,000 are available for the entire territory of the Federal Republic of Germany in the form of line maps, tests have been made as to how these cadastral maps can also be designed as photo maps.

In general, property boundaries cannot be detected, as such, in aerial photographs; whereas buildings, for instance, can be identified very well. In 1970, for example, 222,700 buildings were constructed in the Federal Republic of Germany, which would have to be entered in the cadastral maps in a very short time if a complete proof is striven for. Now, the question arises whether in this case a combination of line representation (e.g., property boundaries) and controlled mosaic is worth while. First investigations on this subject have been made by Beck.[6] An example is the cadastral map at 1:2,500 scale, No. SO 2204, sheet "Burladingen", which has been issued by the State Survey Office Baden-Wurttemberg/1963 as a line map and as a photo map in different versions.

As far as economic maps are concerned, one may refer to the maps produced in the Republic of South Africa and in Sweden. In the Republic of South Africa, a photo-map series at 1:10,000 scale with sheet lines according to the graticule lines of 3' latitude × 3' longitude is currently being produced. An example is sheet No. 2688 AA6, which was issued by the Republic of South Africa in 1969. The scale ratio *mb/mk* is 3.0.[7] Since 1937, the Rikets Allmänna Kartverk has produced the economic map 1:10,000 of Sweden as a photo map with sheet lines 50 × 50 cm. The scale ratio *mb/mk* is 3.0. In less densely populated areas, the map is produced on the scale 1:20,000.[8]

In the Federal Republic of Germany, the function of the economic map is to be fulfilled by the German Basic Map 1:5,000 (Deutsche Grundkarte), of which approximately 40 per cent (representation of planimetry and contour lines) has been completed as a line map. Without the representation of contour lines, approximately 70 per cent of the map has been completed. As far as possible, the German Basic Map contains property boundaries and a relative number of topographic details. The sheet lines are 40 × 40 cm. The cartographic configuration of photo maps at this scale has, in particular, been investigated by Schweissthal,[9] who also has published a number of map samples, some of them provided with hill shading. The State Survey Office of Northrhein/Westphalia introduced the orthophoto method and has issued, since 1969, part of the sheets of the German Basic Map 1:5,000 also as photo maps.[10] As of October 1972, 3,344 sheets had been published,[11] covering an area of 13,376 km². The scale ratio *mb/mk* is approximately 2.6.

Topographic photo maps

In topographic maps, the landscape should be represented in a characteristically simplified and conceptionally clear manner. Contrary to the generalized line map, the aerial photograph shows a non-generalized representation of the landscape. Each detail visible from the air—significant or not as far as the task is concerned—is photographically (objectively) stored, provided the resolving power of camera lens and film, the size of the corresponding detail and its contrast to the surroundings still are sufficiently large. Thus, an important task in the cartographic configuration of topographic maps is to arrange the abundance of information contained in the aerial photograph according to topographic points of view, i.e., to make the represented landscape topographically recognizable by graphic means.

Therefore, it is necessary to ensure that the information contained in the aerial photograph shall as little as possible be made illegible by line drawings to be added.

These requirements are easily made; however, their fulfilment is not quite as easy. Lastly, one more requirement must be made for reasons of economy, namely, to limit the manual work in the preparation of topographic photo maps to a minimum. Otherwise, the time gained by making use of the highly automated orthophoto method would lose its effectiveness.

In connexion with the last requirement, questions of

[3] D. Stiefel, "Aufnahme gezielter Luftbildreihen für Kataster-Photokarten in Thailand", *Bildmessung und Luftbildwesen* (Karlsruhe), 1968; D. Stiefel, "Kataster-Photokarten zur Ausgabe von "Land-Titles" als Grundkarte für die landwirtschaftliche Entwicklung im Königreich Thailand", figure XIII, Sonderdruck, paper presented to the Internationaler Kongress der Vermessungsingenieure, Wiesbaden, 1–10 September 1971.

[4] W. Torge, "Zur Verwendung des Orthophotos bei der Katastereinrichtung in Entwicklungsländern", *Zeitschrift fur Vermessungswesen* (Stuttgart), 1968.

[5] W. H. Bogdan, "Large scale urban mapping techniques within survey control areas in Alberta", *The Canadian Surveyor*, vol. XXVI, No. 5 (1972); T. Oshima, "Photogrammetry in Japan 1968–1972", national report of Japan presented to the Twelfth Congress of the International Society of Photogrammetry, Ottawa, 1972.

[6] W. Beck, "Zur Synthese von topographischer Karte, Orthophoto und Orthophotokarte", *Bildmessung und Luftbildwesen* (Karlsruhe), 1966.

[7] K. J. Lester and J. J. Malan, "The South African 1:10,000 orthophoto map series", paper presented to the Colloque international sur les Orthophotographies et les Orthophotocartes, Paris, 1971.

[8] F. Jonasson and B. Sundquist, *The Official Maps of Sweden: The Modern Series* (Stockholm, Rikets Allmänna Kartverk, 1970); F. Jonasson, "Die Oekonomische Karte 1:10,000 von Schweden: ihre Technologie, Kartographische Gestaltung und Genauigkeit", *Bildmessung und Luftbildwesen* (Karlsruhe), 1965; O. Johansson, "Orthophoto maps as a basis for the economic map of Sweden on the scale of 1:10,000", *The Canadian Surveyor*, vol. XXII, No. 1 (1968).

[9] R. Schweissthal, *Grundlagen, Bearbeitung und Herstellung grossmassstäbiger Luftbildkarten* (Hannover, 1967).

[10] E. Pape, "Die Deutsche Grundkarte 1:5,000 als Luftbildkarte", *Bildmessung and Luftbildwesen* (Karlsruhe), 1971; G. Krauss, "Die Herstellung von Luftbildkarten", *Allgemeine Vermessungs-Nachrichten* (Karlsruhe), 1970; F. Voss, *Die Herstellung von Orthophotokarten 1:5,000 in Nordrhein-Westfalen*, Nachrichten aus dem öffentlichen Vermessungdienst Nordrhein-Westfalen (Bad Godesberg, 1968).

[11] "Landesvermessungsamt Nordrhein-Westfalen, in einem Vortrag in Bad Godesberg", Nach Angaben von E. Pape, Bad Godesberg, 1972.

image transformation also gain a certain importance. Here, single colour or multicoloured half-tone photographs (aerial photographs) are, by photomechanic or digital methods, changed in their ratios of contrast, transformed to line images; or certain gray or coloured tones are filtered out of a photograph in order to obtain colour printing-plates and masks, respectively.[12]

Several reports on the preparation of topographic photo maps have already been published; some examples of such maps are given below.

Examples of cartographic configuration of topographic photo maps

Scale	*Country*	*Published*	*Designation*	*Prepared by*
1:5,000	United States of America	1966	Map section	United States Army Map Service
1:5,000	Federal Republic of Germany	1967	Map section: Greene	R. Schweissthal, Federal Republic of Germany
1:12,500	United States of America	1966	Map section	United States Army Map Service
1:24,000	United States of America	1962	Map-sheet: Roanoke, Virginia	United States Geological Survey
1:25,000	United States of America	1966	Map section	United States Army Map Service
1:25,000	Federal Republic of Germany	1967	Map section: Itzelberg	W. Beck, Federal Republic of Germany
1:50,000	United States of America	1966	Map section	United States Army Map Service
1:50,000	Republic of South Africa	1967	Map-sheet: 2620 CA Mier (15′ latitude × 15′ longitude)	Republic of South Africa
1:50,000	Canada	1968	Map section: Camp Wainwright	Canada, Department of National Defence
1:50,000	Botswana	1970	Map section: Botswana Maun	United Kingdom Directorate of Overseas Surveys
1:50,000	Canada	1971	Map section	Canadian Forces Headquarters
1:100,000	Saudi Arabia	1971	Two map sections: Saudi Arabia	Hansa Luftbild GmbH, Federal Republic of Germany (executed by request of the Government of Saudi Arabia in 1967/68)
1:250,000	United States of America	1969	Map-sheet: Phoenix, Arizona	United States Geological Survey
1:500,000	United States of America	1969	Map-sheet: Phoenix South, Arizona	United States Geological Survey

SOURCES: For Botswana, United Kingdom Directorate of Overseas Surveys, *Photomap Techniques*, technical paper 1/70 (1970); for Canada, Camp Wainright, T. J. Blachut, "Further extension of the orthophoto technique", *The Canadian Surveyor*. vol. XXII, No. 1 (1968); for Canada, map section, M. E. H. Young. "Production of photo maps at 1:50,000 scale in the Canadian Arctic", paper presented to the Colloque international sur les Orthophotographies et les Orthophotocartes, Paris, 1971; for Federal Republic of Germany, Greene, R. Schweissthal, *Grundlagen, Bearbeitung und Herstellung grossmassstäbiger Luftbildkarten* (Hannover, 1967); for Federal Republic of Germany, Itzelberg, W. Beck, "Reproduktions—und drucktechnische Nachbildung und Umgestaltung von Orthophotos", *Bildmessung und Luftbildwesen* (Karlsruhe), 1967; for Saudi Arabia, H. Pape, "Kleinmassstäbliche Luftbildkarten", *Kartographische Nachrichten* (Gütersloh), 1971; for United States of America, Roanoke/Virginia, "M. B. Scher, "New developments in orthophotography", Sonderdruck; for United States of America, other map sections, 1966, C. W. Schlager, "Die Orthophotographie im kartographischen Verfahren", *Bildmessung und Luftbildwesen* (Karlsruhe), 1966.

Thematic photo maps

As is commonly known, in thematic maps one object (the theme) is given preference over the other objects (the topographic base), its graphic representation being especially accentuated. If the theme of the map is geology, one speaks of geological maps; if the theme is hiking, one speaks of hiking maps, etc. So far, only a few examples of thematic photo maps are known, most of them originating from the United States of America (e.g., Geology of the Manila Quadrangle, Utah/Wyoming 1:24,000, issued by the United States Geological Survey, and others).[13] As far as the Federal Republic of Germany is concerned, one may refer, in particular, to the contributions by Schweissthal and Voss.[14] In co-operation with W. Grösschen (Dortmund), Schweissthal prepared an aerophotographic hiking map at 1:15,000 scale of Bad Lippspringe, which also contains hill shading. The experience gained in the preparation of this map are described in detail. Voss explains the map symbols used, for example, the design of forestry maps on the scale 1:10,000 (*Forstbetriebskarten*).

EXAMPLE OF CARTOGRAPHIC CONFIGURATION OF A TOPOGRAPHIC PHOTO MAP AT 1:25,000 SCALE

The Institut für Angewandte Geodäsie has performed several tests as to the cartographic configuration of a topographic photo map at 1:25,000 scale. Some techni-

[12] R. G. Tarkington and W. C. Roemer, "The Kodak Integral Random Dot (IRD) system", paper presented to the Colloque international sur les Orthophotographies et les Orthophotocartes, Paris, 1971; E. Ranz and S. Schneider, "Der Aequidensitenfilm als Hilfsmittel bei der Photointerpretation", *Bildmessung und Luftbildwesen* (Karlsruhe), 1970; G. Kritikos, "Einige Verfahren der digitalen Bildverarbeitung", *Bildmessung und Luftbildwesen*. 1971.

[13] "Proceedings of the International Symposium on Photo Maps and Orthophoto Maps", *loc. cit.*; A. M. Martin, "Neuere Verfahren der Kartenherstellung (mit Hilfe von Luft- und Satellitenaufnahmen) in den USA". *Kartographische Nachrichten* (Gütersloh). No. 6 (1970).

[14] R. Schweissthal, "Topographische und thematische Luftbildkarten", *Grundsatzfragen der Kartographie* (Wien, 1970); F. Voss, "Anwendungsmöglichkeiten von Luftbildkarten für die Forstwirtschaft in Nordrhein-Westfalen", *Bildmessung und Luftbildwesen* (Karlsruhe), No. 5 (1969); F. Voss, "Ein neuer Typ der Forstbetriebskarte, hergestellt auf der Grundlage massstäbiger Luftbildkarten", *Allgemeine Forstzeitschrift* (München), vol. 35 (1970).

cal data on the preparation of the orthophoto plan are given below. The black-and-white aerial photographs at 1:65,000 scale were taken by Hansa Luftbild (Münster) by order of the State Survey Office, Hesse, on 22 September 1971, with a Wild RC8 15/23 at a flight height of about 10,000 m. They cover the area of sheet 5215, "Dillenburg", of the topographic map at 1:25,000 scale of the Federal Republic of Germany, shown in figures 96–98.[15] The scale ratio mb/mk is 2.6.

The map-sheet is covered by two stereo models (sheet lines according to graticule lines 6′ latitude × 10′ longitude). Measurement and storage of terrain profiles for the orthophoto projection were done in the Zeiss Planimat with storage unit SG1 (storage method). The model scale was 1:25,000. The second stereo model was directly coupled to the first model so that all terrain profiles required for the map-sheet "Dillenburg" were coherently recorded on the profile storage plate. The distance between the measuring profiles was $\Delta X_{Pla} = 8$ mm. The orthophoto projection with simultaneous contour-line recording was performed on the Gigas-Zeiss I orthoprojector equipped with the LG1 scanning unit at a transmission ratio of 1:1. The orthoprojector being equipped with an optical interpolation device, the lateral tilts B_x running vertically to the profile axes could be rectified up to 35°. Therefore, strip-by-strip interpolation was not applied so that the width of the strip in the orthophoto also amounted to $\Delta X_{GZI} = 8$ mm. The photographic projection of the orthophoto was done on Gevatone film N31p, the projection of the contour-line representation on Gevatone film N41p (AGFA-Gevaert).

In order to make the landscape represented in the orthophoto plan topographically recognizable from the black-and-white film original by phototechnical means, two tonal-value foils were prepared: a forest foil; and a field foil. A valley foil was prepared manually. After corresponding screening, these foils and the orthophoto foil were used as originals for the printing-plate preparation. For screening, first a 60-dot screen; and subsequently, an 80-dot screen were used. In addition to the foils already mentioned, the grid foil (with place names, map margin and pertinent map information) and the hydrographic names foil were also prepared. For further tests, a settlement foil was prepared manually. Offset printing was done on a Roland Ultra (type RU 4) on coated art paper. The experiences gathered and the conclusions drawn from these tests will be the subject of a separate report.

Some remarks on the economy of the procedure seem appropriate. The accuracy of the photo map evidently corresponds with that of the 1:25,000 topographic map of the Federal Republic of Germany, as could be observed by a visual comparison of the film originals made in the Institute. The measuring of the terrain profiles, including preparatory work and model orientation, and the orthophoto projection, required approximately three days. The manual preparation of the valley and settlement foil required about half a day. Fifteen days were spent on the photomechanical and cartographic work (forest foil, field foil, grid foil, hydrographic names foil); and five days for the printing-plate preparation and the printing proper (including circulation run). Thus, a total of approximately 24 days is reached for the entire working procedure. From this figure, it may be deduced that the preparation of one sheet of the topographic photo map at 1:25,000 scale in the existing version—photo flight and circulation run included—requires approximately one month. Taking into consideration that the preparation of one sheet of the 1:25,000 topographic map of the Federal Republic of Germany as a line map requires approximately 24 months,[16] this time seems to be rather favourable. Naturally, it is understood that the line map contains more information than the presented photo map; but by investing a little more time, this factor can be changed in favour of the photo map. Apart from this, one should bear in mind that the Institute has at its disposal measured and stored terrain profiles at all times and that it is able to prepare with the aid of these profiles a new orthophoto plan from the latest available aerial photographs whenever need arises.[17] This naturally implies that the stored terrain profiles still apply, i.e., that the surface of the terrain can be considered unchanged within certain limits. This will generally be the case with the scale 1:25,000.

As pointed out in the introduction, maps can only be considered a reliable basis of work and decisions if they show the most recent information, i.e., if they are prepared in the shortest possible time and revised at the shortest possible intervals. Many countries do not yet have at their disposal topographic maps at 1:25,000 scale; and if they do, a large percentage of those maps have not been revised for more than 15 years—European countries included. For the Federal Republic of Germany, a series of controlled mosaics at 1:25,000 scale, which can be revised at relatively short intervals, exists for the military sector where the most recent information of a map is of particular importance.[18] In other countries, the situation will probably be similar. Rapid map production and rapid map revision have become tasks of extremely great importance which apply not only to the military sector, as is demonstrated by numerous projects performed in the various countries.[19]

The tests on the cartographic configuration of photo maps on the scale 1:25,000 are not finished with the issue of the sheet "Dillenburg". The colouring does not yet meet expectations. Furthermore, it is intended to print a hill shading in an appropriate form and to perfect the topographic arrangement of the representation. Lastly, it is planned to investigate whether coloured aerial photographs, infra-red aerial photographs or colour-infra-red aerial photographs, and the procedures of image transformation allow for an improvement of the printing-foil preparation. The results of these investigations will be reported at a later time.

[15] Figures 96–98 are in pocket at end of volume

[16] W. Beck, "Die Zukunft der Karte", *Kartographische Nachrichten* (Gütersloh), No. 1 (1972).

[17] H. Schmidt-Falkenberg and R. Olach, "Uber die Wiederverwendung von gespeicherten Geländeprofilen zur Herstellung von Orthophotos aus Luftbildern nachfolgender Bildflüge", *Bildmessung und Luftbildwesen* (Karlsruhe), No. 6 (1969).

[18] E. Müller, "Die Photogrammetrie in militärischen Bereich", *Allgemeine Vermessungs-Nachrichten* (Karlsruhe), No. 10 (1967).

[19] In Australia, for the time being, it is planned to produce topographic maps on the scale 1:100,000 (about 3,000 sheets), part of them as photo maps. The envisaged date of completion is 1977. For a later date, a map series at 1:50,000 scale is planned. In Brazil, for the economic development of the north-east region of Brasilia (approximately 1.6 million km²), topographic maps are being prepared, most of them on the scale 1:100,000, part of them on the scale 1:25,000 and larger. These maps are being produced within the Sudene Project supported by the Federal Republic of Germany. In Japan, it is planned to produce, within the scope of the 10-year plan, 3,010 map-sheets of the topographic map at 1:25,000 scale. In the Republic of Korea, it was planned to produce, within the scope of the five-year plan 1967–1972, maps on the scale 1:25,000 for an area of approximately 30,000 km²; the current status of the project is not known.

AN APPROACH TO A RATIONALIZED MAP REPRODUCTION PROCESS*

Paper presented by Japan

Using the pre-sensitized plate as a printing plate, the Geographical Survey Institute (GSI) of Japan has succeeded in simplifying the plate-making process and cutting down the required working hours to about one third. Further, since the pre-sensitized plate is not suited for correction on itself, the Institute has also established a new system under which the proof print is produced without using the proof press and correction is made on the negative.

This paper deals with the use of pre-sensitized plates and the production of proof prints.

USE OF PRE-SENSITIZED PLATES

For many years, GSI used zinc plates for map reproduction; but when the new small type printing press was introduced in 1966, it began using aluminium plates. In 1971, however, aluminium plates gave way to pre-sensitized plates, which currently constitute the greater part of the printing plates used for map reproduction at the Institute.

The pre-sensitized plate is a ready-made printing plate on which the sensitizer is coated in advance. It is produced by coating with a diazo chemical sensitizer on the base (mostly aluminium sheet), the surface of which has been finished by chemical processing.

The new plate-making process using the pre-sensitized plate is compared below with the former process which resorted to the albumen plate:

(a) *Albumen plate-making process*:
Graining → coating of sensitizing solution → exposure → development → coating of asphaltum tincture → gumming up;

(b) *Pre-sensitized plate-making process*:
Exposure → development → gumming up.

As is clear from this comparison, the pre-sensitized plate completely dispenses with the pre-exposure processing and, at the same time, makes the process after exposure very simple. The graining and the coating sensitizing solution required in the former process had to be conducted for each albumen plate, so that they were subject to a slight lack of uniformity and were liable to affect delicately the reappearance of half-tones and minute images, thickness of lines and printing durability. The adverse effect of graining and sensitizing work on these factors often caused problems in printing, but the pre-sensitized plate provided a solution for such problems.

Simplification of the entire process through use of the pre-sensitized plate has produced two benefits. It has reduced the time required for plate-making to about one third and has made it possible to produce the printing plate with ease. Further, if the plate processor that was developed for continuous work is employed, the plate-making work can be more standardized than it currently is.

PROOF PROCEDURE WITHOUT PROOF PRESS

At GSI, final map correction used to be carried out on the printing plates (zinc plates) according to the inspected proof copies. The printing plates thus corrected, however, had the disadvantage of somewhat poor printing durability and scumming of the corrected image. In the meantime, the rapid development of the printing industry, including technological renovation, caused the zinc plate to be replaced by the aluminium plate, which was then replaced by the pre-sensitized plate. However, unlike the zinc plate, neither the aluminium nor the pre-sensitized plate is suited for use as a printing plate if correction has been made directly on it. Accordingly, the printing plate began to be produced after correction was made on the negative and not on the plate itself; and, in an effort to avoid the need for doing the plate-making work twice, studies were made for developing a new production method (contact-printing method) of the proof copy. Through the accumulation of these studies, the base was improved step by step to the polyester film and then to the synthetic paper base, and the sensitizing solution was also improved by stages. The improved production method, however, was still subject to deficient image density and scumming. Hence, GSI continued its experiments to find a remedy for these problems; and, as a result, succeeded in establishing a simpler and better method, which is briefly explained below.

Base and sensitizing solution

Four kinds of base (synthetic paper) available on the market were used in a series of experiments after a study of various data and reports, and the one which best met the following conditions was selected:

(*a*) Sensitizing solution can be applied uniformly;
(*b*) Image adhesion is excellent;
(*c*) Image density is sufficient;
(*d*) Scumming does not occur.

As for the sensitizing solution, efforts were made to develop a new solution which would provide a higher image density than the marketed solutions, the main ingredient of which is either casein and ammonium bichromate. As a result, GSI succeeded in developing a solution which not only fulfils the above-mentioned four conditions, but makes the image more resistant against water.

Comparison of printing method

The following comparisions of printing method were made:

(a) *Printing by proof press*:
Negative → printing → inking → development → gumming up → proof copy → inspection;

(b) *Contact printing (initial stage)*:
Negative → printing → development → dyeing → washing → drying → inspection;

(c) *Contact printing (improved)*:
Negative → printing → development → drying → inspection.

*The original text of this paper, prepared by the Map Management Division, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.62/L.14

As is clear from the foregoing comparison, introduction of method (*b*) in place of method (*a*) made it possible to omit the stage of making the proof copy with the proof press. Then with the establishment of the improved method (*c*), the complicated dyeing and washing stages were deleted and the entire process was greatly simplified, which made GSI confident that satisfactory proof copies could be produced with ease without proof presses.

Calibration on dimensional stability of base

A base exhibiting a superlative workability is of no use for map reproduction if it lacks dimensional stability. Hence, the dimensional stability after repetitious five-colour printing was tested on the above-mentioned base under the following conditions:

(*a*) As a purchased base;

(*b*) Base immersed in water for five minutes and then subjected to one week of seasoning;

(*c*) Base subjected to one week of seasoning after purchase.

The test produced the following results:

(*a*) Under any of the above-named conditions, the maximum expansion or contraction of the base was less than 0.2 mm;

(*b*) The dimensional stability was not affected by temperature change;

(*c*) Examination of the register after printing showed that the dimensional stability could be maintained almost perfectly up to three-colour printing, but that from 0.1 to 0.2 mm of expansion or contraction developed in the case of four or more colours;

(*d*) Tests on the pin system disclosed that the dimensional stability could be best retained and large-sized bases could also be used by pinning on diagonal lines.

CONCLUSION

The method in which the proof copy was produced by the proof press and corrections were made on the printing plate was replaced by the process of contact proof printing and correction on the negative. Through the development of a new and improved sensitizing solution, the dyeing and washing stages were omitted; and GSI can now obtain proof copies of high image density and adhesion with little concern for resistance against water, scumming or dimensional stability of the base. In addition to producing proof prints, the new method may also be applied for printing a small number of copies and for preparing prints in the desired number of selected colours.

SOME PHOTOGRAPHIC AIDS TO MAP PRODUCTION*

Paper presented by the United Kingdom of Great Britain and Northern Ireland

In times of high labour cost it is important that the uses of cartographic manpower on map production are restricted as far as possible to carrying out only creative work. This fact is of particular importance in the Ordnance Survey of the United Kingdom of Great Britain and Northern Ireland, where, in addition to the production of maps at the basic survey scales, large numbers of maps are also produced at derived scales. Over 1,500 cartographic draftsmen and reproduction staff are employed on map production work at the headquarters at Southampton, where at any one time over 14,000 maps are in work on 21 different flow lines. On average, one new map is produced every 13 minutes of each working day. Thus, it will be appreciated that any duplication of effort caused by draftsmen copying, albeit at different scales, previously drawn work or any work which can be done more economically by other means is both inefficient and costly.

In the Ordnance Survey, photographic techniques are extensively used to achieve good quality results economically. No longer is its use restricted to the conversion of fair-drawn or scribed originals into reproduction material; instead, it now plays an active part in all stages of map production. This paper is concerned with some of these photographic techniques.

SOME RECENT DEVELOPMENTS IN PHOTOGRAPHY FACILITATING ITS USE IN MAP PRODUCTION

Although photography has played an important role in map production work since the early days of the art, its use was restricted, until fairly recently, to camera work. This was so because the only emulsions available, giving the high image resolution required, were those of the wet collodion process. With the introduction of "lith" type of high-contrast, high-resolution dry emulsions in the 1950s, this position drastically changed and made available to map producers all the versatility and skills of photography. Other developments that have also contributed to much wider use of photography are improvements in the carrier base whereby polyvinyl and polyester plastics became available in addition to glass. These materials have high-quality matte drawing surfaces, and the latter material has greatly improved dimensional stability. Thus, for the first time, it became possible to add ink or pencil images alongside or adjacent to photographic images; and, because of parallel developments in image erasure techniques, to delete them as required. Other developments in photographic equipment, such as the introduction of automatic film processors, punch register equipment and equipment for miniaturization, have also increased the range and flexibility of photographic techniques as aids to map production.

PHOTOGRAPHIC TECHNIQUES IN MAP PRODUCTION

Some of the more commonly known uses of photography in map work, such as exposing names and symbols on stripping film for direct use by draftsmen, the supply of key material at varying scales for use in original or derived mapping and the production of reproduction material by conventional methods, are not described here; instead, some other more interesting and more versatile techniques are described in detail.

*The original text of this paper, prepared by A. C. Marles, Ordnance Survey, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF.62/L.33.

Separation of two types of detail from one photographic negative

It is frequently necessary to separate different categories of detail on one negative, e.g., grid from base detail. This can be done by a variety of means, such as opaquing out on duplicate negatives; or opaquing out only one category of detail, say, the grid, and using a positive of this in register with the master negative to produce the other separation. Both these techniques are costly in materials and time, and the latter method is liable to error due to film distortion. The method preferred in the Ordnance Survey is to use a combination of both contact and camera photography. First, white drawing-ink with 5 per cent of yellow added is applied with a brush directly to the back (non-emulsion side) of the master film negative to cover one category of the information to be separated. A contact print is made to record the clear image areas only. The master film is then photographed on a camera, using reflected light and a backing sheet of black paper, to record only the detail opaqued out in white. The white opaquing medium may be removed from the master negative to restore it to its original form.

Double line production

In map work, it is frequently desirable to produce two separate lines from one single line or area mask, examples being road-casing lines from the single line of the road infill or perimeter lines from solids denoting wooded areas. To avoid the considerable expense of scribing, this work can be done by photographic techniques using auto-reversal film, which is a high-contrast, low-speed contact film based on the Herschel effect (a latent density has been formed in the emulsion during the manufacture of the film; this density is destroyed by exposure to light of long wave-lengths). It is capable of selective response to light of a particular wave-length; and on exposure to yellow light, the fogging is removed, leaving the film sensitive to white light only. This sequence can be repeated a number of times. Road-casing lines may be produced by placing a positive of the road filling in contact with a sheet of auto-reversal film and grossly over-exposing it to yellow light. This has the effect of undercutting the original road-filling line. A second limited time exposure is then made to white light which re-exposes the non-image areas, but does not affect those under the road-filling line. On development, a negative is produced of the undercut areas, thus giving very fine lines which faithfully record both edges of the road filling, i.e., road casings. As a separate and subsequent operation, the line gauge can be increased to the desired width by contact using spacers. The whole operation takes about an hour to complete, regardless of the density of line work on the original. An alternative to this technique is to use a negative original, thus positioning the lines to either side of the road-filling line.

Line-gauge adjustment

When camera enlargements or reductions are made of maps, all dimensions, including the gauges of lines, are proportionally altered, depending upon the degree of scale change. The resultant line work is therefore frequently either too heavy or too light. A well-known optical instrument has been developed to control line widths by using a system of oscillating optical flats of varying thicknesses. Its operation is such that it adds or subtracts the same increment to or from all the original line widths, thus partially upsetting the cartographic presentation achieved by using lines of varying gauges. To overcome this problem, the Ordnance Survey uses photographic techniques that incorporate the natural phenomenon of diffraction of light combined with close control over exposure and film-processing. The result is line-width control independent of scale change. For enlargements, positive originals on a transparent base are used. By adjustment of the camera diaphragm and over-exposure followed by dish-processing, line work is reduced on enlargement to the required gauge. A similar technique is used when making reductions in scale except that negative originals are used. For other tasks, such as extending the widths of road infills where these have been produced using etched peel-coat masks with the etched lines dyed in black before peeling, the line gauge is adjusted to achieve overdraw to half the width of the road-casing lines by using spacers and controlled exposure during contact photography.

Production of scribing or drawing keys for derived mapping

To make copies of original survey material readily available at the time and in the form it is required for each specific map production stage, source material is microfilmed on to a 35-mm or 70-mm format and reprojected or printed out at the required scale on either film or paper. These reductions are then butt-jointed and assembled on a foil carrying a precise blue grid to cover the respective new map-sheet area. In addition, information copies for draftsmen are printed out at a readily readable scale to facilitate the recognition of detail, etc. Thus the staff are not kept waiting because, source material is in work on other production lines, the information can be easily supplied at almost any desired scale in either transparent or opaque form, the response time is minimal, flexibility of action is achieved and costs are kept to a minimum.

Adhesion of film to a foil

During map compilation, it is frequently necessary to assemble key components to a foil and yet retain the facility to replace or reposition them as required. To achieve this objective an aerosol spray adhesive is applied to the film or compilation base. The adhesive used is colourless and non-toxic, requires only a thin application and does not interfere with subsequent contact or camera photographic operations. It allows films to be lifted from the base and repositioned as required.

Corrections on film

Corrections on film are made either by staging out on negatives, bleaching or cutting windows in the emulsion and stripping in new detail, or by bleaching out detail on positives, using sodium hypochlorite and penning in. The area to be bleached is masked, using either adhesive tape or, for irregular patches, by painting with a varnish. The chemical is swabbed over the area to clear the emulsion and then swabbed off with water and blotted dry.

Production of colour proofs or colour keys

For half-tone, percentage dot or line colour work, proprietary colour key materials provide a quick pre-plate proofing system. The material is .002-inch polyester pre-sensitized with ink-pigmented coatings which

closely match trichromatic and some standard printing-ink colours. Each colour sheet may be overlaid on the other to check register and to permit tone values and colour balance to be assessed and adjusted. Dark-room conditions are not necessary and operations are quickly executed. Both negative and positive working materials are available. The sheets are exposed in a contact frame to a ultra-violet point light source, developed with a proprietary solution and then washed and blotted dry.

Production from scribed negatives with positive additions.

Another valuable photographic application of auto-reversal film is the production of a positive direct from a scriber, on which has been stuck names and symbols in positive form, using strip film or on which penned drawing work has been added. For this technique, yellow scribing material is used in conjunction with auto-reversal film so that wherever yellow light reaches the emulsion, the latent image is destroyed; but where scribed lines allow white light to reach the emulsion, the latent image remains unaffected. Similarly, in areas where strip film or penning prevents yellow light reaching the emulsion, the latent image remains. The developed film is a positive of the scribed line work complete with all other details.

Photography at the final stage

Vignetting

There is a requirement on some maps to highlight the position of certain features, such as coastlines or perimeters of woods, by a colour band of varying density across its width; this process is called "vignetting". Traditionally, vignetting was done by draftsmen using a hair brush to draw a wide band of varying density by meticulously following along, say, a coastline. This band was subsequently photographed in a camera equipped with a half-tone screen. The manual preparation of the vignette was time-consuming, highly skilled and not entirely satisfactory when it had to be repeated throughout a sheet or series and the process of screening invariably led to reduction in quality.

Currently, a combination of photo-mechanical and photographic techniques are used, involving the preparation of a negative peel-coat mask of the feature to be vignetted (e.g., a coastline), from which a photographic contact positive is made. It will be appreciated that if these two components are placed in register and in contact they will cancel each other out; but that if separated by a translucent diffusion material, such as a plastic sheet, a vignetted light pattern is formed around the periphery of the mask due to the principles of light diffusion. To put this into a printable form, a half-tone contact screen and a sheet of unexposed lith film are placed in contact with the mask. This "sandwich" is then exposed to a diffused light source. The width of the vignette is controlled by simply varying the width of the spacer; the direction of the vignette either outwards or inwards is altered by repositioning the mask to either side of the sandwich. This photographic task takes only 30 minutes to complete for, say, a 30 × 40-inch map and can be repeated for adjacent sheets to a high standard of precision and quality.

Unsharp masking

The legibility of names on maps is adversely affected where clashes occur between names and detail or dense colours. Traditionally, this problem was corrected by scraping away or blocking out on the detail or colour components, a lengthy, intricate and costly manual task which frequently resulted in important detail being lost. Photographic techniques have now replaced this method for improving the legibility of names. From the negative, a film positive with increased line gauge is produced using transparent spacers between the names component and a sheet of unexposed film to produce by contact photography an unsharp positive mask, of much heavier line gauge, which is overlaid in register with the detail or colour components when they are contacted to film or printed down to metal. This forms breaks in the detail wherever names will subsequently be positioned. Providing good register control is maintained, an unambiguous legible result is achieved and the absolute minimum of detail lost. The production of a mask takes about 30 minutes and is independent of the density of detail involved.

Production of a combined film negative from negative and positive components

It is frequently necessary to make a negative from a combination of components in negative or positive form. With the use of auto-reversal film, the facility is available to make a combined negative image from a number of separate components, only one of which may be a positive. The film is first exposed over-all to yellow light, for which a suitably filtered pulsed xenon lamp is advisable; and the positive then exposed to the film using white light. Exposure of the negatives is made using yellow lighting. Register of the various components is achieved by pin register or by developing the register marks for visual fitting. With this technique, it is necessary for all components to be of adequate black opacity; red, orange or yellow masking material, such as peel-coat, is not suited for yellow-light exposure. Auto-reversal film is a high-resolution, slow-speed emulsion suited for contact work only; it can be auto-processed.

SUMMARY

This account of some of the photographic processes used in the Ordnance Survey as either aids to map production or aids to the final production stages shows that through their use maximum flexibility and economy of operations are achieved. By using photography in the active role, draftsmen are freed to do creative work; their efficiency is improved, with resultant reductions in costs and through-put times. In conclusion, it is hoped that this paper will stimulate thought on how increased use might be made of photographic techniques in mapping; and that, if not currently the reader may soon echo the view expressed at a meeting on Aeronautical Space Research, "That if computers had been invented before photography we would now be looking upon photography as the great new way of storing and retrieving information".

MAP COMPLETION FOR 1:100,000 SCALE TOPOGRAPHIC SERIES*

Paper presented by Australia

The inevitable delay between the taking of mapping photography and the publication of topographic maps requires an updating step to be introduced after the preliminary photogrammetric compilation is completed and before the final printing takes place. This paper describes the map completion activities in Australia of the Division of National Mapping of the Department of Minerals and Energy, where map completion is a standard prerequisite of the publication of topographic maps.

Field inspection

The extent of updating will usually be related to the age of the mapping photography and to the amount of development in an area; consequently, many inland map sheets may require no amendments at all. However, a field inspection is necessary to assess each map, and this assessment is largely done from the air. Under Australian outback conditions, ground-checking can be both difficult and time-consuming; and it is considered that far better utilization of trained personnel and available time is achieved by adopting aerial inspection methods.

Because of this aerial inspection, it is important that the inspection map used should clearly and unambiguously portray the map features, particularly those of a developmental nature. This clarity cannot be achieved with a monochrome print of the compilation, and colour-proofing techniques are used to produce multicolour prints which have proved to assist greatly the quick assessment of new map detail.

The actual aerial inspection is made using a high-wing light aircraft flown at about 5,000 ft along parallel flight lines normally spaced at 5,000 m apart, but up to 7,000 m in more remote areas. Two observers, one to each side of the aircraft, compare the compilation with the ground detail and record corrections or areas of new development on the inspection map.

The corrections and additions noted during the aerial inspection are transferred in the field on to a field inspection sheet. New or changed names are checked at local sources, usually the local shire council or police-station; and these names, together with any other information obtained, are included on the field inspection sheet.

Supplementary photography

Supplementary photography is flown to cover new or changed detail, using 70-mm format cameras mounted in the inspection aircraft where scattered small features require coverage, and with an RC9 camera fixed in a larger light aircraft when extensive coverage is required. This photography is flown at an altitude not above 10,000 ft, and it is usual to obtain photography at approximately 1:30,000 scale. A B3 gyro-stabilized drift-meter is used for navigation. Kodak XX aerographic film is normally used, and coverage is provided with a 60 per cent overlap.

Office processing

The supplementary photography is annotated before printing in the normal way, and key diagrams are then prepared. When all the photography, field inspection sheets and field reports have been assembled, a map completion sheet is prepared. This sheet is an overlay to the original compilation sheet and shows the corrections and additions to be included, so that the map can be published as the first edition. Detail identified on the supplementary photography is usually transferred either directly to the overlay by means of a Sketchmaster, or through a differential stereoscope to the mapping photography and then to the overlay. The method used here depends upon the terrain and detail, and the format of the supplementary photography. The use of restitution photogrammetric instruments is kept to a minimum.

The final map completion sheet is registered to the original compilation sheet and then forwarded for cartographic processing. The map is then ready for publishing as a full-colour first edition.

Areas of operation

The Division has been carrying out this field revision of its new maps in Queensland, Northern Territory and Western Australia, in both sparsely settled and heavily developed areas. In practice, full supplementary photographic coverage has rarely been required; but, on the other hand, there have been few map-sheets where little or no additional photography has been necessary. Average figures currently show that the inspection procedures require about five hours for a 1:100,000 map-sheet and about three hours flying time for the necessary re-photography.

Local development information

Most of the detail corrections are associated with road improvements and farm development (vegetation and buildings). There are several areas where the mining boom has been reflected by new towns, mine complexes, services (water storages, power-supply, etc.), port installations and railway projects. Once located, they are, as a rule, easily identified on the supplementary photographs, especially when the developmental authorities can supply town and area plans.

In an endeavour to keep informed about developments and anticipated development in mapping areas, reports on projects are examined; and use has also been made of a press-clipping service, with some success, to collate knowledge of development. The most difficult knowledge to acquire is that concerning the small projects, which are essentially of local importance only, but, nevertheless, have landmark value on maps. Small provincial newspapers are a fruitful source of advance knowledge of these types of development.

This technique is operating on a routine basis, and it is anticipated it will continue in its current form for some time to come.

*The original text of this paper, prepared by the Division of National Mapping, Department of Minerals and Energy, Australia, appeared as document E/CONF 62/L 43

A SYSTEM FOR AUTOMATED CARTOGRAPHIC ANALYSIS AND MAP PRODUCTION*

Paper presented by the United States of America

A graphics software package for cartographic analysis and map production has been developed at the Defense Mapping Agency Topographic Center (DMATC) of the United States of America. The system is basically composed of an integrated map data file and a set of programme modules for map data file generation, editing, analysis and display. It is a production-oriented system designed to be flexible enough to meet changing user requirements and advances in technology. The system data flow is shown in figure 99.

Basic file parameters are used to specify the way in which the data will be stored upon input to the system. These parameters allow for development of efficient data organization with a working system. Also, any parameter changes will not affect the movement of data from digital compilation into the map data file. Of course, in most cases, the parameters should not vary during the generation of a specific digital map.

Map display is usually in the form of verification plots for visual analysis or final symbolization plots for map production. It is the display of in-process data file levels that permit iterative editing procedures to be applied in order to produce an acceptable data file. However, in some cases, the initial map data file may be considered sufficiently correct for final graphic display or plot.

Two forms of data manipulations may take place in order to move the map data file to a higher level of quality. One such method is the pseudo-interactive process of visual examination and user-directed updating. The second form is the automatic analysis of the stored data. This analysis provides for spatial corrections to individual features, such as in-line intersection and line closure problems. Furthermore, the fact that the map data file is an integrated data base allows for additional spatial analysis utilizing a pre-established feature hierarchy to perform feature shifting, masking, etc.

Once the map data file is considered accurate enough to meet final map standards, the final colour separation plots will be produced. Each plot, being user coded by map information type (colour), allows a map to be prepared using overlay methods.

DIGITAL DATA COLLECTION AND COMPILATION

Cartographic information exists in many—not necessarily computer compatible—formats. For example, existing data may be in tabular, textual or graphic formats which have to be converted into a digital mode prior to computer processing. Although the major amount of information input to the system is currently from the digitization of graphic formats, any geographical information can be transformed into the system. In any case, data collected for input to the system must have a positional value and an identification code along with possibly other line descriptions.

GENERATION OF MAP DATA FILE

The map data file is partitioned into a rectangular grid (64 by 64 sections, maximum). Each cell of the grid represents a system section which is the basic reference element of the data file. This partition is controlled by a system parameter which specifies the mesh size of the localized first quadrant rectangular co-ordinate system.

Associated with each section of the map data file is a set (possibly empty) of system segments. These segments are subdivisions of chain-encoded lines which have a maximum length. It should be noted that points are lines of zero length. If a segment is assigned to a section, then the segment must pass through the section and also be contained entirely within that section or any of its eight immediate neighbours.

The directional codes used to encode the lines are also utilized to indicate which neighbouring sections contain the previous segment or the next segment. These directional codes, together with segment entry and exit co-ordinates, and a unique line identification, are used in line-following. Thus, the overhead of direct-address pointers is avoided at the expense of line-following efficiency. However, the basic features of neighbourhood and juxtaposition used in cartographic analysis are local in nature, generally requiring local neighbourhood analysis rather than complete line analysis.

Any system line segments assigned to a section are stored in randomly accessible records called "pages". Every non-empty section is assigned one or more pages to store its associated segments. This paging system utilizes a list structure to avoid problems in file expansion. That is, it avoids restructuring of address files and expands the files by adding pointers to overflow pages.

Page retrieval for a section is facilitated by referencing a tabular directory. This 4096-word (64 × 64) directory is of the form: <Processing flag, page number>. The section number is used as the directory index to reference the first page of a section.

The map data file configuration is defined by controlled parameters. Thus, the grid mesh size used to define a section, the step size used to encode lines, the maximum length of segments and the page size used to store line segments are all under parameter control.

A unique map data file is defined by the geographical boundary which is transformed into a local system boundary. All data going into the system must be transformed to overlay a subset of the sections that cover the file. This transformation process can be applied prior to entry into the system or as the data are first put in.

UPDATING OF MAP DATA FILE

A necessary part of any information system is a capability for changing stored data. The primary consideration in the design of the editing process was that a minimum of effort be required from users at the price of more complicated graphical analysis by the update programme. Line identities, feature codes and end-point symbols may be put out on verification plots through user-controlled options in the display package. These items, however, have a tendency to produce clutter and

*The original text of this paper, prepared by William Burdette, Elmo Dario and Norman Spencer, Department of Computer Services, Defense Mapping Agency Topographic Center, Department of Defense, United States of America, appeared as document E/CONF. 62/L.59.

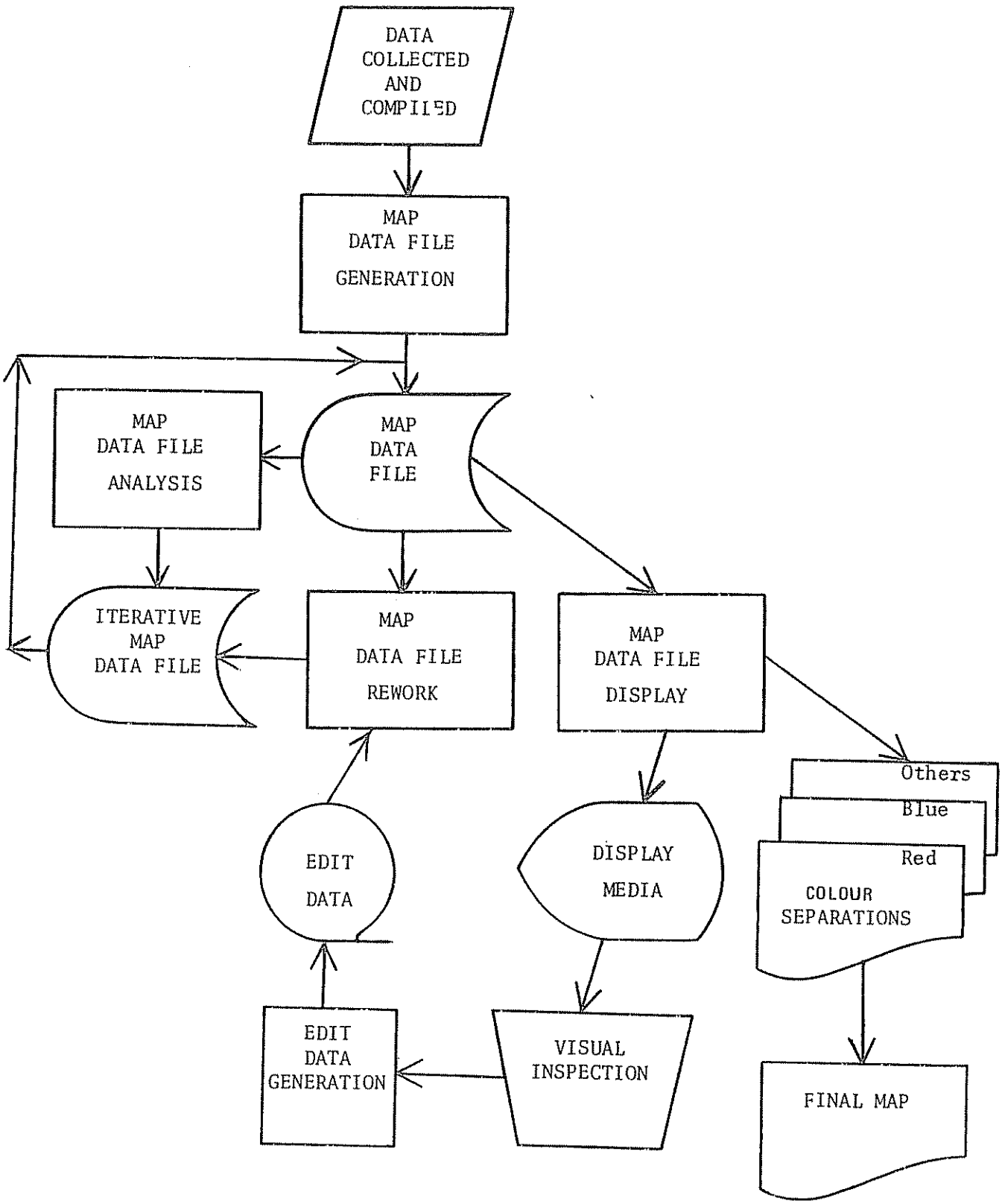


Figure 99. United States of America: system data flow

often require a great amount of manual effort to interpret. By restricting the content of verification plots to centre-line images where pen colours represent line features, visual inspection of verification plots is facilitated. Lines that are missing, improperly classified or badly digitized can be detected visually.

When data update is necessary, an off-line manual digitizer is used in a manner similar to that of a light-pen and cathode ray tube (CRT) display system. Since there is no interactive communication during update processing, great emphasis was placed on simplicity of rules in order to avoid iterative editing. The user places the plot-sheet (or source manuscript) on the digitizing table, points at the reference corners and enters the types of lines on the sheet. The update processor is, in effect, being told to be aware of only those lines in the map model that the user actually sees in the plot. The user may also decide to let the update processor "see" only certain features. With user assistance at line junctions, the update programme recognizes connected lines. The user need not be concerned with where lines actually end or start. He simply "keys-in" the function to be performed and uses a combination of pointing and line-tracing motions to initiate functions for data updating.

Lines on which functions are to be performed may be specified in a variety of ways. For instance, if a complete line without any junctions is desired, the user need only point at the line. A branch of a line is specified by a pointing action and a line trace at the junction. Tracing a portion of the branch conveys not only the location of an end-point, but a direction. Similarly, portions of lines may be specified by two line-tracing motions at the desired end-points. Another very simple rule for specifying any line is to point at the end-points and at any sections necessary to make the line unambiguous.

Functions that operate on specified lines are "delete" and "classification-change". Other update functions are addition of lines, deletion of lines within a polygonal area, marking of desired places for labelling of contours together with suppression of secondary contours and a pictorial print-out of the neighbourhood of a point. Work has been initiated on deletion of arbitrary digitized areas, on applying constraints to "added" lines depending upon stored graphic structures and on applying displacements to lines.

Map data analysis

In order to bring the quality of colour separation plots up to map standards, the system will include modular programmes that will analyse and improve the stored graphic data. The map data file lends itself easily to analysis procedures because all data are, in effect, partitioned into sections. For instance, local graphic relationships can be determined by examining only a neighbourhood of sections.

Work has barely begun in the area of spatial analysis of the map data due to preoccupation with the basic system components. It is currently possible, however, for the system to recognize junctions of the drainage network so that on final symbolization, intermittent lines are continuous at junctions and junction symbols are not duplicated. The system can also rotate small buildings parallel to roads and displace or suppress those that are too close to roads. Programmes are also planned for improvement of stored data by tail-trimming, gap connexion and geometric constraint satisfaction, for elimination of clutter by suppression or displacement of data, for fitting contours to drainage and road networks, and for retrieval of implicitly defined information thereby eliminating unnecessary input.

Map data file display

The system has a display package designed to provide the user with two types of plots. One of these is a verification plot designed to provide a visual check of the data in the map data file. The other is the symbolization plot which, in contrast, contains the symbology necessary for the final map.

The verification plot is only intended for a visual inspection of the data in the file and, therefore, contains only rudimentary symbolization. These plots are utilized by the user for editing purposes. The verification plots can be tailored to the users' needs by means of card input. The plots can contain any combination of line features from the map data file. In addition to centre-line data, the user can obtain the unique identifications attached to the lines, the feature identification and the special symbols to identify the beginning and ending points of the data lines.

Since the verification plots are intended to provide a visual display of the data in the file, there are other options available. They are also controlled by input cards. These are scaling, plotting of small areas of the map and feature selectivity. The purpose of scaling is to enlarge an area of the map. An example of the use of this option would be to allow the user to examine more closely a cluttered area of the map.

The option to allow plotting of a small area of the map allows the user to plot just the changed areas after an edit cycle. The user can therefore see what effect his editing has had on the file without generating complete plots. The user can specify the size of the area to be plotted by input cards.

The last option, feature selectivity, allows the user to plot specific features he is interested in examining. The user can specify a feature or a range of features to be plotted. By not specifying any particular feature, the user can plot all the features in the map data file.

The symbolization plots contain the necessary symbolization to make the colour separations for the file. The system is designed to be iterated through the various phases until the data in the file are correct as far as the system will allow. Only then will the symbolization plots be generated. This is the last step in the computer processing.

The generation of symbolization plots suited for production should be a flexible process. There are several reasons for this requirement. By being able to generate plots for any of several plotters, the effect of production deadlines, priorities and plotter malfunctions can be minimal. Such a process should also be designed to be easily modified to utilize more sophisticated plotters as they become available. The process must also be flexible to handle the symbology of special map requirements.

The symbolization plot process has been designed with the necessary flexibility to handle these requirements. The process has been designed with a control module which directs the symbology of the various features, specifies the output plotter and controls the colour separation. The control module can be easily modified for special requirements.

Colour separation is necessarily a basic function of the symbolization process, because of the role of these plots in making the colour proofs of the final map. The control module directs the grouping of features into colours for colour separation. The control module gives the user colour separation to any degree necessary to meet the requirements of any specific map. The symbolization plots for colour separation may be generated from one computer run or from several, depending upon user requirements.

Conclusion

The current system is directed towards cost-effectiveness in relationship to the bulk of the work involved in mapping, owing to the fact that a major amount of the routine, straightforward and repetitive tasks is well suited for automation. Further development of software for cartographic analysis of the integrated map data file is necessary to meet the continuing demand for a larger number of high-quality maps in less time and at lower cost per unit.

PHOTO MAPPING AT THE DIRECTORATE OF OVERSEAS SURVEYS*

Paper presented by the United Kingdom of Great Britain and Northern Ireland

In a paper presented at the Sixth United Nations Regional Cartographic Conference for Asia and the Far East, held at Teheran, 24 October–7 November 1970, photo-mapping experiments being conducted at the United Kingdom Directorate of Overseas Surveys (DOS) were described.[1]

The main objectives of the experiments at that time were to try to evolve suitable techniques for the cartographic enhancement of rectified photo mosaics of certain types of predominantly flat terrain to meet specified user requirements. The criteria for success were:

(*a*) That user requirements were adequately met;

(*b*) That the techniques could be used under normal production conditions without extensive laboratory control;

(*c*) That the entire process was at least as economical as conventional mapping.

At the time the first paper was written the stage had been reached when DOS was reasonably satisfied that criteria (*b*) and (*c*) had been met, but there was as yet insufficient informed user reaction properly to assess the extent to which criterion (*a*) had been achieved. This information is now available, and this paper first outlines some of the most significant user reactions and then describes the changes made in the production process in an attempt to meet them. Lastly, an account is given of a further experiment which received wide user acceptance, but which failed on economic grounds. The reasons for this failure are discussed, as it is apparent that in some market conditions the process could be viable.

User reactions

Two main groups of map-users are identified. First, the general users, such as tourists, travellers and administrations, who are interested in the over-all picture and "feel" of the terrain. Secondly, the specialist users, such as geologists and hydrologists, who use maps as tools in their investigations.

Reactions from the first group of users to the early production series of DOS photo maps have been generally favourable, particularly among people who are not familiar with the cartographic conventions of normal line maps. It has been found, however, that because of the pictorial nature of photo maps, the choice of colours is critical to their acceptance. Users in this category expect the colours to imitate nature as far as is possible and will not readily accept their use merely to distinguish different terrain categories. In the DOS production series of 1:50,000 photo maps of the Okavango swamps in Botswana, a blue tint was used to distinguish areas liable to flooding. This task it did quite successfully, but there was considerable criticism that this colour made the area look much wetter than it really is, and DOS has accepted this as a valid comment.

Criticisms from the second group of users are more fundamental:

(*a*) The colours detract from the value of the maps as base documents on which specialist information can be superimposed;

(*b*) The terrain features selected by the cartographers for enhancement are not necessarily the ones particular specialists would prefer;

(*c*) The density-slicing techniques used to enhance areas of high vegetation sometimes produce unacceptable interpretation anomalies which destroy user confidence in the product, as compared with a normal photo mosaic where detailed interpretation is left to the user himself.

DOS does not accept items (*a*) and (*b*) as valid criticisms of photo maps in general, as they are equally applicable to any multicoloured topographic map series. Item (*b*) in particular, can be ameliorated by a closer dialogue between map-users and map-makers at the specification stage.

In the case of item (*c*) however, a serious and genuine criticism is established. It must be accepted that any selection process based largely on purely photographic methods will produce some anomalies; but unless the proportion is kept very low, indeed, the credibility of the map is destroyed.

Efforts to minimize interpretation anomalies

DOS efforts to minimize interpretation anomalies are described below:

*The original text of this paper, prepared by A. G. Dalgleish and A. B. Whitelegg, Directorate of Overseas Surveys, United Kingdom of Great Britain and Northern Ireland appeared as document E/CONF.62/L.70.

[1] "Experimental photomapping at the Directorate of Overseas Surveys", *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.72.I.20), pp. 196–199.

(*a*) It is necessary to recall that the previous DOS paper[2] described the components required to form the basic photo map, following the preparation of a photo mosaic. These components are:

(i) A continuous-tone negative (CT) of the mosaic at the prescribed mapping scale, which only serves an intermediate purpose and is not required as part of the final reproduction material;

(ii) A half-tone negative (HT) of the mosaic at mapping scale;

(iii) An over-exposed contact copy (P) to provide a positive in which the tones on CT are presented either as black solids or clear film;

(iv) A conventional contact copy of P to provide a negative (N) In the experimental stages, HT was exposed in the process camera immediately following exposure of CT by interposing the appropriate camera screen. Although care was taken to produce matched prints for the preparation of the original mosaic, tonal differences, particularly between strips of photography still existed; and these were apparent on HT. In order to eliminate or minimize such differences, only CT is now exposed in the process camera. This is retouched either by application of a reducing agent or a diluted black photo tint, according to whether a portion of the negative requires lightening or darkening to achieve a tonal match. From the retouched negative a film positive is made by contacting; and from this positive, the half-tone negative (HT) is produced by exposing through a magenta contact screen;

(*b*) The incorportation of a shadow line to give the effect of height to vegetation, worthy of such treatment has also been described previously and can be seen in the examples illustrating this paper (figures 100 and 101) * This effect is obtained by slightly offsetting P and N to give a line on the required shadow side of vegetation, which eventually becomes one of the reproduction components. An anomolous situation arose, however, when using infra-red photography of an area in various stages of flood. Due to the sharply contrasting tones between wet and dry areas, a shadow line was also apparent on what might be described as the "sunny side" of the dry areas, thus falsifying the effect and hindering correct interpretation of the photo map. This defect can also occur in other cases of sharp tonal contrast, and any unwanted lines of this nature are removed by preparing a "stop-out" mask;

(*c*) Comparison of some photo maps with the original aerial photography showed that, in some instances, areas of very low vegetation, grassland, etc. also contained the shadow-line effect, thus rendering them indistinguishable from high vegetation areas. This fault was due to the concentration on the separation of wet or "damp" areas from dry land. To present a clearer picture to the map-user, it was realized that greater attention must be given to vegetation patterns within the dry land areas where dark tones in the low vegetation areas were reproducing as high vegetation. The categories to be interpreted therefore had to be changed. To minimize production costs, interpretation is generally confined to the separation of low and high vegetation; and by use of appropriate masks, the shadow line is confined to the latter category;

(*d*) Figure 100 is an extract from a six-colour printing of one of a block of 10 photo maps at 1:50,000 scale in the Orapa area of Botswana. In view of the criticism of the blue tint used in the Okavango swamps area, referred to above, this tint is now confined to the depiction of seasonal water, using a 30 per cent, 133-dot screen; and permanent water is shown by use of a 60 per cent, 133-dot screen. As can be seen, this allows the blue printing plate to carry also a solid grid reference system, if required, without detracting from the effectiveness of the photo map. Areas liable to flood are shown in a brown/green colour and, in comparison with the Okavango series of maps, the vegetation has been subdued in an attempt to get closer to the natural colour. All roads, tracks, cut lines, etc. were originally shown in white; but this colour is now confined to the roads, the remainder being depicted by an in-fill of the yellow "undertone" colour which portrays their lesser importance without losing legibility;

(*e*) Figure 101 is an extract from a 1:50,000 scale photo map produced experimentally of an area in the Gambia, prior to undertaking complete coverage of that country by means of the photo map technique. The basic techniques were again employed, but to portray adequately the vegetation patterns, particularly in the vicinity of the River Gambia, extra cartographic and photographic effort is considered to be justifiable. DOS regards six printing colours as being the preferable maximum; and in order to keep to this figure, two half-tone negatives of the mosaic at different screen angles were employed, the additional one being introduced in the swamp area on the red printing plate. Minor amendments will have to be considered for the "production" series to improve legibility of names; but, again, more attention to separation of high and low vegetation may result in less use of the shadow line, which is the main contributing factor to illegibility.

Photo maps on smaller scales

The descriptions given above have all related to maps at 1:50,000 scale. Experiments have been conducted in producing photo maps on the smaller scales 1:125,000 and 1:250,000 by reduction of the original photo mosaics; but new components in the way of half-tones, masks, etc. must be prepared as they cannot be derived successfully from those at 1:50,000 scale. The shadow line was retained for the 1:125,000 example with good effect, but was eliminated at 1:250,000 scale as the effect of vegetation relief was grossly disproportionate to the horizontal scale. These experiments were only taken to negative-proof stage; but results indicated that in certain territories, the photo-map back-cloth to more conventional line detail provides more information than symbolization of vegetation patterns.

Maps of urban areas in Botswana

The acceptance of the photo maps in the rural areas of Botswana led to a request for experiments to be conducted in the similar treatment of urban areas at larger scales. The capital, Gaborone, with its immediate environs was selected as a suitable subject; and, following initial trials which evoked much interest, prints of the most recent aerial photography coverage on the scale 1:10,000 were supplied with a request for a photo map to be prepared on the scale 1:7,500. It must be emphasized that the photography was not flown specifically for the

[2] *Ibid*

* See pocket at end of volume

experiment, and the relationship between the map and aerial photography scales arose simply from the need to include certain areas within a given over-all sheet size. Given photography of good quality, enlargements up to × 4 have been found to be acceptable for reproduction in photo-map form, but at the expense of planimetric accuracy.

The township had been previously mapped in the conventional manner on the scale 1:2,400, and accurate information was available therefore to control the mosaic at 1:7,500 scale; but, even with rectified prints, some difficulty was experienced in obtaining an acceptable fit compatible with the scale. Without recourse to the employment of the more sophisticated orthophoto equipment, one must expect some departure from the accuracy tolerances normally associated with this scale.

In order to give emphasis to urban features, considerable cartographic enhancement was considered necessary, particularly in the preparation of a building mask to show all buildings in a prominent solid colour. A shadow effect to the buildings was obtained by offsetting a positive and a negative of the mask to provide an artificial north-west light source, but much careful obliteration of naturally cast shadows was necessary to eliminate confusion in building shapes. All roads and a railway were shown by colour in-fills; but tracks and foot-paths, being quite visible as part of the mosaic background, were not enhanced.

In this experiment, a vegetation shadow line was not applied; and separation of vegetation categories into three groups—trees, scrub or low bush and grassland—was attempted by means of photo-mechanical processes as opposed to preparation of masks. By using filters of varying density when contacting line positives from the continuous-tone negative of the mosaic and by using a different printing colour for each resultant component, a reasonably accurate separation was obtained. It was evident, however, that the amount of truthful depiction resulting from this technique is dependent upon the original aerial photography being of even quality and contrast throughout the mosaic.

Although such treatment of an urban area may excite interest among certain map-users, it can only be considered economically justifiable where demand dictates a long print run and where, preferably, the area to be so mapped can be contained within a single sheet to eliminate problems of tonal matching to adjacent sheets. If the Gaborone sheet had been undertaken as a "production" job, DOS would have considered it to be an economic failure on the grounds that a more generally useful (and more accurate) conventional line map could have been produced in comparable cartographic time and certainly with less cost in photographic labour and materials.

In rapidly developing townships, a further important consideration is the question of continuous revision. As urban areas expand, the vegetation pattern changes as areas are cleared. Where such patterns are depicted in half-tone on the photo map, the problems of amendment are clearly more complicated than on any line map. They could reach such proportions as to either necessitate preparing a new mosaic from subsequent photography, with its attendant problems of registering with the amended line work; or, alternatively, beginning completely afresh.

ON THE USE OF THE AIRBORNE RADIO DISTANCER FOR 1:50,000-1:100,000 MAP-MAKING AND REVISION*

Paper presented by the Union of Soviet Socialist Republics

The airborne radio distancer (RDS) is intended for determination of photo-centres co-ordinates and distance measurements.

RDS is the phase electronic-measuring system working in decimeter wave-length band. The system measures the distances between aerials of master (airborne) and two slave (ground) stations; the third ground station of the set is used to reduce the number of stations reinstallations when working over vast areas. The master station can also be installed aboard a helicopter. The slave stations are either set at the ground control points if used for determination of photo-centres co-ordinates, or at the both ends of line to be measured, if used for geodetic work. Both measured distances are recorded on 35-mm film. The maximum range is 350 km if there is a direct visibility between an airborne and ground stations, accuracy of one measurement being $m_S = +(1\ \text{m} \pm 10^{-5})$; the permissible aircraft speed being up to 500–600 km per hour.

Airborne radio range-finder tests and field-work were carried out under different physical and geographical conditions: flat taiga and marsh-ridden tundra in the north; areas with a number of large water reservoirs and areas covered with ice and snow, in mountainous regions, in southern areas with high temperature and humidity. Reliability of equipment, simplicity of exploitation and high precision of accuracy have been found in all operations.

To investigate the accuracy of RDS, a number of measurements of many standard base lines with lengths ranging from 40 to 350 km and six sides of geodetic quadrilateral have been measured. The quadrilateral apices were coincided with triangulation points at the angles of astronomical-geodetic polygons, four lines being the diagonals of the first-order triangulation chains. Distances were measured by means of the internal line-crossing method. Average relative value of discrepancies between the obtained geodetic data is 1/400,000. To investigate the accuracy of determination of photo-centres co-ordinates, an experimental aerial survey of a test area was carried out. The scales of the aerial survey were 1:10,000 and 1:17,000; the focal length of the aerial camera is 100 mm. Ground-station remoteness was 100 km; intersection angles were about 60°. Pressure, temperature and moisture at ground and airborne stations were measured to obtain distance correction. The singular models were built and aerial photo triangulation on analogue instruments was made with the aerial survey data; the co-ordinates of separate

*The original text of this paper appeared as document E/CONF. 62/L.77.

check points were subsequently determined. In processing single model measurements, radio geodetic co-ordinates of projection centres were assumed as reference; in aerial photography triangulation, the co-ordinates of projection centres were adjusted simultaneously with their photogrammetric values.

Standard errors of check points of horizontal positions calculated over discrepancies between obtained and geodetic co-ordinates are approximately ±2.5 m. If three to four strips are placed above the point of interest and observations are numerous, then the error is ±1.3 m.

RDS has been used in field-work since 1967. Aerial survey horizontal control on the scales 1:100,000, 1:50,000 and 1:25,000 was established by means of this instrument in remote areas with low density of geodetic net, where conventional methods of control survey would require a considerable expenditure of time, labour and money.

When horizontal control for aerial surveys is conducted by means of RDS, radio geodetic measurements are made concurrent with the aerial survey. In moments of photography tilt ranges between airborne station, aerial and ground ones placed at triangulation points are measured; projection centres co-ordinates are calculated through two distances obtained for each point of photography. Radio geodetic co-ordinate determination may be used when special frame-strips or the total area of the aerial survey are extended.

To develop the horizontal control for aerial surveys, one of the following modes of operation is used:

(*a*) Building up the control for photogrammetric blocks by means of flying with radio measurement rigid frame-strips along the perimeter of the blocks;

(*b*) Building up the control for photogrammetric strip nets by means of flying rigid frame-strips with radio measurements which are perpendicular to the surveying strips;

(*c*) Radio geodetic measurements done simultaneously with over-all coverage of the area of the basic aerial survey.

The rigid frame-strips are used over vast areas having a limited number of days suited for air survey.

Radio geodetic measurements throughout the area of the aerial survey are carried out in map regions with large water reservoirs, which breach the continuous photogrammetric network; and when the identification of points of frame and basic strips is difficult.

In map revision, radio geodetic procedure is the same as for topographic survey of suitable scale. Application of RDS for revision is quite advantageous in regions with poor contours and great changes in the landscape, when photo mosaics have been prepared for revision.

Experience accumulated in the Union of Soviet Socialist Republics confirms the broad technical potentialities and economic expediency of the use of the airborne range-finder for topographic surveying on the scales 1:100,000 and 1:50,000, and also 1:25,000 and 1:10,000, as well as for such work as extension of geodetic networks, and continent and island network conjunction.

CO-OPERATIVE MAPPING AS PART OF AUSTRALIAN AID TO INDONESIA*

Paper presented by Australia

"International co-operation may take various forms or combination of forms and may include the provision of experts, equipments, 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."[1]

Background information

Transmigration as a means of equating the population throughout the islands of Indonesia has been accepted by the Indonesian Government. It is not simply a matter of moving people from the densely populated areas to those lesser populated islands. It is essential to know that those areas prescribed for transmigration are capable of supporting the influx of migrants, that the climate, terrain, water reticulation, etc., are sufficient to support agricultural and industrial growth. It is also necessary to gauge the accessibility of the areas to facilitate the movement of resources and population as the economy expands. To this end, it is essential to have up-to-date maps to implement the above-mentioned proposals.

Australia has responded to the request by Indonesia for assistance by providing funds, equipment, expertise and training to enhance the efforts of Indonesia to promote economic growth and to produce a higher level of living for its people.

Not the least of these is the co-operative mapping programme arranged between Australia and Indonesia, whereby Australian survey teams have been assisting and are continuing to assist Indonesia in establishing control surveys for the production of maps at 1:50,000 scale. In addition to the Indonesian effort, Australia will also undertake to print these maps after they have been compiled and drawn by Indonesia. An additional part of the co-operative mapping arrangement is the training of Indonesian cartographers, photogrammetrists and lithographers at the Royal Australian Survey Corps training establishments in Australia.

The co-operative mapping programme commenced in 1970 with the control survey of approximately 62,000 km² of Kalimantan Barat. The field-survey operations for that project were completed in 1970. The aerotriangulation, adjustments and compilation are proceeding and are at various stages of advancement.

*The original text of this paper, prepared by the Directorate of Survey, Australian Army, Canberra, appeared as document E/CONF.62/L.79 and Add.1.

[1] "International co-operation in surveying and mapping in Indonesia", paper prepared by Soewarno Martojoewono, Secretary of the Board of National Survey and Mapping, Indonesia, *Fifth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II; *Proceedings of the Conference and Technical Papers* (United Nations publication, sales No. E.68.I.4), p. 89.

The subsequent years, 1971, 1972 and 1973, have seen the commencement and progression of control surveys in Sumatra with similar survey operations. It is envisaged that survey control for the whole of Sumatra will be established by 1975, including the connexion of a geodetic network to survey stations situated on the western coast of West Malaysia. This network is being carried out by arrangement with Indonesia and Malaysia.

The basic difference between the Kalimantan Barat survey, which was nicknamed "*Operasi* Mandau"; and the Sumatra surveys, "*Operasi* Gading One, Two, Three" is that Mandau was a trinational venture incorporating Australia, Indonesia, and the United Kingdom of Great Britain and Northern Ireland, whereas the Gading operations involve only Australia and Indonesia. Details of the individual operations are given later in this paper.

Each operation has been conducted within parameters outlined in the Memoranda of Understanding exchanged bilaterally between the countries concerned.

Operation Mandau produced two separate Memoranda; one between the United Kingdom and Indonesia, and the other between Australia and Indonesia. The Gading operations were based on a single Memorandum of Understanding between Australia and Indonesia. All were similar in concept, except that the Mandau operations provided for a variation in the extent of material assistance to be given by the participating countries.

Summary of Memoranda

A summary of the salient points of each Memorandum is given below:

(a) *Mandau.* Indonesia has a requirement for the Province of Kalimantan Barat to be mapped on the scale 1:50,000. To meet this requirement, a geodetic traverse is to be established throughout the area, to which a network of survey control suited for the production of 1:50,000 scale maps may be connected. As a prior task, the acquisition of aerial photography is a necessity. The areas of responsibility are as follows:

(i) *United Kingdom:* provision of aerial photography over Kalimantan Barat; a geodetic traverse and all associated computations; Laplace observations;

(ii) *Indonesia:* ground-marking and station-clearing; heighting by barometric means; Laplace observations; compilation and fair-drawing of each map at 1:50,000 scale; printing of map-sheets;

(iii) *Australia:* Aerodist and Tellurometer control surveys and associated computations; aerotriangulation of the combined traverse and control survey and their adjustments; printing of final map-sheets, including supply of all materials; training of a limited number of Indonesian map-making technicians;

(b) *Gading.* National responsibilities for the conduct of survey operations and co-operative mapping in Sumatra are similar to those of Operation Mandau, except that the United Kingdom is not involved:

(i) *Australia:* Aerodist control surveys and computations; aerotriangulation and adjustments; printing of map-sheets and supply of materials; training of Indonesian technicians; provision of supplementary aerial photography;

(ii) *Indonesia:* provision of aerial photography; ground-marking and station-clearing; horizontal control using Tellurometers; heighting by barometric means; compilation and fair-drawing of each map at 1:50,000 scale; printing of map-sheets

Liaison

Indonesia provides liaison officers to assist in the operations. These officers are appointed directly to each operation and are members of the staff of the Head of Armed Forces Survey and Mapping.

Although national responsibilities were clearly stated, it was agreed that all facets of field operations should be interrelated. Additionally, it was agreed that teams, whether they be predominantly from Australia or the United Kingdom, should also have an element of Indonesian technicians. This agreement served a twofold purpose: it provided on-the-job training in a number of survey disciplines for those who were not familiar with the various techniques; it also overcame any language barrier in the many remote areas visited.

The nature of the survey tasks called for a closely knit series of operations requiring the support of ground, air and marine elements. In addition to the fact that the Indonesian National Mapping Executing Agency is a military organization, it was for the foregoing reason that a decision was made between the participating countries to employ service personnel. To have coordinated a number of civilian organizations, each possibly with its own particular methods of conducting surveys, and with the disadvantages of many and varied types of equipment, was considered not necessarily unworkable, but certainly more complex as far as coordination was concerned. The uniformity of procedures and equipments between Australia and the United Kingdom, and, to a lesser degree, as far as Indonesia was concerned, was an established fact, however, and it only remained to dovetail these into a series of combined operations to provide an excellent workable arrangement.

As a consequence, the first operation was undertaken by:

(*a*) The Indonesian Head of Armed Forces Survey and Mapping Organization;

(*b*) The Royal Australian Survey Corps, supported by the Royal Australian Air Force, Army Aviation; and repair, maintenance and communication teams;

(*c*) The United Kingdom (for Operation Mandau only) provided a troop of Royal Engineer Surveyors and Army sea-transport elements. The Royal Air Force also provided aerial survey photography over the prescribed area of Kalimantan Barat.

Subsequent survey operations in Sumatra in 1971, 1972 and 1973 were undertaken by Australia and Indonesia. The support provided was similar to that stated above, except that marine elements of the Australian military forces were made available to assist in any offshore or coastal supply problems associated with these operations.

The only exception to the use of service personnel was the employment by Australia of a twin-engine Beechcraft Queenair aircraft, hired under contract to fly the airborne master system of the Aerodist equipment. This arrangement had successfully been accomplished by Australia for control surveys within its territories, and there was no reason to change the system for operations in Indonesia.

Equipment employed

The major tasks involved the establishment of control surveys over large areas of terrain where access or intervisibility gave rise to problems for the more conventional survey techniques. It was therefore decided that the Aerodist ground-to-air electro-magnetic distance-measuring equipment (EDM) owned and employed by Australia would be the prime equipment.

Secondary and ancillary equipment used included the Tellurometer, which is a ground-to-ground EDM system of measurement; theodolites of varying orders of precision for first- and second-order, and lower order traverses; astronomical instruments for determining precise positions and azimuth; for heighting, altimeters and barometers were used. In areas where it was virtually impossible to land helicopters without excessive clearing, an "interpolation" technique of Aerodist aircraft altitudes and barometer readings at certain ground stations was devised. This technique is explained below in more detail.

The extent of the support provided is give in table 1.

Table 1. Extent of support provided, by country

Field-survey operations	*Number of personnel*
Kalimantan Barat (Operation Mandau)	
Australia	
Royal Australian Survey Corps	26
Supporting services, including Royal Australian Air Force	47
TOTAL	73
Indonesia	50[a]
United Kingdom	
Royal Engineer surveyors	29
Supporting services	7
TOTAL	36[b]
Sumatra (Operation Gading)	
Australia	
Royal Australian Survey Corps	25
Supporting services	59
TOTAL	84[c]
Indonesia	50[d]

[a] In addition, helicopters were provided to assist United Kingdom survey teams; and large numbers of civilians were employed on many tasks, including station-clearing.
[b] Not including Royal Air Force aerial survey photographic team.
[c] Not including Service marine elements.
[d] Plus helicopter support and civilian labour as in Operation Mandau.

The types of aircraft employed in the operations were as follows:

(a) *Royal Air Force*: the Canberra for aerial photography over Kalimantan Barat; Hercules C130 and Caribou C125 for resupply and positioning of personnel in Kalimantan;

(b) *Royal Australian Air Force*: Hercules C130 for positioning and withdrawing of personnel, Kalimantan and Sumatra; Caribou C125 for close support and resupply on survey operations from main and forward bases; Iroquois helicopters for deployment and resupply of ground survey teams;

(c) *Australian Army Aviation*: Pilatus Porter fixed-wing aircraft for local close support and resupply of survey parties and forward bases; Sioux helicopters for positioning, redeploying and maintaining ground survey teams;

(d) *Indonesian Army Aviation*: Allouette III helicopters to deploy station-clearing parties, Aerodist ground teams and heighting sorties.

Operation Mandau

Topography of Kalimantan Barat

The main topographic and cultural features of Kalimantan Barat are:

(a) *Kapuas River* (Sungai Kapuas). The river originates in the north-east and runs due west until it reaches the South China Sea, south of Pontianak. It is a wide river, generally slow running with numerous meandering branches;

(b) *Pontianak*. This is the principal coastal town and administrative centre of Kalimantan Barat; it is on the Sungai Kapuas Ketgil, situated aproximately 20 km from the sea, and lies virtually on the Equator at longitude 109° 20′ east. Terrain varies from a coastal strip of low salt-water and fresh-water swamp extending between 35 and 115 km from the coast, to mountainous regions in the south-eastern and central northern sections. The mountains range in height from 1,200 to 1,800 m and are very steep and jungle covered. Large areas have been cleared for agricultural purposes, but some of those areas have since reverted to secondary jungle growth.

Climate

The seasons are typically monsoonal, with an average rainfall of 130 inches. The wettest period is from October to May. Temperatures are high, ranging from 26°C to an occasional 35°C. Humidity is also very high.

The Australian teams commenced control surveys on 13 April 1970, and continued until 30 August 1970. A main base was established at Pontianak in close proximity to Supadio airfield. Forward survey bases were placed at Sinkawang, Ketapang and Sintang.

The project area of approximately 62,000 km² was divided into three sectors, (phases) I, II and III, as shown in figure 102.[2] The objective was to designate priorities should there be insufficient time to complete the project as a whole. It also provided for a systematic grouping of Aerodist operations within those priorities.

This pattern of third-order Aerodist control was connected to the first-order Tellurometer traverse established by the Royal Engineer Survey Troop. In the latter stages of the operation, when it became apparent that the first-order traverse would be completed before the scheduled time, agreement was reached for the Royal Engineer Survey Troop to tie in by Tellurometer trilateration four third-order stations, originally the responsibility of Australia.

In addition to this horizontal control, a pattern of vertical control was designed to meet the requirements of aerotriangulation and was established by Indonesian military surveyors.

[2] Figures 102–105 are in pocket at end of volume.

Horizontal control

Two Tellurometer networks were measured in the sector I area prior to the deployment of the Aerodist. The first involved stations P300, P200, P117, P113 and S201, and resulted in the fixation of S201. The second involved stations "A", S214, P122, and P121, and partial fixing of P123 and S227. During these operations, a trigonometrical height value was established at the airfield at Singkawang II. Due to poor intervisibility between the airstrip and P122 and P123, Singkawang II was not co-ordinated.

Aerodist operations commenced with testing over a calibration line established between P200 and P300. Three measurements were recorded.

After the calibration tests were completed, a network of small braced-quadrilaterals was established using six air-mobile Aerodist remote teams. Three Sioux helicopters were employed in moving these teams. Use was made of the United Kingdom first-order traverse to increase the rigidity of the network. Minor delays were experienced due to cloud cover at a few of the higher stations.

Phase I was completed on 10 June 1970, and after a few days of rest, the teams continued in the phase II area. It was eventually decided to combine phases II and III to overcome some difficulties experienced in obtaining sufficient support aircraft and to combat the deteriorating climatic conditions which were increasingly hampering survey operations.

Instead of the planned procedure of using the Aerodist over the virtually inaccessible terrain and employing the Tellurometer over the more easily accessible areas, as in phase I, it was decided to establish most of the survey control using Aerodist.

To accomplish this, selected (primary) stations in the phase II area were more precisely co-ordinated by Aeordist; and from these stations, normal Aerodist techniques were employed to fix the secondary stations.

Two standards of precision were selected for line measurements—primary and secondary, requiring 12 and 6 Aerodist line crossings, respectively. On this basis, a primary and a secondary trilateration net was designed. This method used four relatively stationary teams and two mobile teams which relieved, to a limited extent, the demands on helicopter support.

It became necessary to modify the control network towards the end of phase II/III in the eastern sector, owing in part to unsuitable siting of some stations and to the lack of time and availability of Pilatus Porter aircraft to carry out more detailed forward reconnaissance. At this stage, operations were behind the planned time-schedule.

To effect better progress, all Aerodist ground teams were equipped with Tellurometers and theodolites, which permitted the night-time to be used for angular observations.

Heighting of horizontal control points

Where possible, control stations were connected to sea level or to the first-order traverse stations by one or more sets of simultaneous reciprocal vertical angles. Where this was not feasible, altimetric methods of height control were adopted.

Helicopter support was barely sufficient to maintain the Aerodist measurement programme; and, as a supplementary heighting project would have hampered this schedule, it was decided to use the meteorological readings taken during the Aerodist line crossings to carry heights through the control network.

Height differences were calculated between the aircraft and the two remote stations; and by subtraction, the difference in altitude between any two remote stations was obtained. The number of "diff-heights" into a particular station depended entirely upon the number of Aerodist line measurements into that station.

The method was tested over several lines, and the results were considered acceptable for it to be used for those stations which could not be connected to sea level or to stations in the first-order traverse by conventional means.

A significant factor in employing this method was the large altitude difference between ground stations which made accurate measurements between wet- and dry-bulb temperatures critical. As a consequence, aircraft humidity temperature readings became a painstaking and careful exercise. Correction graphs were designed from readings obtained both inside and outside the aircraft and were applied to the measured distances.

Subsequent operations employed more sophisticated meteorological instruments in the Aerodist aircraft to accurately determine wet and dry temperatures.

Station preparation

During the reconnaissance of Operation Mandau, Aerodist station-clearing information was passed to Indonesia to assist in clearing of the stations selected. The procedure was to fly in an Indonesian liaison officer to the *kampong* (village) closest to the selected station, at which he organized a clearing team from the local residents. This task, which also involved the transportation of ground-marking material, resulted in the virtual full-time employment of one helicopter. When this helicopter became unserviceable, the clearing of survey stations sites became the responsibility of the Aerodist ground survey teams, who handled this arduous task with great alacrity.

Substitute photography

An essential part of the operation was to identify the ground stations on aerial photographs. As a large proportion of this aerial photography had been obtained prior to the establishment of the ground stations, it became necessary to take "blocks" of three or four photographs over each ground station. To assist in the identification of the ground station, white plastic marker panels were placed in the form of a cross over each station. The width of each panel was slightly larger than 1 m, and the length of each arm was 5 m.

Many stations were on high features and needed several photography sorties due to adverse cloud conditions. Difficulty has been encountered in the identification of some targets on the substitute photography because of the poor contrast of the panels against the background foliage.

Conclusion of Operation Mandau

Australia concluded its participation in Kalimantan Barat survey operations on 30 August 1970, and the survey teams returned to Australia. At that time, the United Kingdom also withdrew its teams. Indonesia

continued its heighting programme until all heights required for the adjustment of the whole area were obtained. The Royal Air Force returned to Kalimantan Barat in 1971 to finalize the full coverage of the survey area, which was not completed in 1970.

The venture was most successful. The three countries involved co-operated to the fullest extent, proving that multinational survey projects are not only feasible, but highly productive if all parties show a willingness to work together with a common objective.

There have been problems associated with the aerotriangulation adjustments and in obtaining final values for the network of control. However, these problems have now been resolved, and progress in the production of compilations and fair-drawings by Indonesia is advanced.

Statistics of Operation Mandau

No attempt has been made in this presentation to outline the technical details of station adjustments, misclosures or methods used to obtain these results. Any request for this information should be directed to the Head of Armed Forces Survey and Mapping, Indonesia, at Jakarta. However, a brief summary of these details is given in table 2.

Table 2. Operation Mandau
Summary of stations occupied and lines measured

Horizontal control	*Phase I*	*Phases II and III*
Method of station fixation		
First-order traverse stations	6	6
Established Aerodist	12	—
Established Tellurometer	4	—
Established by Aerodist/Tellurometer	2	22[a]
Stations occupied	24	28
Station details		
Stations resited	5	5
Major clearing required	5	10
Small towers employed (12 metre)	1	4
Large towers employed (22 metre)	2	1

	Lines measured	*Total distance*	*Average*
		(*kilometres*)	
Distances measured—Phase I			
Third-order Tellurometer	20	1,003.3	50.2
Aerodist	45	2,206.0	49.0
Distances measured—Phases II and III			
Third-order Tellurometer	13	866.4	66.6
Aerodist	16 Primary 48 Secondary	5,424.6	84.8

Vertical control method	*Phase I*	*Phases II and III*
First-order traverse stations	7	5
Connexion to sea level	5	8
Third-order simultaneous instrument traverse heights	5	7
Altimetry	7	6
Barometric heights	Numerous VCPs were obtained throughout the area for photogrammetric plotting	

[a]Including six primary stations.

Operation Gading

The island of Sumatra was divided into six phases for ease of priorities, as shown in figure 103. The time-table for the various phases has been laid down as: Gading I 1971; Gading II 1972; Gading III 1973; Gading IV, V and VI 1974–1975.

Included in Gading Three is the plan to connect known survey stations on the western coast of West Malaysia to control on the eastern coast of Sumatra. This project is being undertaken at the invitation of the Indonesian and Malaysian Governments. Aerodist will be used primarily on this project, although Tellurometers may be employed in certain circumstances.

Gading I: 15 May 1971–15 July 1971

Topography of South Sumatra

In the west, the Pegunungan Barisan, a heavily timbered mountain range with peaks up to 3,000 m, runs parallel to the coast. The mountains give way to a central area of low undulating thickly timbered country with occasional areas cleared for cultivation. To the east, a strip of tree swamp extends to the coast, ranging in depth from 10 km inland. The most important river in this region is Sanai Musi, on which lies the principal town and administrative centre, Palembang. This town is approximately 100 km from the Java Sea.

The operation commenced on 15 May 1971 and continued until 15 July 1971. The main base was established adjacent to Palembang Airport; forward bases were formed at Astra Ksetra, Pendopo and at Pangkal Pinang on Bangka Island (see figure 104).

The project area covered approximately 75,000 km². Previously established control exists in the western and southern parts of the operation area; it was therefore decided that the survey control in the area to the east would be established by Aerodist. This area was divided into five phases for ease of logistic support.

Horizontal control

As previously stated, a triangulation network exists through the Pengunungan Barisan; another network runs from Balitung Island through Bangka Island to West Malaysia. Although these two triangulation networks are not yet on a common datum, use was made of them in the design of the Aerodist trilateration net shown in figure 104.

Indonesian surveyors established new stations and upgraded existing ones by theodolite and Tellurometer observations. These selected stations were used to connect the existing triangulation to the Aerodist trilateration.

In the phase I area, a forward base was established at Astra Ksetra. It was at this base that the Aerodist equipment was calibrated.

Another forward base was established at Pendopo in the phase III area. One Aerodist calibration line was measured and a set of Aerodist height checks made. To permit the western end of the mapping photography to be co-ordinated, a strip of RC10 photography was flown between S302 and T3443. This strip straddles the join between phases II and IV.

Although Pendopo is in the phase III area, it was decided to conduct all phase III operations from Palembang. During this phase, two sets of height checks were made.

Likewise, phase IV of the operation was based on Palembang, with the exception of the Aerodist ground station teams on Bangka Island.

The majority of phase V was conducted from Palembang with a small forward base being formed on Pangkal Pinang on Bangka Island. This base comprised two Aerodist ground teams supported by one Sioux helicopter.

As most of the country is covered by tree swamp, station siting was difficult. Towards the end of phase V, build-up of clouds seriously impeded the measurement of long distances, causing the abandonment of two primary lines.

Details of lines measured, stations occupied and established are summarized in table 3.

Table 3. Operation Gading I: summary of work accomplished

	Phase I	*Phase II*	*Phase III*	*Phase IV*	*Phase V*
Method of station fixation					
First-order traverse stations	3	2	1	1	3
Previously established stations occupied	—	4	1	5	7
Primary Aerodist stations (12 line crossings)	2	2	2	2	1
Secondary Aerodist stations (6 line crossings)	12	7	—	1	7
TOTAL	17	15	4	9	18
Station details					
Stations resited	3	2	—	—	4

Distances measured	*Lines measured*		*Total distance*	*Average line length*
	Primary	*Secondary*	(*kilometres*)	
Phase I	8	40	2,967	61.9
Phase II	7	25	2,039	63.7
Phase III	7	—	908	129.7
Phase IV	4	8	926	77.2
Phase V	8	35	2,908	67.6

Heighting of Aerodist stations

The majority of the Aerodist stations were heighted using multiple-base heighting. In this method, three stations of known height on the periphery of the area were barometrically heighted together with the unknown stations. From the readings at the three base stations, the slope of the isobaric surface was determined and isobaric corrections computed for the unknown stations.

The method is considered very well suited for Aerodist operations as it can be conducted simultaneously with Aerodist without the requirement for additional helicopter support. However, accurate altimeter/barometer calibrations are essential.

The western stations of phase IV and the majority of stations in phase III were heighted by carrying diff-heights through with the Aerodist line-crossing nets.

This method, which was devised during Operation Mandau, was selected because of the lack of suitable base stations for multiple-base heighting.

Heighting of vertical control points

The heighting of vertical control points was carried out by Indonesian surveyors using helicopter-supported single-base heighting techniques. First-order triangulation and Aerodist stations were used as base and check stations.

Coastal stations were not heighted. Some inland stations that were situated on rivers or streams also were not heighted. The heights of these stations were obtained by assuming a constant stream gradient between other stations that were heighted. The vertical control plan is shown in figure 104.

Photography

All established stations and selected existing stations were targetted and photographed with short runs of Wild RC10 super-wide-angle photography. The targets used were a white plastic cross with 5-m arms by 1 m in width.

Strips of gap-filling photography were flown when weather conditions were suitable, but these conditions were rare due to continual cloud coverage over the area.

Conclusion of Operation Gading One

The whole operation, including the build-up and withdrawal of technicians and stores, took approximately three months. The co-operation of both countries was again of the highest order.

There were times when the malfunctioning of equipment and adverse weather conditions taxed the endurance of all members, but these difficulties were overcome as each situation demanded, with initiative and resourcefulness, to the successful conclusion of the operation.

As with Operation Mandau, the formidable task of computing, adjusting and aerotriangulation for establishing final values was taken up by the Australian-based units of the Royal Australian Survey Corps. After weeks of concentrated effort, these values were plotted on to gridded manuscript compilation sheets and forwarded to Indonesia. Compilation sheets drawn to publication standard are being progressively supplied to Australia for printing and return to Indonesia on completion of the task.

Gading II: 26 April–29 August 1972

Operation Gading II was an extension of surveys undertaken during Gading I in 1971. The operational area included that portion of Sumatra bounded on the west by meridian 102° east and on the south by 4° south parallel of latitude, as shown in figure 105. Six phases were adopted as priority areas, all of which were completed in the time frame allocated.

Photography

Apart from a small area to the south-east, no suitable super-wide-angle photographic coverage existed. In the area covered by 152.4-mm focal length photography flown by KLM for the Food and Agricultural Organization of United Nations, several gaps exist.

Australia required photo-identifications of additional control stations in the area covered in 1971 in order to complete the aerotriangulation of existing photography.

The order of priority for photographic coverage was:

(*a*) Photo-identification by substitute photography of all Aerodist stations plus previously established stations suited for photogrammetric adjustment;

(*b*) High-altitude photography covering the gap areas in the Gading I project;

(*c*) Acquisition of high-altitude photography in the Gading II operational area in blocks as dictated by the requirement of photography in subparagraph (*b*), to a configuration of map areas at 1:250,000 scale.

The Army Pilatus Porter fitted with an RC 10 aerial camera was used for this project. With an operating ceiling of 7,000 m, control strips were flown at intervals of approximately 15 minutes of longitude in a north-south direction and 1° of latitude in an east-west inland direction, with occasional coastal strips flown to complete the pattern. Installation was completed by 15 May 1972, and the acquisition of substitute photography was obtained at approximately 3,000 m altitude.

High-altitude strip photography was commenced north and west of Palembang on 4 June 1972. This photography was only possible in the hours 0830–1000 and 1600–1630. Some scattered cloud appeared on the prints. Although the cloud cover was excessive for mapping photography, the majority is considered just acceptable for strip adjustment. In the period from 7 June to 5 July, the gap in the priority area south-west of Palembang was covered by six runs of high-altitude photography. This photography also was only possible during the hours 0700–1000. On only 14 days during this period was high-altitude photography flown.

Horizontal control

The following previously established horizontal control was available:

(*a*) A primary triangulation chain extending from Belitung Island through Bangka, the Lingga and Riau Islands to the Malay Peninsula traverses the eastern edge of the area. It is believed to have been established by the Dutch Administration during the mid 1920s;

(*b*) An Aerodist trilateration net observed during Operation Gading I in 1971 extends from near the southern extremity of Sumatra to Palembang, with partial cover-up to Djambi;

(*c*) A primary-order Tellurometer traverse partially observed, generally follows the 103° east meridian in the vicinity of latitude 2° south then swings north-west to cross the 102° east meridian in the vicinity of latitude 1° south. To the west of this traverse, the area is covered by a comprehensive triangulation net varying from primary to tertiary standard.

The basic requirement was for additional control to be positioned along the photographic strips at intervals of approximately 30 minutes of latitude. In the area bounded in the west by the Tellurometer traverse, survey stations falling within the proposed photo strips were selected for substitute photography. In the remainder of the area, a network of primary trilateration figures was selected extending north and west from the 1971 net and tied where possible to existing primary control referred to in subparagraphs (*a*) and (*c*). A network of secondary trilateration figures controlled by the primary network was then selected so that each Aerodist station was fixed by a minimum of four lines. The stations were also selected in the vicinity of villages to assist in identifica-

tion and the procurement of labour by Indonesian station-marking and clearing parties.

The Aerodist stations were to be heighted using the multiple-base method developed during Gading I, the remaining points were to be established by Indonesian airborne teams using single base and/or "leap-frog" altimeter traverse methods.

Aerodist programme

The Aerodist programme comprised the phases described below:

(a) *Phase I.* The forward base was established at Djambi on 13 May 1972, and Aerodist measurement commenced on 26 May. Phase I was completed on 11 June 1972. At two stations, platforms of 12 and 20 m height had to be constructed on the tops of trees. Helicopter support was originally from Palembang and phased into forward base towards the latter stages of this phase. An Aerodist calibration line was measured between P1 and P10 on Bangka Island, and an Aerodist height check was made at Palembang;

(b) *Phase II.* Measurement in this phase commenced 9 June with the forward base at Djambi. The forward base was moved to Djapura on 18 June 1972, with the phase being completed on 22 June. Some difficulties were experienced in measuring across water from a relatively high station at one end. This problem was most noticeable on all lines out of P11 on Singkep Island. Severe thunderstorm activity restricted the positioning of remote parties during this phase. A line between P11 and S353 was attempted, but was abandoned because of a combination of weak signals from a 20-m tower at S353, excessive ground swing from P11 and heavy thunderstorm and cloud activity in the area;

(c) *Phase III.* Measurements commenced 22 June 1972 with forward base at Djapura and were completed 29 June. Progress increased most noticeably during this period in spite of widespread thunderstorm activity, particularly in the Riau Island group. Following heavy rain, the airstrip at Djapura could not be used by the Aerodist aircraft; and for this period, it was based at Pakenbaru. An Aerodist calibration line was measured between P3 and P4 in the Riau Island group;

(d) *Phase IV.* Measurements in this phase commenced on 29 June with forward base at Djapura. This phase was completed on 12 July; the delay during this period was caused by the Aerodist aircraft requiring major servicing. It was originally planned that during this phase a connexion would be made to the Indonesian-Malaysian common datum point on Pulau Pisang. As events turned out however, it was not possible to proceed with this plan; and the programme was modified to measure line S357-P4;

(e) *Phase V.* Measurements commenced 11 July with the forward base at Djapura and were completed 20 July 1972. Some delays were experienced due to malfunctions in the gear-box of the master Aerodist chart-recorder. One Aerodist calibration line was measured between P148 and P145. The primary Aerodist line between P145 and S345 was abandoned after unsuccessful attempts on two successive days;

(f) *Phase VI.* Measurements commenced 26 July with the forward base at Pendopo and were completed 3 August 1972. All instruments were checked and air-tested, and a height check carried out before this phase began. Progress was rapid; but some difficulties were experienced with lines from P85, which, due to its altitude (6,000 ft) was clouded in on most days. The line between T3453 and T3450 was aborted after several attempts; and in lieu, the line from P144 to T3449 was measured, bracing the relevant figure in a complementary direction.

A summary of the stations occupied and established, and the lines measured, is given in table 4.

Table 4. Operation Gading II: summary of work accomplished

	Phase					
	I	*II*	*III*	*IV*	*V*	*VI*
Method of station fixation						
First-order trigonometrical stations occupied	4	2	2	1	2	4
Primary Aerodist stations established	2	3	3	2	2	1
Secondary Aerodist stations established	6	4	7	6	4	6
70-foot tower used	1	1	4	4	9	7
20-foot tower used	2	2	3	1	1	—
Platforms constructed	4	—	—	—	—	—
Primary lines measured	8	10	11	6	15	2
Secondary lines measured	26	17	28	20	18	30

Aerodist programme summary	
Primary lines measured	55
Secondary lines measured	139
TOTAL	194
Days on which Aerodist measurements taken	70
Average lines per day	2.7
Maximum lines in one day	9
Stations occupied	63
Primary stations established	13
Secondary stations established	33

ntrol

y vertical control available was restricted to
)ounded on the west by the 104° 20′ meridian
ed on the north by the 2° 15′ south parallel of
consists of spot heights obtained by altimeter
ıring Operation Gading I in 1971.

dition for the desirable spacing of the vertical
ints was that they fall on each fourth to sixth
ıg the strip and on the end models. In anti-
the photography not being completed during
t, points were selected where the proposed
)graphy crossed the main stream patterns with
sing these for acquiring control by the stream
ıethod. As strips were flown and points be-
able, planned control points were indicated.

ority of Aerodist stations were heighted using
le-base method. Wherever possible, connex-
made to the high-water mark at coastal
Additional vertical control was required to
he aerotriangulation of the 1971 project in the
ern Sumatra area. It was agreed that this area
made a first priority task. Using two Indone-
helicopters, the task was commenced 15 July

II was completed in early August 1972, and
the Australian team departed from Sumatra
gust 1972. Friendly relationships developed
ıe Indonesian and Australian survey teams, as
ıse with previously conducted survey opera-
e mutual benefit of all concerned.

Gading III: 1973

a of operations for conduct of Gading III is
in figure 103. Additionally, it is intended to
the geodetic network across the Malacca
he western coast of west Malaysia.

)peration was in its primary stages at the time
was prepared, it is not intended to elaborate
an to say that the basis of this operation is
he previous operations both in manpower and
ues employed.

posed to expand these remarks during formal
)n of this paper at Tokyo, by which time the
should have been completed and the extent of
ıtrol established and confirmed.

Training

ortant feature of this co-operative mapping
the training given to Indonesian map-making
s by Australia.

es of training fall basically into two categories.
: on-the-job training whereby Australian field
working side-by-side with Indonesians on such
ı as Mandau and Gading impart knowledge
nstrate practically the rudiments of equipment
and procedures. The other is the more formal
f instruction at the School of Military Survey
Army Headquarters Survey Regiment, both
ı Victoria, Australia.

ount of training given thus far does not appear
ge; but it is significant and of considerable assistance to Indonesia, and it is increasing annually. A brief résumé of the training given and that forecast for 1973–1974 is given below.

In 1971 three students attended Army Headquarters Survey Regiment from 13 March to 10 June, for training in the management of a photogrammetric section, a cartographic section and a reproduction section. One other student joined an Australian field survey squadron on survey operations in Western Australia, where he learnt how to mount and conduct survey operations in remote areas.

In 1972 a number of students attended the Royal Australian Survey Corps School of Military Survey to complete the following formal courses:

(*a*) Intermediate survey course 8/72, 3 May-9 August, one student;

(*b*) Advanced survey course 4/72, 19 July-10 October, two students;

(*c*) Intermediate drafting course 7/72, 30 August-22 November, one student.

In addition, formal training, all in ten-week courses, with one student in each, was given in the following disciplines:

(*a*) Instructional staff training;

(*b*) Photogrammetric operators training;

(*c*) Map reproduction;

(*d*) Cartographic drafting;

(*e*) Repair and maintenance of electro-magnetic distance-measuring equipment.

Plans for 1973 included a similar number of courses and formal training periods. There could be variations in the number of students attending or the length of attendance. It is intended that there should be an increase in training and a raising of the level of instruction to meet the needs of the mapping organization in Indonesia. The eventual goal is to expand training until the level of expertise and the number of technicians trained in Australia will provide a strong background for Indonesian training establishments to provide courses within their own map-making organizations.

Conclusion

With the advent of satellite geodesy, wide-scan photography and automated cartography, the world is becoming geographically and cartographically smaller; and the ability for countries to co-operate in mapping developing countries becomes more of a reality.

Australia and Indonesia have shown by example that co-operative mapping is not only feasible, but instrumental in engendering goodwill among countries.

It has been the experience of those Australians employed on survey operations in Kalimantan Barat and Sumatra that the cross-section of people, from Kodam Commanders to the inhabitants of remote areas, has shown a warmth and friendliness which is characteristic of Indonesia.

It is hoped that as these operations proceed, this goodwill will increase and that there will be an expanding interrelationship to the mutual benefit of those concerned.

(b) *Cadastral surveying and mapping*

REPORT OF THE MEETING OF THE *AD HOC* GROUP OF EXPERTS ON CADASTRAL SURVEYING AND MAPPING*

Paper presented by the United Nations Secretariat

The Sixth United Nations Conference for Asia and the Far East, in its resolution 10 on cadastral and urban surveying and mapping, recommended, *inter alia,* that:

> "An *ad hoc* group of experts should be convened by the United Nations as soon as possible to study in depth the problems of cadastral survey and to consider the setting up of a permanent committee to keep developments in this field under constant review".[1]

The Economic and Social Council, by its resolution 1570 (L), requested the Secretary-General to take practical measures for the implementation of the recommendations of that Conference. The Secretary-General therefore appointed an *Ad Hoc* Group of Experts on Cadastral Surveying and Mapping, which met at United Nations Headquarters from 9 to 20 October 1972.

The following persons served as members of the *Ad Hoc* Group:

Gerhard Larsson (Sweden), Chairman
J. C. D. Lawrance (United Kingdom of Great Britain and Northern Ireland), Rapporteur
Franz Au (Federal Republic of Germany)
J. L. G. Henssen (Netherlands)
Arthur M. Heyman (United States of America)
A. J. Van Der Weele (Netherlands)

The Acting Chief of the Cartography Section of the Resources and Transport Division of the Department of Economic and Social Affairs of the United Nations acted as Secretary of the Group. Observers at the meeting included Jose Alberto Gonzalez Garcia (El Salvador); and Jack D. Rosholt, Inter-American Geodetic Survey, Panama.

Among the subjects discussed by the Group were: the definition of cadastre; the general role of cadastre; factors to be considered before establishing a cadastral system; methods of establishing a cadastre; principles for the selection of survey methods; institutional aspects and training; and continuing review of cadastral activities.

Definitions

Resolution 10 of the Sixth United Nations Regional Cartographic Conference for Asia and the Far East, refers to the protection of ownership in those countries where rights of ownership are recognized "by law and by an adequate system of survey and registration". In this context, there are two possible types of "registration", namely, registration of deeds and registration of title.

Under a system of registration of deeds, it is the deed itself which is registered. A deed is a record of an isolated transaction and is evidence that that particular transaction took place; but it is not in itself proof of the legal right of the parties to conduct that transaction and, consequently, is not evidence of its legality. Before any dealing can be safely effected, the ostensible owner must trace his ownership back to a good origin of title.

Where title is registered, this process of tracing ownership back to a good origin of title is unnecessary. The register itself is proof of title, and its correctness is usually guaranteed by the State. There is no need for further investigation.

Of course, where, under a system of registration of deeds, all deeds are related definitely to the parcels of land that they affect and where steps have been taken to examine deeds before registration to ensure their consistency with previously registered deeds, their legal validity and their *bona fides*, the system provides security comparable to that provided by registration of title.

An efficient register of deeds of the type described above or a register of title must consist of an unambiguous definition of the land parcels forming the subject of the register and by a related descriptive record which indicates all relevant information affecting legal rights in each parcel.

These two elements of unambiguous parcel definition and a related descriptive record are basic not only to legal records, but to all cadastral records compiled for fiscal or for any other purpose. There is a further common feature: once the record has been established it must from that moment be continuously maintained if it is to retain its usefulness; and the law must provide for the compulsory registration of any information that affects the parcel definition or the related descriptive record.

For purposes of this report, therefore, the term "cadastre" is used to include not only the record which gives legal force to rights, whether a register of deeds or a register of title, for which the term "legal cadastre" is used, but all other forms of cadastral record, such as a record used for taxation purposes ("fiscal cadastre").

It is emphasized later in this report that it is the legal cadastre which provides the basic tool for maintenance of all cadastral records, for it is as a result of transactions in land that changes must be made in the definition of and rights in parcels. It is also emphasized, however, that once a legal cadastre has been established, it can advantageously be used with the addition of further data for a variety of purposes. The parcel definition provides the common reference point for this additional information which can be recorded on one or on different descriptive records. For a cadastre used for several different purposes, the term "multipurpose cadastre" is used.

The piece of land defined for the cadastre may be a unit of ownership or a unit of use. The term "parcel" is used to describe both these units.

General role of cadastre

Land forms a base for most human activity. Obviously, therefore, systematic records of land and rights in

*The original text of this paper appeared as document E/CONF 62/L.1.

[1] *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol 1, *Report of the Conference* (United Nations publication, Sales No. E. 71 I.15), p. 16

and have great importance for public administration, and planning and land development, and private transactions in land. This situation is particularly true in those developing countries where the rapid growth of population has caused increasing pressure on rural land, while simultaneously a massive migration of people to cities and towns has led to the uncontrolled growth of urban centres. Nevertheless, the need for accurate land records is often ignored by policy-makers; and the cadastral systems of many countries are, in consequence, highly defective.

A cadastre, consisting, as described above, of an unambiguous identification of parcels and a related descriptive record, offers some or all of the following advantages, depending upon the precise purpose for which it has been established:

(*a*) Greater ease, cheapness and security to individuals in dealing in land. Private conveyance of unregistered land is often expensive and unsafe;

(*b*) Consequent stimulation of the land market and investment in land, particularly through longer term credit secured on land. Most banking institutions insist on plans and good title before giving loans or mortgages. Development of both rural and urban land often requires more means than the owners can produce themselves;

(*c*) Reduction in litigation with consequent saving in cost and time to individuals and the State. In many developing countries, much of the work of the courts is concerned with disputes concerning land;

(*d*) Machinery for assessing and levying land tax. Historically, cadastres were often first established for this reason;

(*e*) Basic data and machinery for:

(i) Implementation of land reform measures; it has been the experience of several countries, for example, that it is difficult to draft or enforce reform laws unless precise information about land tenure (e.g., parcel sizes or incidence of tenancy) is available;

(ii) Control of land transactions by means of which compliance is ensured with planning requirements, or by means of which rural indebtedness, uneconomic subdivision, excessive alienation of land to non-nationals, etc. can be prevented;

(iii) Public planning of all kinds; the need for urban planning, in particular, is tremendous. The large-scale cadastral map with the addition of other essential data, such as contouring, is a vital tool for public health or engineering works; while the related records can provide equally essential information on, e.g., owners, land values, buildings, etc;

(*f*) Other working instruments for public administration; for instance, the most natural way to determine and group a population is by reference to its dwelling sites, which can be most suitably defined through the parcel number. Agricultural statistics, electoral registers, assessment books, statistics concerning enterprises, buildings, etc. can be built up in the same way and grouped by reference to the parcels on which the different activities take place or the people live;

(*g*) If automation is introduced, the parcel number can be used as the key by which all registers of this type can be integrated. The information can be arranged according to any desired grouping or area. This system can be further developed by identifying dwellings and the mid-points of all parcels by their approximate co-ordinates as has been done in Sweden;[2] all information in the integrated data system can then be located on maps automatically, a great advantage in inventory and planning operations. Although it may not be practicable or necessary in some developing countries to record these essential statistics on a cadastral basis at the current time, the possible future of a cadastre for these additional data-storing processes should be kept in mind.

The cadastral system can thus be expanded in many ways. The important thing is that the cadastre, when established, should contain basic and reliable information, which is properly maintained and kept up to date and open for public inspection. This information can then be used for special purposes, such as assessment or agrarian reform, by adding data essential for the purpose in question (such data may be included in the same record as the basic information or on separate records). There is already a tendency in all countries with a good cadastre to use it for more and more purposes. Only when a cadastre assumes such a multipurpose character will it provide its maximum usefulness. In short, a cadastre is a basic tool for stimulating economic and social development in both rural and urban areas, and for ensuring effective administration and planning in the public sector.

Factors to be considered before establishing a cadastral system

Although a cadastre offers many clear advantages, there are, of course, many factors which must be considered before a decision is taken to establish a cadastre, which is always a lengthy and expensive operation and which may cause landowners considerable inconvenience, and there are many factors which will affect its form.

Multipurpose cadastres

As already mentioned, a cadastre can be used for many different purposes. It is, therefore, wise in planning any cadastral operations to keep these different purposes in mind in order to ensure that effort and resources shall not be wasted. The intention in establishing a cadastre may be that it will immediately be used for only one of these purposes. For instance, the provision of a comprehensive and efficient legal record is often the immediate and sole purpose of establishing a cadastre, for details of ownership and other legal rights are fundamental to other land records, and it is on the basis of legal rights that the cadastral map is usually maintained. Where adequate legal records already exist, however, the immediate purpose may be to establish a record for taxation or a land-use inventory.

What is important is that the maps and records should be compiled in such a way that they can readily be used for other purposes when the time comes. For instance, decisions must be taken on the appropriate parcel to be identified; usually, this parcel will be a unit of ownership, but in some circumstances, it may be appropriate to identify units of use. The eventual use of computers should be kept in mind; although it is probably more satisfactory at the current time for developing countries to maintain their cadastres manually, data-handling

[2] See Wallner, "The cadastre as the basis of an environmental data system", *The Canadian Surveyor*, Vol. XXIII (June 1969).

systems should be adopted which are amenable to eventual computerization. If, at the time a cadastre is established for one particular purpose, other purposes are envisaged within the foreseeable future, it may prove more economical to collect the data for those other purposes simultaneously in one field operation even though immediate use may not be made of some of the data collected.

Legal factors

Existing legislation will, of course, directly affect the data to be recorded for a cadastre. It will, for example, affect the form of the legal cadastre by determining whether a system of registration of deeds or registration of title is to be used, and the precise rights which are to be registered. It will also affect the type of map that supports the record; for example, some countries specifically exclude the use of photogrammetric processes, while others insist on a verbal description of parcels. Tax legislation will determine what details of land use, buildings or values are to be recorded for a cadastre used for fiscal purposes. Where the law stipulates a procedure that is antiquated or technically undersirable, it should be changed; and the establishment of a cadastre may provide a reason and an opportunity for such change. Nevertheless, an established and familiar legal system will always be an important factor in deciding which form a cadastre should take.

The establishment of a legal cadastre for lands held under customary tenure is always likely to involve new legislation, for the purpose of such a cadastre is to give statutory form to customary rights for the better regulation of dealings in land. Such legislation need not, however, involve any change in the existing customary rights. It is often argued that the conversion of customary rights into registered rights inevitably involves individualization of tenure, which may lead to land-grabbing and inequality; and that individualization will eventually destroy the social security provided by customary land tenure systems which allow any member of the community access to some land within the community area. This is, however, a misconception. On the contrary, it is feasible to register group ownership of land or any other feature of customary tenure, such as "pledging" or separate ownership of land and trees, etc. What is important is to define these features and to provide specific ways of regulating them. For instance, in the case of group ownership of land, it is possible to make simple provisions for the appointment of group representatives, who may deal in the land, but are in no way relieved of their duties to their group. If they default on these duties, individual members of the group can proceed against them: on the other hand, a *bona fide* purchaser can deal with them with absolute security.

However, the establishment of a legal cadastre in customary land areas provides an opportunity for the Government, if it so wishes, to abolish undesirable elements of customary land law or to hasten the process of individualization of tenure. In doing so, careful attention must be paid to possible social consequences.

Social factors

As concerns social factors, for instance, rapid individualization of tenure in customary areas with unrestricted rights of disposal may lead to undesirable aggregation of holdings or to rural indebtedness; it may lead to the suppression of subsidiary rights in land, such as customary tenancies, or to restrictions on the use of lands formerly regarded as free for use by any member of the community. Smaller landowners will benefit from the security provided by a legal cadastre, in particular through the ability to raise long-term loans on the security of their title; but these benefits may be outweighed by the social consequences mentioned above.

Fortunately, however, the establishment of a legal cadastre provides efficient machinery for the administration of control legislation by means of which these undesirable consequences can be minimized. It is essential in planning a legal cadastre for customary tenure areas to ensure that such control measures shall be available from the outset in order to protect landowners unfamiliar with the concept of full individual ownership against unwise dealings, and to restrict, as far as possible, excessive subdivision or dispersal of holdings.

Financial factors

In the final analysis, financial considerations will determine whether a cadastre is to be established and the form it will take. In other words, Governments will wish to be satisfied that the cost of establishing a cadastre is offset by resulting financial benefits. This need is often used as an argument in favour of establishing a fiscal cadastre in advance of a legal cadastre. It is claimed that the survey requirements for a fiscal cadastre are invariably less costly than those for a legal cadastre; and that the process of determining boundaries and taxpayers, who may be the owners or the tenants who actually use the land, for fiscal purposes is invariably quicker and less costly than that of determining boundaries and rights for a legal cadastre. This argument merits closer scrutiny.

The cost of survey will depend to some extent upon the standard of accuracy required, and the law can be made to provide for any degree of accuracy deemed adequate for support of the legal cadastre. In practice, a map compiled by very cheap methods (such as the marking of boundaries on unrectified photographs) has been proved, in many circumstances, to be satisfactory for a legal cadastre. There is no reason why the mapping requirements for a legal cadastre should be more costly than for a fiscal cadastre.

The determination of boundaries and rights for legal purposes may be a slower, and so more costly, process than the determination of boundaries and owners or users for fiscal purposes, but often only marginally so. It is clearly wasteful to record owners or users when with a little more effort all legal rights in the parcel could be ascertained at the same time. Moreover, if the legal rights are not determined, appreciable losses to individuals and to the State will continue to occur until an efficient legal cadastre is established. These losses, although difficult to quantify, may well outweigh any gains from increased tax revenues. For instance, the absence of an efficient legal cadastre usually results in unnecessary and costly litigation; it denies access to credit facilities securable on title to land; and this fact, coupled with insecurity of tenure, inhibits development. A legal cadastre provides machinery for maintenance of ownership rights and necessary alterations to the cadastral map which are essential to efficient tax collection.

Where an efficient legal cadastre already exists, it will provide a basis for a fiscal record; but where it does not exist, the establishment of a cadastre to be used solely

or fiscal purposes will rarely, if ever, be financially ustifiable.

When the intention is to establish a cadastre solely for egal purposes, it must be equally justifiable on financial grounds, difficult though it may be to quantify the financial benefits. This emphasizes the need for selectivity. A cadastre is no less a cadastre if it covers only certain areas of a country; it can be extended and improved as need dictates or resources allow. At first, those areas should be included where there is a clear justification in such terms as dense development, high values and excessive litigation, leaving other areas for subsequent treatment.

Once a cadastre has been established, it must be continuously maintained if the cost and effort in establishing it are not to be wasted. A legal cadastre directly benefits individuals as well as the State. It is a reasonable principle that the cost of maintaining it should be met in whole or in part by those individuals making use of its services, by way of fees payable on dealings. Cadastres used for other purposes, however, benefit the State and only very indirectly benefit individuals. The cost of maintaining them should, therefore, be a charge on public funds. In the case of a cadastre used for taxation, it is easy to justify this principle, as the cost of maintenance will be many times covered by the yield from the tax. In other cases, however, for instance, cadastres used to record agricultural or population data, there will be no direct financial return from the data. They are, nevertheless, essential to planning, however compiled; the use of a cadastre as a basis of collection will provide a more efficient and less costly system than any alternative method.

Administrative and technical factors

Particularly in developing countries, administrative and technical factors may severely limit the possibility of establishing a cadastre or dictate its form. Lack of trained surveyors, for example, is one such factor; terrain that precludes the use of aerial photography is another; inefficient departmental organization involving duplication or fragmentation of effort is another. These factors are discussed in more detail elsewhere in this report, but their importance in deciding whether to introduce a cadastre of any kind is obviously considerable.

Methods of establishing a cadastre

As mentioned above in the definitions, the two essential elements of a cadastre are:

(*a*) An unambiguous definition of each parcel of land, whether a unit of ownership or of use, within a given area;

(*b*) Related descriptive registers which contain, in respect of each parcel, details of all legally recognized rights affecting ownership, or details of use, or such other information (for example, the value of the parcel) as is required for the particular purposes for which the cadastre is designed.

It follows that these particulars must be accurately ascertained and recorded before the cadastre can be established.

In some countries, the immediate and primary purpose of establishing a cadastre is to provide a reliable and comprehensive record of legal rights in land. Indeed, without this record of ownership and rights affecting ownership, the cadastre may be of limited use for other purposes. Frequently, however, some record of legal rights will already be in existence in the form of a register of deeds or a register of title, although it may be neither reliable nor comprehensive.

In establishing a legal cadastre, it may prove possible to use this existing record; and through a simple process of conversion, transfer the information on it to the new cadastre without the need for field investigation.[3] Conversion in this way will, however, be feasible only if the existing record has been efficiently maintained and is supported by unambiguous parcel identification.

More often, a *de novo* field examination of legal rights will be required, even when such rights are documented, in order to establish the legal cadastre. This examination, which must, of course, be given legal force, is usually referred to as "settlement" or "adjudication".

Before adjudication can take place, certain issues must be determined. Among these issues are:

(*a*) The nature of the rights that are to be recorded, e.g., whether title is to be absolute or provisional or, particularly in areas where land tenure is regulated by custom, what rights are to be given legal force;

(*b*) The function of the cadastral map in relation to boundary disputes and boundary relocation, e.g., whether the map is to provide conclusive evidence of the position of boundaries or whether it is to provide an approximate indication only, other factors (such as the existence of visible features) being admissible in the relocation of boundaries. (This issue will, of course, indirectly affect the choice of survey methods used to prepare the map.);

(*c*) The status of unused land, e.g., whether the customary claims of communities to exercise rights over unused lands should be recognized or whether unused lands should be deemed to be the property of the State.

The techniques of adjudication are well documented Methods will naturally vary according to local circumstances, but four points merit particular mention:

(1) *Joint approach.* Adjudication is a process involving demarcation of boundaries, settlement of boundary disputes (the first part of the essential "input" mentioned in the following section), recording of rights and settlement of disputes concerning these rights, survey of the parcels and production of the cadastral map. It is essential that the field staff concerned in all these aspects work together as one team;

(2) *Systematic approach.* Adjudication must be carried out systematically, i.e., all land within a chosen area, which may be of any size, must be adjudicated in one process. A consequence of a systematic approach is that adjudication must be compulsory. Adjudication must, of course, also result in a final determination of boundaries and rights having legal force. The financial arguments for a systematic approach, which incidentally makes the use of aerial photography possible, are obvious. A sporadic approach has many other disadvantages: it can lead to injustice in the ascertainment of legal rights; it can perpetuate the existence of a dual system of land law within the same locality; it means that the cadastre cannot be used for purposes other than recording legal rights because taxation or the compilation of agricul-

[3] As, for example, in Malaysia, under the National Land Code (Penang and Malacca Titles) Act, 1963.

tural or population statistics requires a cadastre compiled on a systematic basis;

(3) *Selectivity*. The areas chosen for compulsory and systematic adjudication should be carefully selected. There is no merit in a rigid geographical progression through a country. Priority may have to be given to particular areas because of such factors as high land values, intensive development or a high rate of litigation over land. When the cadastre has been established, it is likely to be maintained in larger countries at, for example, the district or municipal level. These established administrative divisions and the smaller localities well known to the users of the cadastre by distinctive names should be taken into consideration in planning the boundaries of adjudication areas;

(4) *Finality, speed and accuracy*. Finality is an essential feature of adjudication. If the legal register is to provide certainty and security, particularly if its correctness is guaranteed by the State, it is obviously impracticable to allow the basis of the register to be questioned at some future date. Accuracy in adjudication is therefore important, for lack of accuracy may result in injustice and seriously jeopardize the value of the record. Speed is also important, however, for delay in reaching finality will inevitably increase insecurity and may impede development and cause personal hardship. The procedures of adjudication must be designed to ensure the maximum speed compatible with accuracy. To achieve these objectives of accuracy, speed and finality, adjudication systems should ensure that:

(i) Areas selected for systematic adjudication at one time should be as small as organizational considerations permit;

(ii) The period of notice of adjudication should be kept as short as will provide adequate opportunity for all landowners, including absentees, to make arrangements to submit claims;

(iii) Land suits in the established courts should be stopped; disputes concerning rights or boundaries should be settled in the adjudication process by a specially appointed authority, such as a government official or tribunal;

(iv) If, during the adjudication process, an appeal is to be allowed against the decision of this authority, it should be limited to one such appeal—again to a specially appointed authority;

(v) The period during which the preliminary legal cadastre (i.e., the cadastral map and the accompanying record of rights) is put on deposit for inspection by landowners should be kept as short as will provide adequate opportunity for all interested persons to satisfy themselves as to its accuracy or raise questions or objections;

(vi) When this period has expired, the cadastre should be certified as final and the legal record immediately established so that transactions can take place without further delay, but any aggrieved landowner should be given the opportunity for one appeal, within a defined and limited period, to the established courts against this first registration. The decision of the court will, of course, be final and irreversible.

PRINCIPLES FOR THE SELECTION OF SURVEY METHODS

The purpose of the cadastral mapping operation is the provision of a graphical or numerical definition of the boundaries of parcels. The required "input" for the activities of the surveyor can be divided into three parts:

(1) Identification of the object in the field, which may consist, in its simplest form, of no more than an indication of "here is" the boundary. If this boundary is a topographic feature, the surveyor can do his measurements at any time provided that the feature is still there. If the boundary is invisible, the surveyor will put in some kind of mark. An important function of the record defining the position of a boundary is that it permits the boundary to be reconstructed in the future. The use of aerial photographs on which the boundaries are annotated considerably improves the possibility of such reconstruction, as they automatically indicate the position of the boundary in relation to all visible topographic features and not only to those which have been used in the description or for the measurements;

(2) Existing data about surveys carried out previously in the area (existing framework of known points, etc.);

(3) Specifications with respect to the accuracy and the speed with which the measurements have to be carried out. Higher accuracy almost invariably results in higher costs. The best compromise has to be found between those two conflicting aspects whereby the urgency of the work may lead to the choice of time-saving methods which may require a (temporary) relaxation of the accuracy requirements. Apart from other considerations that are relevant to the choice of accuracy limits, an important technical point is to realize that for the great majority of purposes and, in particular, for cadastral surveys, only an appropriate relative accuracy is required. In other words, it is more important that a parcel is measured and mapped correctly with respect to its immediate surroundings than that its absolute position with respect to some remote reference point (origin of a co-ordinate system) is correct. Similarly, there is no sense in raising the requirements for accuracy beyond the limits within which boundaries can be defined. The traditionally assumed relation between land values and accuracy should be examined very critically. In order to make a cadastral survey an economically justifiable undertaking, tolerances should not be copied from elsewhere, but should be established on the basis of local circumstances, including the purpose for which the system will be used.

Survey procedures

In this paper, survey procedures are considered in two main groups: field survey procedures; and photogrammetric procedures. First, however one important point should be made clear. Photogrammetry can never do without field support. This support is required in two phases of the procedure:

(1) There must be available a number of control points in order to determine the position, the scale and the orientation of the photogrammetric restitution. In this context, the term "control points" (also called "pass points") is meant to describe points of which co-ordinates are known in the system that has been adopted for the cadastral map (national or local) and which are, at the same time, precisely identifiable on the aerial photographs;

(2) All boundaries or other topographic features that are required on the map, but that are, for some reason, invisible or unidentifiable on the photographs, have to be measured by field methods. In order to tie those field measurements to the photogrammetric restitution, it is necessary that a sufficient number of reference points or reference lines be provided. These points or lines have to fulfil the requirement that they are measured in both the field and the photogrammetric systems, and that there is no doubt about their correct interpretation.

The density and the distribution of both the control points and the reference points depend upon the local circumstances. Photogrammetry is generally not economically justified for the maintenance of cadastral maps, as the relatively high initial cost conflicts with the dispersal and simplicity of the work to be carried out. This fact stresses, however, the need to pay careful attention to the provision of reference points for tying future field measurements to the photogrammetric restitution. In the following paragraphs, some of the advantages and disadvantages of the two groups of survey procedures are mentioned in order to provide a first set of criteria on which a choice of survey methods can be made.

Field survey procedures

The advantages in field survey procedures are as follows:

(*a*) The measurement can, if desired, begin directly after the identification of the boundaries. In some cases, these measurements may form a part of the identification (e.g., distances to adjacent objects or directions with respect to the magnetic or astronomical north direction). The chances that, after the identification, a different line may be measured is thus reduced to a minimum;

(*b*) The necessary investment in instruments and other material requirements is relatively small;

(*c*) The process of transforming the field observations into maps is comparatively simple and does not require high investment.

The disadvantages of the procedure are:

(*a*) The detail survey requires the establishment of a comparatively dense network of points. In some cases, where even a primary or secondary triangulation or a similar basic network is not available, this may constitute a very severe drawback. The establishment of a local or regional triangulation or trilateration network may offer a practical solution; but it is time-consuming, weather-dependent and expensive, and thus may cause serious delays;

(*b*) Field procedures are usually very work-intensive, which means that they may either last for a considerable period of time or require a large number of skilled personnel to finish the job in a short time. (The dependence on weather conditions makes strict planning difficult.) In addition, investment in transport facilities will be high;

(*c*) When, during the restitution phase, it is found that reobservations or additional observations in the field are required, this may cause considerable delay and be relatively expensive;

(*d*) This set-up of the system of angles and distances which together constitute the geometrical framework of the survey depends very much upon local terrain conditions. In consequence, it may be expected that the accuracy obtained in the final result is not homogeneous. Moreover, to guarantee the required accuracy at less favourable parts of the network, there is very often an unavoidable tendency to increase the accuracy of the measurements for the whole network, which, however, will always lead to higher costs.

Photogrammetric procedures

The advantages of photogrammetric procedures are as follows:

(*a*) As has been pointed out above, the use of aerial photography during the identification stage has a number of favourable characteristics;

(*b*) Photogrammetry can be applied also when only a very sparse network of known points exists. Photogrammetric block-triangulation has been proved capable of providing a dense network of points with a remarkably homogeneous accuracy, even when only very few control points are available;

(*c*) As soon as the photogrammetric triangulation (if required at all) has been completed and the boundary identifications are available, the basic data for the restitution are complete. The restitution itself can then be done at any suitable time and for any chosen area. The adaptability of the procedure to respond to incidental needs of time and place is thus extremely high;

(*d*) Photogrammetric procedures can provide maps or map substitutes in a wide variety of costs, accuracies and speeds, with the special property that a chosen procedure can be improved at any time without much duplication of work. Thus, the procedure has great flexibility and can be adapted to the constraints of the moment (available means, instruments and personnel). As this is a very important feature, it is discussed below in more detail in the section on photogrammetric procedures;

(*e*) Where aerial photographs, together with the necessary control points, exist, it can be stated that an amount of information has been collected of which the possible use goes far beyond the determination of boundaries only. Within the land registration system, data about land use, buildings, value, etc. may be included with a minimum of extra cost. Topographic maps on large scales (e.g., for planning of engineering projects) can also be produced with relatively small extra cost. In short, the available information can form an excellent and cheap basis for a great variety of other activities. In this respect, special attention should be given to the use of aerial photographs for interpretation purposes applied to natural and human resources studies.

(*f*) The time or manpower required for the production of cadastral maps is, as a rule, considerably less than that for the application of field survey. Apart from the fact that this usually results in a cheaper product, there is the important advantage in cases where the personnel involved in the project has still to be educated.

The disadvantages of this procedure are:

(*a*) Only in exceptional cases will aerial photographs provide the complete information required on the map. Field completion will be necessary for all invisible boundaries, which requires careful co-ordination of field-work and office work;

(*b*) The application of photogrammetry usually requires high investment, which begins with the cost of photographs which is independent of the amount of the useful information that they contain. The instruments to be used are expensive, and they require additional investment for their housing (air-conditioning, protec-

tion against vibration, etc.). These high initial costs are, for economic reasons, an argument both for careful planning and for centralization of the restitution activities in one bureau;

(*c*) As already pointed out, the high initial cost of aerial photographs makes photogrammetric procedures less suited for maintenance work. Only when many changes that have to be measured are concentrated in an area of limited size, such as a new layout of urban areas, in reallotments and the like, will photogrammetry be economically justified;

(*d*) In some cases, pre-signalization of points may be required, e.g., to make invisible boundaries identifiable on the photographs or to provide well-defined control and reference points. The process of signalization itself, as well as the maintenance of the signals until the flight has succeeded, may cause organizational problems, will tend to increase the cost and may lead to delays in the production. The advantages and disadvantages of signalization should, therefore, be carefully considered.

Properties of photogrammetric procedures

With reference to the use of photogrammetric procedures, different possibilities for producing cadastral maps are discussed below in a sequence going from the simplest to the most sophisticated. A few remarks must precede this elaboration. An aerial photograph differs from a map in four major respects:

(1) It represents the terrain in the form of a photographic image and not by means of well-known lines and symbols. An overlay or overprint with lines and symbols may eliminate this difference;

(2) Being a central projection instead of an orthogonal projection (as is a map), the relative positions of points on the photograph are different from those on a map because of the influence of perspective distortion;

(3) For the same reason, differences in height give relief displacements which would not occur on a map;

(4) The scale of the photograph is only approximately known.

Notwithstanding these differences, a photographic image is considered here to belong to the category of maps (in that it is a representation of the terrain), keeping in mind that deviations in metric properties may occur.

Classification of procedures

As mentioned above, an aerial photograph can play a very useful role in the process of land registration. If the aerial photograph is acceptable for this purpose, it can be said that the annotated photograph is automatically a cadastral map, albeit that from a point of metric accuracy it has the errors mentioned in the foregoing paragraph. Beginning from this simplest product, refinements are possible in several stages which lead to the following classifications: (*a*) original photographs; (*b*) enlargements to an approximate scale; (*c*) rectification; (*d*) orthophotographs; (*e*) line-drawn maps; (*f*) numerical restitution.

Each of these products merits detailed technical comment, but the discussion here is limited to a few major points:

(*a*) The original photograph (contact copies on paper or film) deviates less from a map the closer the camera axis tends to be truly vertical at the moment of exposure and the flatter the terrain. The combination of a number of photographs in a (uncontrolled) mosaic permits photo map-sheets to be produced corresponding to a desired division pattern;

(*b*) Enlargements to an approximate scale can be made on the basis of existing maps or after the execution of a simple slotted template triangulation. A more sophisticated triangulation procedure has no usefulness in this stage, as the internal errors in the photograph tend to be larger than those in the relative positions of points in such a triangulation. Nevertheless, enlargements to an approximately known scale may simplify the identification of boundaries; and, in particular, allow the annotation to be supplemented with, for example, some distances;

(*c*) For flat terrain, a rectification can be considered to have the same properties as a map. A transparent overlay on which the boundaries are copied produces a conventional cadastral map with an accuracy that will correspond to the graphical ability of a normal draftsman. The control points for the rectification can be obtained from a slotted template layout or from an aerial triangulation in space;

(*d*) For irregular terrain, orthophotographs can be produced to give a photo map of a similar quality as rectification in flat terrain. Since the time for the production of an orthophoto is, on average, much less than that required for line-plotting in the "classical" way, the orthophoto may well be preferred. Orthophotography has other definite advantages. During the process of restitution, height information in the form of drop lines can be automatically recorded without much extra cost, making the orthophoto map into a base document which can serve many other purposes, such as irrigation or road planning;

(*e*) Line-drawn map procedures are assumed to be well known;

(*f*) A numerical restitution of aerial photographs (automatic registration of model co-ordinates followed by a transformation into the map system) is the most accurate solution as it avoids the errors due to a graphical presentation.

No general solution to the problem of making a choice between the various possibilities can be given; the final choice depends upon the particular circumstances of each project. One must consider not only the purely photogrammetric aspects of each solution, but the related aspects of the unavoidable field completion work. Where maps or diagrams produced by original photographs or enlargements to an approximate scale, although adequate for the purpose of the moment, are not of the same quality as is usually found in a map, it is advisable to attach a warning to prevent their use for other purposes for which their short-comings may have unfavourable effects.

Conclusions

The choice of an appropriate survey method will, in fact, consist of finding the most appropriate combination of field and photogrammetric methods. As an example, a situation may exist where the network of points to which the field measurements are tied in is provided by photogrammetric triangulation, whereas the detailed measurements are carried out by field procedures.

The choice between the methods listed above under classification of procedures need not necessarily be a final one. As the basic information required for a more accurate result is available, it is always possible to adopt an improved procedure at a subsequent stage; for instance, the material and/or personnel that were not at first available may become available, or it may be that in the course of time it will be found feasible to use the cadastral data for an additional purpose requiring a higher accuracy.

In order to select the most efficient procedure, a systematic approach should always be adopted, e.g., according to the lines indicated by H. G. Jerie.[4] Copying existing procedures and tolerances from elsewhere, although they may appear suited for the country in which they are to be applied, may endanger the success of the whole operation.

Some of the most important general aspects to be taken into account are:

(*a*) Current and future accuracy requirements;

(*b*) Available resources of finance, materials and personnel, both current and future (e.g., through training programmes);

(*c*) Urgency of the project in whole or in part;

(*d*) Availability of necessary foreign currency; on occasion, the Government may prefer to choose a more expensive method if it can be paid for in local currency;

(*e*) Possible new developments: there will be future needs to adopt automation and new methods and/or instruments;

(*f*) Availability of instruments and personnel for maintenance of maps and records;

(*g*) Other possible uses for maps and/or aerial photographs.

Institutional aspects and training

Institutional aspects

Institutional problems are among the most difficult to resolve in the establishment and maintenance of a cadastre, and the lack of recognition and adequate resolution of such problems are probably the most common causes for the ineffective functioning of a cadastre.

The effective implementation of a cadastre is a complex operation involving the establishing of a functional system of relationships among several institutions for the establishment, maintenance, use and future refinements of the cadastre. No part of the system is entirely independent of the other parts; and if one part fails to work, the system breaks down.

The functions to be performed by the various offices concerned with a cadastre have already been described. It will be apparent from this description that:

(*a*) There must be an office or offices in which information concerning legal rights and other information concerning parcels relevant to the particular purpose for which the cadastre is used will be registered and maintained;

(*b*) There must be a survey organization responsible for the production and maintenance of the cadastral maps and the description and numbering of parcels; this organization might also collect, if feasible, other information required on such subjects as land use or buildings.

Ideally, the registration and survey functions described above should be performed by a single agency. This arrangement guarantees the best possible co-ordination between the various parts of the whole operation. In many countries, however, there already exist different agencies, sometimes established by law, which are charged with performing different aspects of the activities involved in establishing a cadastre; or there may be several agencies in one country each charged with establishing cadastres for particular purposes. These agencies may already have collected at least part of the information needed for a new cadastre, and this work must therefore be correlated with that of any new agency. In practice, it will be difficult to alter existing arrangements of this kind, for which there may be historical or political reasons.

Regardless of what agencies exist, however, and regardless of how their activities will be correlated with those of any new organization, it is essential that there should be some form of control authority responsible for:

(*a*) Deciding policy for the rules governing any new cadastral system, possibly including the drafting of necessary legislation;

(*b*) Co-ordinating the work of various offices involved, which may be offices actually executing work or offices merely providing ancillary information;

(*c*) Planning the transition of responsibilities from the establishment to the maintenance phase;

(*d*) Preparing legislation for effective maintenance of the cadastre. One of the most important factors in this respect is that the law should compel registration of all transactions in land that take place after the cadastre is established. In transactions involving a mutation (change of boundaries), there should be a simple, but obligatory procedure to ensure that the change shall be surveyed and mapped before registration takes place.

The functions to be performed by the various offices are interrelated in the various phases of work. One of the most important phases in which correlation is essential is the collection of the original data in the field, for which purpose persons with different backgrounds and from different agencies should operate together as a single team.

As an illustration: a decision may have been taken to establish a cadastre for both legal and fiscal purposes; in so far as the fiscal purposes are concerned, the ministry of finance could play a vital role in the initial collection of data in the field and from available records; thereafter, it should operate by using such information as is available in the legal registry which is relevant to its operations (e.g., the names and addresses of owners); but it would operate as a separate executive body for assessment and collection of the tax. Similar arrangements would apply to other ministries.

For practical reasons, particularly at the maintenance phase, it is often advisable to decentralize activities. Care should be taken to ensure effective co-ordination with the central offices, and uniformity of procedure must be guaranteed.

[4] H. G. Jerie, "System analysis applied to the planning of photogrammetric projects", paper presented to the Symposium of the International Society of Photogrammetry, Commission IV, Delft, 1970.

Attention should be paid to two factors which may endanger the success of cadastral operations when assistance is sought from other countries:

(*a*) In order to overcome the difficulties posed by lack of finance or trained personnel, recourse is often made to assistance from outside the country for carrying out parts of the operation, usually the survey part. This arrangement will not prove satisfactory unless local institutions are equipped to carry out related parts of the operation simultaneously;

(*b*) For similar reasons, attention must be paid to the implications of maintaining any cadastre established by a foreign organization before work on its establishment starts.

Cadastral programmes should be evaluated periodically by an independent authority, in order to guard against the cadastre being continued by inertia into areas where it is not yet justified and against the continued application of methods which may have been valid in one area or at one time but are no longer so.

Training

Requirements of personnel for the agencies that participate in cadastral operations provide the basis for planning programmes of training. In a broader sense, however, everyone upon whom the cadastre will impinge should receive some form of training or orientation. The principal groups are: high-level policy-makers; professional personnel; technical and subprofessional personnel; the general public (property owners); and relevant government agencies which will use the cadastre.

Training requirements are so varied from country to country that little useful information of a general nature can be given. Nevertheless, there are some demands for training, common to developing countries, to which international bodies and countries having technical assistance programmes could address their attention:

(*a*) High-level policy-makers in developing countries sometimes require short-term intensive training in the fundamental aspects of cadastres, particularly when a country is about to initiate a cadastral programme. This demand could best be satisfied by periodical regional seminars;

(*b*) High-level administrative and professional staff could benefit by observation of cadastral programmes in effective operations in other countries in order to adapt procedures and techniques to their own local circumstances;

(*c*) Professional personnel should also have the opportunity to receive mid-career training for the purpose of broadening their outlook and keeping up to date on modern developments in their fields by means of periodical seminars in particular disciplines;

(*d*) The general public must, of course, be reached through mass media. Such information programmes are particularly important in countries where customary rights prevail or where a segment of the population fears that the cadastre threatens its property rights. While simple in concept, these information programmes are frequently exceedingly difficult to administer and require knowledge of mass media techniques.

CONTINUING REVIEW OF CADASTRAL ACTIVITIES

In subparagraph (*e*) of resolution 10 of the Sixth United Nations Regional Cartographic Conference for Asia and the Far East, the *Ad Hoc* Group of experts was asked to consider the setting up of a permanent committee to keep developments in the cadastral field under constant review.[5]

Certain points are clear:

(*a*) There is a great and growing need in developing counties for the establishment or improvement of cadastral systems as a prerequisite of accelerated development;

(*b*) In several countries, the measures, if any, that have been taken so far to fill this need are inadequate or have failed, mainly because of lack of insight into the complexity of the problem;

(*c*) Frequently, *ad hoc* systems are being established to fulfil an urgent and/or local need, without any thought being given to future integration into a final national system, thus contributing to often-existing confusion and to a waste of energy and money;

(*d*) Although there exists a vast amount of experience of cadastral systems, in part in the form of publications, this knowledge is not adequately used due to a lack of communication. There is, for example, no comprehensive bibliography; achievements in various countries are often not adequately documented.

The *Ad Hoc* Group of experts considers that the situation described above requires definitive action by the United Nations and its specialized agencies, and the United Nations Development Programme (UNDP). This action should cover three aspects:

(1) Establishment of a systematic collection of published and unpublished information on legal, administrative and technical aspects of cadastral systems relevant for developing countries;

(2) Promotion of a systematic and critical study of the available information to provide possible answers on particular questions related to the establishment, improvement and maintenance of cadastral systems;

(3) Promotion of an adequate distribution of knowledge concerning subparagraphs (1) and (2) by special publications, the organization of seminars, etc.

In order to implement this action, the *Ad Hoc* Group recommends that an advisory panel should be established to advise on the initial action to be taken and to evaluate periodically whether further aspects should be added.

The advisory panel should, in particular, pay attention to effective co-ordination with existing or planned technical assistance activities relating to cadastral systems under the sponsorship of the United Nations or its specialized agencies. There should, of course, be liaison with existing international, regional or national organizations active in this field.

An advisory panel of this nature would not, however, satisfactorily fulfil all three of the aspects mentioned above. The *Ad Hoc* Group, therefore, suggests that the United Nations ask Member States to make means available to fulfil these functions adequately.

CONCLUSIONS

The basis elements of any cadastre are: (*a*) an unambiguous definition of parcels; and (*b*) a related record giving the required data about those parcels.

[5] Vol. I. *Report of the Conference*, p. 17.

A cadastre containing these elements can have great importance for public administration, planning and development, and for private transactions.

When a cadastre is being established, it should be designed for ultimate multipurpose application. Only when it eventually assumes such a character will it provide its maximum usefulness.

A legal cadastre is the most appropriate basis for any other type of cadastre. Compared with other types of cadastre, a legal cadastre may require some extra investment for unambiguously ascertaining legal rights, but the technical requirements are not necessarily more expensive. The extra cost is, compared with the cost of the whole operation, marginal, and its investment will be more than compensated by savings for the Government, as well as for individuals and by acceleration of economic development.

A cadastre should be established systematically, area by area, covering all land within the chosen area. This procedure necessarily involves the use of compulsory powers. The areas should be carefully selected. The procedure must be designed to ensure finality and the maximum speed compatible with accuracy.

The choice of survey methods should be based on a careful analysis of the whole procedure in relation to local circumstances. Copying procedures from elsewhere will never lead to an optimal result.

This is particularly true of specifications of accuracy, which have a great influence on the efficiency of survey operations. Legal impediments that prevent the use of speedy survey methods where they are technically and economically justified should be removed.

In establishing a cadastre, it is vital that the proper measures for future maintenance be incorporated. For a legal cadastre, these measures must include legal provision for compulsory registration of transactions in land.

If, for practical reasons, it is not feasible to concentrate the task of establishing and maintaining a cadastre in one single agency, it is vital that a close and well-defined co-ordination be established between the various offices involved and that a central body be charged with the planning and supervision of this co-ordination.

METHOD OF CADASTRAL SURVEY IN JAPAN—ORTHOPHOTO METHOD*

Paper presented by Japan

Cadastral survey in Japan

Many of the cadastres currently existing in Japan are the results of the land survey which was conducted along with the land-tax revision measures taken in the Meiji era (1867–1912). These cadastres have been revised and systematized since then; but they have never been reformed in conformity with the development of the social conditions of Japan and this situation has resulted in various problems in land administration. It is therefore quite necessary to revise expeditiously the deficiencies and inadequacies involved in these cadastres.

In order to cope with this situation, the Land Survey Law was passed in 1951. The objectives of the cadastral survey required by this law were to distinguish the relationship between the possession of land and the utilization of land, thus clarifying the cadastres; to prepare the fundamental materials for the various aspects of land administration, including land development and preservation; to ensure the fairness of the burden on the people, such as taxes and other public charges; to prevent disputes over land. It was also planned to use the results of the survey for many other purposes.

The main purpose of the cadastral survey based on the Land Survey Law is not to establish a new cadastre, but to correct the existing cadastres; and no one can abolish or revise it without a legal procedure.

Progress of the method of cadastral survey

The cadastral survey consists, of course, of two aspects—investigation and survey. The survey is broadly classified into the ground survey and the aerial photography survey. Thus far, the rate of application of the ground survey is overwhelmingly higher than that of aerial photography, because the area currently being surveyed is the agricultural area where the parcels are comparatively small and more importance is placed on the clarification of the cadastre.

What is expected in the most recent situation of Japan represented, for instance, by the theory of reconstruction of the Japan Archipelago, is to furnish materials for land development, etc. The area requiring survey extends to the mountainous regions; and, furthermore, there was need to survey a wider area in a shorter time. Therefore, the cadastral survey using the orthophoto method has come to be favoured as one of the means of coping with this situation. As it is unreasonable to believe unconditionally the accuracy, etc. of this survey method solely on the basis of data supplied from other countries where conditions are different from those in Japan, the Government selected a model district in 1971, mobilized specialists in the fields concerned and conducted repeated experiments. As a result, although various problems arose due to insufficient experience, it was found that the Government could obtain a satisfactory result which could be applied for the mountainous districts which require less accuracy than residential and agricultural districts. As it is easier to instal signals in the mountainous districts, where there are comparatively fewer boundary corner points, the orthophoto method was selected. When these districts are viewed from the standpoint of scale of the cadastral map, most of them are areas of 1:2,500 and 1:5,000 scale.

The process of making cadastral maps by the orthophoto method is as follows:

(*a*) Increase in the number of control points to a density of one control point per square kilometre (by ground survey);

(*b*) Installation of signals at the existing control points and additional setting of control points (including orienting points);

*The original text of this paper, prepared by Akira Joukou, National Land Survey Division, Development Bureau, Economic Planning Agency, Japan, appeared as document E/CONF.62/L.18.

(*c*) Selection of aerial survey supplementary control point, with which the geodetic co-ordinates can be obtained in the aerial photography survey. This step is necessary for the process, maintenance and administration of cadastral map-making; the density is one point per 2–4 hectare). Setting of monuments at the site;

(*d*) Setting of signals for the aerial survey supplementary control point mentioned above for the boundary corner points, etc.;

(*e*) Photography. The scale of photographs thus taken is 1-2.5–1-3.0 of the required cadastral map scale. The overlap is 60–80 per cent; the sidelap is 30–60 per cent, and care has been taken to use only the centre part of the photographs;

(*f*) Confirmation of signal points on the photographs, which have been magnified approximately four times. The objects to be confirmed are all signal points, such as control points, aerial survey supplementary control points and boundary corner points;

(*g*) Computation of geodetic co-ordinates, such as the aerial survey supplementary control point and the major boundary corner points, by aerial triangulation;

(*h*) Preparation of a recording board of profile scanning through a combination of the first-order stereoscopic plotting instrument and the SG-1 recording system;

(*i*) Preparation of an orthophoto negative through the combination of the slope correction system (fibreglass optical ring), the GZ-1 orthophoto projector and the LG-1 reading system;

(*j*) Confirmation of the boundary corner points and indication and delineation of parcel border lines and sheet lines—by red or reddish colours—on the orthophoto printed on the aluminium-foil copy paper;

(*k*) Confirmation and additional indications of boundary corner points, etc. by the field survey at site;

(*l*) Accurate indication of the cadastral items on the polyester matte base by transferring these items from the orthophoto and adding required marginal designs, thus completing the cadastral map copies.

The success or failure of the method outlined above depends upon the setting condition of signals at the numerous parcel border points.

Characteristics of orthophoto method

As stated above, the orthophoto method of producing cadastral maps has just come into use in Japan, and the districts surveyed are still small; but from the information obtained from the actual survey operation, a few points that are different from the ground survey may be mentioned.

First, the photographs have highly effective persuasive power, i.e., the position of a parcel border point is obtained as a result of surveying of a parcel of land on which the required wooden markers and signals are set; the aerial photos are taken; and, then, by converting the photos into the orthophoto, the condition of the parcel border points at that time is clearly shown on the photo. Furthermore, the relationship between the parcel border lines and the planimetric features, constructions, etc. in the vicinity of the points is so clearly indicated that no explanation is necessary. Therefore, landowners can so readily understand the results of the survey that obtaining their consent, which has been troublesome in the past, is now easily done.

The second point concerns automation and the savings in costs. When every boundary corner point is recorded on the orthophoto, the parcel border line can be obtained by connecting the parcel border points, thus eliminating the process of conducting the parcel border survey outdoors by means of plane-table surveying. It is impossible to photograph and record every parcel border point; but it is possible to eliminate a considerable percentage of the plane-table surveying process, which accounts for about one half of the cadastral survey cost in the ground survey, thus contributing to the automation and cost-saving of the entire survey.

The final point relates to the wide-range application of the orthophoto method. As has been mentioned above, the results of cadastral survey are requested to be supplied as the fundamental materials for development and preservation of land. When the result of the orthophoto method is compared with the result of the conventional ground survey method, i.e., the cadastral map, which mainly consists of the recording of parcel border lines shown as lines drawn on a white paper, one finds that through the orthophoto method, one can obtain not only the cadastral maps mentioned above, but an orthophoto showing every condition on the surface of the earth in addition to the boundary corner points. That being the case, the application of the orthophoto method is not limited to the above-mentioned field, but can be considered to expand without any limitation.

The foregoing paragraphs summarize the information obtained in Japan after utilization of the orthophoto method as one of the cadastral survey methods. Of course, there still remain problems, such as more rational improvement and contrivance of the operation system and process management; but, after all, the completion of this method is urgently required in current circumstances in Japan.

THE DESK-TOP PROGRAMMABLE CALCULATOR AND ITS APPLICATION WITHIN THE SMALLER ORGANIZATION, WITH PARTICULAR REFERENCE TO CADASTRAL REQUIREMENTS*

Paper presented by the United Kingdom of Great Britain and Northern Ireland

Until the Desk-top Programmable Calculator (DTPC) became available at a price within the capabilities of the smaller organization, such an office had little chance of departing from the traditional methods of manual computation and drafting; these methods, inevitably, are time-consuming, error-prone; and, with increasing costs, becoming ever more expensive. Since it first arrived (effectively) in 1970, DTPC, in its various forms, has opened up a wide field of possible value as an economic *via media* between the old manual methods

*The original text of this paper, prepared by J. L. Fleure, Associate of the Royal Institute for Chartered Surveyors, Directorate of Overseas Surveys, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF 62/L 32.

and the full-scale electronic computer with all its ancillaries.

It is not within the scope of this paper to discuss the relative merits of the different makes and/or models of DTPC currently available, though, for the record, details of the equipment of which the author has had practical experience are given in annex I.

When Hewlett-Packard introduced its 9800 series of calculators, in particular, the 9820, with its ready ability to write alphabetic and numeric characters on both the print-out and plotter, the door was clearly opened for the use of DTPC in the production of annotated plans and diagrams, in addition to its more normal computational work.

It is appropriate to acknowledge here that the Survey Department in Sabah has been working on the cadastral application of the Hewlett-Packard 9100B with plotter, and has been using the system on a production basis for the drawing of cadastral diagrams on which the necessary annotations have subsequently been entered manually.

Capabilities

The scope of the system currently available to the author, of which the current United States price is of the order of $12,000, which may be taken as illustrating current thinking in the field of DTPC can be summarized as follows:

(*a*) Internal memory of 429 registers, each capable of holding a single item of data to 12 significant figure accuracy;

(*b*) Basic mathematical functions available at single key-strokes;

(*c*) Programmability, by means of simple algebraic expressions, which does not require lengthy training;

(*d*) Option of input by marked card or keyboard entry;

(*e*) Input and storage of mixed alphabetical and numerical characters, six to a register;

(*f*) Output of mixed alphabetical and numerical characters, under programme control, as annotation on printer or plotter output, from store;

(*g*) Plotting, as required, under programme control;

(*h*) Through appropriate use of magnetic-tape cassettes, virtually unlimited storage of programmes and data, at not less then 6,000 registers per tape, with full forward and backward search capability, under programme control.

To the foregoing can be added, as being available on the market: input by paper-tape reader; typewriter output; line-printer output, currently up to 80 characters per line; further tape cassette units up to a maximum of nine.

Requirements

For a system to be economically viable, it should be capable of sufficient use by the whole of the purchasing organization to ensure the minimum of stand-down or idle time on the part of the equipment.

For this reason, maximum flexibility and ease of programming must be the first essentials when deciding on the equipment to be purchased. The need for all programmes to be written by the "expert", as would be the case with a larger computer having a sophisticated language and programming, can produce a bottle-neck in the smaller organization. Ease of operation, to minimize the possibility of human error (which is inevitably the weakest link in the chain), is also essential.

A fundamental necessity of all operations, to ensure the accuracy of the final result, is the provision of a printed record of everything that is fed into the system by way of input.

Application

To illustrate the operation of a DTPC system, a package of programmes designed to produce a final cadastral diagram, suited for inclusion as part of a legal document of title, is now considered.

Such a system is based upon the following requirements:

(*a*) Input and printing of the original field data, including station names and labels, with starting and closing values, combined with storage thereof, so that accuracy of the data entered may be assured before proceeding further. Such storage is transferred automatically under programme control to an external store (card or magnetic tape) so that operation of the system need not be suspended during checking of the data which have been entered;

(*b*) From the stored (and checked) data, derive print-out and adjust for misclosure of bearings; compute and store positions based on the adjusted bearings; derive, print-out and adjust for positional misclosure, storing the finally adjusted positions;

(*c*) From these last stored positions, compute and store the bearings and lengths of the lines between adjoining stations;

(*d*) Determine the appropriate scale to ensure that the whole of the task shall lie within the plotting area;

(*e*) Plot stations, with relevant labels (alpha-numerical) and joining lines as necessary;

(*f*) Store data for and plot offset cuvilinear and/or natural feature boundaries as necessary;

(*g*) Store data for and plot adjoining (contiguous) boundaries;

(*h*) Compute enclosed area(s) for entry on the diagram;

(*i*) Tabulate boundary data, bearings and lengths, or enter same along lines where so required by local regulations;

(*j*) Tabulate final co-ordinates if so required;

(*k*) Provide for entry of general information and identification, such as administrative area, state and/or district name, field-book number, names of surveyor and operator, and so forth;

(*l*) Draw in any other items required, such as a north point, grid-ticks and neat-line.

In organizations where more than one copy of the diagram is required, it is essential that as much data as possible should be stored; the objective should be to achieve the production of subsequent copies without the need for any entry of data or information on the part of the operator—without this, the need for expensive manual checking recurs. This condition, would, at first, appear to impose a severe limitation on the extent that can be dealt with in one operation; use of the magnetic-tape cassette as a backing store for programmes and

data, with its full search capability, is the answer as it provides the ability to operate on programmes in smaller blocks and to interchange blocks of stored data, all under programme control.

To guard against the effects of possible, if infrequent, breakdown in the operation of the system, it is considered advisable to incorporate sufficient automatic checks within the package or suite of programmes to provide a clear indication to the operator, coupled with the cessation of operation, if any machine error does occur; some indications are usually incorporated by the manufacturer, principally in connexion with unacceptable operations; but the user will find it desirable to add some of his own.

Current progress

Progress in the cadastral field to the time of writing may best be illustrated by reference to the example shown as figures 106–108, with figure 106 illustrating the amount of information and data required to produce the interim and adjusted values included in figure 107, which in turn lead to the final result which appears in figure 108.

These figures illustrate the current state of development, based on earlier knowledge of the requirements of one particular administration, while preparing a suite of programmes which, it was hoped, would be operational in another territory by the time of the Conference in October 1973.

It is stressed that no errors of omission have been made in connexion with the indication of items requiring input from the keyboard at the time of printing or plotting; for instance, the closing values at the foot of the second column in figure 106, being the starting values, are found under programme control from store and subsequently printed and relocated as necessary. Similarly, names and labels only require the initial input when the data are first entered and can subsequently be recovered from store when needed.

An earlier version of a sample cadastral diagram appears in figure 109 as, in particular, an illustration of the entry of bearings and lengths along the lines to which they refer.

While development work has been in progress on the suite of programmes intended to meet the demands of the cadastral diagram, opportunity has been taken successfully to produce programmes having a wider user potential, a summary of which is given in annex II.

Individual items of equipment

Discussion of two particular items of peripheral equipment of which some experience has been gained may be of value in demonstrating further potentials. These items are the mark sense reader and the magnetic-tape cassette.

The mark sense reader, with 7½- or 11-inch cards currently available, when the calculator has been suitably programmed, has been found to be capable of entering four items, such as the degrees, minutes and seconds of the bearing of a line, together with its length, from one of the shorter cards. Alternatively, it is possible to read up to 15 characters, whether alphabetical, numerical or mixed, from one such card.

As an example, there is the possibility that field data may be entered on cards, preprinted with certain basic essential data, which could, in turn, considerably reduce the time taken in entering data into the equipment. Such cards may, therefore, provide a means to effectively direct transmission of the field data to the calculator.

The reader, in fact, provides the ability to input, without manipulation of the keys by the operator, from cards prepared elsewhere, or, when appropriate, from a library of cards holding data or other information which may frequently be required for use.

The magnetic-tape cassette has the obvious advantages deriving from the great extension of storage capacity, whether for programme or data, including any particular items of data or information which may be required frequently, yet whose storage within the internal memory of the calculator would be too expensive in terms of space.

Additionally, its use in conjunction with the Hewlett-Packard 9820 requires the introduction of a control unit (by plugging-in by the operator), which, apart from controlling the tape unit(s), can considerably extend the range of operation of the equipment with special programmes available from the manufacturer. It is one of these facilities which contributes to the ability to store names or labels by allotting to each key a decimal number equivalent, thereby converting the input to a quantity capable of normal handling by the user's programme.

An additional benefit deriving from this same programme is that it greatly increases the number of branch options available to the programmer for the operation of the equipment, permitting different paths (as many as there are keys on the keyboard) to be selected on a single key depression.

Conclusion

It is hoped that the foregoing discussion may have served to give some indication of the capabilities of the current types of desk-top programmable calculators and thereby to have suggested a means of alleviating the problems of the smaller organizations, which are fighting a losing battle in trying to meet increasing commitments with only limited resources of trained personnel at their disposal.

Further developments are beyond the scope of this paper; suffice it to predict here that this type of equipment will, without doubt, prove its worth on the grounds of accuracy, saving of time; and, consequently, economy.

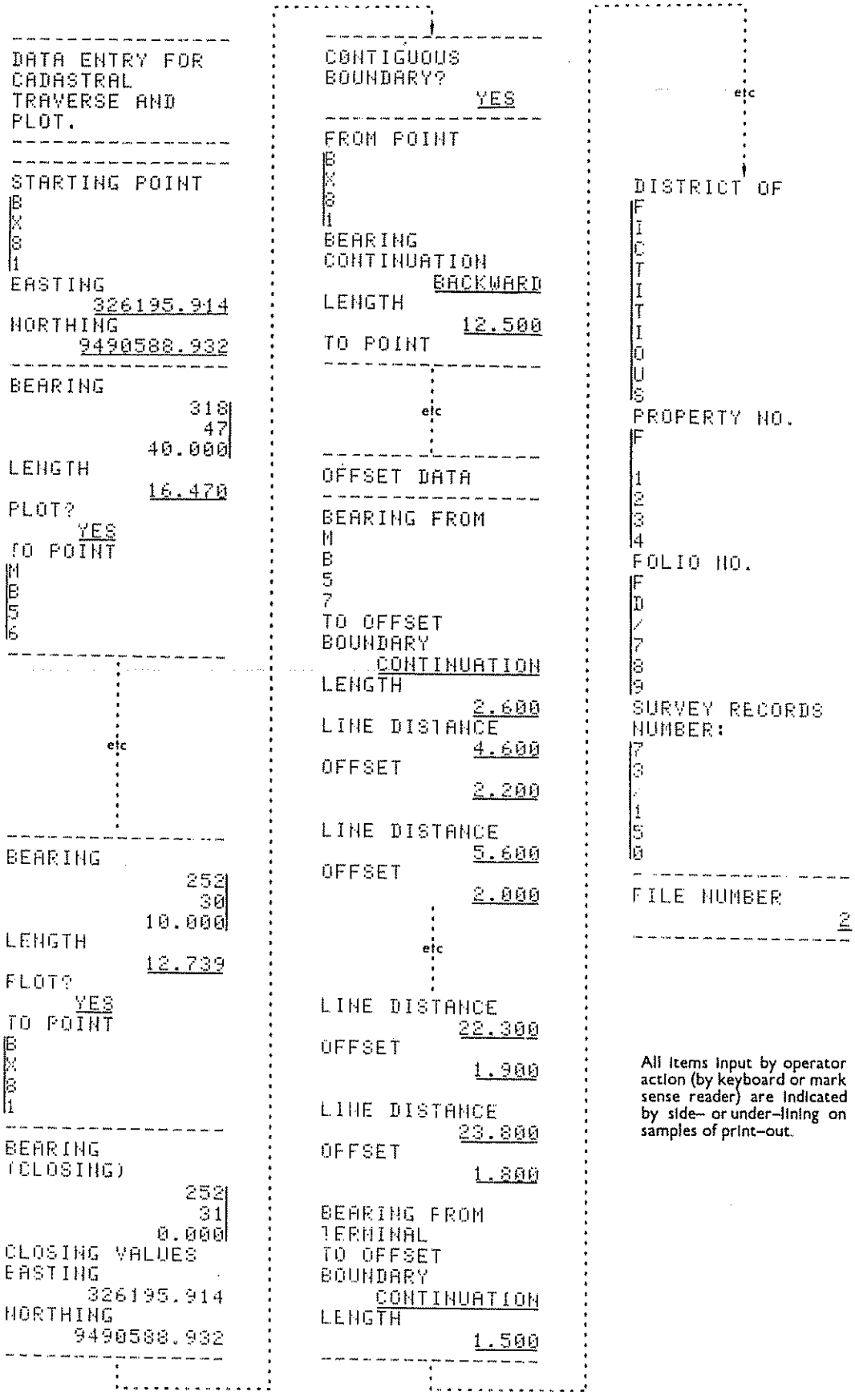


Figure 106. United Kingdom: sample input for current cadastral suite

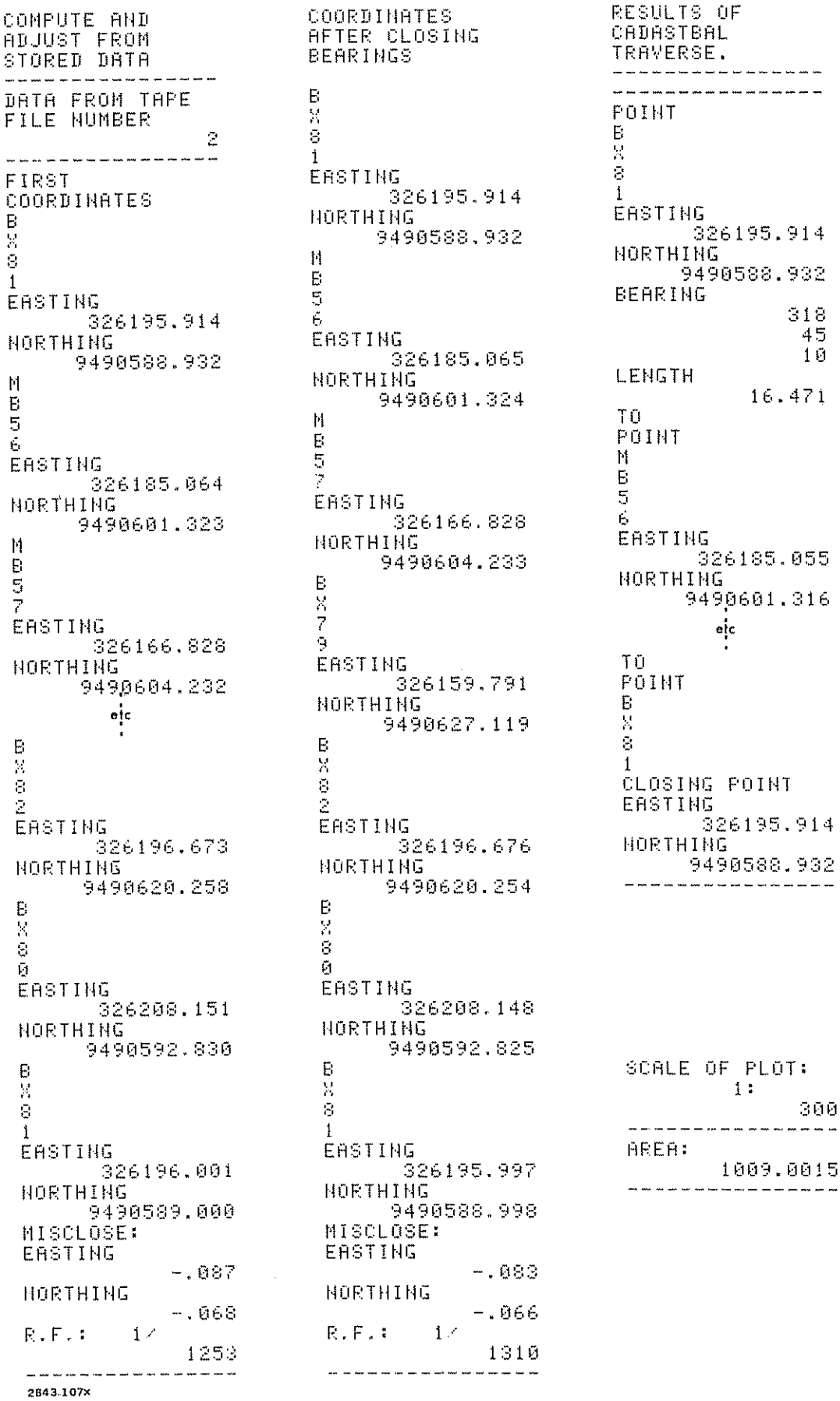


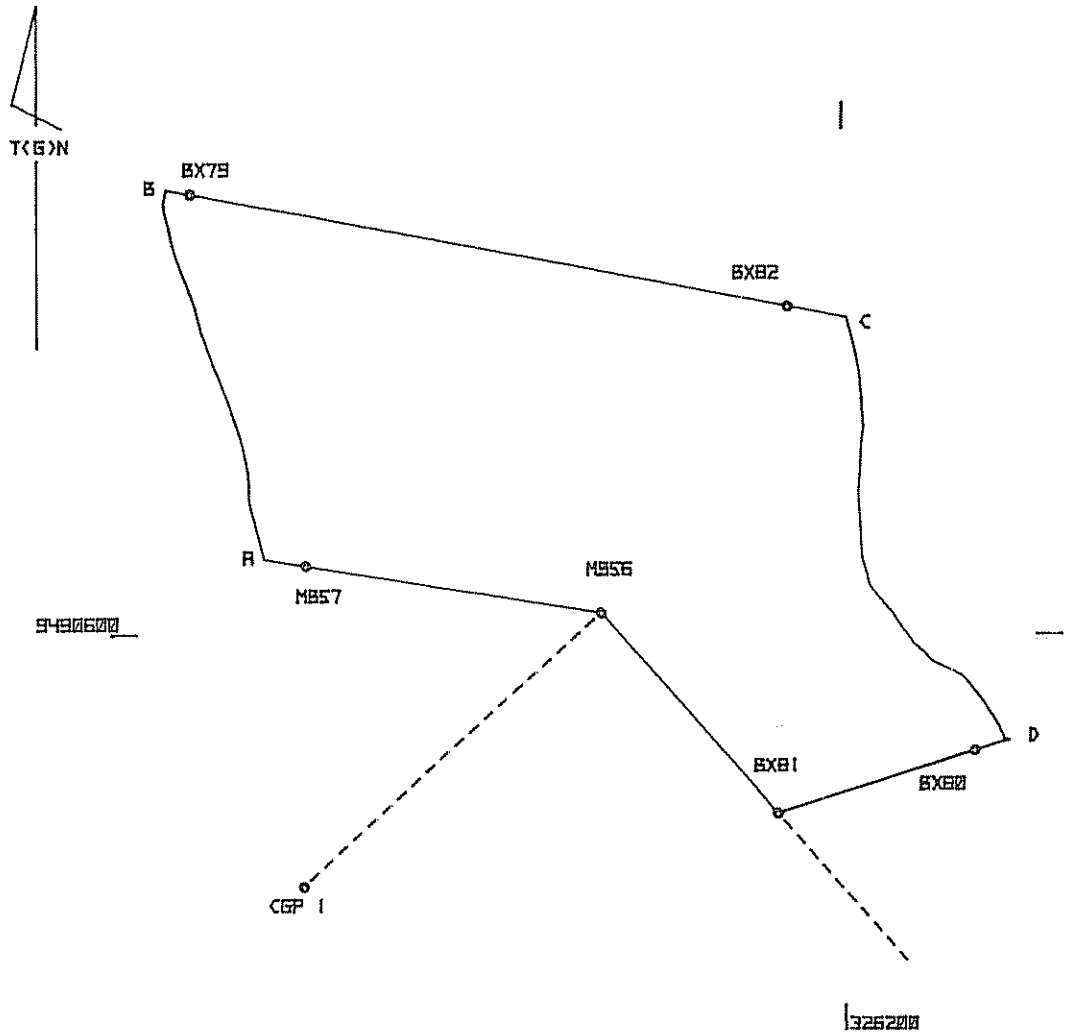
Figure 107. United Kingdom: sample printer output for current cadastral suite

CADASTRAL DISTRICT FICTITIOUS PROPERTY NO. F 1234 FOLIO NO. FD/789

LINEAR UNIT - METRE SCALE 1 / 300 S.R.NO. 73/150

U.T.M. ZONE 40

POINT	DIRECTION	DISTANCE	EASTING	NORTHING
BX81			+326195.914	+9490588.932
	318 45 10	16.471		
M856			+326185.055	+9490601.316
	279 02 00	18.477		
M857			+326166.807	+9490604.217
	342 52 00	23.936		
BX79			+326159.756	+9490627.091
	100 34 30	37.499		
BX82			+326196.618	+9490620.209
	157 20 40	29.738		
BX80			+326208.072	+9490592.765
	252 30 00	12.748		
BX81			+326195.914	+9490588.932



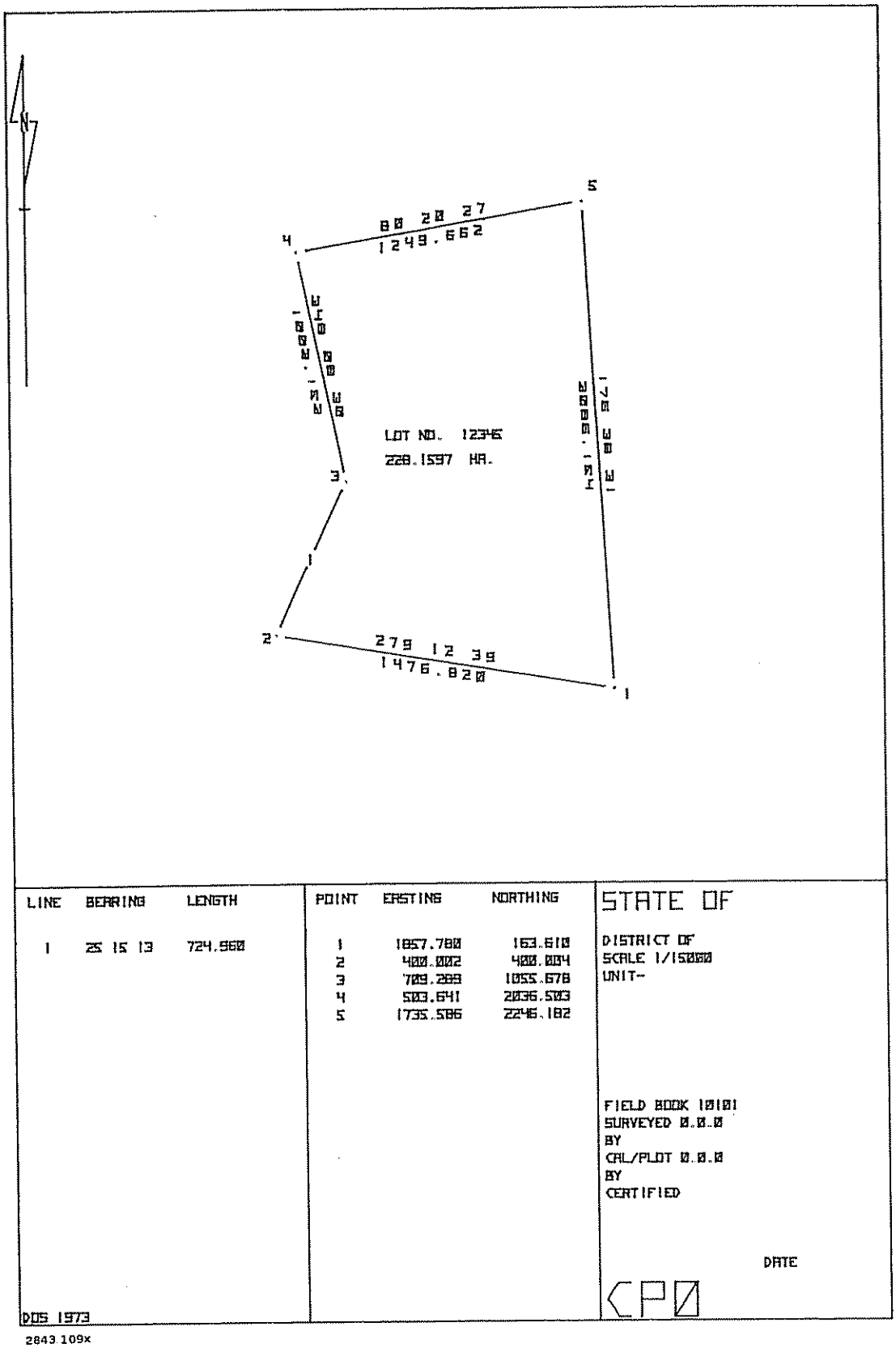
AREA 1009.0 SQ. METRES
.1247 ACRES

CURVILINEAR BOUNDARY DATA

M857 TO A	279 02 00	2.6
BX79 TO B	280 34 30	1.5
BX82 TO C	100 34 30	3.5
BX80 TO D	72 30 00	2.2

2843.108x

Figure 108. United Kingdom: sample diagram resulting from output for current cadastral suite



LINE	BEARING	LENGTH
1	25 15 13	724.960

POINT	EASTING	NORTHING
1	1857.780	163.610
2	400.002	400.004
3	709.289	1055.678
4	503.641	2036.503
5	1735.586	2246.182

STATE OF

DISTRICT OF
SCALE 1/15000
UNIT-

FIELD BOOK 10101
SURVEYED 0.0.0
BY
CAL/PLOT 0.0.0
BY
CERTIFIED

DATE

DOS 1973

2843.109x

Figure 109. United Kingdom: sample of alternative cadastral diagram

ANNEX I

Desk-Top Programmable Calculators used by the author

From September 1970: Hewlett-Packard 9100B, with 9120A printer

Mid-1971: Three month loan of WANG 700A

February 1972: Extended memory 9101A added to 9100B

From August 1972: Hewlett-Packard 9820A with 9860A mark sense reader; 9862A plotter; 11220A peripheral control I; 11221A mathematics ROM

February 1973: Magnetic-tape cassette unit 9865A and 11223A cassette control unit added to 9820A

ANNEX II

Additional programmes of wider user interest

Programmes in plane terms

Simple intersection

Simple resection

Least-squares solution of compound of intersection and resection

Reduction to centre (satellite solution)

Tacheometric reduction

Programmes in spheroidal terms

Reduction of slant ranges to spheroidal distances

Geographical co-ordinates from the azimuth and length of the geodesic from a known point (forward single line)

Geodesic inversion (mid-latitude) for the azimuth and length of the geodesic joining-points of known latitude and longitude

Universal Transverse Mercator convergence from geographical co-ordinates

Grid conversions, geographical co-ordinates to rectangular co-ordinates and *vice versa*, for the following projections:
(*a*) Universal Transverse Mercator;
(*b*) Transverse Mercator;
(*c*) Lambert Conical Orthomorphic

Other programmes:

Tellurometer slant ranges

Trigonometrical heights

Height traverse

Sheet sizes for a block of sheets

Derive and apply constants of a second-order conformal transformation

SURVEY INTEGRATION IN WESTERN AUSTRALIA*

Paper presented by Australia

The interpretation given to survey integration in Western Australia is, no doubt, similar to other interpretations given to this much-discussed concept for the orderly control of surveys and the capture and storage of survey data.

If the Western Australian system is to vary from others, it can only be in depth or scope, for modern survey integration is generally standard; and, listed in its broadest sections, will include: a mathematical framework; a graphic framework; a pictorial framework; systems of data processing; legislation.

Irrespective of the restrictions applying to the introduction of new practices or the broadening of the practices already in existence, the major influence on the "depth" or "scope" of survey integration will ultimately depend upon what definition is applied to the term "survey".

For the expansion of current survey practice in Western Australia, "survey" is to be regarded as a total system which will provide a framework for the capture, storage and analysis of data relating to all surveys. It has been defined as a mathematical, graphic and/or pictorial framework which serves not only the three-dimensional co-ordination of the earth's surface, but is sufficient in its design to assist in the capture, storage and subsequent analysis of all earth sciences and related social sciences data.

Survey integration is therefore considered an all-embracing system rather than a system serving traditional survey practices only. It acknowledges that all measurements should be subjected to analysis, adjustment and correlation, provided there exists a standardized framework for reference or co-ordination. It assumes that if such a framework is to be created, its origin will best lie in the geodetic survey of the state and any subsequent referencing will be served by mathematical co-ordination tied to the geodetic framework. Therefore, for the purpose of maintaining a homogeneous system common to all surveys, the Australian map grid has been chosen as the referencing framework for integration and the Australian geodetic survey as the origin for the co-ordination of data.

In the development of the system, the following considerations apply:

(*a*) Survey integration developed to serve a total system can operate in a structure designed to service traditional survey practice, but the converse is not possible unless special conditions apply. This anomaly is one of co-ordination; or, more particularly, the gap that exists in the proportion and accuracy of co-ordination demanded by a cadastral or engineering survey and that demanded for, say, regional geology;

(*b*) A system embodying a "broad" proportion of co-ordination serviced by mathematical co-ordination or the digitizing of maps can be introduced most rapidly. One founded upon cadastral proportions and accuracies, demanding a dense network of standard survey marks, takes the longest time to introduce;

(*c*) It should prove easiest to introduce in areas of new development where standard surveys are in existence and mapping is readily available or capable of being compiled in the framework of the standard surveys;

(*d*) It should be capable of being introduced effectively in areas where no geodetic surveys are available, by adopting a point of origin and co-ordinates scaled from an existing map of the area, or by astro fix and azimuth observations. In these circumstances, future connexion to the geodetic system would automatically permit transformation into the parent system;

*The original text of this paper, prepared by J. F. Morgan, Surveyor General of Western Australia, appeared as document E/CONF.62/L.42

(*e*) The use of co-ordinates should be treated as a tool of integration rather than the converse, and the system should permit co-ordinates to be upgraded without influencing the validity of data referred;

(*f*) Although legislation might ensure inclusion of specific surveys—and maps—within the integrated system, the true value of the system will be verified by making possible inclusion of a variety of additional data.

Historical development

Western Australia comprises an area of approximately 2,527,600 km² and has a population of nearly 1,053,000. The majority of its development lies in the south-western portion of the state, embracing 312,000 km² or the equivalent of 20 × 1:250,000 map-sheets. The area of greatest urban development lies in a radius of 30 km, the central point being the port of Fremantle and containing part of what is known as the metropolitan area of Perth. The area of most intense rural development stretches along the coastal plain between Perth and Bunbury, some 160 km to the south. While there are, and will continue to be, small concentrations of human habitation, the increasing number of "regional" centres, such as those emerging in the Pilbara as a result of iron ore, natural gas and other mineral activities, clearly indicates the benefits to be derived from a fully integrated survey system.

The Swan River Colony was first established in 1829; and in 1875, the first geodetic survey was undertaken in Western Australia, culminating in triangulation networks extending from Perth to Port Hedland, Perth to York, and isolated systems in the Eastern Goldfields and in the Kimberley Division in the far north.

In 1901, the transit circle of the Perth Observatory was adopted as the initial point of Western Australian surveys, and all geodetic surveys were subsequently tied to this point and co-ordinated in respect of its derived latitude and longitude value.

Co-ordination was achieved by adopting Everest's (1830) figure of the earth and formulae detailed in the ancillary tables of the Survey of India. At the same time, two standard mapping series were introduced at scales of 80 chains to an inch and 300 chains to an inch, based upon a Bonnes modified conical projection as used in compiling the Atlas of India.

In 1909, the Licensed Surveyors Act of Western Australia was introduced, together with General Regulations controlling cadastral suveys. Additional regulations governing authorized surveys effected under the provisions of the Land Act, Transfer of Land Act and the Mining Act were also provided. As a result of the practice thus introduced, Western Australia has since enjoyed an undefined form of survey integration, but without mathematical co-ordination. These controls were introduced at about the same time that survey technology witnessed the introduction of the "long wire" and the basic concept of the modern theodolite. Thus, authorized surveys, which have at all times been under strict examination in respect to marking and accuracy, have developed as a standardized system which provides a firm basis for the introduction of an integrated system.

The mapping series on the scales 80 chains to an inch and 300 chains to an inch were soon expanded into series at 20, 40, 240 and 800 chains to an inch, and until the Second World War and the subsequent development of the Transverse Mercator 1:250,000 national series with 5° zones, provided the only composite mapping coverage of the state.

Some mathematical co-ordination of survey data began in the middle 1940s following the War, and this was to increase in content as general-purpose topographic mapping at 1:250,000 scale gained momentum and the national geodetic survey progressed. It was invariably a mapping co-ordination, and the cadastral data remained unaffected unless serving as basic horizontal control for mapping.

The completion of the geodetic survey in 1966 and the subsequent establishment of the Australian map grid and the tables to support it meant that, for the first time, the Australian survey had a framework upon which to develop uniform and realistic co-ordinated practices.

The decision to adopt metric measurement in September 1972 further enhanced the prospect of developing survey integration and confirmed the necessity to introduce a new state cadastral mapping series. The development of this new series began in 1969, although the maps at 300 chains to an inch had been previously replaced by the 1:250,000 series.

The new development has included:

(*a*) The adoption of the national topographic series — and sheet lines as the basis of a state cadastral map system—in scales ranging through 1:25,000, 1:50,000, 1:100,000 and 1:250,000;

(*b*) The development of a state large-scale series of maps in scales ranging through 1:500, 1:1,000, 1:2,000, 1:5,000, 1:10,000 (see figures 110 and 111).

Maps are being produced in both series, and detailed specifications are being compiled in accordance with research being conducted into the usefulness of data currently shown, the desirability of showing new data, key compilation scales, user participation in compilation practices, and automation. In this respect, the co-operation and advice by members of the State Survey and Mapping Committee have been invaluable.

Orthophoto equipment is used in a programme of maps in the format of the state large-scale series covering the metropolitan area of Perth on the scale 1:5,000, and rectified mosaics in the format of the national series are under active programme for the south-western area of the state on the scale 1:25,000.

A land data bank has been the subject of development and trial, and is currently under due appraisal following the completion of a "model" experiment in which the 9,000 land units of a single local authority were captured. At first conceived to promote the automated plotting of cadastral maps, the feasibility study indicated a potentially wider application. The system may be used to describe on magnetic tape any single lot or location registered in the Department of Lands and Surveys or the Office of Land Titles. The description includes datum co-ordinates in the Australian map grid for one corner in each block of land and a singular description of each boundary of the lot or location by way of a surveyed distance and azimuth. It is designed to serve any data file which uses a block of land as its basic reference.

Automated plotting practices have been developed from stored data using a Calcomp 763 drum plotter which has been replaced recently by a flat-bed plotter. Other developments include a programme for automated plotting from surveyors' field notes and practical tests in the digitizing of original survey plans and diagrams to support data bank capture. Both develop-

ments are very promising, but have not yet been formally applied to work in the Survey Division.

Microfilm and its potential applications in survey integration have not been fully examined. A State Public Service Steering Committee chaired by the Surveyor-General is examining the over-all needs of the Service in respect of microfilming and microfilm systems. All plans and diagrams registered in the Department of Lands and Surveys have been copied on to 35-mm film, and a reader-printer has been installed.

Facilities for survey integration

In terms of the sections listed for modern survey integration, facilities currently available for survey integration in Western Australia include:

(*a*) A mathematical framework in the form of the Australian map grid and the national geodetic survey;

(*b*) A graphic framework comprising:

(i) The national medium- and small-scale topographic series;

(ii) The state medium- and small-scale cadastral map series;

(iii) The state large-scale map series;

(*c*) A pictorial framework comprising:

(i) Orthophoto maps to standard sheet lines;

(ii) Mosaic maps to standard sheet lines;

(iii) A library of aerial photographs and special-purpose mosaic and orthophoto maps;

(*d*) Survey plans and diagrams completed from surveys authorized under the provisions of the Land Act, Transfer of Land Act and the Mining Act;

(*e*) A cadastral map series and a growing store of earth sciences and social sciences data related directly thereto;

(*f*) A computerized land data bank capable of accepting and processing traditional survey data consistent with established methods;

(*g*) A computerized data bank capable of being expanded into a storage house for all records referenced to a block of land;

(*h*) Rigid legislation to control cadastral surveys.

Current and proposed actions

Mathematical framework

While survey integration should ideally seek an accuracy and proportion of co-ordination suited to its most exacting tasks, examination of the index (see figure 112.) will show this to be a tremendous survey problem when considering the whole state of Western Australia; and some form of generalization is necessary if the practices of integration are to be quickly effected.

The first generalization has been to adopt the current density of cadastral surveys, or land units as the criteria for the distribution of standard survey marks. This has resulted in a programme of monumentation and survey in which electromagnetic distance-measuring equipment is used almost exclusively and has permitted the affected portions of the cadastral system to be related to the geodetic survey.

As mentioned above, the most densely settled portion of Western Australia is in the south-west of the state, which is covered by 1:250,000 map-sheets. Within the rural areas of that region, the 1:250,000 map-sheets are used as the basic unit for planning Ultimately, each sheet will be covered by standard survey marks of sufficient density to ensure that practising surveyors should be able to effect connexions with economy through the media of triangulation, resection, traverse or a combination. Initial control has been carried out in conjunction with the national mapping programme at 1:100,000 scale, and the objective has been to provide standard survey marks at intervals of approximately 20 km. Eleven of the 20 map-sheets at 1:250,000 scale in the south-west of the state have been marked in this way, which has resulted in the placement of about 25 standard survey marks on each map-sheet.

In urban, suburban and rural areas of dense survey development, the basic unit for planning is the 1:10,000 map-sheets of the state large-scale series. The initial programme is to provide standard survey marks at intervals of approximately 800 m throughout, about 60 marks per sheet. Ultimately, however, the coverage of marks will be increased to ensure that all surveys shall be brought directly into the system. In the meantime, the coverage at 800-m intervals permits numerical co-ordination of all cadastral and topographic mapping and is generally sufficient to process the existing survey system into the data-file concept as developed within the Department. Priority is being given to the area of highest density population, which is between Perth and Bunbury along the coastal plain. This locality is covered by about 100 map-sheets on the scale 1:10,000 of which the equivalent of 10 have been completed to date. Efforts are directed towards completion of the total region during the next five years.

In the outer mining areas, the density of standard survey marks will vary in accordance with the degree of mining activity and the size of the leases. It is hoped that ultimately each 1:250,000 map-sheet in these areas will carry on the order of 96 standard survey marks. Work until now, however, has been minimal and largely restricted to upgrading the existing trigonometrical stations.

The second generalization is that co-ordinates will not be treated as absolute and used as such in the legal definition of a cadastral corner unless circumstances decree that they should, and only then when they can be expressed within limits sufficient to match the accuracy standards of the legal cadastre.

The third generalization to be expressed in the rules of integration will ensure that co-ordination practices can be adopted and standardized within the scope of any survey, even though the absolute values of the co-ordinates may be suspect in the framework of the geodetic system. In other words, rules will be described to cover such emergencies as:

(*a*) Co-ordination where no geodetic framework or standard survey mark is in evidence;

(*b*) Co-ordination in areas where the existing surveys are not standardized.

Graphic framework

Modern mapping is functional; and in the development of the new cadastral series, an attempt has been made to determine:

(*a*) What is actually required;

(*b*) The most acceptable scales to maps;

(*c*) The most economical method of producing and maintaining the maps.

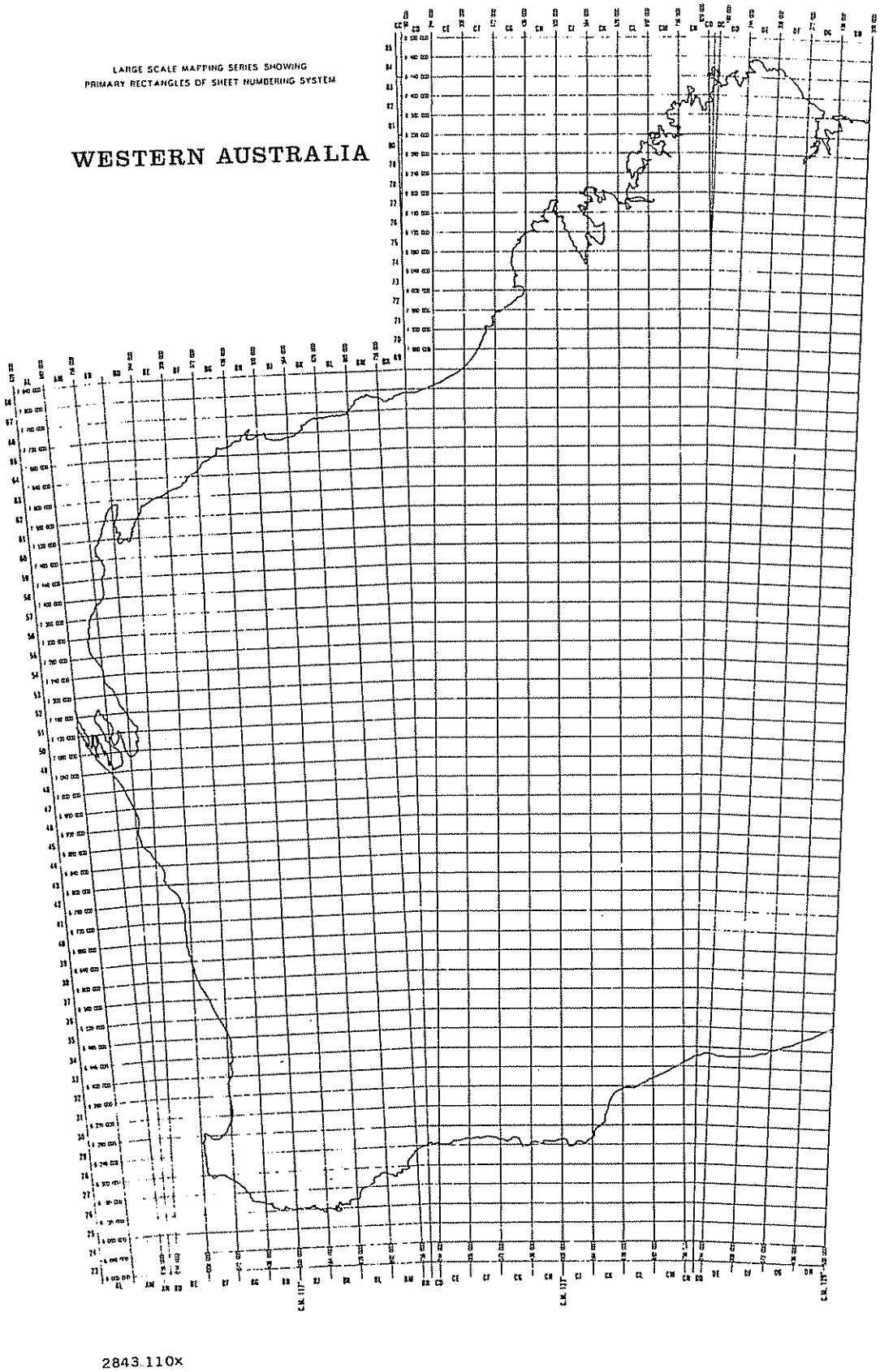
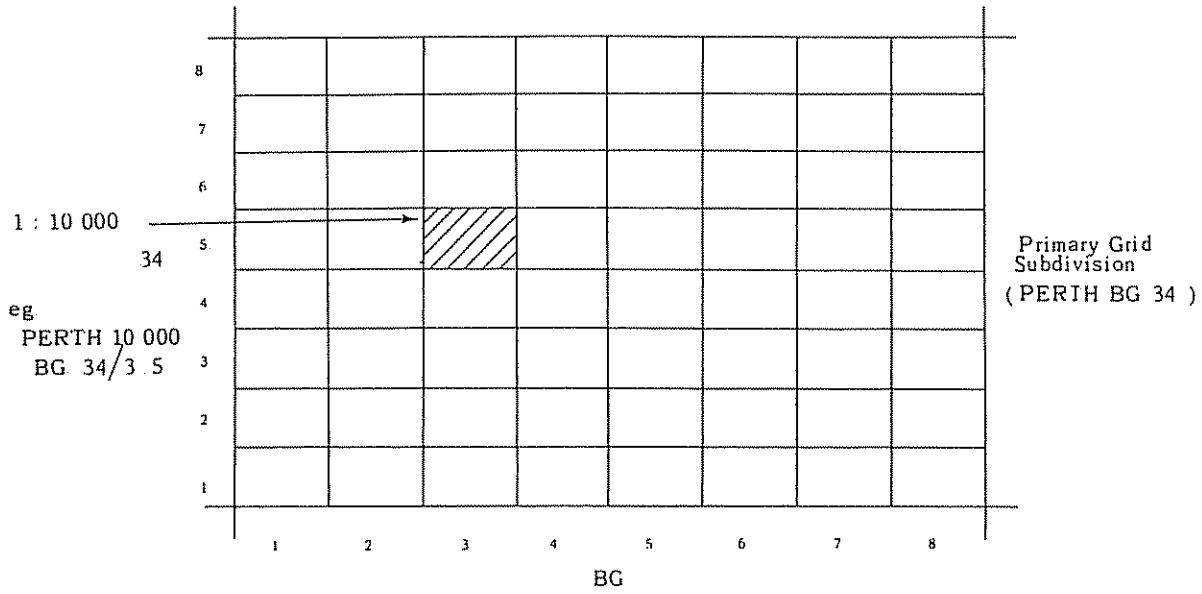


Figure 110. Australia: Western Australia, large-scale mapping series

DIAGRAM SHOWING BREAKDOWN OF THE PRIMARY GRID UNIT TO 1 : 10 000 SHEETS



NUMBER OF SHEETS IN BREAKDOWN OF MAJOR GRID

1 10 000	8 X 8
1 5 000	16 X 16
1 : 2 000	40 X 40
1 : 1 000	80 X 80
1 : 500	160 X 160

DIAGRAM SHOWING BREAKDOWN OF 1 : 10 000 SHEET BG 34/ 3 5 TO LARGER SCALES

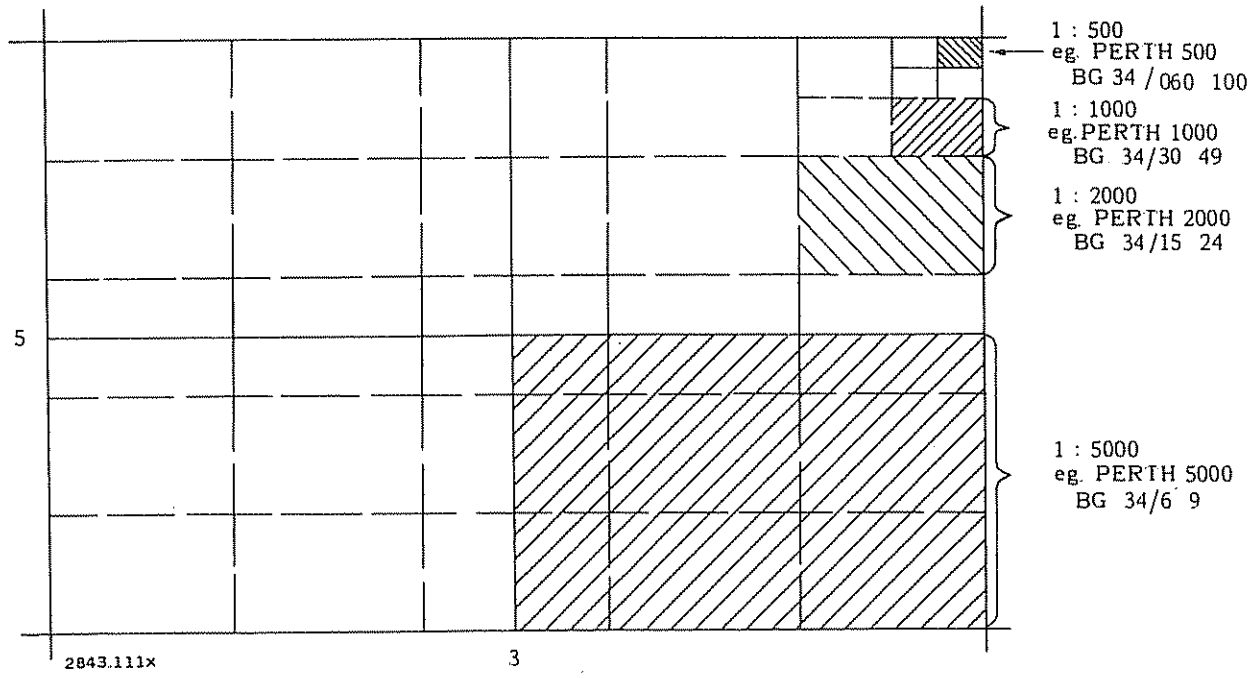


Figure 111. Australia: Western Australia, sheet-numbering system for large-scale mapping series

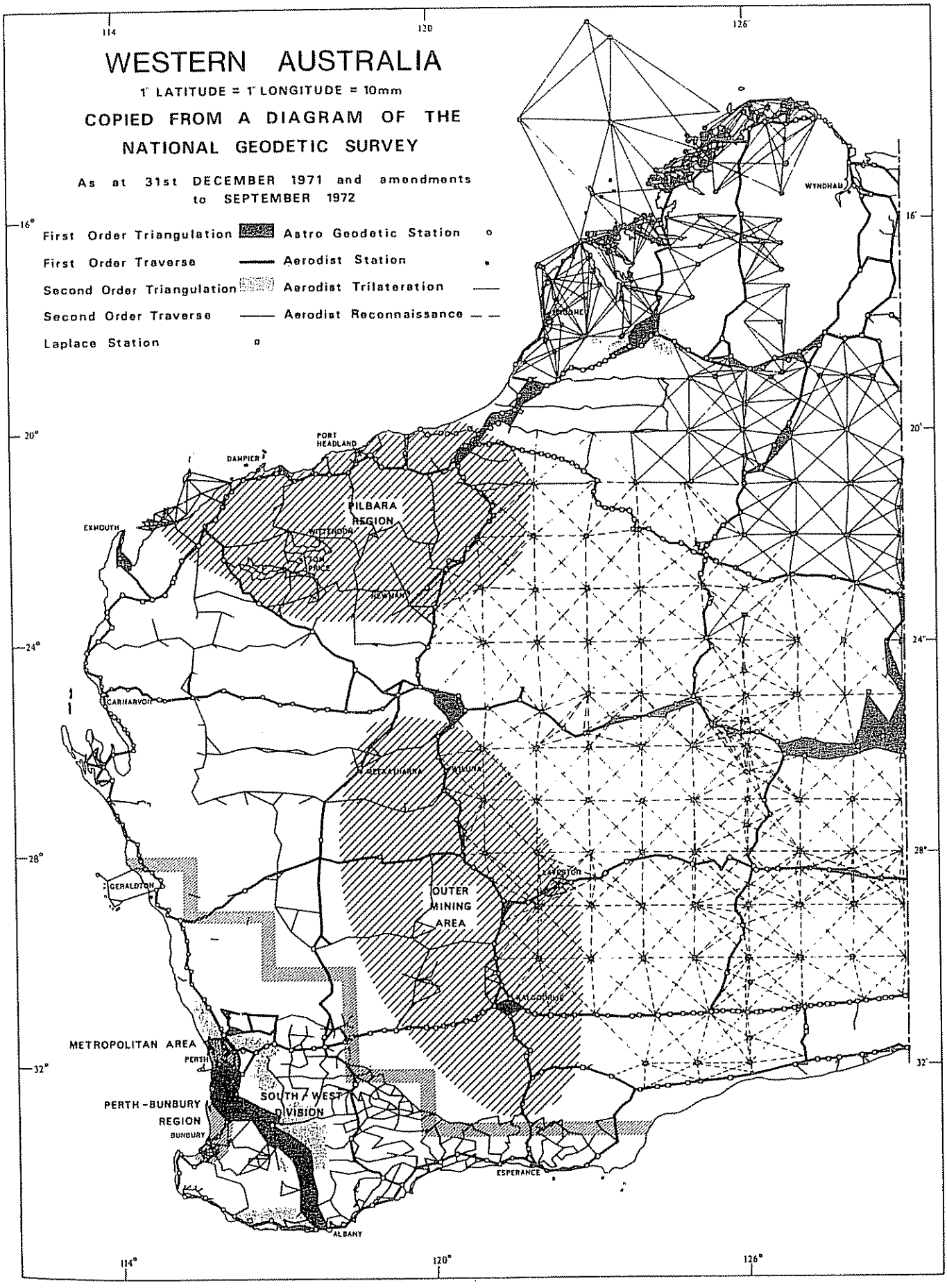


Figure 112. Australia: Western Australia, geodesy

The new large-scale mapping series is a result of such a study, and it is significant that not only have 11 different scales of government mapping been grouped into five new scales, but a system of compilation is evolving in which all the various interested departments participate. Overlapping of effort is thereby reduced to a minimum.

The basic function of all the maps is to show an up-to-date legal cadastral situation; but, in addition, the same maps will form the nucleus of a property cadastre index and a tax cadastre index, besides being important in civil engineering development. This is particularly true for the maps on the scales 1:500, 1:1,000 and 1:2,000, of which the 1:2,000 finds favour with all authorities and, as such, represents the basic map unit of the large-scale series. In medium- and small-scale mapping, the choice of scales is defined by the national topographic programme. The compilation scale for the cadastral counterpart to this series is 1:50,000 in rural areas and 1:25,000 in the closer developed rural areas abutting urban development.

Whatever the scale of compilation, all systems are designed about a master plot subjected to daily updating and from which copies are made as the basic framework for many other forms of special-purpose mapping. Wherever possible, the cadastral framework is used as the horizontal control for topographic mapping, thereby ensuring the maximum relativity between the two series. In areas of sparse control, the converse of this practice may apply.

Cadastral maps are rarely printed and stored, but are retained as a transparency and printed upon demand through high-speed ammonia machines.

In rural areas, 54 cadastral map-sheets at 1:50,000 scale with 10-m contours have been compiled; and 180 map-sheets at 1:2,000 scale are held of urban and suburban localities. This latter programme is now being effected by such Departments as State Taxation, Town Planning, Public Works; and the Metropolitan Water Supply, Sewerage and Drainage, working in close liaison with the Department of Lands and Surveys. The 1:50,000 programme remains the prerogative of the latter Department.

Pictorial framework

No system of integrated surveys can ignore the value of aerial photographs as a fundamental source of valuable information. Although this statement might justifiably include all modern "sensing" systems, none has provided the scope for measurement provided by aerial photographs. Discounting any digital or graphic treatment, aerial photographs remain the storehouse for a broad spectrum of sociological and earth sciences data and thereby a subject for interpretation and reproduction. The terms "photo mosaics" and "orthophoto maps" express practices common to reproduction for a pictorial framework.

In Western Australia, orthophoto maps are programmed to cover the metropolitan area of Perth on the scale 1:5,000; and 40 map-sheets, or 12 per cent of the programme, are completed. The rural areas of the south-west are the subject of a programme of controlled mosaics rectified and compiled in the framework of the 1:50,000 cadastral compilations enlarged to 1:25,000 scale. Work has just commenced on this series, and distribution will be at the 1:25,000 scale.

Systems of data processing

Data are defined as "facts of any kind"; and while the processing of traditional survey data is contained by well-established customs, the processing of data in a total system of survey integration is not so easily expressed.

As a result of investigations, it was found that the practice of recording data against a block of land was a viable system and could be continued until circumstance deemed otherwise. More important was the discovery that the existing system of land title referencing could be programmed for computer-oriented storage and remain a unique referencing system. This meant that a data bank defining land was a practical proposition without alteration to the current system of land referencing, and it appeared that it would complement the efficiency of existing systems and could parallel them without interference. The data finally programmed for capture in the data bank include the title description of a single land unit with four additional references:

(1) The local authority in which the land is situated;

(2) A map reference;

(3) An Australian map grid reference for one corner of the land unit in question;

(4) A grid bearing for one side.

These additional references have introduced new opportunities in processing, including the ability to group data per local authority map reference or Australian map grid co-ordinates; and indirectly provide the means for perhaps the most important aspect—automated plotting. Experience has shown that a 1:2,000 map-sheet containing about 800 land units can be plotted in a matter of 45 minutes once the "plot tape" has been created from the "master file". A 1:1,000 map-sheet of some 200 land units can be plotted in 18 minutes.

Although it has only recently been introduced, the system provides control of the cadastral mapping situation in that surveys effected under the provisions of the Land Act, Transfer of Land Act and the Mining Act, once co-ordinated, can be added to the master file and the necessary adjustments made to the records already held. It also provides, either directly or indirectly, the core material upon which to build special-purpose data files; and the facility to display graphically any data which can be expressed in X, Y co-ordinates—preferably linked to the cadastral or standard survey mark framework.

Legislation

As previously indicated, legislative control of surveys is currently confined to the requirements of the legal cadastre and includes the Land Surveyors Licensing Act, 1909, and its regulations, as well as the regulations governing authorized surveys effected under the provisions of the Land Act, Transfer of Land Act and the Mining Act. It is considered, however, that these regulations may be too restrictive to serve a total system of survey integration as defined in the introduction to this paper.

The Standard Survey Marks Act of 1924 provides for the placing and subsequent protection of standard survey marks; and, therefore, the basis for co-ordinating the cadastral framework in the Australian map grid. It is intended that regulations to be gazetted under the provisions of the Standard Survey Marks Act will

provide for the co-ordination of surveys other than cadastral and thus encompass the integration of all mapping control.

The basis geodetic framework will remain the province of the Surveyor-General and the National Mapping Council, and specifications standardizing such work will continue to originate from that source.

Ultimately, there will be a need for legislation to embrace the whole concept of survey integration, including the storage, processing and distribution of data. Currently, however, the pressing need is for the systematic development of the mathematical, graphic and pictorial frameworks for which the rules of participation are available or which require little further elaboration.

Further investigation is currently being undertaken for the purpose of a total review of regulations applying to the Acts mentioned above.

Conclusion

If this paper expresses survey integration as a more expansive philosophy than systems currently operating or proposed, and in so doing disposes of the perennial discourses on zone widths, scale factors, etc., it will have achieved its objective. These are matters which surveyors are trained to understand and utilize, and have been the subjects of much previous discussion. In the light of decisions already made, it is hoped that the Western Australian concept may have something additional to offer in the meaning of survey integration and, although formative, the means to achieve it.

OPTIMIZATION OF CADASTRAL SURVEYS*

Paper presented by Israel

The system of land property registration in Israel is based on the principles laid down by Torrens. The principal feature of this system is a unique definition of boundaries of blocks and their subdivision into parcels through a precise survey of the premarked boundaries. Such a survey provides for either graphic or digital definition of parcels and their areas; and, if connected to a national geodetic control network, the ability to reconstruct or restore the unique definition is ensured. The defined parcel becomes a basic unit for the Land Registry, which maintains a record of ownership, leases, rights, reservations, mortgages, etc. in accordance with existing laws. Any boundary mutations caused by transactions, new subdivision caused by development, acquisition for public purposes, etc. have to be registered on the basis of a mutation plan, which is acceptable to the registrar only if prepared by a licensed surveyor according to prevailing laws and ordinances, and on condition that it conforms to the approved plan of land utilization.

In this way, the ownership and rights to land property are conclusively guaranteed; and, indeed, within the areas in Israel that are covered by this system, land boundary disputes are virtually non-existent. However, approximately 22 per cent of the area of Israel is still to be settled within this system; and the cadastral surveys are one of the principal tasks of the Survey of Israel, in addition to the dealing with numerous boundary mutations caused by rapid development.

The cadastral surveys, beginning with demarcation of boundaries, their survey, computational processing; and preparation of preliminary, intermediate and final plans, constitute a lengthy and painstaking task.

Technological advances, particularly those in the fields of electronic distance-measurement, electronic data-processing and automated plotting, were the principal factors that prompted the Survey of Israel to initiate a programme of optimization of cadastral surveys. The primary objective of this programme can be specified in general terms as "to produce a high standard cadastral plan with a saving of time, cost and professional manpower".

The principal features of the programme currently being developed by the Survey of Israel, in co-operation with the Surveying and Geodetic Research Station of the Technion—Israel Institute of Technology, are outlined here. The programme is due for completion in the middle of 1974, although parts of it have already been implemented.

Basic mapping

The first stage of the planned cadastral survey is a general map of the area, prepared by photogrammetric means at the scale of the final block plans, which vary from 1:625 in densely built-up urban areas, through 1:1,250 in built-up areas, 1:2,500 for agricultural land, with 1:5,000 and 1:10,000 for partially developed land and down to 1:20,000 for desert and arid regions. Orthophotography is being incorporated into this preliminary mapping, carrying the distinct advantage of a wealth of information not ordinarily available in conventional line maps.

Planning of block and parcel boundaries

The planned boundaries of blocks and parcels are drawn on the above-mentioned basic map. The size of blocks is determined by the standard dimensions of the final cadastral plan, and the block boundaries follow as far as possible, distinct natural or man-made features. The subdivision into parcels is planned in part on the basis of the aerial photography and in part according to land-holding data supplied by the Directorate of Lands. The proposed block and parcel subdivision map is called the "planning map", on which further operations are based.

Control network

In many cases, the existing national geodetic control network has to be densified for the forthcoming cadastral surveys, usually through traverses.

In planning the traverse network, a number of requirements are taken into consideration, namely:

(*a*) Adequate rigidity of the control network;

*The original text of this paper, prepared by Ron K. Adler, Director, Survey of Israel, appeared as document E/CONF.62/L.52.

(*b*) Optimum coverage of the area;

(*c*) Convenience in demarcating boundaries in subsequent stages;

(*d*) Holding the extent of the surveys down to a minimum.

The traverse network is, of course, connected to the national geodetic network of higher order.

The planned traverse network is marked on the planning map; and its details are digitized through a flat-bed orthogonal digitizer, so that instrument settings can be precomputed with the aid of a high-speed electronic computer.

The field measurements are recorded in the form of a simple list of angles and distances. A computer programme has been developed which sorts out the input, prepares the traverse network structure, determines junction points, checks for incompleteness of observations and afterwards proceeds to adjust first the junction points and afterwards the intermediate station co-ordinates.

The adjustment is by the method of variation of parameters and in the formation of observation equations, the co-ordinates obtained by digitizing during the planning stage are utilized as preliminary co-ordinates of stations. Up to three iterations are usually sufficient to obtain a final complete result for the block network.

Digital description of the block and demarcation plan

The actual demarcation and monumentation of cadastral boundaries is planned on the basic map with relation to the planned control network. The decision is made as to which boundary points are to be physically monumented on the ground. The demarcation data are supplied through the digital description of the block obtained through digitizing the planning map.

The proposed demarcation is translated from x and y digitized co-ordinates into polar or orthogonal setting-out data.

Part of the programme described here consists of practical and analytical comparison between the efficiency and accuracy of a polar survey based on distances measured by an infra-red electronic distance-measuring instrument and a theodolite against the conventional survey by abscissae and ordinates. The preliminary results show a definite advantage of a polar survey.

Field setting-out

The setting-out in the field incorporates only those points which were preplanned as described above. The set-out points are surveyed anew by a different survey party from that which carried out the setting-out. This survey of monumented points determines the final location of all boundaries.

Here, a point should be stressed that the field records must be kept in such a way as to be transferable to punch cards or another computer-acceptable input medium by personnel not necessarily familiar with surveying.

Preliminary map

The survey of the selected and monumented boundary points described above updates the digital description of the block and its subdivision. The digital description is then processed in the computer, which prepares input data for the electronic flat-bed plotter (co-ordinatograph).

The Survey of Israel utilizes a Gerber 1232 plotter capable of preparing a graphic product in one of three forms: a ball-point or rapidograph drawing; scribing on coated film surfaces; and light-projecting on photo-sensitive materials. The tested accuracy of positioning is better than 0.005 mm, which exceeds considerably anything feasibly achievable by manual methods.

The operation is fully automatic. The preliminary map is drawn with the aid of ball-point pens and rapidographs mounted in a six-turret head. The preliminary plot is used for editing and serves as the basis for claims consideration by the settlement officer.

Final map

As result of the activities of settlement officers, certain changes may be necessary in the preliminary plot. The digital description is again updated, and the computer turns out the plotter input for the final block plan preparation. The graphic quality of such a map is much superior to that of hand-drawn maps. The final plot includes a table of parcel areas computed and adjusted from digital data.

Concluding remarks

The system described above increases the efficiency of cadastral surveys by producing better results as concerns both accuracy and quality of the graphical representation. It results in a considerable saving of manpower through strict preplanning of operations, digital data-processing and automatic plotting. It is estimated that when fully implemented, it will result in at least 40 per cent improvement of over-all performance.

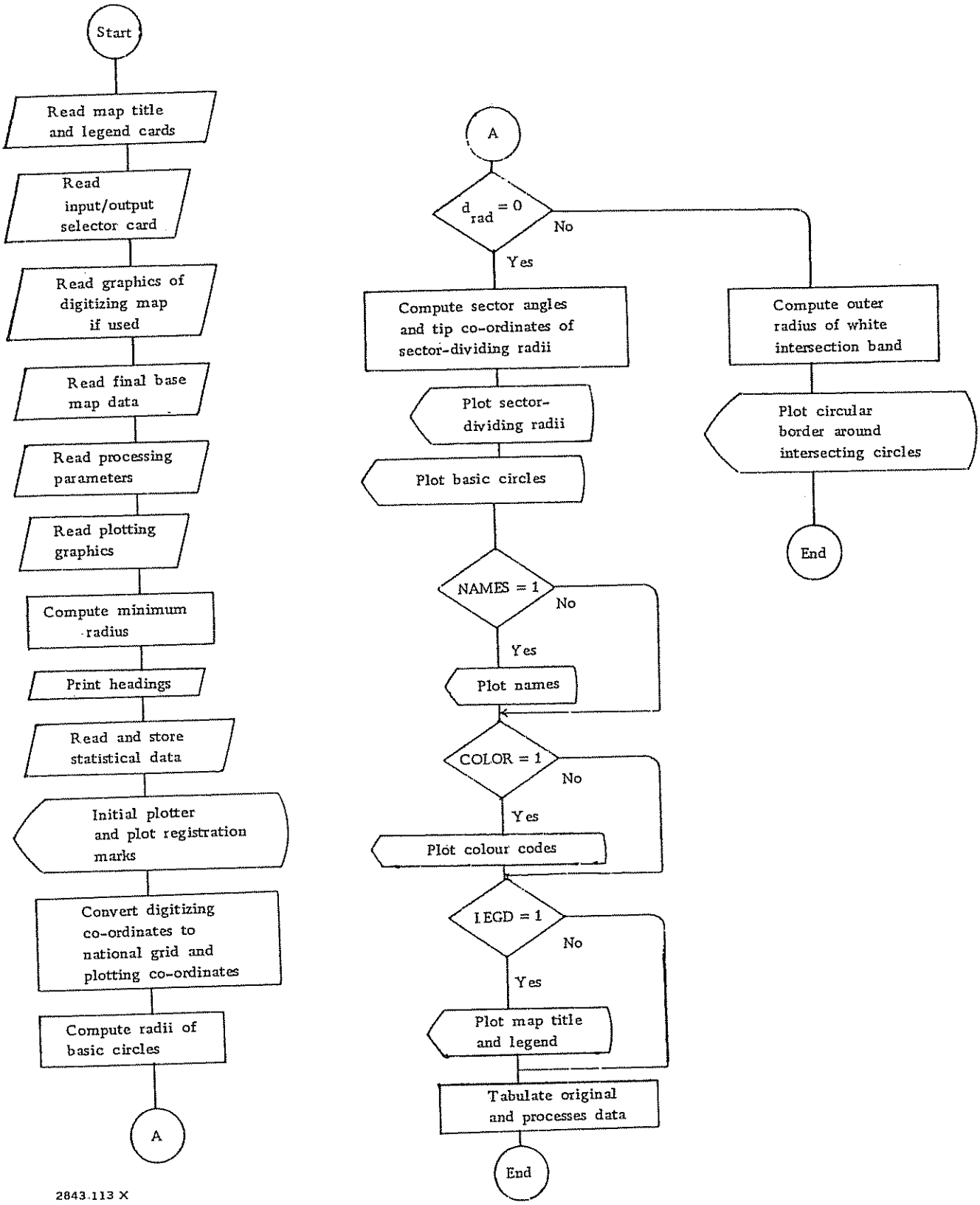


Figure 113. Israel: flow diagram

CADASTRAL SURVEYING AND MAPPING IN AUSTRALIA*

Paper presented by Australia

CADASTRAL SURVEY

The Australian cadastral survey has developed as a series of separate systems, introduced by each of the six states. Although developed separately, they are similar; and all display the common characteristic of having commenced as a series of isolated and often disconnected surveys.

To find the reason for this situation, it is necessary to examine the early history of the development of Australia. Within the first 50 years of settlement, rural and elementary urban development occurred in varying degrees of density around much of the perimeter of the continent and over a good deal of the interior of the eastern states. Accompanying the rapid spread of development came the need to register dealings in land (mostly Crown Grants) based on surveys. The limited resources of the states did not allow for a comprehensive system of survey control or triangulation to be carried out over such vast areas, ahead of the rapid spread of settlement. Consequently, the various survey systems have been based on isolated surveys lacking any integration into a co-ordinated cadastral system.

With the completion of the national geodetic survey in recent years, attention is currently being given to the integration of surveys based on the national geodetic datum. This paper explains the current position in Australia with respect to integration and the use of modern survey techniques and equipment.

Integration of surveys

Integration of surveys has been commenced in all states. Basically, it takes the form of co-ordination of surveys and cadastral information within the mathematical framework of the national geodetic survey. The initial objective of the integration programme of each state, will be to establish a series of co-ordinated control traverses within the framework of the national geodetic survey. All surveys are to be connected to these traverses and thus be capable of being co-ordinated on a local, state and national basis.

At the current time, the states and territories in Australia are at various stages of planning or implementing their integration schemes. While most are using the 6° zone widths of the Australian map grid for their integrated surveys, some, for historical and other reasons, are not. New South Wales, for example, has adopted a 2° zone width, while the Australian Capital Territory has retained its special projection.

Some Australian states are already researching the problems of storage and retrieval of cadastral information using computers. Western Australia has set up a model experiment in which 9,000 parcels of land were documented in a land data bank. The results of this experiment are still being appraised.

The integrated survey systems are a logical prelude to land data banks, and it is in this field that rapid developments can be expected over the next few years. All states are proposing to use the Transverse Mercator projection for mapping and for integrated surveys. Data stored in the bank can then be retrieved by the user in any specified zone. This confirms that the "integration surface" is really the Australian geodetic datum and not any given map projection of a portion of it.

Electronic distance-measuring equipment

The use of infra-red and laser measuring equipment in Australia is widespread. In cadastral survey work, it is probably used more for control than, for example, relatively shorter measurement along urban boundaries. In these cases, conventional measurement by tape and chain is still common. In rural surveys where holdings are larger and boundaries are much longer, electronic distance-measuring equipment is often used.

In most states and territories, the local legislation has been amended to permit use of this equipment. Outside cadastral work, electronic distance measurement is common, particularly on large engineering projects requiring precision control for construction or settlement checks.

Photogrammetry

The use of photogrammetric measurement for title surveys is not common. In some states, it is permitted in certain circumstances, for example, the measurement of certain leases where areas are large and land values are low.

In South Australia, it is expected that photogrammetry will play a significant part in setting up a legal cadastre. However, outside its use in cadastral mapping, photogrammetry is not used extensively in Australia for land boundary measurement.

CADASTRAL MAPPING

Cadastral mapping programmes in most states and territories are well established. Until recently, they generally consisted of parish and county maps in rural areas, with some larger scale special series in metropolitan areas. In recent years, many cadastral mapping programmes have been revised and incorporated into the framework of the Australian map grid.

The scales and information shown on the maps vary from urban to rural areas and from state to state. In some instances, contours are shown, while in many cases, the information is restricted to boundaries of roads, land parcels and so on. A trend to produce topo-cadastral maps has been noted in some states.

A recent development, particularly in urban areas, has been to use an orthophoto map as a base to which contour and selected cadastral information is added. These maps can then be used for property and taxation cadastral purposes, as well as for land administration and planning purposes.

The use of data plotters for the drawing of cadastral maps has commenced, and it is expected that increasing use will be made of this equipment as the necessary computer programmes are developed and refined.

*The original text of this paper, prepared by the Department of Services and Property, Australia, appeared as document E/CONF.62/L.69.

URBAN MAPPING IN AUSTRALIA

Much of the current urban development in Australia is directed towards decentralization and urban redevelopment. Much emphasis has been placed on building new cities in proposed growth centres throughout the country. Studies are under way to assess the feasibility and type of development required for these future cities, and some specific localities have been selected. The renewal of selected areas in established cities also offers considerable scope for urban planning

This type of planning leads to a heavy demand for large-scale maps of both existing urban and proposed development areas. To keep pace with the need for data related to the new growth areas, mapping programmes must be flexible and capable of supplying accurate maps at short notice.

The scale of maps needed for urban planning varies from 1:500 to about 1:10,000. Most of the strategic planning usually takes place on the scale 1:10,000. There is a need for maps on a scale of approximately 1:2,500 to carry out more detailed engineering studies and to fill in the broad outlines of the strategic plans. Final detailed studies are mostly carried out on the scale 1:500 to ensure the success of the design.

Orthophoto mapping

The requirements for orthophoto maps have been met largely through the medium of conventional photogrammetric techniques. However, orthophotomap techniques are now being used more and more as a means of keeping pace with the demand for maps.

Various types of orthophoto-map equipment, such as Zeiss Topocart, SFOM and Zeiss Gigas, are in use. Details of the equipment used and the maps being produced are given in the report of the Australian Government on activities during 1970–1973.[1]

The final product is usually a half-tone diazo print or a full-tone bromide. Contour information is superimposed from drop line or from conventional plotting for planning projects. Cadastral information is compiled using the orthophoto map as a basis where survey information is scanty.

Those states which have not commenced production of orthophoto maps are investigating the process, and it is expected that they will each have orthophoto equipment within the next few years.

Data plotters

The use of data plotters as part of automated cartographic systems is being examined by some Australian survey and mapping organizations. The preparation of plans, particularly at very large scales, such as 1:500, from raw data, e.g., field notes; digitized data from stereoplotters or existing manuscripts can be expected in the near future.

The systematic mapping of areas using these techniques will be particularly useful for the planning of urban redevelopment schemes.

[1] See pp 3-21

PHILIPPINE CADASTRAL SURVEY PROGRAMME*

Paper presented by the Philippines

Under existing statutes, the Bureau of Lands is charged with the cadastral survey of the country and the disposition of the public lands. The cadastral survey programme was initiated in 1906 upon the passage of Act 2259, commonly known as the Cadastral Law. The first cadastral survey conducted pursuant to this law was that of Pilar, Bataan (BL Cad. No. 1), which was completed in 1909. After more than 60 years of operation, out of the 1,483 cities and municipalities of the country, about 1,000, estimated to cover about 17,019,191 hectares or roughly 56.75 per cent of the total land area of the Philippines, still remain to be surveyed.

The current Philippine Cadastral Survey Programme is envisioned to make extensive use of large-scale photographs. The objective is to determine the metes and bounds of land parcels which are the basic requirements for the issuance of land patents or titles.

DESCRIPTION OF THE PROJECT

The project includes: (*a*) the delineation of political boundaries between provinces, cities, municipalities and *barrios*; (*b*) the measurement of land areas within these political subdivisions; and (*c*) identification of each parcel, providing technical description thereof for titling, land inventory and development purposes.

To carry out the survey, the Bureau of Lands proposes to adopt photo-cadastral mapping techniques or more rapid methods of land surveying which combine the good features of the conventional transit and tape method and those of photogrammetry. This procedure has been found effective not only in developed countries, but in developing countries in Asia. The method will make extensive use of aerial photographs, which will be rectified for tilt and scale displacement, and of orthophotographs corrected for relief displacement. The identity of the lots can be readily ascertained because these photographs are, in effect, the orthographic projection of the objects on the ground.

PLAN OF OPERATION

The Bureau of Lands currently has about 60 operating survey parties which are undermanned and underequipped. If the Bureau of Lands is to pursue the programme vigorously, it should form 40 additional survey parties and augment its existing parties not only in manpower, but in equipment. Ideally, 40 men will compose a survey party. It is estimated that 4,139 men will be needed.

Considering the magnitude of the task and also the limited capability, both in manpower and equipment, of

*The original text of this paper, prepared by the Inter-agency Study Group, National Committee for Mineral Exploration and Survey Operations, Philippines, appeared as document E/CONF 62/L 90

the Bureau of Lands, the Bureau alone cannot handle the job. It must seek the assistance of other agencies and organizations. For this purpose, the help of the Philippine Air Force, the United States Agency for International Development (USAID) and the private sector will be sought.

Bureau of Lands

The Bureau of Lands will provide the supervision, direction and control of programmes and projects. In the field of operations, it will take charge of the establishment of controls, lot sketching and monumenting, and the establishment and survey of political boundaries. It will also handle office operations and laboratory work. In this phase, it will be responsible for control traverse computations, preparation of control overlay, rectification of photographs, orthoprojection, preparation of cadastral maps, and reproduction and distribution of the same.

After the maps are prepared and completed, the Bureau will initiate the filing of compulsory registration proceedings as provided for in Act 2259 (Cadastral Law). The Courts, under said Law, adjudicate ownership of cadastral lots. Lands declared by the court as public lands are disposed to deserving claimants-settlers in accordance with the provisions of Act 141 (Public Land Act).

Philippine Air Force

Under Joint Administrative Order No. 1 on Photogrammetry, which was approved by the Secretaries of Agriculture and Natural Resources and of National Defense on 5 August 1958, a joint task force, composed of the Bureau of Lands and the Philippine Air Force, was established. The goal was the execution of the photogrammetric survey of the Philippines. The order provides that aerial photography shall be done by the Philippine Air Force, and the ground survey and stereocompilation was assigned to the Bureau of Lands.

Under this programme, existing aerial photographs taken for the Department of Agrarian Reform and found suited for the purpose, will be used. Areas not covered by existing photography will be photographed by the Philippine Air Force for this programme.

United States Agency for International Development

One of the drawbacks that hinders the complete and early realization of target goals is the lack of suitable equipment. This lack has reached a critical stage in so far as the Bureau of Lands is concerned because, for the past several years, only a limited amount has been allotted for the purchase of equipment under the Appropriation Laws. Such being the case, for lack of replenishment, most of the surveying equipment of the Bureau of Lands is either in unserviceable state or badly in need of repair.

In this project, the Bureau will solicit aid from USAID in the form of equipment. In order to have a continuous supply of knowledgeable technicians, USAID will be requested to finance the training of technicians who will be sent abroad. Of course, the Government of the Philippines is expected to provide the counterpart funds for training purposes.

Private sector

Because of the magnitude of the project and the limited capability of the Bureau of Lands, a part of the project will be assigned to private contractors. Those contractors who qualify not only in technical expertise, but in equipment capability as determined in the prequalification, will be invited to participate. Awards of contract will be done after sealed bidding.

RÉSUMÉ OF WORK TO BE DONE

Areas not previously covered by aircraft imagery and those covered by substandard photographs will necessarily be photographed. Photographs that do not meet specifications will have to be retaken. The two procedures to be followed, therefore, are: to make full use of existing photography; and to undertake the photography still needed. In areas covered by photographs which do not meet specifications, those photographs will be used only as a guide in the sketching and monumenting of lot corners. Subsequent photography will be used as a basis for the production of cadastral maps.

Procedure I: use of existing photographs

Procedure I includes the following tasks:

(a) *Control layout.* Prominent points appearing on the photographs which are located at the periphery and middle of the project will be selected, monumented and connected to existing controls by ground method with the use of electronic distance- and direction-measuring instruments, e.g., the DI-IO Distomat, to determine their geographical and grid position. As much as possible, the procedure prescribed in the Philippine Land Surveyor's Manual will be followed;

(b) *Notification of claimants: monumenting and sketching.* As much as possible, notification monumenting and sketching should be done simultaneously to avoid conflicts. The claimants will be notified and requested to indicate or point on the ground the position of their lot corners. The field staff of the Bureau of Lands will then monument these corners and locate these corners on the photographs. The points will then be joined to form the polygon which will indicate the metes and bounds of the lot;

(c) *Point marking on diapositives.* After the field-point identification of the control points, their positions will be marked on the film diapositives of the aerial film negatives with the use of point markers, like the Zeiss snap markers. Photo control points or pass points will also be marked in the same manner on the diapositives. An average of 17 points per photo is needed to be marked in order to have a rigid control of the photograph. For purposes of orientation later, to meet additional requirements to establish X-Y co-ordinate positions as required for cadastral descriptions of properties, marked points appearing on the film diapositives will have to be transferred to the aerial photo negatives. Two points, the centre and its wing point, are to be transferred to the negative by pricking;

(d) *Comparator measurement and recording.* The marked film diapositive will then be placed on the X-Y positioning stage of the mono digital comparator. On order of the computer call-up, the photo fiducial marks, marked control and photo points are mensurated—averaging approximately 17 points per photo. Production records show that an average of 3½ minutes per photo

is required for measuring and recording the X-Y position of the 17 points. Rapid identification and recording of the points are facilitated by use of an operational coding keyboard which is the digital recording component of the comparator. Recording can then be made either on punch paper by means of supplied teletype or on the punch cards;

(e) *Analytical computations*. The punched paper-tape generated by the recording system of the comparator is the digital data input for the IBM 360 computer. Through the use of the HDF analytical programme, the IBM 360 will compute the X and Y tilt and Z, magnification data, on punched paper-tape, punched cards or magnetic tape to drive the automatic rectifier. The programme will also produce the true X, Y and Z co-ordinates position of all marked points observed on the comparator.

(f) *Automatic rectification or orthoprojection*. For relatively flat terrain, all photographs will be rectified to correct for tilt and scale, using, as much as possible, extreme corner points. In cases where the difference in elevation is more than 1 per cent of the flying height, an orthoprojector will be used. The digital data medium computed by the IBM 360 is data blocked in segments for each roll of aerial film to be rectified by the automatic rectifier. The roll of aerial film is placed in the rectifier and its associated components, X, Y tilt and Z magnification data tape, are entered to the reader of the rectifier for automatic X, Y and Z rectifier positioning and exposure of the rectified print. Current production rate of prints, according to the manufacturer, is within an envelope of 2X = 600 prints/day, 5X = 250 prints/day;

(g) *Co-ordinate and area recording*. The resulting rectified prints are used to provide a data base for establishing a cadastral co-ordinate system of property corners, to locate property boundary and for the determination and identification of area holdings. A digital recorder will be utilized for this purpose. The print is placed on the co-ordinatograph table and properly scaled and rotated, using the two co-ordinated points in step (*c*). After orientation, any point appearing on the print is in its correct position so that the co-ordinates of each point can be determined by just coinciding the cursor of the co-ordinatograph rails over the desired point and activating the coded record button. A coded recording of the X-Y co-ordinate values is punched on paper tape and printed as hard copy of the teletype. In addition to measuring and recording X and Y co-ordinates, areas can be computed automatically with the use of a digital planimeter. Areas are computed in real time upon tracing the perimeter. Upon closing on the starting-point of a perimeter, the area will have been computed, displayed and ready for recording. With the use of the electronic scaler function, the area can be determined in any desired square value or in acres or hectares. The area obtained can also be recorded if so desired;

(h) *Preparation of cadastral maps*. Details obtained from the field will then be transferred on the rectified prints. It is better that at this stage the lots are assigned their corresponding lot numbers. All cartographic details will be completed on the finished photo-cadastral map, including lot numbers, corner number, old survey number, name of claimants, if space is available; names of such natural features as creeks, rivers and roads; names of *barrios* and cities; and other details which might help identify the land;

(i) *Reproduction*. The photographs will then be reproduced at convenient sizes so that a lot, which is subject of a title to be issued, will be entirely inside the photograph. Care should be taken so that the photographs show clearly the boundaries of the lot. All details about the lot, including the adjoining lots, will be clearly shown. This information is then to be attached to the back of the title to serve as a description.

Procedure II: no photographs available

Procedure II is designed on the assumption that there are no photographs; or that if photographs exist, they do not meet specification so that new photography has to be undertaken. In either case, it is necessary, in order to produce more accurate results, to lay out the control network first. Points, preferably at the periphery and in the middle, across the project should be selected to compose the control points. The main control should be of primary precision, and the subsidiary control should be of secondary precision. To facilitate the determination of the geographical and grid positions of the points, electronic direction and distance measuring devices, such as the DI-IO Distomat, should be used. In order to assure proper point identification on the subsequent photographs to be flown, these points should be properly signalized. Any form of signal, as long as it will help properly to identify the point, will be acceptable for the purpose.

As much as possible, flight planning will consider that a 1-minute quadrangle of the ground should appear in one photograph, in order to facilitate the production of cadastral maps, which are normally in 1-minute quadrangles. The average forward overlap will be 60 per cent and the sidelap, 20 per cent, which will ensure the appearance of points in two or three photographs, thus affording a way of checking the correctness of their positions.

Accuracy requirements

Experience shows that a relative accuracy of 1–3 m is attainable. This accuracy is true in the Bay cadastre, in the Province of Laguna. However, with care, automation and the measurement of plane co-ordinates directly from the rectified photographs or orthophotographs and not from the photo mosaic, as was done in Bay, a better accuracy can be attained. It is hoped that with extra care and fewer human errors introduced as in the photo mosaics, an accuracy of 0.5–1.0 m will be obtained easily.

PARCELLARY MAPPING ACTIVITIES IN SUPPORT OF THE PHILIPPINE LAND REFORM PROGRAMME*

Paper presented by the Philippines

Presidential Decree No. 2, dated 24 September 1972, proclaimed the entire country of the Philippines as a land reform area; and Presidential Decree No. 27, dated 21 October 1972, decreed "The emancipation of the tenant from the bondage of the soil, transferring to them the ownership of the land they till and providing the instruments and mechanism therefor". Guidelines and the programme of execution were set by the Department of Agrarian Reform and co-operating agencies which would undertake the various support services for the successful implementation of the Land Reform Programme. The National Action Co-ordination Group was formed and now executes the operations and activities of the entire implementing machinery, dubbed "Operation Land Transfer".

Participation of Bureau of Lands

The Bureau of Lands, as part of the implementing machinery for the prosecution of the land transfer programme, was asked to organize survey parties within designated pilot projects for the purpose of gathering lot data information, parcellary sketching of private agricultural lands devoted to rice and corn, and the production of parcellary maps as the basis of land transfer. The initial phase of the land transfer operation was the sketching of large landed estates in municipalities tagged as pilot areas.

Land reform survey parties were first organized in several pilot municipalities in central Luzon, where tenancy has given rise to social unrest. Organizations of more survey parties had to be spread out in the southern Tagalog, Bicol Region, the Visayas and Mindanao, in accordance with approved priorities. Phases of operations were broken down according to priorities of 100 hectares or more, and then to 50 hectares or more and so on, until the 7-hectare ownership has been reached, which is the maximum area that an owner may retain under Presidential Decree No. 27.

Within the 11 geographical regions of the Philippines, 57 land reform survey parties were organized. All these survey parties are actively engaged in parcellary mapping operations and in the collection of lot data.

Contract surveys by private surveyors

To expedite lot identification for the parcellary mapping operations of the Bureau of Lands, the Secretary of the Department of Agriculture and Natural Resources, upon recommendation of the Director of Lands, issued Lands Administrative Order No. 22(A) authorizing regional land directors and district land officers to engage the professional services of practising geodetic engineers in the subdivision mapping of priority land reform areas in their respective jurisdictions.

In accordance with this administrative order, invitations to bid were sent out to various practising geodetic engineers or firms engaged in the surveying profession, indicating thereon the scope of work, the specific property to be surveyed, work specifications and other pertinent information. This is what is popularly known as the *Pacquiao* system in the local parlance, or the contract system of surveys. So far, only two regions (region III with five provinces and region X with six provinces) have awarded contracts to private surveyors for the parcellary mapping of areas pin-pointed by the Department of Agrarian Reform in their respective regions.

Specifications for parcellary mapping

To effectuate the land transfer scheme, the National Action Co-ordination Group, with the assistance of the Bureau of Lands, formulated the following guidelines and specifications on parcellary sketching under which the land reform survey parties are to operate.

General purpose

The general purpose is to gather information for publication and production of parcellary maps of agricultural lands devoted to rice and corn as the basis of land transfer. All tenanted private agricultural lands throughout the country with an aggregate area of 100 hectares or more devoted to rice and/or corn as the primary crops shall be sketched.

Specific purposes

The specific purposes are to determine:

(*a*) Boundaries and areas of ownership lots;

(*b*) Boundaries and areas of lots actually occupied by each tenant farmer;

(*c*) Extent of cultivation for every land category;

(*d*) The crop/crops grown on every farm lot;

(*e*) Irrigated and non-irrigated lots;

(*f*) Names and addresses of tenant-cultivators and landowners;

(*g*) Lots having titles and those which do not;

(*h*) Validation of identities of the actual occupants of the parcels.

Sketching requirements

Methods

The methods of sketching will utilize:

(*a*) Aerial photographs (see annex I);

(*b*) Any appropriate ground method (sketching by the use of a plane table with alidade, transit, stadia and scale);

(*c*) A combination of (*a*) and (*b*).

Materials

The materials to be used include:

(*a*) Aerial photo-enlargements on double-weight semi-matte paper as working-sheet for method (*a*);

(*b*) White-print copies of the cadastral maps for areas with cadastral or public land subdivision surveys as working-sheet for method (*b*);

*The original text of this paper, prepared by Oscar A. de Castro, Assistant of the Acting Director of Lands, Philippines, appeared as document E/CONF.62/L.93.

(*c*) Waxed manila paper as working-sheet, if (*a*) and (*b*) are not available;

(*d*) Plastic film, at least 0.002 mm in thickness, polyester age-proof, as overlay or parcellary map-sheet.

Scales

Sketching shall be executed on the scale 1:4,000 (approximate on photo-enlargements) directly on the working-sheets, then traced on plastic film. If the lot lines would appear to be generally less than 0.5 cm on the scale 1:4,000, an enlarged scale 1:2,000 shall be used. The boundary and index map of the project shall also be prepared on plastic film at a convenient scale. To determine the actual scale of the photo-enlargements, at least two non-parallel lines of at least 500 m in length shall be measured on the ground and the corresponding distances measured on the photo-enlargement. The actual scale is

$$1: \frac{\text{Ground measurement}}{\text{Photo measurement}} \qquad \text{Ex: } 1: \frac{507 \text{ m}}{125 \text{ m}} = 1:4056$$

Map-sheet specifications

The parcellary map-sheets or overlays shall be of the same size as the working-sheets (20 inches × 20 inches or 20 inches × 30 inches for photo-enlargements; 21 × 21 inches for cadastral map-sheets on manila paper), with a marginal allowance of at least 2 cm at the top and side border for the marginal data.

The parcellary map-sheets shall be numbered consecutively from one for each municipal project, the numbering to correspond to that appearing in the boundary and index map in a manner similar to cadastral projects. For sheet 26, for example, the corresponding number or designation is PMS-26.

The titling of parcellary map-sheets shall essentially be the same as that for the cadastral maps, with the following changes:

(*a*) At the bottom right portion:

Project Name	AGRARIAN REFORM SKETCHING
Municipality	Municipality of Guimba
Map-Sheet No	PMS No. 26
Photo Scale	Scale 1:4000

(*b*) At the bottom left portion:

CERTIFIED CORRECT: APPROVAL RECOMMENDED: APPROVED (DATE)

JUAN DE LA CRUZ — Chief of Party; _____ Regional Chief, Surveys Division; JOSE CRUZ — Regional Land Director

(*c*) At the bottom middle portion:

	31	32
25	26	27
20	21	22

Lots to be identified and information to be shown

All tenanted parcels devoted primarily to rice and corn within ownership lots with aggregate areas of 100 hectares or more, as pointed out by the tiller and/or claimant, shall be sketched. In case of conflicting claims, the contested areas shall be sketched as a separate lot.

All existing permanent improvements and topographic features, such as roads, trails, irrigation canals, creeks, barns and orchards shall be indicated. Changes of topographic features and improvements (photo *versus* ground) shall be properly noted.

Portions of claimed lots devoted to crops other than rice and corn shall be indicated.

Corners of ownership lots not yet marked on the ground at the time of sketching shall be marked by any of the permanent markers prescribed in the Philippine Land Surveyors' Manual. Corners of tenancy lots need not be marked.

All parcels shall be numbered from No. 1 in each municipality.

Preparation of working-sheets and parcellary map-sheets or overlays

Preparation of the working-sheets and parcellary map-sheets, including lettering, symbols used, drafting, etc., should conform to the accepted surveying principles and practices of the Bureau of Lands and other mapping agencies and pertinent provisions of the Philippine Land Surveyors' Manual. Black ink should be used for lot numbers, lines and corner symbols, and red ink for the projection lines (latitude and longitude). Drafting-pens and India ink should be used in the cartographic work. Boundary lines of lots shall be drawn in bold or thick lines to differentiate them from boundary lines of tenant or leasehold lots, which shall be drawn in fine lines.

The following information is to appear on the working-sheets:

(*a*) Lot numbers, lot lines, lot corners;

(*b*) Latitude and longitude lines of 1′ or 30″ interval, depending upon the scale used;

(*c*) Extent of cultivation, portions of the lots planted to crops other than rice and corn (to be indicated with dotted lines);

(*d*) Improvements and other features.

The following information is to appear on the parcellary map-sheets:

(*a*) Lot numbers, lot lines, lot corners;

(*b*) Latitude and longitude lines of 1′ or 30″ interval, depending upon the scale used;

(*c*) Border lines, to be inked in black;

(*d*) Area of the parcel in hectares;

(*e*) If space will permit:

(i) Corresponding claimants (tenants, landholder, leasee),

(ii) Class and category of the parcel (*f* for rice land, fully irrigated; *p* for rice land, partially irrigated; *u* for rice land, unirrigated; *c* for corn land);

(iii) Extent of cultivation. Portions of the lots planted to crops other than rice and corn shall be indicated with dotted lines;

(*f*) Improvements and other features.

Area measurements

Measurement of the area of each lot shall be determined by templet planimeter, or any acceptable device, to be computed to hundredths of a hectare.

Land reform sketch record and notification letters

Land reform notification letters shall be distributed to all affected parties prior to the sketching operations in a manner similar to that of the final lot survey in a numerical cadastre. Sketch teams shall carry to the field the land reform sketch record cards. Original and duplicate

cards for each lot sketched shall be prepared and filled with the information required thereon, supplied by the respective owner-cultivator, tenant-cultivator or leasee-cultivator, as the case may be. (See annex II.)

Political boundaries

Political boundaries, exact or approximate, shall be indicated on both the working-sheets and the overlays.

ANNEX I

Lot Sketching Using Aerial Photographs

1. *Observation.* The use of aerial photographs on the scale 1:4,000, size 20" × 30", for lot sketching is ideal for open areas where the corners of lots could be easily identified on the photograph. This method is especially adapted to the sketching of lots planted to lowland rice because boundaries of these lots almost always follow earthen dikes that are easily identifiable on the aerial photographs.

2. *Personnel.* Each sketching team will consist of the person in charge of sketching and one assistant. The man in charge identifies the point on the photograph corresponding to the lot corner on the ground. His assistant may serve as front chain-man when a line is to be measured. Each team is assigned to sketch the area covered by only one photograph. This will avoid overlapping of work and ensure that no gaps shall show in the area being sketched. Photographs overlap by as much as 60 per cent. The overlapping edges of the photographs are marked off, making the boundaries of adjacent photographs coincide with dikes running in a north-south or an east-west direction. Adjoining photographs assigned for sketching to the other teams are delineated by identical boundary lines.

3. *Equipment and materials.* These include the following items:

- 1 Photographs (Aerial) 20" × 31", 1:4,000
- 1 Plywood board 21 × 31 inches
- 1 Compass
- 1 Chain band (or 50-m improvized nylon cord)
- 1 Draftsman triangle
- 1 Triangular scale
- 1 Magnifying glass
- 1 Soft pencil
- Tracing paper
- 1 Plastic pouch 24 × 34 × .003 inches
- Transparent gummed tape

4. *Procedure.* The procedure is as follows:

(*a*) Attach photograph on plywood board by means of transparent tape;

(*b*) Tape tracing paper overlay on the photograph;

(*c*) Orient the photograph on the area to be sketched by means of the compass, using the north-south line indicated on the photograph;

(*d*) To determine more closely the scale and orientation of the photograph, the sketching team will actually measure on the ground the length and magnetic bearing of (about) a 200-m well-defined line on each photograph. By using a simple conversion ratio, a much closer approximation and directional orientation of each photograph could be determined;

(*e*) Identify and mark points on the photograph ("on the photograph" here, and henceforth, will mean "on the tracing paper placed over the photograph") corresponding to lot corners on the ground;

(*f*) Connect by lines the points marked on the photograph corresponding to lot lines on the ground;

(*g*) Plotting of new dikes that do not appear on the photograph may be done by the following procedures:

(i) Locate on the photograph the intersection "A" of two old dikes, one of which also intersects at "B" with the new dike. Measure the ground distance from the intersection "A" to the intersection "B" of the new dike and the old dike. Plot the intersection "B" on the photograph by utilizing the photograph distance corresponding to the measured ground distance. In the same manner, plot the other end of the new dike at its intersection "C" with another old dike;

(ii) Connect with a line the two plotted new intersections of dikes on the photograph. The line plotted on the photograph will now correspond to the new dike on the ground;

(iii) For plotting new curve dikes on the ground not appearing on the photograph, the usual plane-table method will be used with a triangular scale being substituted for an alidade and a nylon cord substituted for a stadia and transit;

5. Field-sketching returns submitted to the office will consist of the following material:

(*a*) Sketch sheet on tracing paper of photo quadrant containing the following data:

(i) Photo index sheet number;
(ii) Photo quadrant numbers;
(iii) Adjoining quadrant or adjoining photo index sheet numbers;
(iv) Location of area;
(v) Sketching team number;
(vi) Members of team;
(vii) Date of sketching;
(viii) Plotting of tenant lots;
(ix) Plotting of recovered cadastral lot monuments;
(x) Names of adjoining lot-holders along area boundary;
(xi) Political boundaries;
(xii) Numbers on tenant lots;

(*b*) Lot sketching cards.

ANNEX II
Bureau of Lands
Land Reform Sketch Record

LOCATION _____ _____ _____ _____
Lot No. PMS No. Barrio/Street Municipality/District Province/City

AREA: _____ _____ 1. OCT _____
Hectares Old Survey No. 2. TCT Title No.

REGISTERED TENANT/FARMER

_____ _____ _____
Surname First Name Middle Name

P. O. ADDRESS

_____ _____ _____
Barrio/Street Municipality/District Province/City

REG. LANDOWNER _____ _____ _____
Surname First Name Middle Name

P. O. ADDRESS _____ _____ _____
Barrio/Street Municipality/District Province/City

ANNEX II *(continued)*
Bureau of Lands
Land Reform Sketch Record

CLASS OF LAND: [ ] Riceland [ ] Cornland [ ] Others (Specify) _____

CATEGORY OF LAND (Encircle number) 1. Fully Irrigated 2. Partially Irrigated 3. Unirrigated 4. Upland

Sketched by: _____ Date: _____

SKETCHING NOTIFICATION

_____ Philippines

_____, 19____

_____

_____

_____

You are hereby notified, pursuant to Presidential Decree No. 27, dated October 21, 1972, that the property claimed by you and situated in the barrio of _____ _____ adjoining that of Mr. _____ and others, will be sketched by the undersigned on _____, 19____. As claimant thereto, you are requested to appear on the ground on _____ 19____, at_____m., to furnish all information possessed by you concerning the boundary lines of the said lot.

_____

Chief, LR Survey Party No. _____
Bureau of Lands

Received: _____

Date: _____

The undersigned tenant/farmer to Lot _____ hereby acknowledges that he personally appeared during the sketching of the same and agreed to the boundaries thereof as sketched in accordance with his indication.

_____

Name & Signature of Claimant

DATE OF BIRTH: _____

PLACE OF BIRTH: _____

ATTESTED BY:

_____

DAR Representative/Barrio Captain

_____

Designation

(c) *Urban mapping*

DESIGN OF URBAN LAND-USE MAPS: CASE STUDIES*

Paper presented by Japan

ROLE AND CONTENT OF URBAN LAND-USE MAPS

It is taken for granted that the land-use maps of cities and their environs play a very important role as basic data in city planning. The land-use map needs to be minutely represented in its contents to depict the pattern of classification on an appropriate land-use basis, as well as on the distribution of urban facilities. That demand will be fulfilled in the sense that detail comparison of the locations can be made, if the land-use factors are surprinted on the base of the surveyed topographic map. The current situation of the cities is more easily comprehended when maps representing the chronological changes of the urban area are attached.

Urban land-use maps are classified into the following categories: (*a*) maps for current use of buildings, which depict the use of individual buildings by cadastral scale (large scale); (*b*) urban land-use maps or urban function maps which depict mainly land-use classifications on a district basis at topographic scale (medium scale); and (*c*) chorographical land-use maps which present the functions of cities in relation to its linkage with the environs by chorographical scale (small scale). Another classification can sometimes be made with respect to their content; (*d*) land-use maps intended for accurately elucidating the objectives and existing situations of the maps; and (*e*) land-utilization maps mainly intended for representing the possibilities of development. These classification criteria, however, are not necessarily clear.

Land-use maps intended mainly to express the existing situation at topographic scale are described here.

EXAMPLES OF URBAN LAND-USE MAPS

In many cities of Japan, maps for current use of buildings on the scale 1:2,500 were prepared from the late 1960s to the early 1970s with subsidies from the Government, based on the field survey and on standard specifications for classifying the function of buildings stipulated by the Ministry of Construction. The municipal offices of those cities are preparing urban land-use maps in succession to those maps. The Geographical Survey Institute (GSI) has prepared urban land-use maps of several cities with the objective of standardizing the specifications of medium-scale land-use maps by synthetic compilation based on large-scale land-use maps. In preparing these maps, the common printing-paper size of 94 × 64 cm is used for the convenience of map users. The cities of Sendai, Sapporo, Fukuoka and Tokyo were chosen as mapping areas in succession. Among these maps, that of Tokyo was mainly intended for a guide map; and, therefore, is excluded from the examples taken up here. The other three cities are classified as the central cities in the broad regions, next to the capital city, where the tertiary industries, in particular, official administration offices and liaison offices of large enterprises, are intensively located. The area and population of some densely inhabited districts are shown in table 1, from which it may be seen that those of Sendai are half those of Sapporo and Fukuoka.

Table 1. Population and area of selected densely populated districts

City	Population (units)	Area (square kilometres)	Share of the entire area (percentage)	
			Population	Area
Sapporo	823,233	88.3	81.5	7.9
Fukuoka	720,202	82.0	84.4	33.8
Sendai	439,290	51.4	80.6	21.7

The styles of these maps have been gradually improved in the order of preparation. They are commonly composed of: (*a*) a land-use map of medium scale; (*b*) a map showing the chronological changes of the urban area and restoration maps of smaller scale; and (*c*) a district map expressing the linkage of the city and the environs under the sphere.

Characteristics of content of each example

Although the densely inhabited districts of each city selected accounts for 80 per cent or more of population share to its total population, the densely inhabited districts of Sapporo, Fukuoka and Sendai are, respectively, 8 per cent, 33.8 per cent and 21.7 per cent of those entire areas, as shown in table 1. The chronological changes of these cities are also different. Therefore, the configurations of their urban areas and their land-use patterns have the proper characteristics. The contents of those maps are as follows.

Combined map of Sendai at 1:25,000 scale

The combined map of Sendai at 1:25,000 scale, produced in 1969, composed of a land-use map for the main area of the city, in which land use is classified into 13 categories including agricultural land-use; and a restoration map, in which the functions are classified into five categories, showing the functional district pattern of the central area of the city in the feudal ages. The function of each district of Sendai as a castle town since the feudal ages is clearly classified. In 1945, the city suffered from war damage, in which fire destroyed most of the urban area at the time and the current urban area; it was subsequently rebuilt. Comparison of the current map and the restoration map, however, facilitates the understanding that the old town districts are still maintained. As a trial, the map was prepared on the basis of a 1:25,000 topographic map, and the land-use patterns are generalized in larger district units.

*The original text of this paper, prepared by Masayoshi Takasaki and Kei Kanazawa, Geographical Division, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF 62/L 20.

Urban function map of Sapporo at 1:15,000 scale

The urban function map of Sapporo at 1:15,000 scale, produced in 1971, appears on the front side of the map-sheet. Urban functions are classified into 12 categories, including agricultural land use; but there are nine urban land-use categories, compared with seven for Sendai. The other side of the sheet contains a 1:50,000 topographic map, showing chronological changes of the city; a district map on the scale 1:200,000 and the surveyed maps at the foundation area of the city. The urban function map was compiled from the 1:10,000 topographic map prepared by the Sapporo Municipal Office and from sources prepared by the same office. In this map, measures are taken to show explicitly the content, such as colouring the classification of building use and changing the width of border lines, as well as through use of light and darker shades of the colour. For tall buildings (more than five storeys), the most intense colour is used; for buildings of medium height (3–5 storeys), shaded colour; and for low buildings (1–2 storeys), light colour. From the standpoint of discernibility, the scale 1:15,000 is the limit at which the above-mentioned measures are used. Though the scale of 1:10,000 could conceivably have been selected, the scale 1:15,000 was chosen in view of the wide range of the area compared with the size of the map paper. The urban chronological-change map shows the city configuration and its administrative borders, restoring every 20 years with colours based on the 1:50,000 topographic map. The district map, based on the 1:200,000 geographical map, shows the border of the city and of its environs, the current transportation networks and the ranges of national parks. Comparison of the current maps with the city map showing the construction at the foundation of the city about 100 years ago makes it clear that the pattern of the city districts and the central area of the city are still maintained under a well-organized plan. Recently, the central part of Sapporo has been developed vastly, including construction of tall buildings, underground shopping areas and subways, which are also considered main characteristics of the city.

Urban land-use map of Fukuoka at 1:25,000 scale

The urban land-use map of Fukuoka, produced in 1972, shows, on the basis of the first two examples, a land-use map based on the 1:25,000 topographic map; and, on the reverse side, a map of the municipal area based on the 1:50,000 topographic map showing chronological changes, a district map based on the 1:200,000 geographical map and an omnibus-route map by the cartogram method. In comparison with Sapporo, the redevelopment process of the central part of Fukuoka has not progressed so far; the land readjustment of the area has just been completed and buildings of medium height are appearing. As tall buildings are not found throughout the city, the classification of buildings by height is abbreviated. From the standpoint of discernibility at 1:25,000 scale, 13 categories are used for the land-use classification, including the site use of buildings and the categories for agricultural land-use, in which urban land use is classified into eight categories. The classified unit patterns are generally shown so that the shorter length of the minimum block appears as 0.5 mm or more on the map, on the scale 1:25,000, in which the entire urban area of Fukuoka can be covered by the designated paper size. In the district map, the entire area of Fukuoka Prefecture is represented in the map sphere. The whole administrative area of the city is also shown in the urban chronological-change map. Public transportation in Fukuoka city consists mainly of tram-cars and omnibuses. The omnibus routes cover the suburban area, starting from Fukuoka city. The traffic system is very complicated, and it is difficult to find any route, except those of the tram-cars. To cope with this situation, the map of the omnibus routes suggests the solution of using the cartogram method to show the directions of the omnibus-route system. When compared with the main map, the traffic congestion along the roads in the central area of the city is easily understood.

There are a number of ancient tombs, and many historical episodes emanated from the city of Fukuoka. The prototype of the current city was formed by the consolidation of two heterogeneous cities approximately 100 years ago. One is Hakata, the commercial city, which was prosperous in the overseas-oriented era of the sixteenth century, like many of the free cities in western Europe. The other is Fukuoka, which was the castle town constructed in the western area. Currently, the redevelopment of the central area of the city and the residentialization in the suburban area are progressing rapidly. These developments are clearly shown on the chronological-change map.

Summary of examples

On the basis of these three examples, the following information is to be included in urban comprehensive land-use maps (see also table 2):

(*a*) From the standpoint of discernibility, the maximum preferable number of classifications of urban land use may be nine;

(*b*) The representive unit of land-use pattern at 1:25,000 scale is to be generalized, including site land rather than dealing only with buildings, in order to show the clear characteristics of the land-use pattern. The sizes 0.5 mm or more are desirable from the point of view of discernibility for the shorter length of the minimum block of land-use pattern unit shown on the map. The land-use classification of the minimum block area depends upon the dominant item in its area and upon the dominant item on the first storey in the case of aggregate buildings, thus using the same standard in both cases;

(*c*) As concerns those cities where tall buildings are conspicuous, the three-dimensional effect of representation for their heights is to be considered. In this case, two or three categories can be clearly made through use of light and dark shades of the colour and also by changing the width of the border line;

(*d*) It is desirable that the map showing the chronological change of the urban area should be attached. In city planning, there is a keen need to understand the chronological characteristics of the city in any case. The map can be prepared by coloured depiction based on the most recent edition and former editions of topographic maps. In addition, indication of the chronological change of administrative boundaries and a description of the former names on their proper location are preferable.

Technical problems and problems of revision

Urban comprehensive land-use maps can be made from field land-use surveys at medium scale, as well as from the comprehensive compilation based on field sur-

Table 2. Comparison of classified urban functions

Draft of Ministry of Construction, 1970 Item	*Combined map of Sendai, 1969, 1:25,000* Item	Colour
Public agencies	Public agencies	Brown
Business facilities	Commercial district	Red
Commercial facilities	Industrial district	Light blue
Amusement facilities	Welfare and medical facilities	Purple and pattern
Sport facilities	Education and cultural district	Purple
Accommodation	Circulation, storage and transportation district	Dark blue
Household industries	Residential district	Yellow
Heavy industries		
Light industries		
Education and welfare facilities		
Transportation and warehouse facilities		
Dwellings		
Co-operative houses		
Dwellings with shops		
Dwellings with workshop		
Others		

Urban function map of Sapporo, 1971, 1:15,000 Item	Colour	*Current utilization map of Sapporo, 1970, 1:2,500* Item	Colour
Public agencies	Brown	Public agencies	Brown
Business facilities	Purple	Specified commercial facilities	Purple
Specified and general shops	Orange	Specified commercial facilities and general shops	Orange
Amusement facilities, hotels	Red	Amusement facilities and specified commercial facilities:	Red
Industrial facilities	Blue	Industrial facilities	Blue
Welfare facilities	Beige	Welfare facilities	Beige
Education facilities	Green	Education facilities	Green
Public service facilities	Grey	Public service facilities	Grey
Dwellings	Yellow	Dwellings	Yellow

Land-use map of Fukuoka, 1972, 1:25,000 Item	Colour	*Current utilization map of Fukuoka, 1969, 1:2,500* Item	Colour
Public agencies	Brown	Public agencies	Orange
Commercial and business area	Purple	Commercial facilities	Red
General shops	Orange	Amusement facilities	Purple
Amusement area	Red	Industrial facilities	Blue
Industrial area	Blue	Welfare facilities	Yellow
Education and welfare area	Beige	Education facilities	Yellowish green
Public service area	Grey	Public service facilities	Brown
Residential area	Yellow	Dwellings	Yellow
		Agricultural and fishing facilities	Green

vey of the current use of buildings at large scale. In each case, use of the most recent surveyed topographic maps is desirable as a base. Moreover, it is desirable that the most recent aerial photographs should be available for the field survey. As the final results of the work are printed in many colours, it is important to save the labour of map drawing and the time needed for work by application of the scribing mask methods.

The introduction of computer-derived maps, such as the lin-map and the col-map by grid-square analysis, will decrease considerably the time needed to prepare an up-to-date land-use map or to revise it frequently to meet rapidly changing urban features, although some differences of expression, style and symbols exist. In this case, however, the problems of the laborious field survey remain unsolved.

DEPICTION OF MULTILEVEL COMPLEX STRUCTURES ON ORDNANCE SURVEY LARGE-SCALE MAPS*

Paper presented by the United Kingdom of Great Britain and Northern Ireland

The construction of modern complex buildings causes problems for the surveyor and the draftsman in depicting this detail on monochrome publications of large-scale maps. The Ordnance Survey found that a minor alteration to the basic rules gave the best compromise solution for a general map user.

A detailed plan at each level of the structure can be obtained as a special service for which the customer pays the full cost.

Background

The Ordnance Survey is the national mapping organization of the United Kingdom of Great Britain and Northern Ireland, and it surveys all the major towns in the country at its largest basic scale of 1:1,250. Each 1:1,250 sheet represents an area of 500 m^2; and, subject to the limitations of the scale, has as its objective to show all permanent detail by its outline at ground-surface level. Some 50,000 sheets in the series have been published; and the survey is maintained by a system of "continuous revision", which, as the name implies, means that changes on the ground are surveyed soon after they occur. When justified by the amount of change, a revised edition is published. Meanwhile, copies of the surveyor's survey document can be produced at short notice.

Traffic congestion, land shortage and advances in building construction methods are some of the factors leading to the introduction of multilevel, multiamenity complex structures which are replacing the traditional facilities in some of the cities in the country. The omnibus station close to the main street, with its shops, banks, cinemas, theatres and clubs, are all clearly defined and individually located on the map. Such detailed clarity of depiction is difficult to maintain when attempting to portray multilevel complexes which are designed with different elevation patterns and with public communications and concourses, both vehicular and pedestrian, running through, around, over and under them. They also contain within them separately named or numbered individual premises with roofed areas at one level often providing a communication or service at the next.

Survey principles

When the first and rather uncomplicated structures of this kind were constructed, the existing rules for survey and depiction were applied. Those rules were based on the principle that the outline of buildings and structures were surveyed at ground-surface level. Where more than one level existed, ground-surface level was defined as "the upper level of surface communication"; and detail at, above and below this level was distinguished by its type of line; a firm line was used for the outline of the structure at ground-surface level, a pecked line at four pecks per centimetre for detail below and pecks at eight per centimetre for minor detail at ground-surface level and important detail above it. Normally, detail below ground-surface level was restricted to the outline of communications in tunnels or subways, and overhead detail was only shown when its size and character constituted a useful feature of the plan (see figure 114). A stipple infill denoted all roofed structures except when the roof served an additional function, which changed the level of survey to the roof itself. An annotation describing the function was added to the unstippled area (figure 115).

The problem

The application of these rules proved inadequate for many users of the 1:1,250 scale monochrome publication. Confusion was caused by the omission of stipple from structures having a "roof function" and by the amount of minor detail shown at the chosen level of survey, which resulted in the exclusion of public communications and naming and numbering of divisions within the structure at levels below that selected as ground surface.

The scope for resolving the problem and for providing clearer intelligence was limited by the necessity to comply with a common specification for the 50,000 sheets in the 1:1,250 series, each covering 0.25 km^2. Radical changes in specification to accommodate the few, but growing, number of sheets containing complex structures could adversely affect the costs at revision stage of the bulk of the series; and the need to limit such cost increases was an important constraint.

The objective was to simplify the representation of detail within a complex structure, to make communications clear and to give an indication of names and numbers to provide the map user with sufficient information to identify his position on the site.

Defining the level of survey

It was therefore necessary to produce a compromise solution with enough flexibility to allow the important features of the complex to be depicted. A reappraisal of the definition of ground-surface level showed that the "upper level of surface communication", while sound in its application to bridges, aqueducts, etc., was not entirely practicable when related to complex structures. The treatment of structures having roofs used for motor-car parking was inconsistent in that the inclusion of a stipple infill depended upon the fact that access to the motor-car park was internal rather than external to the structure. Map users found this rather fine distinction confusing. In other cases, a too rigid application of the definition allowed minor detail at the chosen level to dominate the character of the complex. A slight change of emphasis and a more liberal application was desirable; yet, it was essential that the surveyor be given a sound basis for selecting his main level of survey, which should be one also readily understandable by and acceptable to the user.

As in the former definition, a public communication appeared to be the best common element. It was considered that "the upper level of through public communication" which excluded motor-car parks at any level; and the occupation and service roads, ramps, bridges, paths

*The original text of this paper, prepared by W. C. Loveless and C. S. J. Rouse, Ordnance Survey, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF 62/L 34

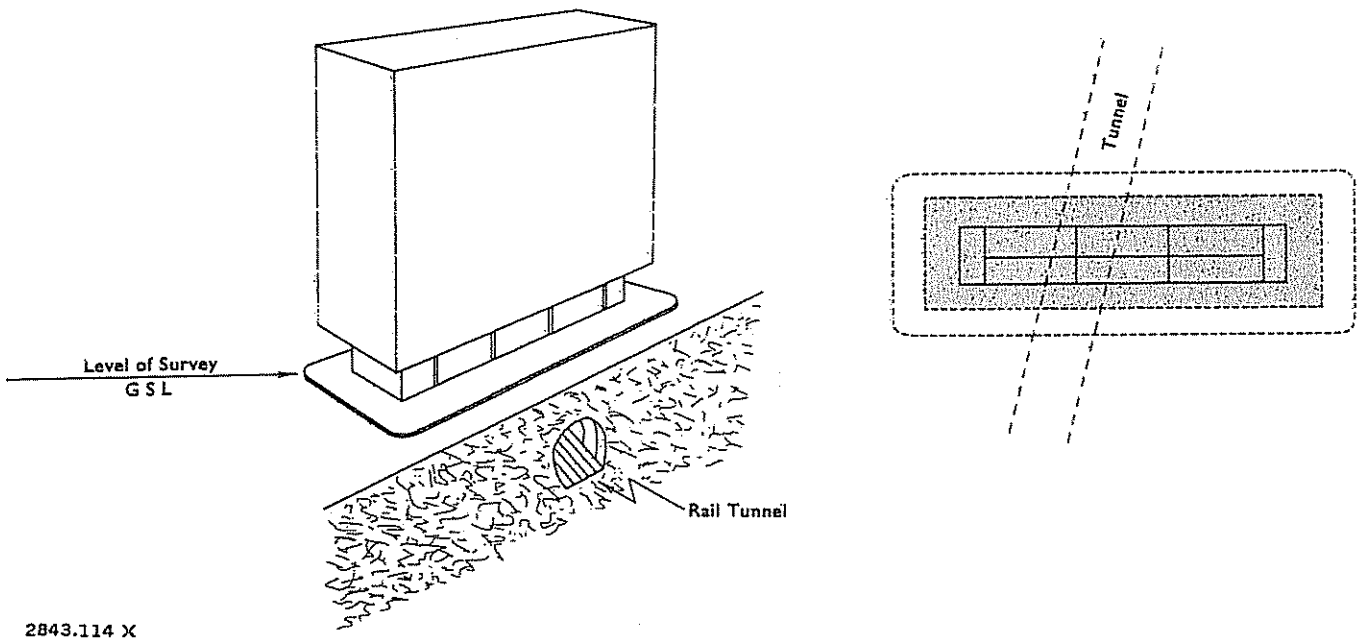


Figure 114. United Kingdom: normal convention where street level is ground-surface level

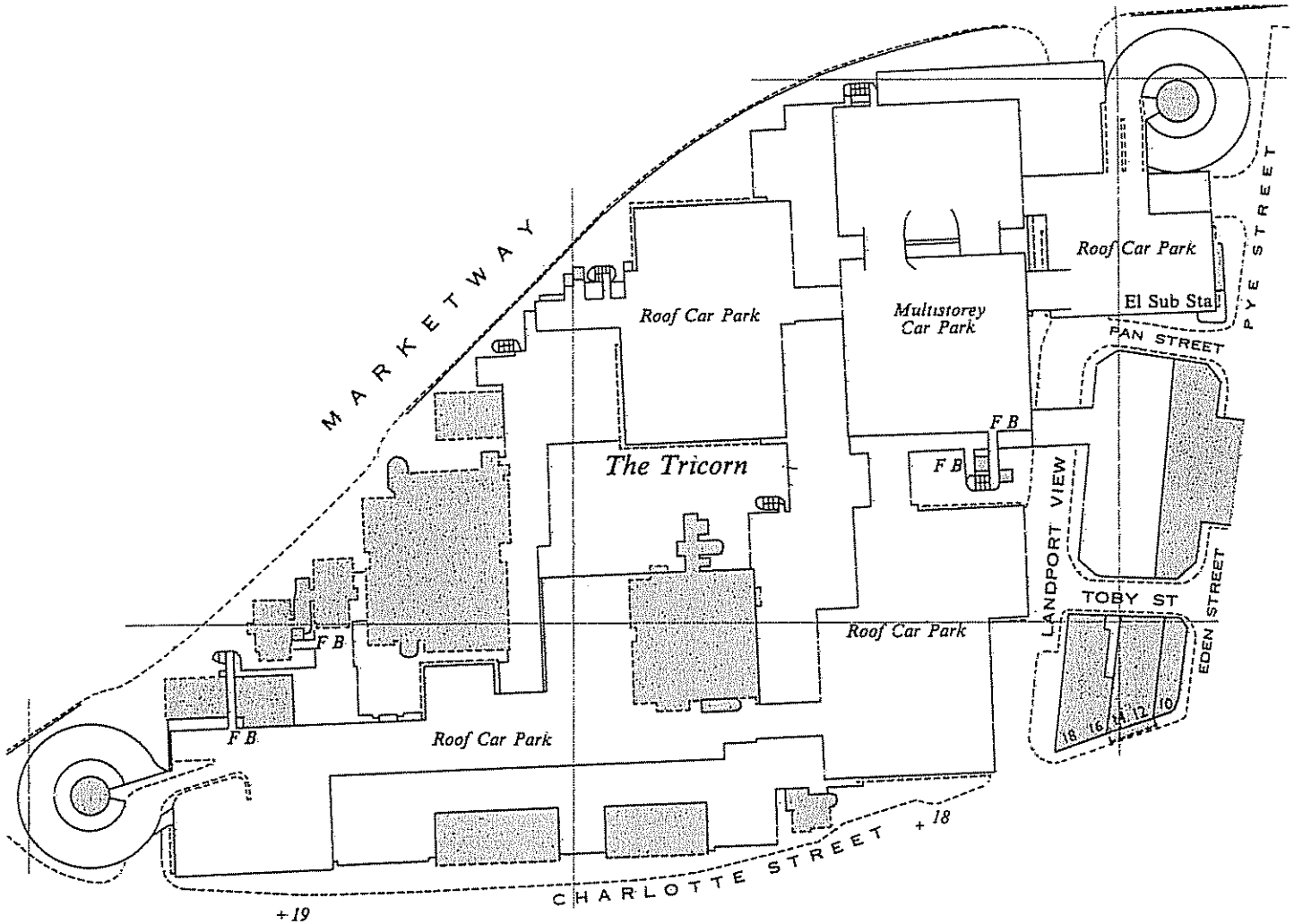


Figure 115. United Kingdom: convention accepting upper level of surface communication, including roof motor-car parks etc., as ground-surface level.

or corridors leading to them, would satisfactorily serve the purpose. The definition was to include all ways to which the public normally has access, such as arcades, paths, roads, bridges and railways, or waterways, in order to proceed from one point to another, thereby preserving the specification for the series (figure 116).

Solution adopted

Line detail

Having selected the prime level of survey, detail is shown within the outline of the complex structure at, above or below that level according to the conventions outlined above. To maintain a reasonable degree of clarity and to depict the most useful information, the surveyor is required to consider the site as a whole. He shows the major structural divisions which, when combined with overhead and underground detail, names and annotations, provide sufficient detail adequately to depict the general character of the structure and enable a map user to locate a position within the complex (figure 117).

Although the line convention previously described is rigidly applied, changes in the level of survey are not always obvious to the map user. The possibility of drawing attention to these changes by thickening the gauge of line at the points of change was considered. The resultant depiction was considered to be of doubtful value; and, if introduced, would have led to an extension into normal building depiction, thus adding considerably to the field and drawing effort in the revision of a large number of plans throughout the series. It was therefore decided to adhere to the existing conventions for firm and pecked line work on the assumption that changes in level would become immediately apparent to any map user on the site.

The main type of overhead detail encountered in complex structures are cantilevered buildings, balconies and buildings on pillars. Where these features extend beyond the surveyed position of the structures at ground-surface level (shown by a firm line), they are depicted by pecked lines (at eight per centimetre) and infilled with stipple. Because pecked outlines at the same interval (without stipple infilling) are used at ground-surface level to show minor detail less than 0.3 m high, such as kerbs, the omission of the pecked outline was considered, allowing the stipple to define the extent of the overhead structure. While this procedure removed the possibility of confusion with ground-level obstruction, the ragged stipple edge did not give a surveyed result of sufficient accuracy for certain map users, nor was it aesthetically pleasing. The idea was abandoned.

The detail shown beneath the level of the survey is normally limited to:

(*a*) The main outline of the structure where it does not coincide with that shown at ground-surface level and falls within it;

(*b*) Internal structural divisions defining through public communications within the complex;

(*c*) The outline of through public communications which complete those shown outside the structures where they are not already defined by structural divisions.

Building stipple

The main user criticism of earlier depiction methods arose from the fact that once the roof of a structure became the selected level of survey (ground-surface level), it was no longer possible to indicate the presence of a building below by the convention of a stipple infill. Such annotations as "roof motor-car park" and "multi-storey motor-car park" clearly indicated the presence of some form of structure below the level of survey, but similar annotations could not easily be applied to vehicular and pedestrian ways regarded as part of the normal public communications system. By changing the definition of "through public communications" to exclude motor-car parks and domestic access routes, the level of survey is changed. This permits the stipple infill to be restored within the outline of many structures from which it was previously excluded. To complete the picture, a second, less dense stipple infill is now added to those areas where public communications at the level of survey also constitute roofs to structures at a lower level, provided the communications are not themselves roofed, in which case the standard stipple infilling is applied.

Names and numbers

Where named or numbered areas fall one above the other, it is impracticable to locate all of them precisely. Information at one level may be chosen to the exclusion of others or the structure considered as a whole so that as much generalized information as possible is provided and located correctly within the complex.

The major divisions and communications shown on the field survey document are supplemented by floor-level traces to locate names and numbers at the various levels. Following the concept of the upper level of through public communication taking precedence, it was thought that names should follow a similar principle, with priority given to the indication of public communications; and, if space allowed, to other designated areas. The name is qualified by a description indicating its position in relation to the ground-surface level, e.g. (below); and, if necessary, a leader arrow.

The possibility of showing names at lower levels in a type with a screened effect or in a lighter type face was examined, but was rejected because, within a stippled area, the legibility of the type was impaired.

The numbering system of the individual premises may be related to the distinctive name of the complex or to subsidiary names within it. In the former case, the numbers are applied to the specific area or structural division with the various numbers of each level conjoined, e.g., 201–215 and 301–315, the first digit often indicating the floor level. In the latter case, the numbers are applied to the subsidiary name.

The entrances and exits to public motor-car parks within the complex are shown by annotation.

An extract from a plan containing a complex structure before and after the application of the foregoing principles is shown as figures 118 and 119.

Specialist users

For those who require it, a special survey may be made to provide a detailed plan at each level of the structure. For this service, the customer pays the full cost.

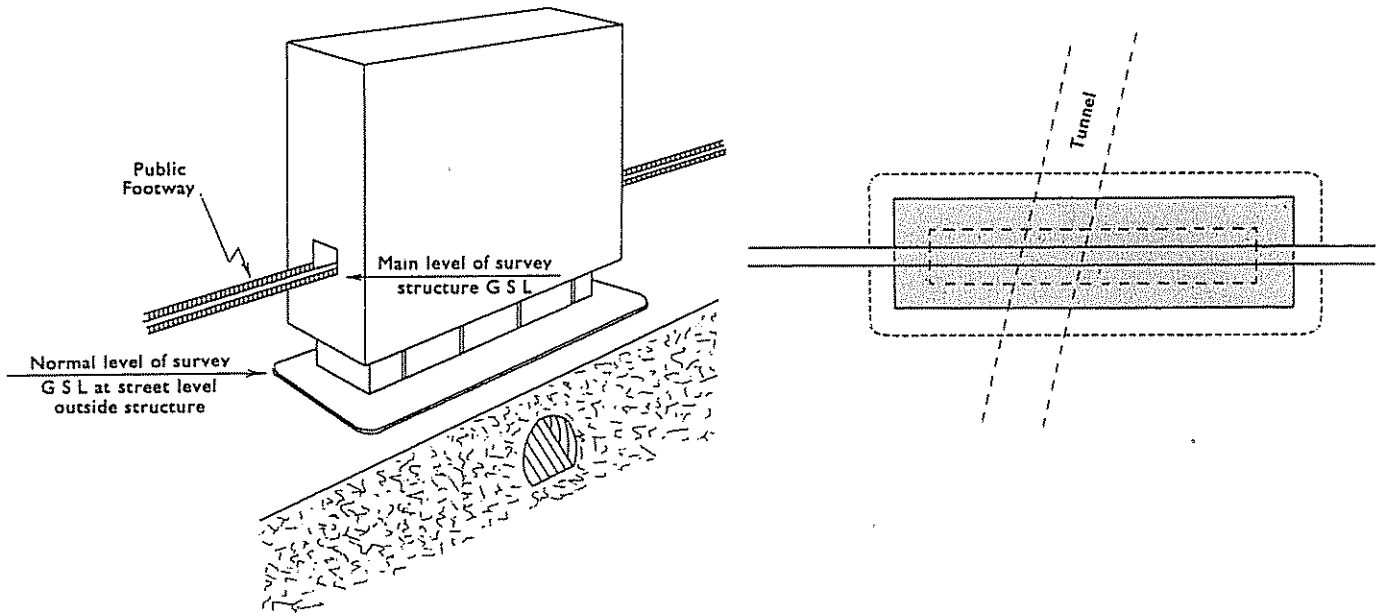


Figure 116. United Kingdom: convention accepting upper level of through public communication as main level of survey

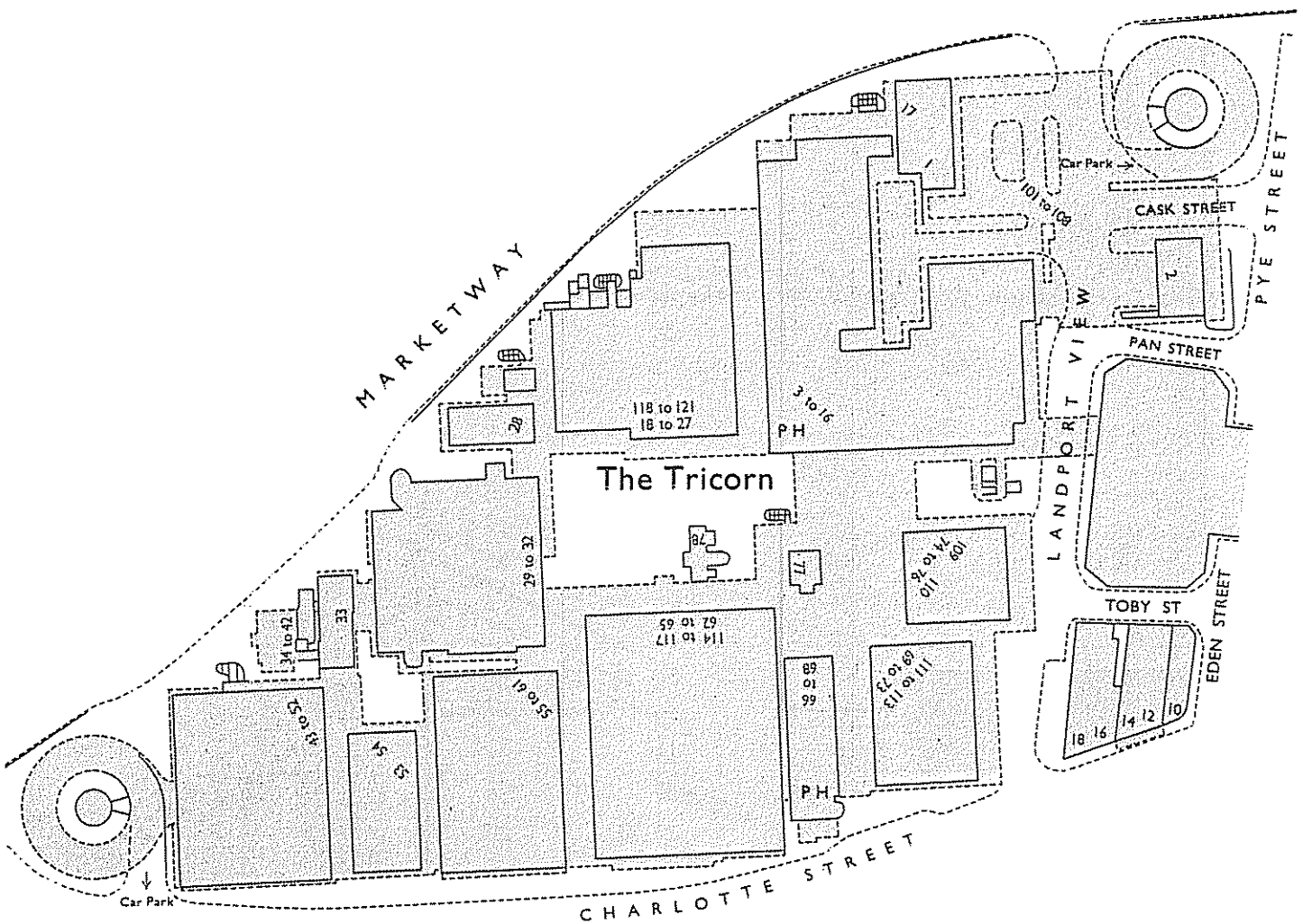


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Figure 117. United Kingdom: convention accepting upper level of through public communication, excluding roof motor-car parks, as ground-surface level

Conclusion

While the Ordnance Survey is sensitive to the shortnings of the depiction methods described above, it is nsidered that, within the limitations of a monochrome ndard series production, the result shows, in an uncluttered way, the main characteristics of each complex in sufficient detail to enable a general map user to locate his position within it and then to add other detail of importance to his needs within the survey framework provided.

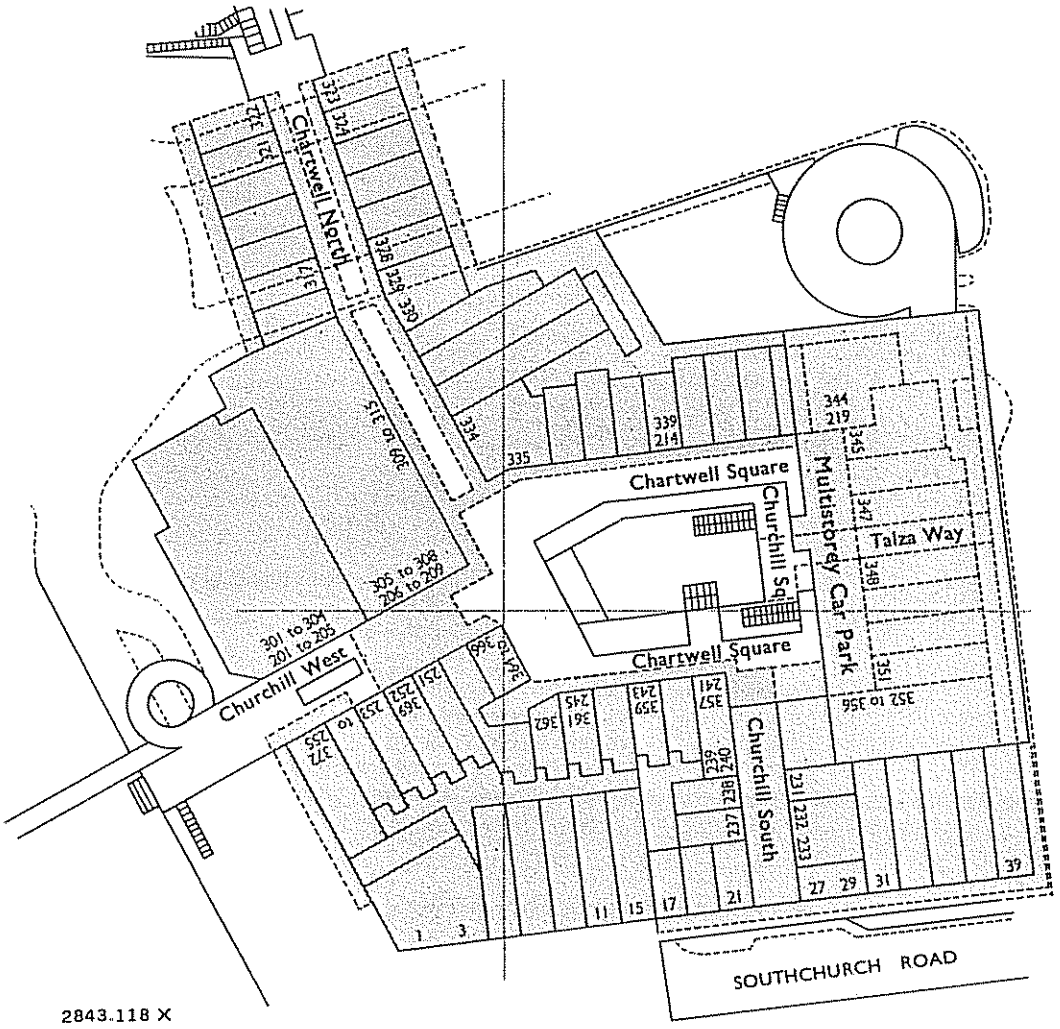

Figure 118. United Kingdom: convention accepting upper level of surface communication as ground-surface level with minor detail as unspecified levels

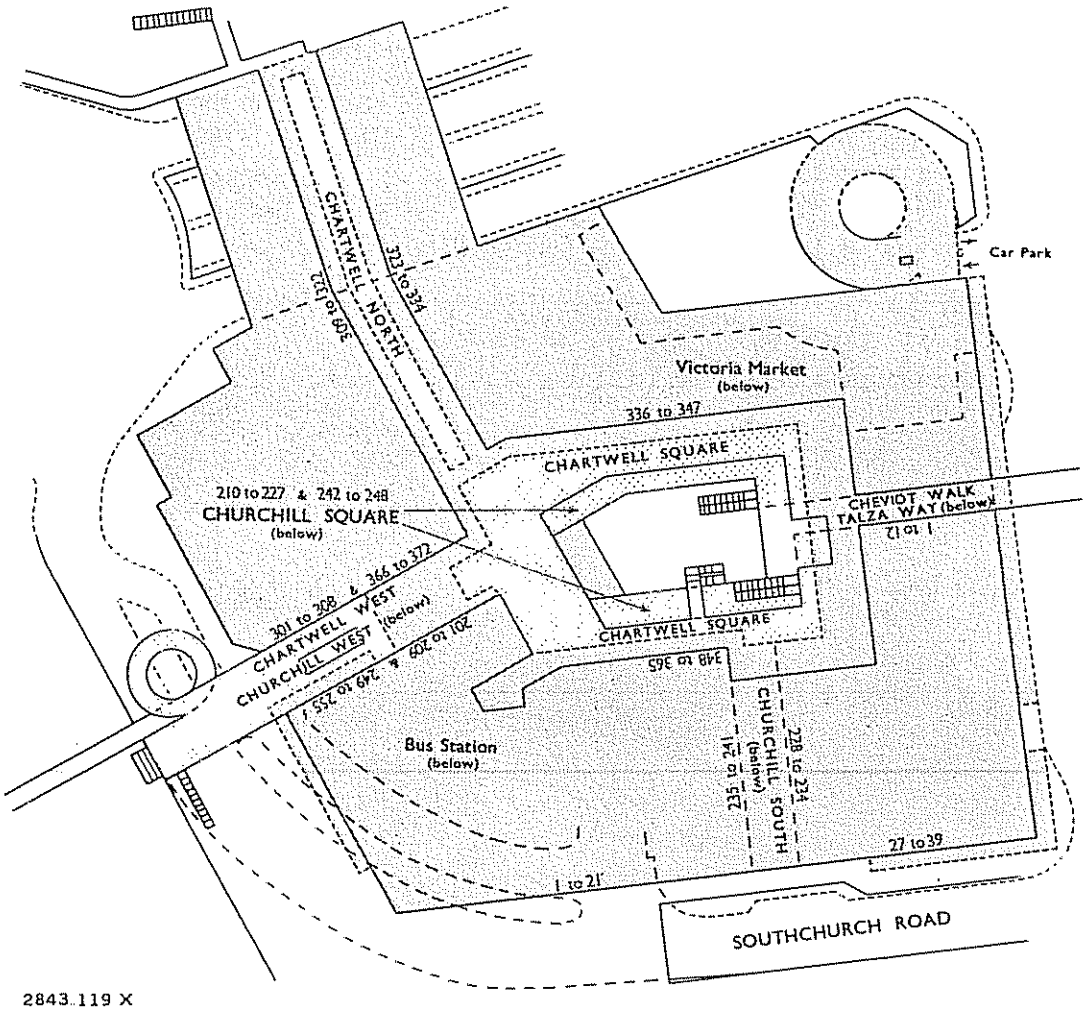

Figure 119. United Kingdom: convention accepting upper level of through public communication, excluding motor-car parks, as ground-surface level and simplified depiction by omission of minor internal detail

LARGE-SCALE MAPPING IN NEW SOUTH WALES*

Paper presented by Australia

The Central Mapping Authority of the Department of Lands in New South Wales commenced operations in 1951 and directed its initial efforts towards the production of medium-scale multicolour topo-cadastral maps of the state. Large-scale mapping of the state up to 1971 was undertaken primarily as project mapping by the Authority and, over a period of time, by four private mapping firms.

With the introduction of the first orthophoto-mapping instrument in the state by the Central Mapping Authority in 1971, it became apparent that large-scale mapping of urban areas could be undertaken effectively and efficiently as series orthophoto mapping within a reasonable time-scale.

*The original text of this paper, prepared by F. Urban, Central Mapping Authority, New South Wales, Australia, appeared as document E/CONF.62/L.41.

CHOICE OF GRID, SCALE, CONTOUR INTERVAL AND FORMAT

Grid

The Universal Transverse Mercator (UTM) system effectively meets the needs of users of medium-scale maps for both regional development and defence; and, in the interests of homogeneity, it has often been suggested that the UTM system should be extended to engineering surveys. Unfortunately, many engineers are not prepared to accept the discrepancies that arise in the UTM system between "data" and "true" distances, and would rather work on an arbitrary survey system than apply a correction of up to one part in 2,500. In order to avoid a proliferation of arbitrary systems in New South Wales, it was decided in 1970 to introduce a Transverse Mercator Projection with 2° belts known as the "Integrated Survey Grid" (ISG). The ISG scale factor does not exceed one part in 16,666 and is generally acceptable to

ngineers. The question then arose as to whether large-cale mapping should be on the UTM or the ISG system. Because the mapping is primarily intended for engineers, SG and its format were selected for scales 1:10,000 and arger while the UTM grid and a graticule format were etained for scales 1:25,000 and smaller.

Scale

At a meeting of all major users of large-scale mapping n New South Wales some 10 years ago, the scale 1:4,000 vas selected as the basic mapping scale for urban areas. The scale is not too different from the earlier 1:3,168 cale. It is, moreover, a most suitable scale for showing ndividual dwellings—an important consideration in a :ountry where 70 per cent of the people own their own iomes.

Contour interval

The logical metric contour interval for 1:4,000 map-)ing in New South Wales is 2 m. A closer interval has the :ontours bunching excessively, while a less close interval ;upplies insufficient slope data for many users.

Format

Having reached a consensus of opinion for grid, scale and contour interval, the Department was faced with the :hoice of map format, i e., whether it should be the grati-:ule or the grid, and whether it should be governed by paper size, printing-machine size or orthophoto size. As it was apparent that over 2,000 map-sheets at scale 1:4,000 would be required to cover the urban areas of the state, it was considered that the primary criterion in the selection of a format should be "efficiency of map production". The most economical aerial photography scale that can be used for 2-m contouring is 1:16,000. In producing orthophoto maps, it is not difficult to join two orthophotos together; but it is difficult to join three or more because of the problems that arise: (*a*) with grey tones mismatching; and (*b*) with the "lean-over" of tall features at the edges of stereo models. It was therefore decided that the basic sheet format would comprise two 1:16,000 stereo models. When enlarged four times to 1:4,000, this gives a sheet size of 750 × 625 mm.

The choice of the 1:4,000 format leads very conveniently to identical formats for 1:2,000 and 1:1,000 mapping, as shown in figure 120. Moreover the photogrammetric work at each scale can be undertaken by almost identical techniques merely by doubling the aerial photo scale and ground control accuracy criteria.

PRODUCTION METHODS FOR 1:4,000 ORTHOPHOTO MAPS

Aerial photography

Aerial photography for mapping at 1:4,000 scale is taken to the following specifications:

(a) *Flight lines*: east-west down the centre of the sheet;
(b) *Forward overlap*: 90 per cent;
(c) *Camera*: Wild RC10, f = 152 mm;
(d) *Scale*: 1:16,000;
(e) *Solar altitude*: minimum 45°.

As illustrated in figure 121 these criteria ensure that one centrally located 1:16,000 aerial photograph and two suitable stereo models, always cover every 1:4,000 map-sheet.

Ground control surveys

In undertaking the ground control surveys necessary for 1:4,000 × 2-m mapping control, the Central Mapping Authority has investigated two methods.

The first method was used at Wagga Wagga for the control of 23 map-sheets and is illustrated in figure 122. Wagga Wagga is situated in rolling terrain with sparse tree cover and is surrounded by numerous trigonometrical stations. It presented an ideal opportunity to use theodolite electronic distance-measuring radiations to establish by direct procedures both position and height for 57 required control points. Horizontal observations were undertaken on two arcs using a theodolite, while the distances were measured both ways together with simultaneous reciprocal vertical angles. In the centre of the city, existing state survey marks were used for control. The work was undertaken by two surveyors, one instrument man and three field-hands, working as three survey parties. The work required a total of 17.5 days in the field. The cost of the work is shown in table 1.

Table 1. Cost of Wagga Wagga ground control survey (Australian dollars)

Item	*Cost per sheet*
Field work	223
Office work	63
Field control survey	286

There were no aerial triangulation costs.

The second method, which was used at Newcastle-Greta for the control of 36 map-sheets, is illustrated in figure 123. The Newcastle-Greta area is rather flat terrain and is well suited to cross-country levelling. The control survey involved the field-heighting of all required vertical control, together with aerial triangulation procedures to establish the internal horizontal control requirements. The basic planimetric field control was effected by radiations to four control points, checked by angular observations, together with the adoption of 19 existing planimetric control points. The horizontal control occupied five and one-half days in the field and included the targeting of 12 planimetric control points. The vertical control took 27 surveyor days and 82 instrument-man days. The cost of the work is given in table 2.

Table 2. Cost of Newcastle-Greta ground control survey (Australian dollars)

Item	*Cost per sheet*
Horizontal control and targeting	29
Vertical control	230
Office work	99
Field control survey	358
Aerial triangulation	34
Total cost of *X*, *Y*, *Z* control	392

Aerial triangulation

Analytical aerial triangulation is undertaken when required, either on a Hilgar-Watts stereocomparator or on a Zeiss Jena stereocomparator fitted with Dell Foster encoders. The aerial triangulation is adjusted using

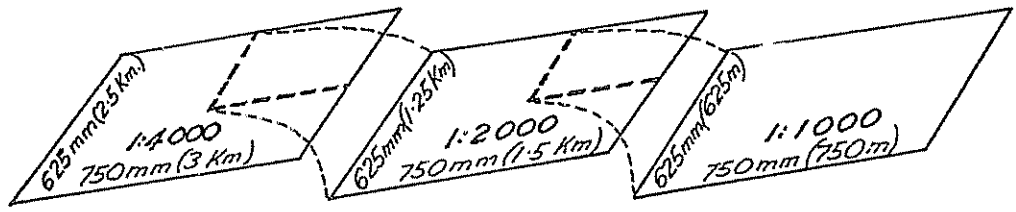

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Figure 120. Australia: quartering of formats from 1:4,000 to 1:2,000 to 1:1,000

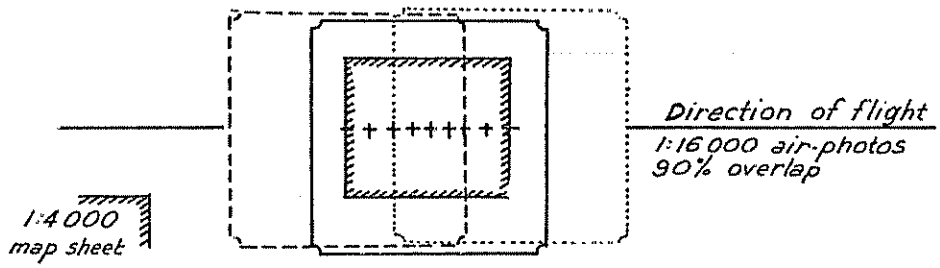

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Figure 121. Australia: coverage of full 1:4,000 sheet by one 1:16,000 aerial photograph

Schut's polynomial procedures. The standard deviation in position for both of the first two blocks adjusted was 0.75 m. The blocks were also adjusted in height, as this means has been found to be an effective method of guarding against gross errors in height control values or photo identifications. It is emphasized, however, that all stereo models are levelled on field survey heights and not on aerial triangulation heights.

Contouring

Contouring is undertaken on white-coated rust Stabilene using either a Wild B8 or a Kern PG2L stereoplotter and 4X enlargement from photo to map. Direct scribing on the stereoplotter is undertaken where the terrain is gently undulating and free of trees. More frequently, the plotting is in pencil and the contours are scribed subsequently. Contouring is always undertaken before orthophoto production and averages four man-days per stereo model, that is, eight man-days per sheet.

Orthophotos

Orthophotos are produced by direct 4X enlargement on a Zeiss Jena Topocart. The scanning width at 1:4,000 is normally 8 mm, but 16 mm has been used in very flat terrain and 4 mm in very broken terrain. The two orthophotos that comprise each map-sheet are always developed together to ensure evenness of grey tones. Orthophoto output averages one man-day per orthophoto, that is, two man-days per sheet.

Assembly

The assembly of the orthophotos into a photo map used to supply users with dye-line reproduction is an extensive and exacting task and involves the successive photography of the following:

(*a*) The two orthophoto negatives masked to the sheet-edge and to the central grid;

(*b*) The scribed contour sheet;

(*c*) A negative made from a positive title overlay. The overlay comprises a printed title, grid and legend to which contour values, spot-heights, grid values and a few names have been added using photo-mechanical type or Letraset. The assembly of provisional orthophoto maps averages four and one-half man-days per sheet.

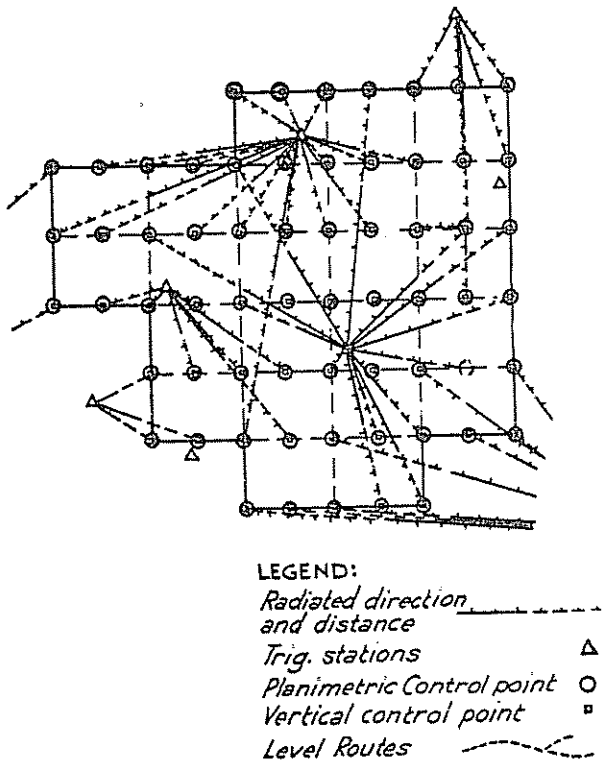


Figure 122. Australia: Wagga Wagga, survey control for 23 map-sheets at 1:4.000 scale

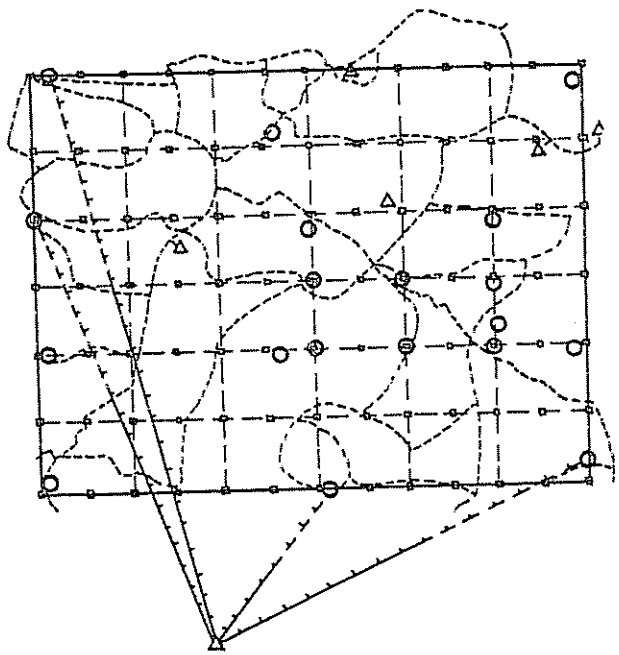


Figure 123. Australia: Newcastle-Greta, survey control for 36 map-sheets at 1:4.000 scale

Provisional and final orthophoto maps

The screened positive transparency is known as a provisional orthophoto map and is used to supply users with dye-line copies on an "as required" basis at a charge of $A1.60 per 1:4,000 sheet.

Upon completion of the provisional orthophoto map, the Authority commences the two steps necessary for the production of the final orthophoto map. The first step is the field completion of the sheet, which is primarily concerned with the location of all significant names, while the second is the preparation of a cadastral overlay. The orthophoto, being true to scale, provides an ideal base on which to prepare compilations where cadastral boundaries are imaged on the orthophoto. In New South Wales, the majority of property boundaries in urban areas are demarcated by wooden fences made of eucalyptus planks. These fences image very clearly on the orthophotos; and, as property surveys to date have been undertaken on arbitrary origins rather than on the ISG system, it will be appreciated that the orthophoto, in fact, provides an extremely efficient and economic means of establishing cadastral compilations.

Accuracy

All orthophotos are scanned at ground level, and accuracy of detail is assessed at ground level. Several checks against line maps have been undertaken, and it has been ascertained that inaccuracies in position rarely exceed 0.5 mm at orthophoto-map scale. The mapping is, therefore, well within the national mapping criteria that 90 per cent of all planimetric detail must be within 0.85 mm. The figure 0.5 mm on the map amounts to 2 m on the ground at 1:4,000 scale and 1 m at 1:2,000 scale. For altimetry, the conventional criteria are applied, namely, that 90 per cent of all contours must be within half the contour interval.

Costs and times

Two major orthophoto projects undertaken to date have been costed, and the approximate costs per sheet have been determined (see table 3).

Table 3. Costs of two major orthophoto projects (Australian dollars)

Name of project	Wagga Wagga	Newcastle-Greta
Scale and contour interval	1:4,000 × 2 m	1:4,000 × 2 m
Number of sheets	23	36
Costs:		
Aerial photography	96	78
Ground control survey	286	358
Aerial triangulation	—	34
Contours and orthophotos	618	544
Assembly	144	147
Total cost per sheet	± 1,144	± 1,161

Some of the sheets have included over 2,000 houses, which would have involved the individual plotting of over 8,000 corners and sides of buildings by conventional procedures. As the average cost of 1:4,000 × 2 m line maps up to compilation stage is $A2,200, it is evident that orthophoto maps have halved the costs of maps at 1:4,000 scale.

The elapsed time in producing orthophoto maps is also frequently less than that of line maps; in the case of Wagga Wagga, the elapsed time between the City Council giving instructions to undertake the mapping and the delivery of the 23 provisional orthophoto maps was 51 weeks.

User comments

The Deputy Town Clerk has supplied the following comments on the 1:4,000 × 2 m orthophoto-map series of Wagga Wagga:

(*a*) The maps are being used:

(i) As photo maps or photo plans to depict more clearly proposals to the relevant Council Committee, e.g., maps are used with overlays of new subdivisions, roads, bridges, etc.;

(ii) For the initial location of roads and bridges;

(*b*) It is proposed that the maps be used for the preparation of the road and drainage networks in areas to be rezoned and in the detailed layout of the internal road patterns;

(*c*) The maps have provided very valuable information for the uses which have been outlined. The maps are very useful in planning proposals in built-up areas where buildings are involved and in open areas where preservation of trees is involved;

(*d*) The 2-m interval is too large a contour interval to carry out detailed sewer design although it does help in the over-all design of sections of the sewerage system. It is considered that a 1-m interval would be needed for such design, particularly in the flatter flood-plain areas of the city.

USER COMMENTS ON 1:10,000 ORTHOPHOTO MAPS

As a matter of urgency, the Central Mapping Authority was requested to produce four 1:10,000 × 1-m orthophoto maps for the Department of the Interior early in 1972. The area required to be mapped was photographed at two scales to provide: (*a*) eight stereo models at 1:32,000 scale, from which the four orthophoto maps at 1:10,000 scale were prepared; and (*b*) stereo models at 1:8,000 scale, from which 1-m contours were plotted.

The total area of the project was designed to comprise exactly sixteen ISG sheets at 1:4,000 scale so as to enable the Authority to produce its series of 1:4,000 orthophoto maps without recontouring. The elapsed time between the Department of the Interior giving instructions to undertake the work and the delivery of the four 1:10,000 × 1-m orthophoto maps was 22 weeks.

The four sheets were used for a feasibility study of a ssible airport site, and the Director-General of Civil viation has offered the following provisional coments: From a discussion of the subject by engineers and aftsmen, the thoughts at this stage are:

(*a*) While the orthophoto map gives an excellent cture of an area being considered, it lacks annotation nich defines restraints from an aviation point of view, g., hospitals and large radio masts;

(*b*) Orthophoto maps are excellent for the special udies necessary in ecology, land usage, etc.;

(*c*) Whereas mapping at 1:50,000 scale with complete notation is considered to be ahead of orthophoto aps for initial site selection the orthophoto map will sually be more up to date, particularly as concerns oads, housing and cultural detail in general. The definion of property boundaries is more positive on the rge-scale mapping;

(*d*) Pictorially, the orthophoto map does, of course, ave many useful aspects, e.g., water features and tree ounts;

(*e*) Over-all, the orthophoto map is considered to be a ost useful document, and this Department will connue to request their production.

Enlargement of 1:2,000 orthophoto maps

Production methods

On behalf of the Public Works Department, the entral Mapping Authority has undertaken the production of 32 sheets of 1:2,000 × 1-m orthophoto maps north f Sydney at Woy Woy. The terrain is frequently broken nd tree-covered. The techniques used in production ere the same as those used for 1:4,000 × 2-m orthohoto maps, except that the aerial photographs were :8,000 instead of 1:16,000, and vertical control accuracy vas 0.1 m instead of 0.2 m.

The cost of producing the 32 sheets of 1:2,000 × 1-m rthophoto mapping is given in table 4.

Table 4. Costs of orthophoto maps at Woy Woy (Australian dollars)

Aerial photography	100
Ground control survey	628
Contours and orthophotos	712
Assembly	168
Total cost per sheet	± 1,608

Reduction to 1:4,000

The Woy Woy series was designed so that the 32 sheets at 1:2,000 scale comprise eight series 1:4,000 sheets. The derived 1:4,000 × 2-m orthophoto maps differ in appearance from the conventional 1:4,000 × 2-m orthophoto maps only in that the four component sheets inevitably have grey-tone variations, particularly in the water areas.

The Authority considered the desirability of masking the water areas to a neutral grey density, but accepted the view of the Public Works Department that mangrove trees, jetties, underwater sandbanks and other off-shore detail are essential for hydrographic surveys. The hydrographic department is particularly enthusiastic about orthophotos and has initiated a 1:4,000 × 2-m orthophoto-map programme for numerous harbours. An example of unmasked water areas is given in the annex as figure 126.

Enlargement to 1:1,000

The 32 sheets of 1:2,000 orthophoto maps at Woy Woy have been enlarged to 1:1,000, and transparencies thereof are being used by the Public Works Department for the final design of a major sewerage scheme. The Authority at first investigated the feasibility of screening the 1:1,000 orthophotos after enlargement. The work involved was found to be many times greater than that necessary for direct enlargement, and the latter method has therefore been adopted as the production technique.

Comparisons of orthophoto equipment

A 1:15,000 f152-mm stereo model of a test area at Sydney has been undertaken on: (*a*) Zeiss Jena Topocart; (*b*) SFOM 9300; (*c*) Hoborough Gestalt photomapper. The main conclusions reached were as follows: The SFOM 9300 is more tiring to operate than the Topocart and is restricted in the photo-to-orthophoto enlargement factors available. The Hoborough Gestalt photomapper entirely eliminates tedium, but its product is less sharp at enlarged scales than that of the Topocart, presumably because it is an electronic scanning process rather than an optical process. The Topocart suffers from the disadvantage that a stepped image is produced in sloping detail away from the centre of a stereo model. In approximately 1 per cent of the orthophotos produced to date, this has necessitated the use of a 4-mm scan which results in 4.5 hours scanning per model. An extreme example is illustrated in figure 126 (see annex).

Sydney: the role of digital mapping

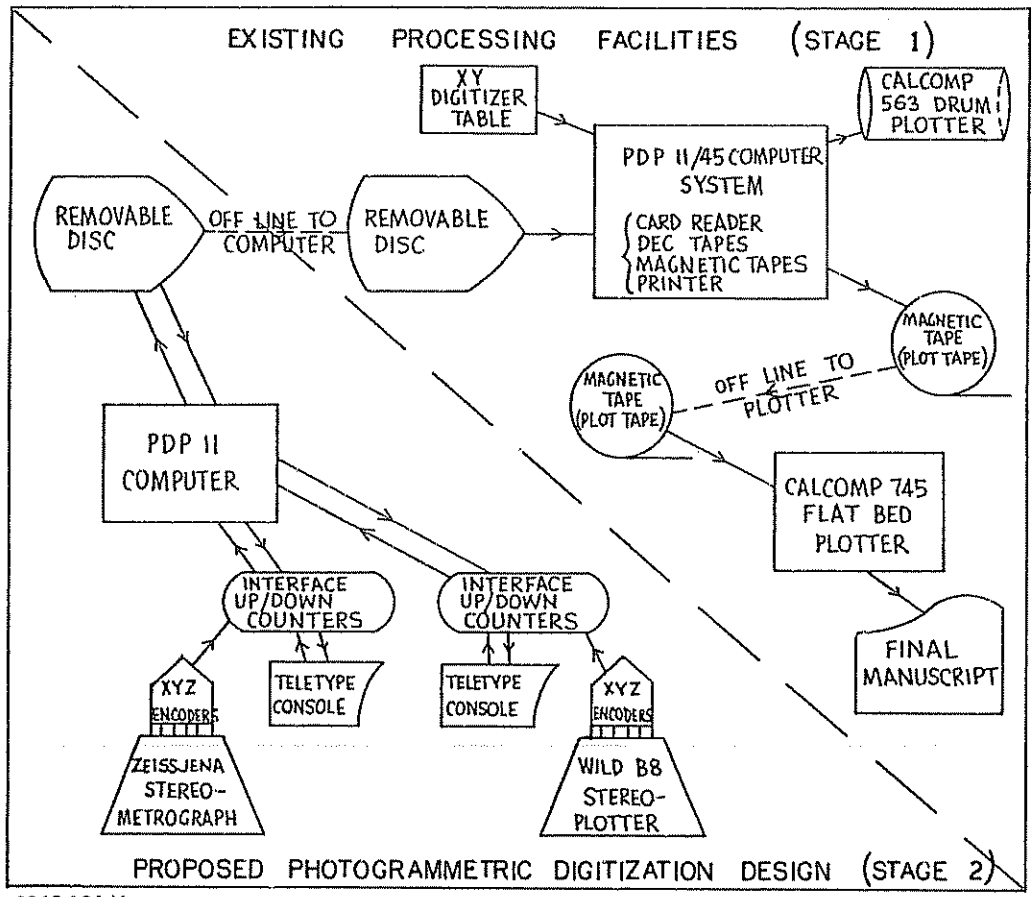
Mapping of greater metropolitan area

At a meeting of the major instrumentalities using large-scale mapping, held at Sydney on 20 September 1972, a priority order was decided upon for the mapping of the 600 map-sheets at 1:4,000 scale that cover the greater metropolitan area. A second Topocart will be obtained, and it is anticipated that the majority of the sheets required will be completed during the next three years.

Mapping of central Sydney

Due to the "lean-over" of the high-rise buildings it will not be possible to produce orthophoto maps in the centre of Sydney. This area has, therefore, been designated a 1:2,000 line-mapping area; and the initial steps have been taken to effect digital photogrammetry in the area. The system to be used comprises two stages, the first of which has been purchased and the second of which will be ordered shortly. The two stages are illustrated in figure 124.

The proposed photogrammetric digitization procedures are based on the work undertaken by M. MacLeod of the Ontario Highways Department. It is anticipated that the introduction of photogrammetric digitization will produce an increase of 30 per cent in cartographic output.



2843.124 X

Figure 124. Australia, existing processing facilities (stage 1) and proposed photogrammetric digitization design (stage 2)

"The Rocks" area of Sydney

In April 1970, the Central Mapping Authority was requested to undertake mapping at 1:600 scale near the heart of Sydney, in an area known as "The Rocks". The area was photographed in colour at 1:3,300 scale using a Wild RC5 camera with f210-mm lens cone. A segment of the completed 1:600 × 2-ft map is given in figure 125. While this particular map was produced by the Authority, it represents the typical product of the private sector and the Central Mapping Authority in the large-scale mapping sphere over the past decade. It is evident that the numerous buildings in the example could have been drafted efficiently on a flat-bed plotter after photogrammetric digitization, and it is predicted that during the next decade, the majority of maps of the type illustrated in figure 125 will be produced by photogrammetric digitization and subsequent automatic drafting.

Conclusions concerning orthophoto maps and digitized maps in built-up areas

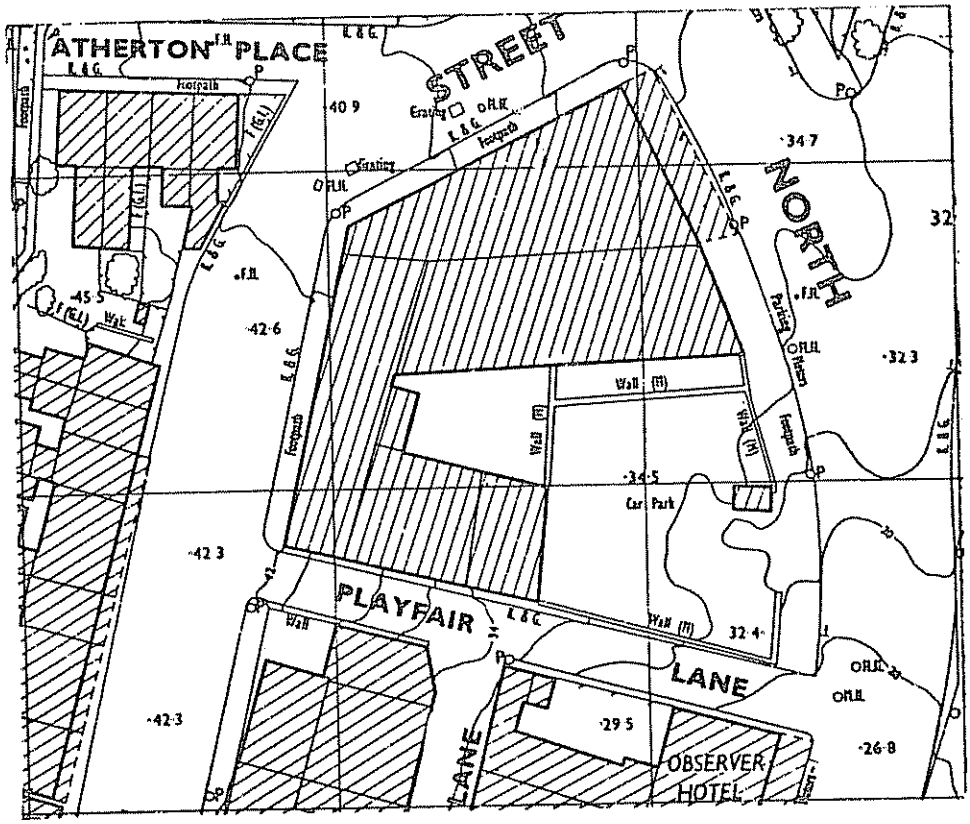
Figure 127 (see annex) illustrates orthophoto maps on the scales 1:1,000–1:10,000. Houses are clearly imaged at 1:1,000, 1:2,000 and 1:4,000 scales but at 1:10,000 scale it is not possible to distinguish between a house, a derelict house, foundations, a formal garden or even a swimming-pool.

It is submitted that annotation of detail is essential for orthophoto maps at scales 1:10,000 and smaller.

At scales on the order of 1:4,000–1:2,000, it is suggested that the orthophoto map provides an ideal map product, being essentially self-explanatory except for names, boundaries and detail obscured by trees.

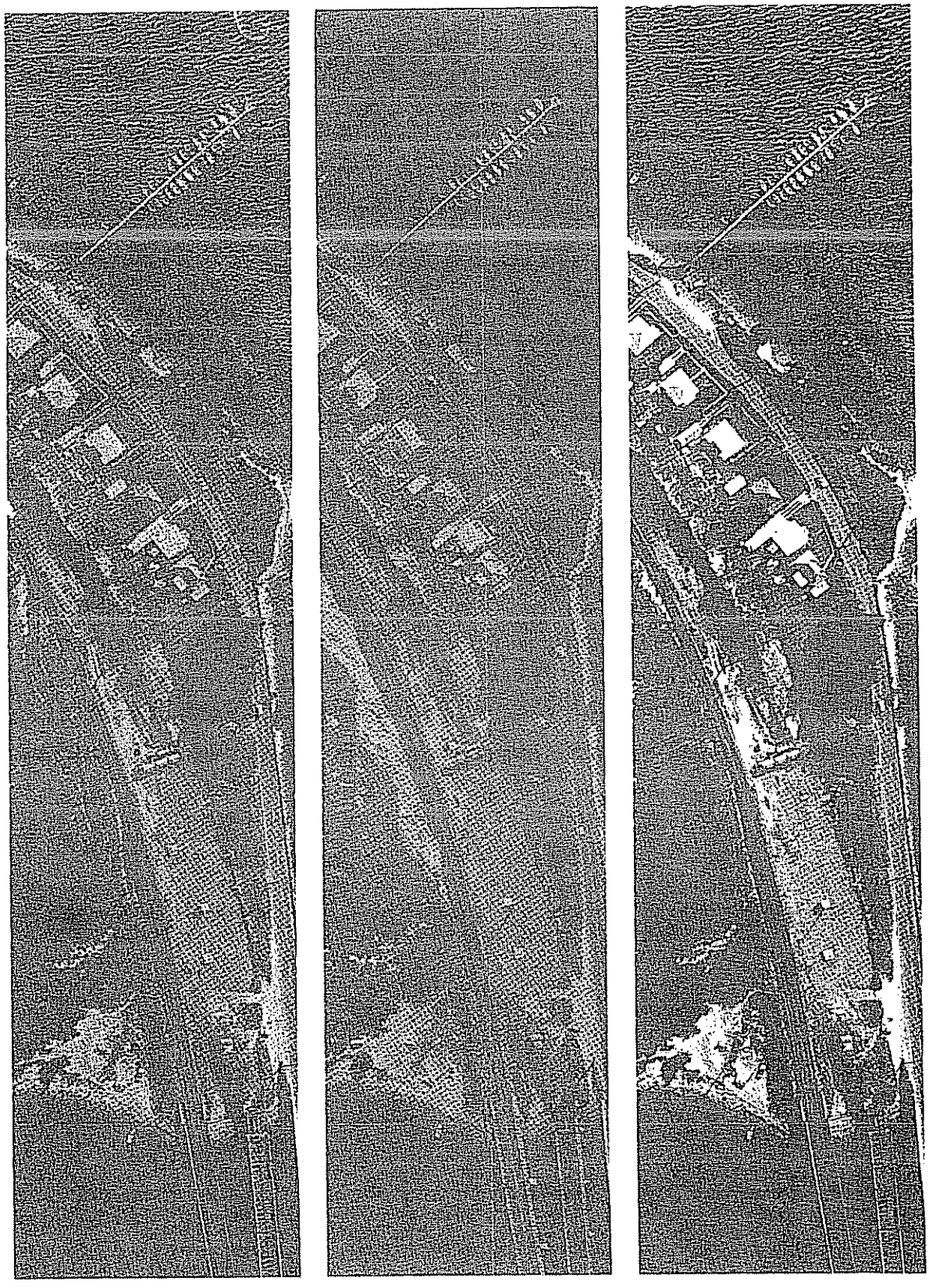
The production of orthophoto maps is not possible in high-rise areas due to the "lean-over" of buildings. It is suggested that four storeys is a practical limit for 1:4,000 orthophoto maps using a f152-mm lens, which in turn implies that the "lean-over" of both trees and double-storey buildings may become objectionable on scales 1:1,000 and larger.

It is suggested that by the end of the next decade, the majority of mapping on scales on the order of 1:1,000 will be undertaken by photogrammetric digitization and subsequent automatic drafting.



2843.125 X

Figure 125. Australia: portion of a 1:600 × 2-foot line map of "The Rocks", Sydney

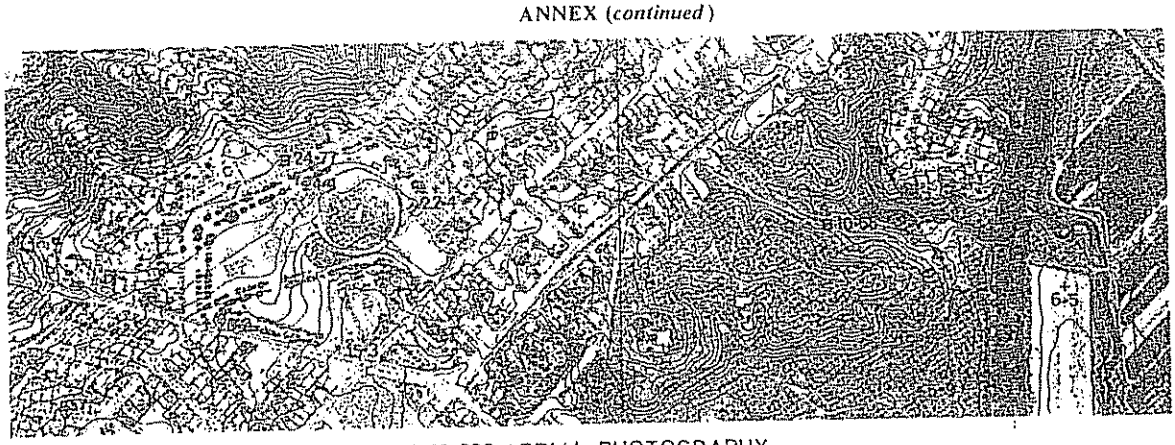


Ex A Ex B Ex C

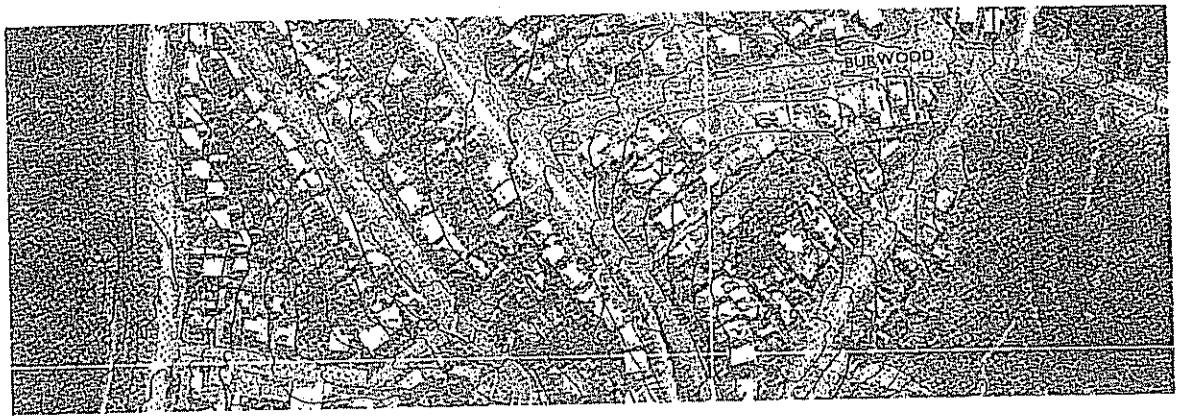
Figure 126. Australia: exceptional problems in orthophoto mapping

Ex A is at the extreme right edge of a stereomodel. Scan width is 8mm. The operator has raised the floating mark at the railway embankment thereby breaking the track into segments. Ex B is at the extreme left edge of a stereomodel. Scan width is 8mm. The position of the track is retained but the embankment has become serrated. Ex C shows the finally accepted orthophoto. Scan width is 4mm. The examples also illustrate the problems of matching grey tones in water areas.

2843.126 X



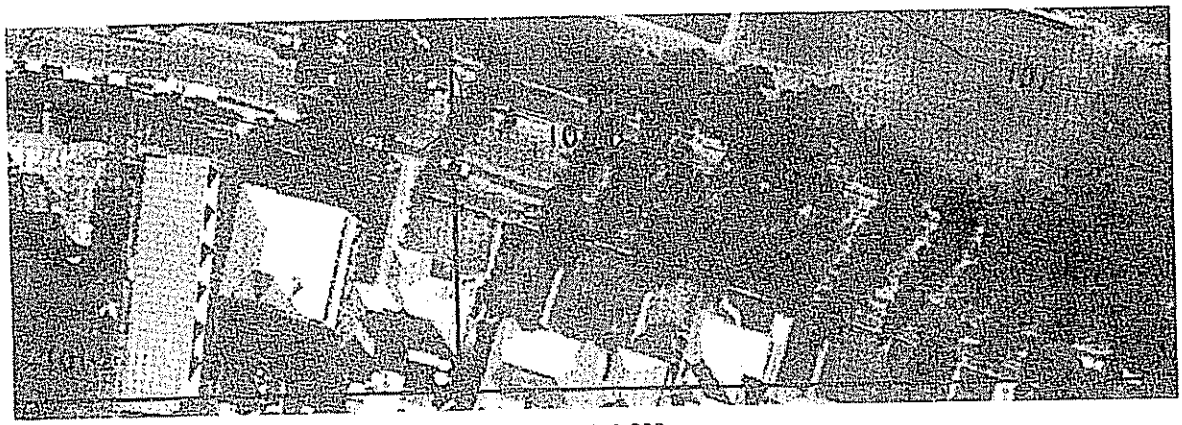
Ex D: 1:10,000 ORTHOPHOTO FROM 1:32,000 AERIAL PHOTOGRAPHY



Ex E: 1:4,000 ORTHOPHOTO FROM 1:16,000 AERIAL PHOTOGRAPHY



Ex F: 1:2,000 ORTHOPHOTO FROM 1:8,000 AERIAL PHOTOGRAPHY



Ex G: ENLARGEMENT OF 1:2,000 ORTHOPHOTO TO 1:1,000

Figure 127. Australia: large-scale orthophoto maps

URBAN MAPPING RESEARCH*

Paper presented by the United States of America

The urban crisis in the United States of America is real and explosive. The pattern of a deteriorating inner city surrounded by a belt-way spawning flourishing new enterprises is familiar. Statistics testify to formidable population growth and migration to already overcrowded cities. The cities need a fresh approach to master the problems of unplanned growth in their surrounding areas and the challenges attendant to an ever-increasing population. The solutions will come from increased federal-state-city co-ordination which seeks, identifies and attacks these problems, thus assuring desirable patterns of urban growth, prudent use of natural resources and protection of the physical environment. "Leadership will recognize the value of maps when seeking creative solutions to urban problems".[1]

CURRENT SITUATION

The topographic map at 1:24,000 scale currently produced by the United States Geological Survey (USGS) is the largest scale map series, available nationally, prepared by the federal government and available to the cities. Maps on this scale are revised at about five-year intervals. These maps are very valuable as an aid to solving problems where the matters being considered involve a major section of a city or an entire metropolitan area. They are the base or source map for many special maps and supply information for different purposes. The map at 1:24,000 scale keys all features to the same reference system, permitting information to be collected and spatially related.

Since 1960, there has been tremendous growth in urban population and construction. Numerous professional records refer to the urban crisis, population explosion, energy crisis; and a variety of fiscal, social, and economic problems. In response, there have been many federal government programmes and studies relating to new towns, urban planning and renewal, waste disposal and treatment, land-use inventories, etc. As a result of those activities, an emphasis has been placed on land-use planning for the first time in the history of the United States. The need for maps at scales larger than 1:24,000 in metropolitan and urbanizing areas is readily apparent. Federal government uses include flood-plain and flood-prone-area delineation, planning maps for sewerage and sewage-treatment plant modernization, urban renewal planning, comprehensive planning, federal highway routing and general studies involving urban environment and land use. As a result, the Geological Survey has received many requests from federal, state, metropolitan and urban planning agencies for mapping support. These requests exceed current programme capabilities, and only the highest priority needs can be satisfied.

When William T. Pecora, late director of the Survey, was made aware of these new federal programmes, he encouraged actions to determine how a federal mapping agency could be helpful to cities in a cartographic way. This led to an in-depth study of map use in the government of Washington, D.C. A specific objective study was to determine how the functions of the city agencies could be better served by maps graphic data or related services. There have b other highly significant studies: one made by th Mapping Coordination Group in 1965; and the 1967-1968 by the System Development Corp which reviewed the National Topographic P These studies found that within cities, there wer cations of map scales ranging from 1:240 to 1: The scale 1:2,400 was found to be popular for e ing, planning and tax purposes. The studies als that few cities had co-ordinated their mapping ne activities among their various agencies. Mapp done usually by one or two departments without ing other departments. The cities, in general, hav to develop a mapping system that will be helpful of their functions. As a result, the various map se do exist are not compatible with one another as format, reference systems, accuracy and content

This lack of compatibility is detrimental to th opment of computer-supported information s Unrelated maps cannot be expected to yield co map co-ordinates for common features in the city is critical because the approach requires that X positions be developed for those features as a m addressing the computer for related data. For e at a specific X and Y co-ordinate address on map, there may be a house about which city need to know several facts. Decision-making r quire information about that house, such as: construction material; (*b*) the property evaluat the tax load on it; (*d*) number of families living i whether the residents are of welfare concern; (*f*) there is a patient having a communicable disease location; (*g*) whether the house is used for com and industrial purposes; (*h*) whether it is in a floo area. A multitude of facts can be related to that p and entered into the computer with the X and ordinate values. This geo-coding approach is th for many of the urban information systems t being sponsored by: (*a*) urban managers to wh highly desirable to have at their finger-tips information that they would need to make decisio (*b*) by the computer industry, which is enco computerization of map data to aid cities (and computers and storage capacity). The approa encounter difficulties unless the co-ordinates house can be developed consistently from variou mation maps and sources.

As part of the in-depth study of Washington officials of the city agencies having responsibilitie area of civil defence, law enforcement, fire pro flood clearance, finance, sanitation, community r zoning, transportation, land-use planning, etc. shown large-scale geographically controlled photographic products.[2] Their response to the ducts was favourable. Representatives of the agencies appreciated the value of the orthophot as the common base upon which they could superi

*The original text of this paper, prepared by Marvin B. Scher and Paul A. Antill, United States Geological Survey, Washington, D.C., appeared as document E/CONF.62/L.65.

[1] United States of America, *Congressional Record*, 6 July 1970.

[2] One of these products is the orthophotoquad, an orthopho or orthophoto mosaic in standard quadrangle format with lit cartographic enhancement.

physical, demographic, economic, land use, social and administrative factors. They recognized that such a map product with a plane co-ordinate reference system would have sufficient metric accuracy to facilitate geo-coding of data. Furthermore, superimposed data, for the purposes of the computer mapping and computer support information systems, would be feasible. Orthophotographic products furnish a clear picture of the physical environment. They show, for example, the congestion of downtown buildings, where tree removal will be necessary for proposed street widenings, what building razing is required to construct a road in a given direction, where to build a new recreation area and more. Officials pointed out that this kind of map product would ease communications between designers or engineers with the non-technical administrators.

After the in-depth investigation of a single city, it was considered advisable to determine whether the findings in this city applied to many cities. For this purpose, the findings in the original city were documented and forwarded to the mayors of 44 cities, which constituted a 20 per cent sample of the cities in the United States of America, with populations exceeding 50,000. Knowledgeable officials in those cities were requested to review the report and indicate whether their mapping needs and applications were similar to or different from those of the studied city; and, if different, to specify in what ways their situation differed. The responses indicated that the findings in Washington, D.C. were typical, namely, that many local government agencies make or contract for single-purpose maps for individual agency needs. Co-ordination between different departments is frequently lacking, and many data are collected unknown to and unused by agencies other than the sponsoring agency.

Current activities

Using the findings of the in-depth study and the responses from the other cities as guides, a new phase of the study was initiated. In this activity, mapping projects are being undertaken in co-operation with selected cities to obtain map products indicated by the studies to be of value for urban purposes. Lessons to be learned in this phase are: (*a*) problems of communication in dealing with city officials; and, because it is intended to use the services of private mapping firms for these projects, (*b*) the ramifications of the contracting process for this purpose.

Fort Wayne, Indiana; and Charleston, South Carolina, are the first two cities to be selected for this activity. Fort Wayne represents a central plains city of moderate size. (177,000 population). It lies at the junction of the St. Mary and St. Joseph rivers, whose combination forms the Maumee River. About 20 bridges cross the three rivers. A "belt-way" stimulates urban growth at the expense of the inner city. Growth follows the general land-office sectional pattern on which most records are based. Each of the proposed orthophotoquads (1 inch equals 200 feet) will portray a half section. These will be very compatible with existing records and plans in Fort Wayne and will aid in their updating. The contract is for 440 monochromatic orthophotoquads covering 220 square miles.

Charleston, with a population of 67,000 is one of the oldest cities in the United States, with settlement begun in 1670. This coastal city is located on a narrow peninsula between the Cooper and Ashley rivers at the head of a broad, essentially land-locked bay formed by their junction. Its street pattern is very irregular. Land records are predominantly by city blocks, but the relation to other blocks is mostly non-existent. Orthophotoquads will correctly relate blocks to one another and will serve as a base for verifying old boundaries. The contract is for approximately 590 monochromatic orthophotoquads at 1:2,400 scale covering about 500 square miles.

It is anticipated that in the fiscal year 1974, portions of additional cities will be similarly treated with modifications learned from the first year's experience. Contracts will be let with private surveying and mapping firms for much of the work, but in-house experimentation will also be done.

Directions for research

A subsequent phase will involve an evaluation by city officials of the products made for them. Reports by the city officials and follow-up interviews with them are to furnish information that should: (*a*) suggest modifications to the products prepared in order to increase their usefulness; (*b*) furnish data upon which to develop final specifications and standards for a national urban map series; and (*c*) furnish statements by city officials that would give support to such a programme.

It is well established that maps of a wide variety of scales are used in urban area activities. To be responsive to many of the needs of urban-map users, it is likely that a family of base maps will be required. These maps should have a common reference system and have a multiscale relationship (i.e., a family of maps with a multiple-scale relationship of 10 would be 1:1,000, 1:10,000, etc.). In order to determine what the optimum multiple-scale relationship should be (the larger the value, the fewer the number of base maps in the family), it has been suggested that research in map scales be undertaken to:

(*a*) Determine the map characteristics that limit the amount a map, prepared at a given scale, can be enlarged or reduced photographically without a detrimental effect upon content and readability;

(*b*) Develop map styles, symbols and characteristics that increase the amounts by which maps can be enlarged or reduced without detrimental effect;

(*c*) Determine the maximum allowable limits by which an appropriately designed map can be enlarged or reduced;

(*d*) Determine the scales of a family of base maps that, by enlargement and/or reduction within prescribed limits, would permit the photographic reproduction of the base maps at all scales between 1:500 and 1:200,000.

Continuing research is needed to identify existing and potential map uses/users in the cities. Proper use of digital data, microfilm, colour renditions, overlays, composites and special products must be identified.

Conclusion

Although the first urban mapping research projects are at 1:2,400 scale, no final decision on the scales has been made. Research will be continued with different scales, varied focal length cameras, different flight heights, different instruments and various reproduction methods and materials. By the fiscal year 1975, enough experience should be available to identify the role of the federal government in this programme.

ORTHOPHOTO MAPPING—INTRODUCTION OF TECHNIQUE IN INDIA*

Paper presented by India

The present paper surveys the current state of the art in the field of orthophoto mapping. The problem of selection of the instruments and the introduction of technology in a developing country is not merely a technical issue, but embraces socio-economic issues, e.g., retraining of men and increasing job opportunities. In introducing the technique, a "systems approach" has been utilized. Towards the end, the paper describes the experience of India and the various alternatives of mapping available to the map-making organizations. It is also proposed to have a training course for professionals and technicians in orthophoto mapping in India.

In resolution 9, the Sixth United Nations Regional Cartographic Conference for Asia and the Far East recommended that "increased use should be made of orthophotos for map production and revision in order to save time, expense and highly skilled manpower"; that countries of the region should be assisted by "countries which have already gained experience in the pr application and production of orthophoto maps map revision using orthophotos"; and that "clo operation should be encouraged between the dif disciplines using maps in the countries of the reg order to obtain the maximum benefit from ortho maps".[1]

The recommendation could not have been timed. The pressure of the developmental project nected with irrigation, forest and town-planning great in India that the "maps" are needed almost "y day". The inevitable time cycle of some years in pr ing a map is a major obstacle in satisfying the der of the various users. It is here, namely, produ which has given added impetus to the techniq orthophoto mapping. Some statistics given in t would help in comprehending and identifying th bottle-neck in production.

Table 1. Distribution of manpower potential, by phase of work (*Man-months*)

Scale	*Area (square kilometres)*	*Photogrammetry*			*Cartography*	*Ratio of cartography to field-work*
		Field-work[a]	*Control aerial triangulation*	*Plotting*		
1:5,000	100	6.5	0.5	8.0	25.0	$\frac{25.0}{6.5} = 3.8$[b]
1:15,000	120	2.1	0.5	6.0	5.0	$\frac{5.0}{2.1} = 2.4$[b]
1:25,000	120	1.5	0.5	1.5	5.0	$\frac{5.0}{1.5} = 3.3$[b]
1:50,000	700	3.5	0.5	4.0	7.0	$\frac{7.0}{5.3} = 2.0$[b]

SOURCE: Based on published general reports of the Survey of India.
[a]Including field control and verification
[b]Cartography
Field-work

Referring to table 1, one finds that the ratio of cartography to field-work ranges from two to three times, on average. Therefore, if cartography could be eliminated or reduced, the time cycle would be bound to decrease. In orthophoto mapping, not only is this objective achieved in India, but further advantage is gained in reducing or avoiding the time taken in plotting. The same arguments also hold good for conventional rectification.

The decision was, therefore, taken by the Survey of India in 1970 in favour of the method of orthophoto mapping when the pilot map production plant of the Survey of India at Hyderabad was confronted with the demand for large-scale maps 1:5,000 and 1:10,000 of the Pochampad project in Andhra Pradesh.

A little background of the Pochampad project would be interesting history for the technique of orthophoto mapping in India. The Pochampad project, an irrigation project located in Andhra Pradesh, has been aided by the International Bank for Reconstruction and Development (IBRD) for its foreign exchange comp About $US 300,000 were earmarked for the purch orthophoto and allied equipment to permit maps produced at the most expeditious speed, so that engineers, soil scientists, agriculture experts and re officials would not be delayed in their planning pr The equipment would also be used for any projects by IBRD in future. The decision to use the ortho method was supported by the technical experts United Nations and IBRD.

EQUIPMENT

The equipment includes two planimats, two storage units and one Gigas-Zeiss orthoprojector w LG-1 scanning unit. The orthoprojector is fitted electric contour-liners and optical-interpolation de The Zeiss system was preferred in the off-line mo working. The off-line system has several advan First, the profiling speed can be adjusted to the "

*The original text of this paper, prepared by Lieutenant-Colonel P Misra, appeared as document E/CONF.62/L.72

[1] *Sixth United Nations Regional Cartographic Conference f and the Far East*, vol. I, *Report of the Conference* (United N publication, Sales No E.71.I.15), p. 16.

convenience" of the operator and terrain, thus making it possible for the operator to be more accurate in profiling. Secondly, the supervisor can easily check the work before it is used in the orthoprojector unit. Thirdly, since the orthoprojector (GZ-1) can operate at three times the speed of the on-line mode, production of orthophoto maps can be greatly increased. The off-line working mode is ideally suited to a production organization like the Survey of India.

There is an existing cartographic unit which can carry out cartographic operations. The organization also has a modern printing-office which has a Klimsch Autohorica (1 × 1 m) automatic camera, as well as Densitometers and other facilities, such as point source light, plate-making accessories, contact printer and offset rotary presses.

As concerns equipment, there is no immediate need for any major item. It may, however, be pointed out that the orthoprojector can take only 153-mm focal length photography. The organization currently has two cones of 115 mm, but the photography from these lenses cannot directly be used. The Survey is about to test the equipment for the projection of an affine model. Currently, attempts are being made to get only 153-mm photography flown so that in future, where it may be technically possible, it would be possible to switch over to orthophoto mapping.

Testing of the equipment

With respect to testing of the equipment, the United Nations Consultant, J. Visser, who was assigned to the Survey of India during January-February 1973, reported the following procedures and results.

In each of the planimats, a pair of grid plates was oriented and numerically restituted. Both planimats proved to have a very good height accuracy (on the order of 0.05 per cent Z) and a reasonable planimetric accuracy (on the order of $\sigma_x = \sigma_y = 8$ microns at negative scale).

The model scale used was 2.5 times negative scale (maximum ratio in planimat: 2.8 times, for C = 153 mm). Scaling was carried out numerically.

The stereogrid model, thus obtained, was profiled in one of the planimats, using X-intervals of 8 mm. Next, the right-hand grid plate was shifted to the left-hand plotting camera; and a second grid model was oriented, after a scale-transfer using the annular marks on the guide rods, etc. (just as is normally done for a real double-stereo model) and the second model was profiled. Profile data and orientation data were subsequently used to produce an orthogrid of the central grid plate in the GZ-1.

For profiling in the GZ-1, first, an 8-mm slit was used. The planimetric co-ordinates of all grid intersections in the two orthophoto negative films, thus obtained, were measured on the co-ordinatograph of the Wild A7. First results showed that:

(*a*) The projector table top and the film had been sufficiently flat, but the negatives had an over-all scale error of about 1.0 per cent per 1,000, a differential scale of some 0.70 per cent per 1,000 and a differential azimuth of some 0.50 per cent per 1,000;

(*b*) The setting-up of two stereogrid models on the planimat, their profiling and the subsequent production of an orthophoto grid negative on the GZ-1 was then repeated; and more orthophoto negatives were produced on the GZ-1 from the same storage plates and orientation data;

(*c*) In total, six orthophoto negatives were made, which were observed on the co-ordinatographs of the Wild A7 and the Wild A9, on each in two positions, where the second position is reversed and 90° rotated with respect to the first position, in order to have independent repeated observations and also to detect co-ordinatograph instrument errors;

(*d*) From these data, it appeared that the co-ordinatograph of the Wild A7 produced a *shear deformation* of 0.47 per cent per 1,000.

Final results showed that: (*a*) the over-all scale of the orthophoto negatives was 0.80 per cent per 1,000 too small; (*b*) the scale in Y was 0.70 per cent per 1,000 smaller than in X; and (*c*) there was no shear deformation in the orthophoto negatives.

It was concluded that the first error must be due to a height difference between the white platen used for scaling.

Accuracy check against field measurements

From aerial photography of a test area near Hyderabad, with the RC8 camera 9 × 9 inches, f = 6 inches, three successive photos (forming two stereo models) on the scale 1:27,000, and two strips of five successive photos (forming 2 × 4 stereo models) on the scale 1:13,500 were selected. The two 1:27,000 models cover the area of one sheet at 1:10,000 scale, while the eight 1:13,500 models cover in pairs each of the four quadrants of the area covered by the sheet at 1:10,000 scale.

Orthophoto maps, one sheet at 1:10,000 with a contour interval of 5 m and four sheets at 1:5,000 with a contour interval of 2.5 m, were to be produced. Within the area covered, there are some 350 check heights and some 20 targeted points of which the planimetric co-ordinates and the heights are known. The necessary planimetric minor control points for the 1:13,500 photographs were marked by PUG 4 on these and transferred to the central photograph at 1:27,000 scale. Subsequently, the two models at 1:27,000 scale were numerically restituted on the Wild A7, using the 20 targets as control and producing the planimetric co-ordinates of the minor control for the 1:13,500 photography.

In all, 10 stereo models were set up in the planimats before executing the profiling; thus, a large number of check heights had to be observed, in forward and backward cycles. This task appeared to be very time-consuming and unsatisfying because the check heights had not been identified on aerial photographs, but could only be identified through their planimetric co-ordinates, marked on the plotting sheets. Each point setting on a mark on the sheet, oriented on the internal drawing-table of the planimat, required much time and was yet imprecise. Any mistake in the field determination of the planimetric co-ordinates of the check heights, moreover, introduced errors into the check heights.

The final results of the accuracy checks appear in annexes I and II.

Details of production procedures

Aerial photography

The photographic specifications of quality, as well as flying (navigation), are stringent in the case of flying for

subsequent orthophoto mapping, as the final product is a photograph. The requirements of navigation are much higher than for line maps because it is essential that one photograph should cover one map-sheet. It is therefore imperative to mark the centre line of aerial strips for the navigation and to call for high-overlap photography.[2]

Furthermore, the quality of aerial negatives has to be controlled. While the Survey has no practical experience of controlling the photographic quality of aerial negatives, it has flown photography for the Pochampad project at 1:30,000 scale with flight lines marked on a 1-inch map and with 80 per cent overlap. The photography obtained was of excellent quality, which has given the Survey staff confidence that the specifications can be met by the flying agency.

Aerial triangulation

Any modern method of aerial triangulation would be sufficient. The Survey of India has used the independent model method of triangulation adjusted by Schut's programme on the IBM 1620 computer.

In fact, in the Pochampad area, the new photography at 1:30,000 scale taken in January 1973 was not triangulated. The existing aerial triangulation data on 1:40,000 scale photography taken earlier with an RC5 camera was used. The PUG 4 was used to transfer the control points. The transferred points proved excellent for planimetry, but not good for relief. Fortunately for the Pochampad project, contouring at 1 m is to be done in the field; from the GZ-1, it is possible to obtain only 5-m contours.

Profiling in planimats

The control points generated out of aerial triangulation procedures are used for setting the model. The points are all PUG marked on the PUG 4. The absolute orientation is checked with the help of a control plot-sheet on which control points are plotted with the help of the co-ordinatograph. An attempt is made to have the scale of the stereo model in the planimat the same as that required for the orthophoto, which can be possible provided the scale of photography is 2.5 times that of the orthophoto.

A suitable scan-width is selected from the available values of 2, 4 and 8 mm. The operator then sets up the storage plate on the storage unit (SG-1) and begins the operation of profiling. The speed of profiling can also be regulated by him. The operators on the new instrument (planimat) could be trained for the profiling mode of working in about one month. Hence, a productive organization need have no difficulty in retraining their men if it decides to use orthophoto mapping procedures.

Operation of the orthoprojector

The diapositive for the orthoprojector is specially prepared according to the density specifications. The aerial film negative is checked beforehand so as to obtain a suitable diapositive. The diapositive used in aerial triangulation and planimats is not used on the orthoprojector.

[2] P A. Brucklacher, "The optimum—photo scale for production of orthophoto maps".

Production figures

The production figures given in table 2 were obt during the work on the Pochampad project. however, too early to stabilize these figures.

**Table 2. Pochampad project, production time (*Hou*

Preparation: making of control plot-sheets	1.0–2.0
On planimats	*Model scale 1:2*
Orientation (RO and AO)	1.5–2.5
Working on SG-1 and setting up	1.5
Profiling and any other work	3.5
Total on planimat	6.5–7.5
On orthoprojector	*Scale 1:10,(*
Transferring control point on fresh diapositive	1.0
Setting up the orthoprojector (scale orientation of diapositive, laying film, etc.)	1.5–2.0
Setting scanning unit	0.5 } 3
Exposure time	1.5
Additional work on photographic processing	0.5
Checking against control plot-sheet	1.5
When contour liner is used, editing of contours	3.0

According to (A) in table 2, it may be seen that or produce from one-and-one-half to two maps per da shift. Taking the example of the Pochampad proje planimetry alone (for 1:10,000 scale) would have more than six days for conventional plotting. output, therefore, is one factor which overwheln supports the technique of orthophoto mapping.

Contouring for orthophoto mapping

Several factors must be considered for contour many alternative courses are normally available.

In order to have contours using the electric co liner method, the scale of photography would have commensurate with the accuracy of contours. The racy of contours is from 0.35 to 0.4 per thousa flying height, which limits the use of small-scale ph raphy, say, 1:70,000, for producing 1:25,000 ortho maps. Therefore, if one can separate the planimetry the elevations, small-scale photography (high-l could be used to very great advantage in savings cost of photography.

When this point is related to the Survey of Indi finds further alternative means of providing conto the field. The cost of field-work in India is still nc high, when compared with the cost of office wo have a rough idea, the Survey of India may h spend about double the cost of field verificat contouring is done in the field. In any case, it is ized that verification in the field is to be done in al for completion of the orthophotograph or the re image. Hence, with almost nominal cost, the information can be obtained from the field.

The method of providing contours in the field more applicable when smaller contour interva specified or the terrain is flat, which is generally th in projects. Another possibility is to obtain th heights from high-flown models and general "form

(rough level lines). Both can be utilized by field-workers to get accurate contours. In any event, in flat terrain, they would like to use rectification rather than the ortho-system. Summarizing, the alternative courses shown in figure 128 would have to be considered.

In course A, shown in figure 128, low-flown photography would be set in stereo mode, and contours would be drawn as usual. The orthophotograph would be made from high-flown photography because of the advantage of coverage of one full map-sheet by one high-flown photograph. This method would be useful in hilly and/or forested terrain where ground operations are difficult.

In course B, high-flown photography could give both an ortho-image and the spot heights. These spot heights would be used by field-workers in providing contours. This course would be worth taking only when the flying heights were such that it could give the accuracy of spot heights, but not the accuracy of contouring. It has been stated that accuracy of spot heights is from 1.2 to 1.6 times that of contouring, and the author was also informed about this result during a visit to the United States Geological Survey in July 1971. The results of the research carried out by Mr. Nelson of that organization, which are to be published shortly, support the theoretical consideration reported by Kratky.

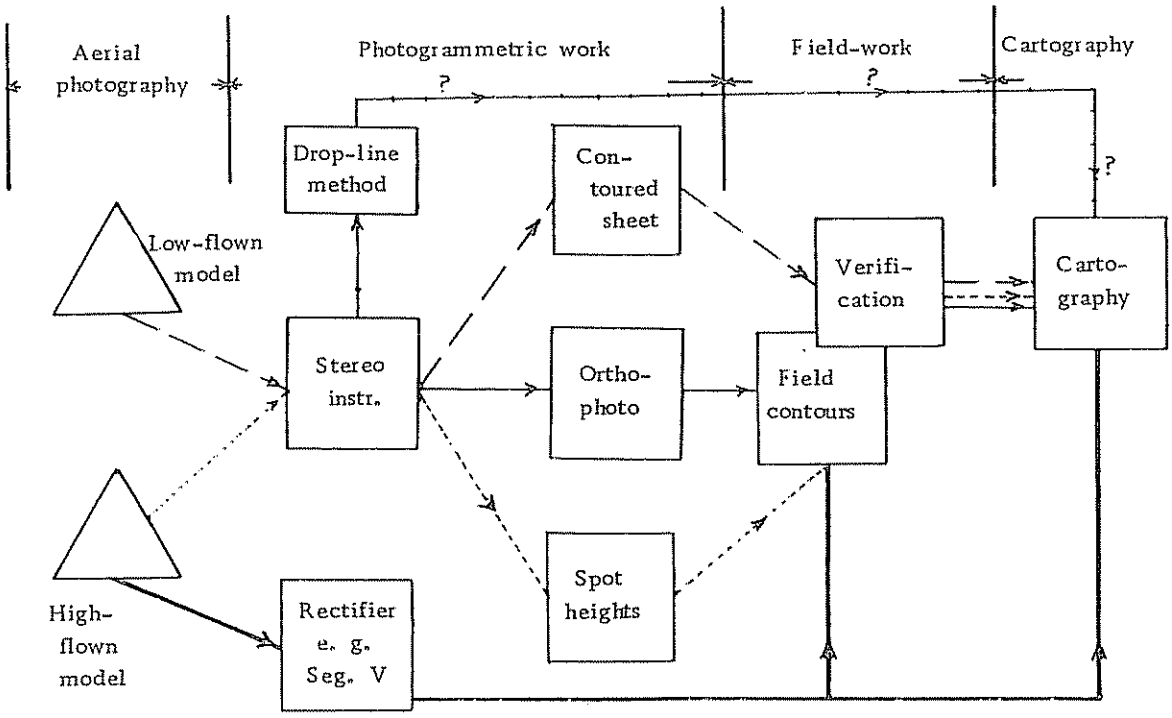
In course C, if the undulations in the ground are less than 1 per cent of the flying height, the high-flown photograph can immediately be rectified and enlarged on the SEG V rectifier, which obviates the use of orthoprinters completely. In fact, this method is adopted in the Survey of India. Thus, a large portion of 1:25,000 mapping can be taken up with the help of photos at 1:70,000 scale.

In course D, the contour-liner/drop-line method of producing contours is not considered essential, though the instrument may have the capability as the accuracy is only 0.4 per mile. Incidentally, the drop-line method has not yet found favour with the United States Geological Survey, El Salvador and many other mapping organizations, owing to its ineffectiveness in mountainous and very plain regions. The interpolation and editing of contours becomes very difficult in hilly regions.

Cartographic assistance in producing orthophoto maps

As described above, an orthophoto negative is obtained on the orthoprojector. This orthophoto negative needs additional information before it takes the shape of a map. The cartographic and printing procedures are shown in figure 129. It should be noted here that if the image as obtained on the GZ-1 is "tampered" either in rastering or duplicating, there is some loss of resolution. Too many names, contours and emphasis of roads will mar the good effect of photographic image and hence cartographic processes have to be well formulated.

It is proposed to give five copies of rastered orthophoto positives reproduced on Renkir-Safir paper to the Pochampad project authorities. The remaining copies, namely, 95, would be printed by offset process with image in black-and-white photo-image and contours in brown.



Source: P Misra, based on his Master's thesis

Figure 128. India: flow chart showing alternative courses

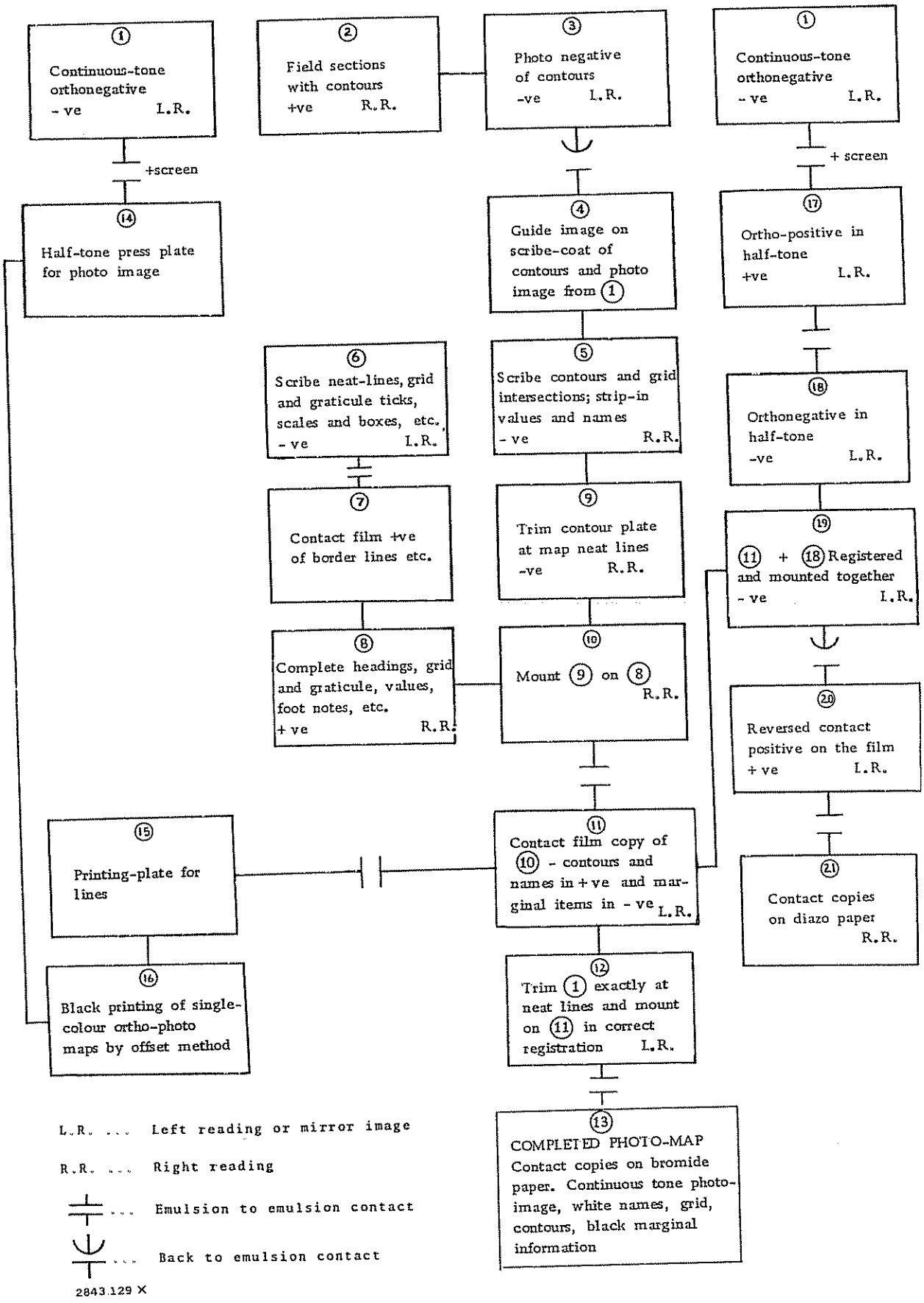


Figure 129. India: flow chart for preparation of orthophoto maps

CONCLUSION

The orthophoto technique is still new in India, and it must evolve on the basis of the prevalent economic and technical factors. The film, storage plates and reproduction paper (Renkir-Safir) are all imported. This factor could prove to be a great bottle-neck in future. A deliberate attempt has, therefore, to be made so that the polyester film, etc., are manufactured indigenously. The Survey of India is very hopeful in this respect. The electronic components of any equipment are bound to increase with the progress of technology, which points out the requirements of immediate assistance for electronic maintenance and repair of instruments. Further, it is essential that the user be educated for the efficacy of the product.

If all the factors for the growth of the technique are kept in view, progress is bound to take place.

ANNEX I

SPECIFICATIONS FOR EXPOSURES OF DIAPOSITIVE AND ORTHOPHOTO NEGATIVE MATERIALS FOR ORTHOPHOTO MAPPING

Test area diapositives

Zeiss KG 30 contact printer

Kodak medium-contrast aerographic plates

Exposure time: $^5/_{10}$ second

Developing time: 3¼ minutes

Diffusers used: two glass plates and seven tracing papers in between

Developer: Kodak D 60 at room temperature

Pochampad diapositives

Same as for test area diapositives, with the following changes:

Exposure time: $^6/_{10}$ second

Developing time: 3 minutes

Orthophoto negatives in orthoprojector (at 3 × magnification)

Illumination setting at GZ-1: 13.5

Film: N 31 P

Development: 3 minutes

Developer: Kodak D 60 at room temperature

Model 32/34 of strip 5

1. *Precision of observations*: 36 check heights have been observed, all but one in forward and backward cycles. The standard deviation in a single observation appeared to be 10.5 cm, i.e. 0.05 per cent of the flight height;

Accuracy: comparison of the 36 heights with field values: standard deviation of 41 cm, i.e., 0.2 per cent of the flight height.

Model 14/16 of strip 3 (1:17,000 photography)

1. *Precision of observations*: after subtraction of a constant error of 0.6 m between forward and backward readings, the standard deviation in a single observation appeared to be 0.6 m, i.e., 0.15 per cent Z.

2. *Accuracy*: comparison of 102 heights with field values. After subtraction of a constant error of 0.9 m between photogrammetric heights (average) and field heights, the standard deviation was 0.95 m, i.e., 0.24 per cent Z.

ANNEX II

ACCURACY CHECKS AGAINST FIELD MEASUREMENTS AND COMPARISONS BETWEEN NUMERICAL RESTITUTION AND ORTHOPHOTO MAPPING

Models 36/38 and 38/40 of strip 4 (a double model covering photo 38) (1:13,000 photography)

1. *Precision of observations*: 35 check heights have been observed twice, viz., in a forward and a backward cycle. The average of the 85 differences was practically zero; the maximum difference was 0.8 m (1×). The standard deviation of the differences was 0.25 m; the standard deviation in a single observation thus was 0.175 m or 0.09 per cent Z, a very high precision;

2. *Accuracy of the photogrammetric heights*: the averages of the forward and backward observations have been compared with the field heights. Twelve points appeared to have no field heights; seven points had gross errors of several metres, due to field errors; consequently, 66 check values were available. Their standard deviation was 0.37 m, i.e., 0.19 per cent of the flight height, a reasonable accuracy.

PREPARATION OF MAPS ON SCALE 1:500 FOR CITIES IN IRAN*

Paper presented by Iran

After many years of study and research, and consulting with a number of foreign experts, the National Cartographic Centre has achieved preparation of a 1:500 scale map for the centres of cities, plus a 1:1,000 scale map for suburbs. It is clear that these maps could be used both for urban works and for cadastral purposes.

To accomplish this task, numerous conferences and meetings were organized to discuss the subject with different Iranian and foreign experts in order to select the most suitable method. In view of the requirements, taking into consideration the time and economic factors, a decision was made to adopt the photogrammetric method.

The method selected gives satisfactory precision; nevertheless, after preparation of the photogrammetric original, the areas that cannot be seen on the plotting instrument should be completed by field survey.

The largest aerial photographs that could be flown were at 1:4,000 scale, due to the speed of the aircraft and the camera shutter at the disposal of the National Cartographic Centre. Therefore, the eight-times enlargement between photos and map had to be accepted although the precision was consequently somewhat reduced.

In order to improve conditions, changing of the RC8 camera to either one normal angle or to a camera with a 210-mm focal length is being considered, with a view to utilizing the existing plotting instruments available at Teheran.

The two cities of Ghazvin and Mashad were chosen to begin the necessary test work in order to visualize difficulties which might arise during the work and to work out proper solutions. The 1:500 scale map of the Ghazvin area is expected to be completed in a month. At Mashad, the field-work has already been executed, as has a part of the aerotriangulation work.

The two projects have resulted in broadening the technical experience of the Centre; they involve the tasks described below.

The area was covered by photography at 1:4,000 scale with 60 per cent overlaps and 60 per cent sidelaps in

*The original text of this paper, prepared by E. Khonsari, Chief of Research Section, National Cartographic Centre, Teheran, appeared as document CONF.62/L.118

order to use the centre of the models only for plotting, thus avoiding the dead areas on the sides of the photographs.

In the Ghazvin area, six control points were prepared directly by ground survey for every model.

Due to the fact that the work had to be begun immediately, there was no possibility of premarking the control points. Consequently, picture points were selected after the photographs were flown and their co-ordinates determined by a precise triangulation. Three plotted sheets were sent to Ghazvin for field-checking. Results were quite satisfactory, and the precision was identical to that obtainable on a map at 1:500 scale.

During scaling of some models, discrepancies of more than 0.2 mm (map scale) were noted on control points. Extensive study and the application of different solutions have led to determination of the causes of the discrepancies, which apparently, are due to lens distortion, identification errors, film shrinkage, etc.

These errors resulted in considerable residuals at control points at edges of the models, especially when the point was situated out of the model area. Some research was done to overcome the difficulties. For example, the co-ordinates of the control points were redetermined by aerial triangulation, but the models were still not good. Therefore, the preparation was changed in order to have all the minor control points in the model area; and by aerial triangulation, the co-ordinates were found with which there was no difficulty in scaling the models. It will be appreciated if the participants will study the subject, express their opinions and consult with the Centre on the matter.

As the co-ordinates obtained by the two methods of aerotriangulation and direct observation of full control points by field survey resulted in the same accuracy, the aerotriangulation method was selected, considering time and economy factors.

In the Mashad area, ground control points premarked to provide better identification accura

Further details concerning the Mashad cac survey are given below:

(*a*) A basic grid of 10-km distances was establis an area covering 400 km^2;

(*b*) A triangulation network was established approximately 4-km side lengths covering the whol (see figure 130);

(*c*) A grid network of traverses with 1-km side l was established, joining the triangulation stations

(*d*) A grid with 200-m side lengths was estab inside the prior traverses. (Bench-marks at every crossing were required by the cadastral office.);

(*e*) Computation and adjustment of the triangu network was carried out using CDC 6400 compute calculation of minor traverses was done on a Pa desk calculator. Closing error of the traverse approximatley +15 cm.

For plotting of scale maps of suburban ar 1:1,000 scale, the conventional photogrammetric m was used, and control points were provided by aerc gulation.

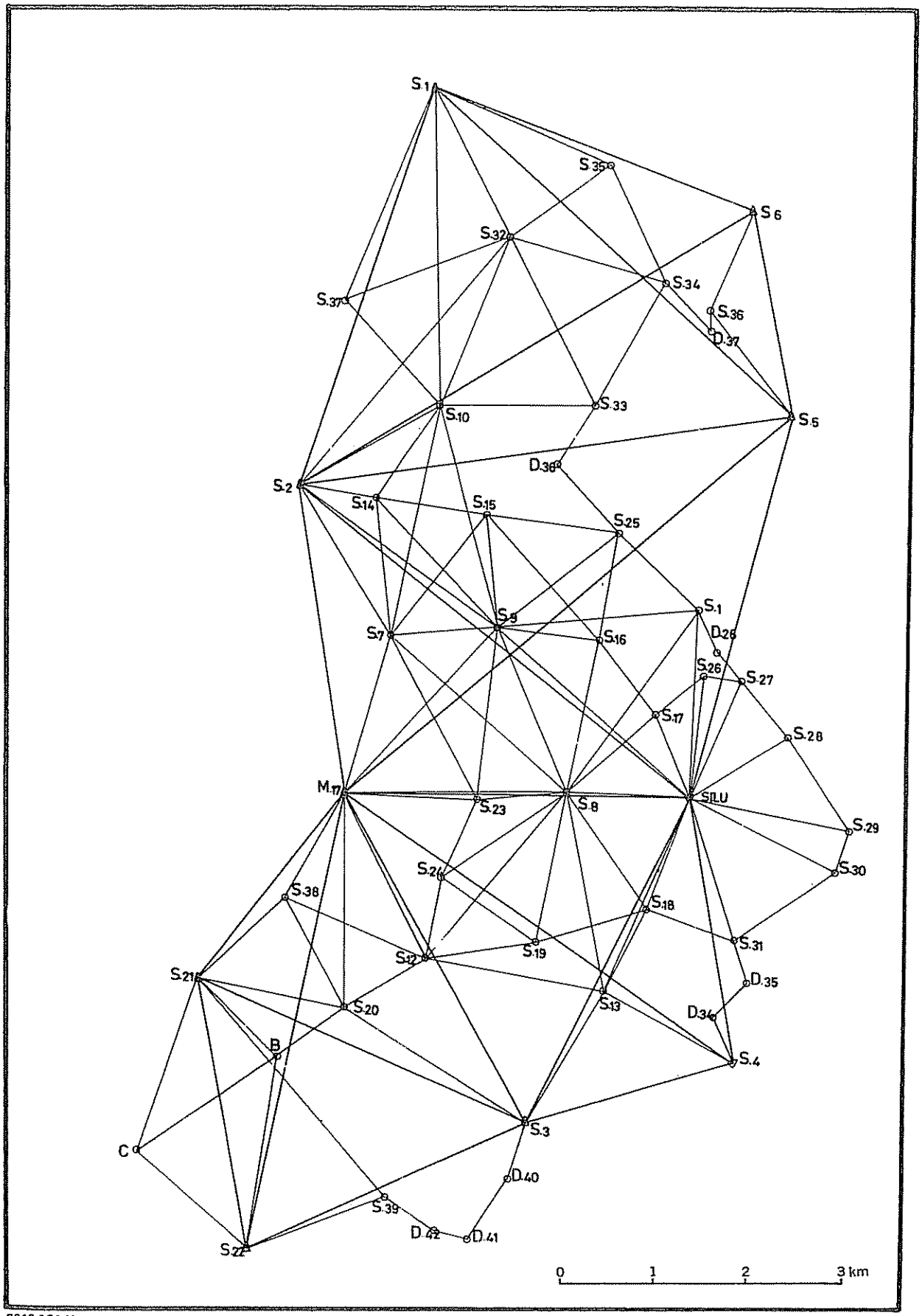
Different general methods were adopted for he

From the above-mentioned considerations, in ration of the maps of cities in Iran at 1:500 sca sample map, see figure 131), the following proc resulted:

(*a*) Ground control points to be premarked on g (with exception of 200-m points, which were requi the cadastral office);

(*b*) Minor control points to be provided by aerc gulation and block adjustment.

The possibilities of numerical cadastre and ana aerotriangulation using stereocomparators also studied.



2843.130 X

Figure 130. Iran: triangulation network of Mashad City

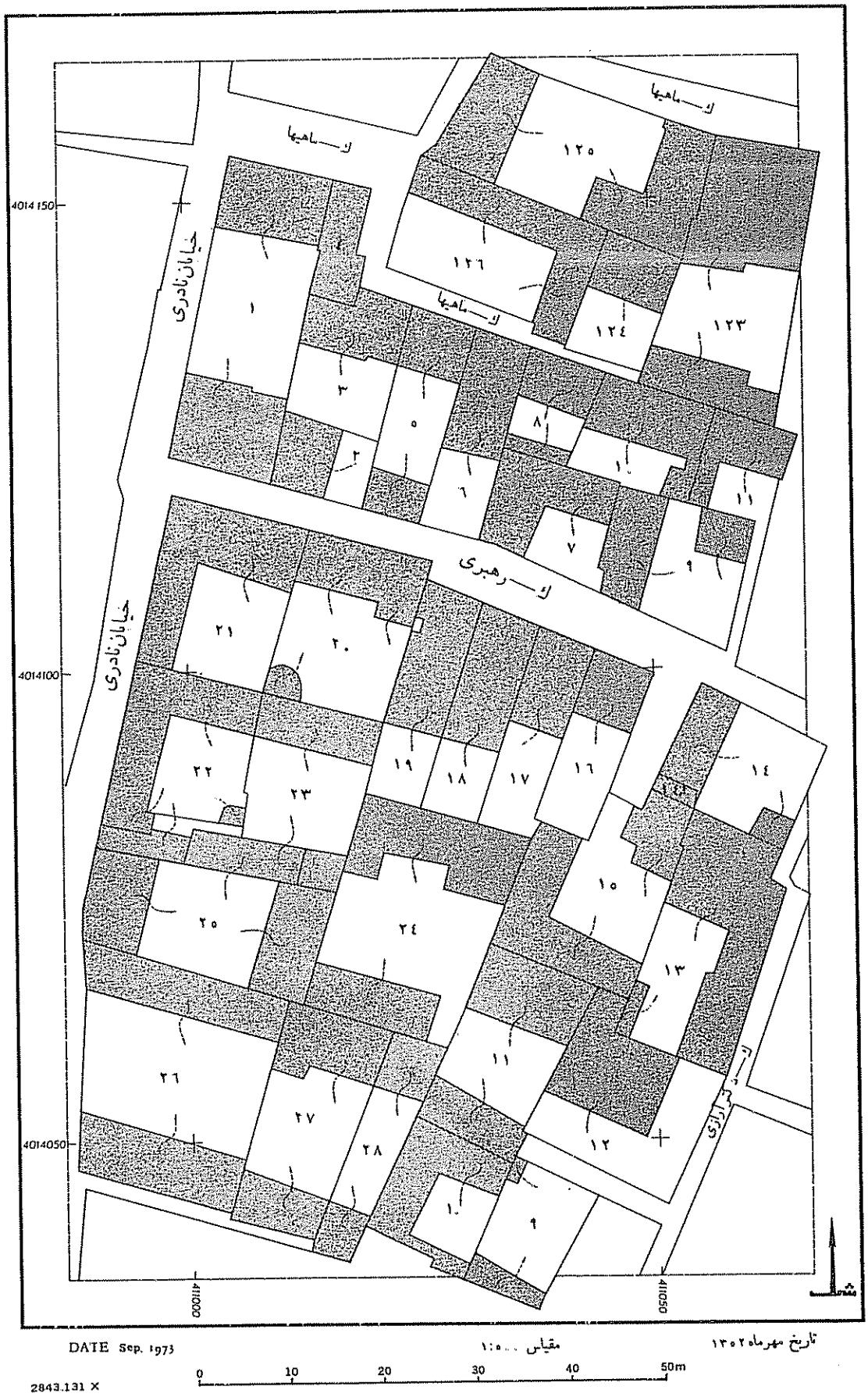


Figure 131. Iran: sample map at 1:500 scale

REPORT ON THE AVAILABILITY OF TRAINING FACILITIES TO FOREIGN TRAINEES IN SURVEYING AND MAPPING*

PURPOSES, SCOPE AND REMARKS

The present report has been prepared in pursuance of resolution 13 of the Sixth United Nations Regional Cartographic Conference for Asia and the Far East on the subject of training facilities[1] on the basis of materials made available by national bodies, such as surveying and mapping agencies and universities, and by international governmental and non-governmental organizations, to the United Nations Secretariat. It will serve as an aide-mémoire for national agencies concerned with surveying and mapping of their national terrorities, and, in particular, for those in developing areas confronted with the problems of lack of trained staff in all branches of technical work and at all levels.

The training urgently required by these agencies is of such magnitude and variety, and its need increases so rapidly with the unprecedented progress in the economic, social and technical fields throughout the world, that it is obviously important that the aide-mémoire cover as many of the numerous aspects of training facilities available to foreign nationals as possible. On the other hand, bearing in mind the practical purposes of this undertaking, as well as the conditions prevailing in developing areas and their immediate particular needs, a preliminary study based on information neither complete in coverage nor homogeneous in substance in some respects could render a valuable service to interested parties in both developing and developed areas. For instance, those who need to send staff abroad for training would have a general indication as to where to obtain up-to-date and more detailed information and those having facilities available would be in a better position to provide the United Nations Secretariat with the necessary information in order to fill the gaps in the present study and to bring published data up to date so that a more comprehensive handbook could be prepared for wider distribution not only to fulfil more efficiently the objective of resolution 13 mentioned above, but to assist in the consideration of the question of training by regional cartographic conferences.

In line with this consideration, the coverage of this report is limited to training facilities especially organized for foreign trainees. Existing facilities which could be made available through *ad hoc* arrangements between parties involved are included unless they are specifically reported to be unavailable to foreign students. For instance, many national surveying and mapping agencies, in both developed and developing countries, have established technical schools and conducted training courses (or programmes) for their new recruits or for the staff who have a certain amount of working experience in the agencies. Experience has shown that such courses and programmes have, from time to time, through special arrangements, accepted trainees from sister organizations of other countries. Moreoever, almost all national educational institutions have traditionally accepted students from other countries, though conditions of admission may vary on account of the language problems and the differences existing among the various educational systems. In turn, numerous universities, colleges and technical schools offer, for credit in other disciplines or other branches of sciences and techniques, one or several isolated courses in selected subjects of surveying and mapping. It would be neither practical nor useful to list all these courses.[2] In general, more attention is given to courses intended for students who have selected surveying and mapping as a profession or as a career in cartographic organizations.

Many seminars and pilot courses organized by international organizations and national institutions deal with a specific subject or a new development in surveying and mapping methods, techniques and organizations, and are of particular interest to mapping agencies in developing areas; some of the seminars and pilot courses are especially designated for these areas. With respect to those organized by the United Nations and its specialized agencies under the United Nations Development Programme (UNDP), they are usually based on the interest expressed by Governments interested in attending. A list of such seminars and courses can be found in annex I to this report.

It is well known that private mapping firms and manufacturers of mapping instruments and equipment agree, through *ad hoc* arrangements, to borrow the staff of surveying and mapping agencies with whom they have contracts, in order to train them at their offices and factories in activities related to the mapping projects assigned to them or equipment supplied by them.

Training facilities from outside sources are available in the expert missions which are assigned to developing countries under the technical assistance programmes of international organizations and individual Governments. UNDP has made available, on request from interested Governments, experts in surveying and mapping whose duty it is, among other things, to train local technicians in many developing countries. In general, UNDP projects include training. Similarly, national aid agencies will lend the services of such training experts through bilateral arrangements between donor and recipient Governments. The various subjects in which United Nations technical experts have organized and conducted training are given in annex II as an illustration.

The cost of study abroad often constitutes a heavy burden to developing countries which have very limited foreign exchange resources. Availability of fellowships and scholarships is very important to them. It is well known that most of the technical assistance programmes

*The original of this paper, prepared by T. L. Tchang, United Nations consultant, appeared as document E/CONF.62/L.2.

[1] See *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.71.I.15), p. 18.

[2] The *Catalogue of Institutions Providing Instruction in Cartography*, compiled by Commission I, Education in Cartography, of the International Cartographic Association, contains an indication of the number of courses on map preparation as a small part of the study in other disciplines. The address of the Commission is c/o Comité français des cartographes, 39, rue Gay-Lussac, 75005-Paris, France.

of international organizations and national bodies include the granting of fellowships and scholarships. An attempt has been made to include the source of information thereon in individual countries for regular study. The publication entitled *Study Abroad,* issued periodically by the United Nations Educational, Scientific and Cultural Organization (UNESCO), contains information on fellowships and scholarships granted by international and national bodies throughout the world for study and research work in foreign countries.

With respect to technical subjects of training, this report covers the following: geodesy, control surveying, topography, aerial photography, photogrammetry, photo-interpretation, hydrographic surveying and oceanography, application of space surveying, cadastral survey and land registration, map preparation; map production, including all phases of topographic mapping and hydrographic charting. Some seminars and courses are closely related to organization and management of services.

The definition of the level of training varies somewhat with each country because systems of education vary throughout the world. It must be viewed in the context of the education and assignment of the country providing training. With respect to the term "cartographer", the definition of Commission I, Education in Cartography, of the International Cartographic Association (ICA) is used whenever possible.[3]

Summaries of training facilities in selected countries

Argentina

In Argentina, the Institute of Technology, at Buenos Aires, offers a special course in hydrography. The teaching is in Spanish and the duration is two years. Field-work is carried out during the summer period. The course includes the following subjects: hydrography; hydrographic surveying; geodesy; general electronics; physics (complementary); radio techniques and acoustics; physical oceanography; review of previous surveying projects.

A two-year preparatory course, designed to enable the trainees to acquire the standard knowledge they should have before specialization, is also available.

Australia

A school in hydrography has been established at Sydney by the Royal Australian Navy for the training of junior officers and surveying recorders. Some foreign students are accepted at the school.

The University of Sydney offers two new diploma courses in surveying science and photogrammetry in its Department of Civil Engineering. Both diplomas are one-year full-time or three-year part-time courses, comprising formal course work and a thesis. They are open to graduates in civil engineering or surveying, registered surveyors, or such other persons as may hold qualifications approved by the Faculty of Engineering.

[3] Four categories are considered, corresponding to different levels and functions: W.1, scientific or academic cartographers: geographer-cartographers, scientific or academic engineer-cartographers; W.2, engineers in cartographic work or university graduates in cartography or editing cartographers (head cartographers); W.3, authorized cartographers; W.4, draftsmen or assistants

Austria

Austria educates surveying engineers for itself ar other countries. Its universities are open to stude any country.[4] Two universities of technology established institutes dealing with specialized subje the field of surveying and mapping.

The University of Technology, at Vienna, has such institutes covering, respectively, the followin jects: cadastral survey and triangulation; general su ing; photogrammetry; astronomy and earth survey. year, 25 students graduate with a diploma in surv

The University of Technology, at Graz, also ha institutes dealing with the same subjects. Approxin 10 students graduate every year.

These technological universities, as well as the U sity of Vienna and the University of Innsbruck, alsc architects, mechanical engineers, civil engineer geographers in various branches of surveying an tography, including photogrammetry and reprod works.

Belgium

Under the sponsorship of the Office of Develo Co-operation of the Government of Belgium, th gian Military Geographic Institute offers a num possibilities for in-service training or study relat the following mapping activities: aerial photog photo-processing laboratories; topographic wor tronomy, triangulation, levelling, gravimetry, grammetry); computation office; printing shop training is carried out in French, in the following

(*a*) In-service training designed for staff req further training in one or several subjects men above. The duration may vary from three months year, depending upon the trainee's achievements;

(*b*) Courses designed for qualified staff to wor higher level. The training includes several phases can be separated with return to work in the na agency for one or two years. Four levels of cour available: course A, for the training of engineers; B, for the training of engineer-technicians; course the training of principal cartographers; course D, training of qualified cartographers.

Applications must be sent to the Office of De ment Co-operation through diplomatic channels.

Brazil

In Brazil, the Directorate of Hydrography and gation, through the Department of Education, out the instruction, specialization and training personnel of the Ministry of the Navy.

The course in hydrography and navigation is av at three levels. The instruction is given in Portu About six vacancies are made available to naval from Latin American countries.

In the course of hydrography and navigati officers, the subjects taught include aerophotogr try, astronomy, cartography, geodesy, hydrog electronics as applied to hydrography, magneto meteorology, navigation, oceanography and to phy. On the completion of the course, the train

[4] For information for foreign students, see Austrian Comm Education Exchange, *Study in Austria* (in English, French a man). The address of the Committee is Türkenstrasse 4, Vier

qualified to carry out technical duties on board hydrographic and oceanographic vessels. The duration is 46 weeks from February to December each year.

The courses in hydrography and navigation for ratings are conducted at the secondary level of knowledge, including mathematics, physics, ethics and civil instruction, naval military training, navigation, hydrography, meteorology and oceanography. On completion of the course, the trainees are qualified to become technical assistants on hydrographic and oceanographic vessels. The duration is 44 weeks from February to December each year.

The course in hydrography and navigation for petty officers has the same programme as the course for ratings, except that the courses are at a more advanced level to prepare the trainees for carrying out higher responsibility

Canada

The technical assistance programme of Canada contains, among other things, two items dealing with training: (*a*) the attachment of senior supervisors and technicians from developing areas to work units of counterpart organizations in Canada, such as the Surveying and Mapping Branch of the Department of Energy Mines and Resources, for the study of Canadian methods and procedures; and (*b*) the provision of undergraduate and post-graduate training of survey engineers. The arrangements are made through the Canadian International Development Agency.

The Canadian Hydrographic Service conducts basic and intermediate courses in hydrography:

(*a*) *Basic hydrography course*. This course is for trainees who should be graduates of a technological institute with a good background in mathematics and a good working knowledge of the English language; it is held every year from 15 October to 15 December (approximately); and is both theoretical and practical, field training being normally conducted aboard a survey ship in the Caribbean Sea;

(*b*) *Intermediate hydrography course*. This course is for trainees having completed at least three years of field-work; it is held every year in May-June and is only theoretical.

The training is primarily for Canadian hydrographic staff; but candidates from other countries may participate if their application, directed to the Dominion Hydrographer in the first instance, is finally accepted by the Department of External Affairs.

The Department of Surveying Engineering of the New Brunswick University at Fredericton (New Brunswick) offers the following categories of courses as regular programmes:

(*a*) *Diploma course in surveying*. The course is designed mainly to give a technical education in the surveying field to selected professionals from countries outside North America and Europe. The course consists of regular subjects of the Bachelor of Science in surveying engineering curriculum;

(*b*) *Degree of Bachelor of Science in surveying engineering*. The duration is five years. The curriculum of the first three years is identical to the civil engineering curriculum, and that of the last two years includes technical subjects in surveying and mapping and related subjects.

(*c*) *Graduate studies in surveying engineering*. Courses are offered in three major categories: geodesy; photogrammetry; and advanced surveying within a programme leading to the degrees of Master of Science in surveying engineering, and of Doctor of Philosophy.

Laval University, at Quebec, has two independent departments for surveying and mapping in the Faculty of Forestry and Geodesy, namely, the Department of Surveying and the Department of Photogrammetry. These departments offer a five-year curriculum leading to the degree of Bachelor of Science, and post-graduate programmes leading to the degrees of Master of Science and Doctor of Philosophy.

The Nova Scotia Land Survey Institute, at Lawrencetown, offers a one-year course as a preparation to the certificate of draftsman.

The publication entitled *Awards for Graduate Study and Research*, issued by the Canadian Universities Foundation, Ottawa, contains information on fellowship possibilities.

Colombia

The Centro Interamericano de Fotointerpretación, at Bogotá, offers a regular programme and some special courses dealing with the application of photo-interpretation methods to geology, soil and forestry studies; as well as to engineering work. The duration of the regular courses is about 10 months. The courses, given in Spanish, are primarily designed for students from Latin American countries.

Egypt

The Survey Department of Egypt, at Cairo, through its Institute for Survey Technicians, organizes a two-year syllabus, including theoretical and practical training in geodetic control, photogrammetry, cadastral and topographic mapping and other related subjects for candidates with secondary-school certificates.

Federal Republic of Germany

In the Federal Republic of Germany, the various land survey offices, land registration offices, town survey offices and some other offices, and the Institute for Applied Geodesy have trained staff from many developing countries. Normally, such training requires two years, including from three to four months for language courses. In most cases, the training is of the in-service type, in geodesy, photogrammetry, cartography, reproduction, cadastral survey and land registration as required.

The Institute for Applied Geodesy, at Frankfurt am Main, has also organized a regular training course on mapping techniques for foreign trainees. This course consists of a 12-month programme including preparation of originals and map manuscripts of all kinds, at different scale, on paper, transparent plastic foils or other drafting bases. Although the teaching staff speaks English or French, the candidates have to attend a four-month course in German at the Goethe Institute.

The Landesvermessungsamt Nordrhein Westfalen of the Ministry of Housing and Public Works, at Bad Godesberg, offers regular cartographic courses at two levels: a three-year course for students having completed their high school studies and leading to a diploma in cartography; and another three-year course leading to a

certificate of cartography for students with eight years of primary school.

The Staatliche ingenieurakademie für Bauwesen Berlin-Fachrichtung Landkartetechnik (at Berlin West) has a three-year programme leading to a diploma in engineering for cartographic techniques for students having completed their high school studies.

The Landsvermessungsamt Baden Württemberg, at Stuttgart, has a three-year programme leading to a certificate of cartography for students with eight years of primary-school study.

Finland

The Finnish Geodetic Institute, in addition to scientific and practical work, has carried out special surveys abroad and the Finland Institute of Technical Research has research programmes in cadastral mapping.

For higher education, the Technical University of Helsinki has a Land Surveying Department with teaching in geodesy, photogrammetry and cartography. For the training of surveying technicians, four technical schools offer three-year courses on the same subjects.

Information on fellowships and scholarships is published by the Finnish Commission for International Fellowship.[5]

France

The Ecole nationale des sciences géographiques at Paris, organizes courses primarily designed for education and training of career technical staff of the Institut géographique national of France, the activities of which cover all phases of surveying and mapping. Foreign students are admitted. In addition, some special courses are organized for the staff in cartographic services of foreign countries.

The regular courses of the school of interest to foreign students include the following:

Cycle A: designed for education of polyvalent engineers to occupy a position of direction, research and education in geographical (surveying and mapping) techniques. The duration is two years (foreign candidates must have a diploma in engineering).

Cycle B: a two-year course designed for the education of engineers in geographical work capable of leading field missions and shops;

Cycle C: a two-year course designed for the education of technicians for carrying out work in geodesy, photogrammetry and topography;

Cycle D: a two-year course designed for the education of highly qualified cartographers capable of solving all the problems raised in the conception, preparation and editing of the various types of maps, with skill in drawing;

Cycle D': for students, non-staff of the Institut géographique national. While the practical training is similar to that in cycle D, the theoretical course is at a lower level;

Cycle E': a one-year course for foreign students preparing for the profession of cartographic draftsmen.

Each year the school also organizes a five-week (May-June) training course on applications of aerial photography for students who already have some knowledg the subject-matter and a fair command of French. course includes lectures, applied work in laborat visits and field-work. Two options of study are avail photo-interpretation and photogrammetry. For the option, an extension of two weeks for field-work is organized.

In addition, the school arranges short course special circumstances and individual in-service trai at the Institut Géographique National on an *ad* basis.

The Ecole nationale du cadastre, at Toulouse, c nizes courses for the professional education of technical staff of the Sous-Direction du cadastre o Ministry of Finance and grants certificates giving following titles: inspector-student; first-grade su technician; surveyor; and inspector. The duratio such courses varies from one to two years, depen upon the category of study; and the technical educa is supplemented by in-service training at the departi tal offices (province). Foreign trainees can be admitt these courses by special arrangements.

The Training School of the French Naval Hy graphic Office organizes courses designed for trai personnel in three categories including hydrogra engineers (officer rank), naval technicians (petty o rank) for field or for office employment and civil te cians for office employment. Qualified foreign nati with a good working knowledge of French may fc such courses.

The courses are described below:

(*a*) *Courses for hydrographic engineers*. The dur of these courses is two years, beginning with a ter practical training (October-March), then followed six-month participation period in hydrographic wo the field and by a second term of further theor training;

(*b*) *Courses for naval technicians*. The instruction 13 months, including a six-month term of theor work and supervised practical work at the Headqua of the Hydrographic Office in Paris (October-M and a seven-month participation in hydrographic in the field (April-October);

(*c*) *Courses for civil technicians*. The courses ar signed for training civil technicians in one of the following specialties:

(i) Specialists in graphic arts: cartographers; er ers; photo-engravers; printers;

(ii) Specialists in scientific instrumentation: g instrumentation specialists; electronic instrument cialists;

(iii) Technical secretaries; computers, cartogr and nautical librarians.

The duration of the courses is two years, with th year devoted to general training common to all specialists and the second year to training in respective specialities in selected schools outsid Hydrographic Office.

The Ecole supérieure de cartographie géographiq the University of Paris offers a two-year progra leading to the title of cartographer-geographer.

The Institut de géographie of the University of S bourg has a one-year course leading to a certifica geography.

[5] Finnish Commission for International Fellowships, *Finnish Government Fellowships Available to Foreign Students and Scholars for Study and Research in Finland*. The address of the Commission is Korkeavuorenbatu 21, Helsinki.

Ghana

The Survey of Ghana, at Accra, runs courses at technician level for training surveyors' assistants, draftsmen, lithographers and lithographic draftsmen. The last two are in-service training courses.

The Kumasi University of Science and Technology, at Kumasi, offers a three-year certificate course and a five-year diploma course for technicians, and a four-year degree course and a two-year post-graduate course for professional surveyors.

Hungary

In Hungary, the Technical University of Budapest offers, for students with the *baccalauréat,* a five-year course leading to a diploma as an engineer-surveyor.

A two-year post-graduate programme is also offered at the University for graduate surveyors with adequate practice. The 1971 course was organized on the subject of geodetic automation.

The Institute of Geography of the Eötuös Lórád, at Budapest, offers, for students with the secondary-school certificate, a five-year course leading to a diploma in cartography.

The Technical High School of Geodesy, at Szekesfe Hervar, offers, for students with grammar-school qualifications and a minimum of one year of professional practice, a three-year course in surveying at technician level.

India

The Survey Training Institute, at Hyderabad, a component of the Centre for Survey Training and Map Production, was established within the framework of the Survey of India with the assistance of UNDP. The Institute runs basic and advanced courses on various aspects of surveying and mapping. The courses are designed so as to be employment-oriented at all levels. Students from foreign countries are accepted as are private candidates and employees from departments of the Government of India. Some courses can receive a very limited number of trainees, and preference will be given to the staff and recruits of the Survey of India. Courses offered are listed in table 1.

Most of the courses are given once a year, with the exception of those on scribing and junior level of supervision (four times a year) and those on survey instructions, photogrammetric operations and electromagnetic distance measurements (twice a year). The qualification for admission varies with the courses. The training is in English.

The Indian Photo-interpretation Institute, at Dehra Dun, another Directorate of the Survey of India, offers a 12-month course on photo-interpretation in forest survey, a 12-month course on photo-interpretation in geology and a 12-month course in soil survey. Advanced courses on the same subjects are also offered with a normal duration of 12 months.

The courses include both laboratory work on photo-interpretation and related subjects, and a period of from five to six months of practical survey of selected areas. Trainees and specialists from other countries of South-East Asia and the Far East are accepted. All training is in English.

The Naval Hydrographic School of the Indian Naval Hydrographic Department, at Cochin, Karala, conducts

Table 1. Courses offered at Survey Training Institute, Hyderabad

Course	*Duration (weeks)*
Drafting	52
Course for survey technicians	104
Control surveying techniques	52
Scribing	12–13
Course on junior level of supervision	12–13
Computation	52
Cadastral central surveying	26
Course on civil engineering surveying	26
Control surveying supervision at junior level	12–13
Survey instruction (for training instruction)	8
Surveying supervision at intermediate level	104
Cadastral surveying	52
Course for photogrammetric operators	26
Electromagnetic distance-measurement	9
Surveying engineering	104
Map reproduction	12–13
Cartographic editing	12–13
Senior level supervision	12–13
Survey management	12–13
Advanced geodesy	52
Advanced photogrammetry	52
Advanced survey management	12–13

four courses for training hydrographic officers and surveying recorders. Candidates from foreign countries with a good knowledge of English should apply to the Government of India through their respective national agencies. The courses offered are as follows:

(*a*) *Hydrographic specialist officers' course.* The duration of the course is 18 months; the candidates are trained in actually carrying out all phases of a complete hydrographic survey. The minimum academic qualifications required is a Bachelor's Degree in mathematics or science;

(*b*) *Surveying recorders third-class course.* This basic course is intended to initiate junior sailors with at least a school-leaving certificate in the hydrographic field. The duration of the course is 14 weeks, including four weeks of practical training on board a survey ship;

(*c*) *Surveying recorders second-class course.* A third-class surveying recorder with a minimum of three years of experience can be admitted to this course; the duration is 12 weeks;

(*d*) *Surveying recorders first-class course.* A second-class surveying recorder with a minimum of three years of experience can be admitted to this course; the duration is 12 weeks.

A plan to conduct a course for officers in a higher surveying grade is under consideration.

Israel

In Israel, the Higher School of Surveying, at Holon, offers, for students having completed their secondary education, a three-year course leading to a surveyor's diploma. Students must have a working knowledge of Hebrew.

Italy

In Italy, the Centro di Addestramenti e Studi Fotogrammetrici of the Politechnico Di Milano, at Milan, has carried out training courses and research on various

subjects of photogrammetric mapping. In 1965, the Centre organized a seminar on photogrammetry for participants in the First United Nations Interregional Seminar on Application of Cartography for Economic Development, during their study tour in Italy.

Ivory Coast

The Ecole supérieure des travaux publics and the Training Centre of the Ministry of Public Works, both at Abidjan, have accepted students from the Dahomey, Guinea, the Upper Volta, and other countries, in addition to those from the Ivory Coast. The Institut Géographique of the Ivory Coast has participated in their programmes for training middle-level personnel (senior technicians and assistant geographers).

Japan

The Geographical Survey Institute at Tokyo has carried out group training courses for foreign students, a programme sponsored by the Government of Japan as a part of its technical co-operation schemes for developing countries. The arrangements for implementing the courses are made by the Overseas Technical Co-operation Agency, a semi-governmental body. The courses, designed for introducing modern techniques of surveying and mapping used in Japan to foreign participants through lectures, practical work and study tours, are held in rotation in the following order: geodetic survey; photogrammetry; cartography; and printing.

The Technical School of the Institute regularly organizes a one-year course for training new staff members of the Institute as surveying and cartographic engineers and another one-year advanced course for selected staff after five years of service.

The Hydrographic Office, a division of the Maritime Safety Agency of Japan,[6] continues to accept a limited number of foreign students for training in hydrography, including physical and chemical oceanography, map compilation and map drawing. The duration of the courses varies from a few weeks to one year according to conditions. The courses are conducted in Japanese and English. Five private technical schools for training of surveying technicians are in operation. The graduates from these schools are eligible to be registered for the licence of "assistant registered surveyor". With two years of additional practice after graduation, they can obtain the licence of "full professional surveyor" "(registered surveyor).

Kenya[7]

The Training School of the Survey of Kenya, at Nairobi, conducts training courses for cartographers and advanced courses for survey assistants.

The University of Nairobi carries out professional training for surveyors and awards the degree of Bachelor of Science in engineering (survey).

Plans are in hand for the training of cartographers to be carried out at Kenya Polytechnic, at Nairobi.

[6] The Maritime Safety Agency operates a training school for hydrographers. Currently, however, the courses are not open to foreign students.

[7] The United Nations Economic Commission for Africa is considering the establishment of a regional centre of special survey and mapping services in Kenya. The centre may offer facilities for on-the-job training of certain operations.

Lebanon

Lebanon welcomes students from other countries follow the technical courses given by the newly ope School for Topographic Studies. These courses inclu

(*a*) *Secondary technical courses.* These courses con of:

(i) Preparation for the *baccalauréat,* first p aide technician;

(ii) Preparation for the *baccalauréat,* second p technician;

(*b*) *Semi-university technical courses.* Preparation the degree of high-level technician;

(*c*) *Full university technical courses.* Preparation f degree in engineering and cartography. The duratio five years after the secondary school.

Malaysia

The Directorate of National Mapping, at Ku Lumpur, offers a seven-month course in cartogra drafting to students having completed their second school education. Foreign trainees are accepted if t are sponsored by their own Government.

Netherlands

The International Institute for Aerial Surveys Earth Sciences (ITC), at Enschede, Netherlands, according to its statutes, two main mandates: (*a*) provide education at university level and to carry research in the application of aerial photography in widest sense and in some subjects of earth science; (*b*) to use the facilities of the Institute for education training at a different level as required by the need developing countries. In this context, the Departmen Photogrammetry of the Institute has the follow groups of courses:

(a) *Courses in survey flight.* Two such courses offered, one leading to an ITC post-graduate diplo and the other to a diploma of ITC engineer. duration of each course is approximately 14 months

(b) *Courses in photographic technology.* Two s courses are offered, leading, respectively, to an ITC p graduate diploma and a diploma of ITC engineer. duration of each course is also 14 months;

(c) *Courses in photogrammetry.* Three such cou are offered, leading, respectively, to an ITC p graduate diploma in photogrammetric engineering diploma of ITC photogrammetric engineering, an diploma in ITC photogrammetric technique. The du tion for the technician course is 8-12 months, while t for the two others is 12-18 months;

(d) *Course in cartography.* Two such courses offered, leading, respectively, to an ITC diploma cartographic engineering and an ITC diploma of ca graphic technician. The duration of each course is year.

The courses are given in English, with some in Fre when there is a sufficient number of requests.

The Department of Natural Resources Surveys of a number of courses in photo-interpretation applied studies in geology, geography, soil and agricult surveying and forestry. The Department of So Sciences and Integrated Surveys offers courses in the of aerial survey for urban area studies.

The Cartographic Department of the Geographic Institute of the University of Utrecht offers a one-year course in cartography for foreign students who have completed their secondary-school education.

The Netherlands Bureau for International Assistance publishes training information for foreign students.[8]

Nigeria

The Federal Survey Department, at Lagos, runs basic and advanced courses in photogrammetry, cartography and photo-lithography for all the Survey Departments in Nigeria.

The School of Surveying, at Oye, Western Nigeria, which formerly provided training in surveying for technicians and paraprofessionals, is also offering training to professionals, to allow competent technicians who may not qualify to enter a university to achieve professional status by obtaining a Nigerian surveyor's licence.

The Survey Unit of the Northern Polytechnic, at Kaduna, offers courses for technicians in surveying the photo-lithography.

The University of Lagos offers a post-graduate course leading to the degree of Master of Science in surveying for graduates in subjects cognate to surveying, namely, mathematics, physics and geography with mathematics.

Undergraduate courses in surveying are available at the University of Nigeria at Nsuka and at Ahmadu Bello University at Zaria. All these universities are investing in modern instruments in geodesy and photogrammetry.

The United Nations Economic Commission for Africa (ECA) Regional Centre for Training in Photogrammetry was opened at Ile-Ife in October 1972, beginning with courses at technician level. The Centre was established under the auspices of ECA and with Nigeria as host Government, and Dahomey, Ghana and Senegal as charter participating Governments. The Centre is to be run on a bilingual basis (English and French).

Norway

In Norway, the Oslo Tekniske Skole, at Oslo, offers a course in cartography leading to the certificate of cartographer.

Philippines

It was reported that a training centre in photo-interpretation had been established in co-operation with the University of the Philippines at Quezon City.

Poland

In Poland, the Department of Cartography of Marie Curie Sklodowska University, at Lublin, offers a course leading to the degree of Master of Geography, with specialization in cartography, for students with secondary-school education. The duration is five years, with three years in cartography study.

The Department of Cartography of Warsaw University offers a similar course with the same duration.

Spain

In Spain, the Servicio Geográfico del Ejército, at Madrid, organizes a three-year course leading to a diploma in geodesy.

The Instituto Hidrográfico de la Marina, at Madrid, organizes a two-year course leading to a diploma in hydrographic engineering and a one-year course for hydrographic technicians.

The Escuela Ingeniera Técnica Topográfica, at Madrid, offers a three-year course leading to a diploma in technical engineering in topography.

The Instituto Hidrográfico de la Marina, at San Fernando (Cadiz), offers a two-year course at authorized cartographer level.

Sri Lanka

In Sri Lanka, the Training School of the Institute of Surveying and Mapping, at Diyatalawa, primarily designed for training technicians of various levels of the staff of the Institute, has organized several courses with lectures, including control, levelling, photogrammetry, block triangulation, land registration and cartography, by experts provided by UNDP. The School has also organized advanced courses for officers at supervisory grades.

Sudan

In the Sudan, the Khartoum Polytechnic (formerly the Khartoum Technical Institute) organizes a four-year professional course of surveying and a two-year post-secondary (subprofessional) training on land surveying and photogrammetry, with a certain emphasis on the practical work.

Switzerland

The Swiss Federal Institute of Technology, at Lausanne; and the Swiss Federal Institute of Technology, at Zurich, both have full courses of study up to diploma level in their respective departments of geodesy and photogrammetry. Post-graduate studies of at least one-year duration are also available. The institutes organize, from time to time, special courses on selected subjects, including new developments.

The Swiss School for Photogrammetric Operators, at Saint Gall, annually offers a training course lasting from the month of September to the month of April of the following year. A maximum of 30 students from any part of the world can be accepted. The lectures are given simultaneously in four languages, namely, English, French, German and Spanish. One particular feature of the course is the extensive practical exercises on geodetic and photogrammetric equipment of various provenience. In the remaining four months, individual courses on specific applications on particular instruments can be arranged.

At the level of authorized cartographer, the Ecole des arts et métiers, at Berne; and the Oreil Fussi, SA, arts graphiques, at Zurich, have a four-year course leading to diplomas or certificates in cartography for students who have completed their secondary-school education.

The Department of the Interior and the Bureau for Technical Co-operation of the Swiss Government grant fellowships to students from developing countries, not only for study in schools, but for on-the-job training in private survey offices.

The Swiss Tourist Office publishes general information of interest to foreign students.[9]

[8] Netherlands Bureau for International Assistance; *Facilities for Training in the Netherlands*. The address of the Bureau is Van Alkemadelaan, 500 s'Gravenhage.

[9] Swiss Tourist Office, *University Education in Switzerland* (in English, French, German and Spanish). The address of the Office is Bahnhoplaz 9, 8001 Zurich.

Turkey

The Department of Navigation and Hydrography of Turkey organizes two courses, one for commissioned naval officers from a naval academy or naval college, the other for non-commissioned officers from a petty officers' school who have followed a navigation course. The former is given in even years and the latter in odd years. Both courses last six months, from 1 September to 1 March. They may be completed by practical training in chart construction and reproduction.

Courses are conducted in Turkish, but all instructors are fluent in English.

Foreign students may be admitted to the courses, their requests being subject to approval by the Turkish General Staff and provided that no expenses are incurred by the Department.

Uganda

The Training School of the Ugandan Department of Lands and Surveys, at Entebbe, organizes two courses for staff of government departments: a course in land surveying and draftsmanship; and a course for training tax-valuation assistants. Both courses are three-year diploma courses.

Union of Soviet Socialist Republics

The Institute of Engineers in Geodesy, Aerial Photography and Cartography offers cartographic study in two categories:

(*a*) A programme for the diploma of engineer-cartographer. The duration is four years and 10 months;

(*b*) A programme for the diploma corresponding to the level of authorized cartographer. The duration is also four years and 10 months;

The title of the Institute appears to indicate that similar courses for the diploma of engineer in surveying should also be available.

The Faculty of Geography of the N. V. Iomonossof University of Moscow has two five-year programmes, one leading to a diploma in cartography and the other to a diploma in geography.

Foreign students have to attend a preparatory course in Russian.[10]

United Kingdom of Great Britain and Northern Ireland

The School of Military Survey at Newburg admits foreign students to its survey course.

The United Kingdom Directorate of Overseas Survey (DOS), at Surrey, England, offers, for students above the secondary-school level, a two-year course in cartography leading to the Kingston College certificate in cartography (theoretical instruction is provided by the Kingston College for Further Education). Foreign students sponsored by Governments are accepted.

DOS has also accepted foreign trainees to be attached to its technical services to enable them to gain practical experience of modern methods of map production in a large organization.

[10]General information for foreign students is contained in *Come to Study in the Union of Soviet Socialist Republics*, prepared by Bhemennikov and A. Medvedev (available in Arabic, English, French and Spanish). This publication may be obtained from the Permanent Mission of the Union of Soviet Socialist Republics to the United Nations, 136 East 67th Street, New York, N.Y.

The Royal Navy Hydrographic School, at Davenport, offers the following courses for training in hydrography:

(a) *Officer courses*:

(i) Basic course: two per year beginning in April and in September, with a duration of 12 weeks. Level of sublieutenant and junior lieutenant;

(ii) *Intermediate course*: two per year beginning in April and in September, with a duration of 15 weeks. Level of lieutenant with about three years of experience in the rank;

(iii) *Advanced course*: one per year beginning in January, with a duration of 12 weeks. This course is largely theoretical, and practical work is limited to those aspects of field-work in which candidates consider they lack experience. It is therefore suited only for those with at least five years of surveying experience;

(b) *Rating courses*:

(i) *Survey recorders, initial course, SR Star.* two per year beginning in January and in April, with a duration of 10 weeks. Level of able seaman of above-average intelligence and initiative;

(ii) *Survey recorders, second class, course SRII*: two per year beginning in September and in November. Qualifies a man to act as trained assistant to a surveyor in all aspects of field-work ashore or afloat, and to make straightforward observations himself under supervision;

(iii) *Survey recorders first class, course SRI*: one per year beginning in January, with a duration of 13 weeks. Level of petty officer or senior leading seaman. On completion, a candidate should have a theoretical knowledge comparable to that of a newly trained officer; and, depending upon experience, should be able to undertake a simple survey without direct supervision. Subject to the circumstances prevailing in certain cases, additional sea experience may be possible in surveying vessels after the course is completed.

Although maximum numbers in the course are being restricted to ensure the proper supervision of practical work, one or two places are usually available for other than British naval candidates, particularly in officers' courses. Preference is given to students from Commonwealth or ex-Commonwealth countries.

All candidates must be able to speak, read and write fluent English, and have a knowledge and experience of seamanship appropriate to the naval rank for which the course is designed. Candidates for officers' courses must have a mathematical qualification at least equivalent to the British General Certificate of Education at ordinary level, and a knowledge of navigation (including plane and spherical trigonometry) appropriate to a naval or merchant navy cadet on completion of initial training. Candidates for ratings' courses must have reasonable ability and speed in simple mathematics and neat handwriting.

The Department of Surveying of the North East London Polytechnic (including the former Waltham Forest Technical College) offers a regular course leading

to professional qualification in land surveying. The complete course is three years. The College is the approved centre in the United Kingdom for full-time studies for the first, intermediate and final examination of the Land Survey Division of the Royal Institution of Chartered Surveyors. The Department also offers, three times a year, a short course on hydrographic surveying of five weeks' duration; each enrolment is limited to 12 students. Practical work is provided in the form of survey projects; and, whenever possible, a boat survey is carried out.

The Department of Geography of the University of Glasgow, at Glasgow, Scotland, offers a four-year undergraduate course leading to the degree of Bachelor of Science in topographic science and a one-year post-graduate study for a diploma in cartography.

The Department of Geography of the University College of Swansea, at Glamorgan, Wales, also offers a one-year post-graduate study for a diploma in cartography.

The School of Design of the Oxford College of Technology, at Oxford, England, offers a two-year programme for students with a general certificate of education for a diploma in cartography.

United Republic of Tanzania

In the United Republic of Tanzania, the Survey Training Centre of the Department of Land and Survey, at Dar es Salaam, organizes courses of instruction for new recruits to serve as survey assistants, as well as drafting assistants.

United States of America

The United States Coast and Geodetic Survey, at Washington, D.C., participating in the various international co-operative programmes, offers training awards to foreign nationals in scientific, engineering and cartographic activities carried out by the agency. This training is effected under the sponsorship of the Agency for International Development (AID), the United Nations and its specialized agencies and the Military Assistance Programme, and under bilateral agreements between the Department of State of the Government of the United States of America in co-operation with the participating foreign Governments. The training awards are of the in-service training type and include scientific and technical aspects and practical instruction. The selection of qualified applicants is the responsibility of the sponsors in co-operation with the participating foreign Governments. All courses are conducted in English.

The courses for further instruction for those already familiar with certain methods and practices are listed in table 2.

The Cartographic School of the Inter-American Geodetic Survey, at the Fort Clayton Canal Zone, offers training in the specialized skills required for the various phases of geodesy and cartography. The training is being provided in the Spanish language in order to assist national cartographic agencies of the Latin American countries in developing talent for the production of topographic maps and other cartographic charts, that can be used for economic development. The training of the school is designed primarily to develop technical talent in persons of average scholastic background, but with little experience in mapping activities. It is of a practical nature. Advanced training may be arranged by the school for a few candidates who will fill supervisory positions at their sponsoring agencies. The specialized courses offered regularly twice a year include those in table 3.

Table 2. Courses offered by United States Coast and Geodetic Survey

Course	*Duration (weeks)*
Hydrographic survey (cartography, electronic equipment, triangulation, geomagnetism and photogrammetry)	48[a]
Tides and currents:	
Tides	20
Currents	22
Geodetic surveying	48[a]
Gravity and astronomy	6[b]
Geomagnetism	48[c]
Map and chart construction	48
Map and chart reproduction	48
Photogrammetry	38[d]
Seismology	48[e]

[a] Including 12 weeks field-work.
[b] Including 6 weeks field-work.
[c] Including 18 weeks field-work.
[d] Including 5 weeks field-work.
[e] Including 10 weeks field-work.

Special courses are arranged from time to time on two subjects: geodetic triangulation (12 weeks); and geodetic levelling (10 weeks).

The School has also an advanced photogrammetry programme at the level of third-year college engineering, encompassing the theory and practice of photogrammetric engineering as applied to surveying and mapping.

The United States Naval Oceanographic Office (NAVOCEANO) has two courses suited for junior naval officers, warrant officers and civilians of allied nations: (*a*) a series of courses in hydrographic engineering and basic oceanography, with a duration of 24 weeks; and (*b*) a series of courses concerning basic oceanography and applied oceanography, also of a 24-week duration.

These two series of courses can be taken consecutively. In that case, the duration of the oceanography course would be of 16 weeks only, since basic oceanography is common to the two series.

Table 3. Specialized courses offered at Cartographic School of Inter-American Geodetic Survey

Course	*Duration (weeks)*
Map compilation and photogrammetric editing	5
Basic cartography	16
Advanced cartography	16
Map-editing and colour separation	5
Basic photogrammetry	16
Aerial triangulation	16
Supplemental map control	16
Geodetic computations	16
Field classification of aerial photography	8
Precise electronic traverse	16

Special courses are arranged from time to time on two subjects: geodetic triangulation (12 weeks); and geodetic levelling (10 weeks).

The Cartographic Training Section of NAVOCEANO also has a six-week training course for cartographic draftsmen. Foreign trainees from countries receiving military assistance from the United States are accepted.

The National Aeronautics and Space Administration (NASA) of the United States organizes, from time to time, courses for the exploitation of space photography and satellite multispectral imagery in order to permit all countries to share the benefit from the earth resources technology satellite programme. A one-month workshop programme was being considered to be held in May or June 1973 at the EROS Data Center.[11]

At many universities of the United States of America, surveying and mapping subjects are traditionally a part of the civil engineering curriculum; and, in some instances, are offered to students majoring in geography. Recently, a few universities have introduced courses leading to degrees in surveying and mapping subjects, such as geodesy, photogrammetry and cartography.[12]

Ohio State University at Columbus, Ohio, established the Department of Geodetic Sciences, which constituted a recognition within the university structure that geodetic science is one of the basic disciplines. The regular programmes offered include the following:

(*a*) A four-year undergraduate programme leading to the degree of Bachelor of Science with a major in geodetic science;

(*b*) A programme leading to the degree of Master of Science in geodetic science. The candidate to this course will be expected to show proficiency in several areas of geodetic science, including geodesy, geodetic astromony, photogrammetry, adjustment computation, physical geodesy and electronic surveying;

(*c*) A programme leading to the degree of Doctor of Philosophy. The candidate must be proficient in all areas of geodetic science. To demonstrate his comprehension, he will be required to pass a general examination covering the basic principles in the entire field of geodetic science. The areas of research activities include physical geodesy, photogrammetry, electronic surveying, geodetic astronomy and navigation.

The International Student Office of the University provides information for students outside the United States of America.

The University of Illinois, at Urbana, Illinois, under its civil engineering curriculum, also offers three programmes leading to three academic degrees, with particular emphasis on the programme in photogrammetry and geodetic engineering, which is one of the four areas of specialization in the curriculum.

The undergraduate study is a four-year programme. The courses in photogrammetric and geodetic engineering included in the approved list of technical electives are: control surveying; adjustment of observations; electronic distance-measurement; analytical photogrammetry; observational astronomy; photogrammetric engineering; geodetic engineering.

The photogrammetric and geodetic engineering programme for the Master of Science degree and for that of Doctor of Philosophy in engineering included in the graduate studies are the same courses mentioned above. For this programme, the candidate's bachelor's degree does not necessarily have to be in civil engineering, as long as his undergraduate studies are appropriate to advanced work in photogrammetric and geodetic engineering.

In 1972, Purdue University, at Lafayette, Indiana, began offering a new four-year programme leading to the degree of Bachelor of Science in land surveying. This is the first such programme in the United States devoted entirely to the profession of land surveying. It is administered under the School of Civil Engineering, with a limited enrolment of 25 students per class.

After two years of basic courses in general and related sciences, the students proceed with other courses, including engineering survey, hydraulics, hydrology and drainage, roads and streets, land survey system, property surveys and description, geodetic surveying, engineering astronomy, cartographic surveying, photogrammetry and photo-interpretation, legal aspects of surveying, geometrical data adjustment, urban planning, legal aspects in engineering practice, subdivision planning and design, summer surveying field projects (four weeks). It is essentially a non-engineering degree programme, bearing enough relationship to several engineering subjects to allow application to subdivision land development in an urban practice.

Advanced graduate studies and research in surveying, mapping, geodesy, photogrammetry and aerial photo-interpretation have been offered during the past seven years. Twenty graduate students can be enrolled each year in programmes leading to the Master's degree or to that of Doctor of Philosophy.

George Washington University, at Washington, D.C., through its Department of Geography, offers a geodetic and cartographic science programme leading to the degree of Bachelor of Science in geodetic and cartographic science; about one third of the time is devoted to theoretical courses in cartography and practical cartographic exercises. Some short courses are also offered.

Several universities, in their Departments of Geography, offer study programmes for undergraduate and graduate students, including intensive courses on cartographic preparation subjects leading, respectively, to the Bachelor of Arts, Master of Arts and Doctor of Philosophy degrees. Some of these universities are listed below:

(*a*) University of California, Davis, California: degree of Bachelor of Arts in geography;

(*b*) University of Kansas, Lawrence, Kansas: degrees of Bachelor of Arts, Master of Arts and Doctor of Philosophy in geography with cartographic specialization;

(*c*) University of Washington, Seattle, Washington: degrees of Bachelor of Arts in geography, and Master of Arts and Doctor of Philosophy with a minor in cartography;

(*d*) University of Wisconsin, Madison, Wisconsin: degrees of Bachelor of Arts, Master of Arts and Doctor of Philosophy in geography;

(*e*) University of Hawaii, Honolulu: the Department of Geosciences has a programme of graduate studies in geodesy leading to the degree of Master of Science.

[11] The address of the EROS Data Center is 10th and Dakota Avenue, Sioux Falls, South Dakota 57198, United States of America.

[12] With respect to the possibility of fellowships and other related information for foreign students to study in the United States of America, the following publications, in addition to programmes of the United Nations Development Programme and the programme of the United States Agency for International Development, may be helpful: Institute for International Education, *Handbook on International Study for Foreign Nationals* and *Graduate Study in the United States* (address: 809 United Nations Plaza, New York, N.Y. 10017); and Russell Sage Foundation, *Foundations Directory* (address: 505 Park Avenue, New York, N.Y.)

ANNEX I

United Nations seminars and pilot courses dealing with surveying and mapping subjects

United Nations Seminar on Cartography for Economic Development held at Teheran, Iran, 1957, for Iran and neighbouring countries

United Nations Seminar on Aerial Survey Methods and Equipment, held at Bangkok, Thailand, 1961, for the region covered by the United Nations Economic Commission for Asia and the Far East (ECAFE)

United Nations pilot courses on photo-interpretation and airborne geophysical surveys, held at Bangkok, Thailand, 1961, for the ECAFE region

United Nations Interregional Seminar on Application of Cartography for Economic Development. Two such seminars were held in Denmark: the first at Elsinore in 1965; and the second at Humlaeback in 1967. Study tours in the surveying and mapping establishments of countries in the region were also organized as post-seminar activities (in Belgium, Denmark, the Federal Republic of Germany, Italy and Switzerland)

United Nations Seminar on Photogrammetry, held at Milan, Italy, 1965, in conjunction with the study tour mentioned above

United Nations pilot course on photo-processing, held at Khartoum, Sudan, 1968, for the region covered by the United Nations Economic Commission for Africa (ECA)

United Nations Seminar on Cadastre, held at Addis Ababa, 1970, for the ECA region

United Nations Interregional Seminar on Photogrammetric Techniques, held at Zurich, Switzerland, 1971

Plans for two interregional seminars are being considered by the United Nations, one on cadastral surveying in 1974 and the other on photogrammetric techniques in 1975

ANNEX II

Subject-matter for which United Nations technical experts have been made available on request to some countries to help in the training of local staff in their respective national surveying and mapping agencies

Some receiving countries are given in parentheses:

Geodesy (Afghanistan, Ivory Coast, Pakistan Sudan)

Photo-processing (Mali, Senegal, Somalia)

Photogrammetry (Afghanistan, Colombia, Congo, India, Iran, Pakistan, Republic of Viet-Nam, Saudi Arabia, Somalia, Sri Lanka, Uruguay)

Topography (Afghanistan, Burundi, Democratic Yemen, Iran, Laos, Somalia, the Sudan)

Hydrography (Fiji, Khmer Republic, Madagascar)

Cartography (Afghanistan, Cameroon, Somalia)

Draftsman (Jamaica, Zambia)

Cadastral survey (Laos, Liberia, Seychelle Islands, Turkey)

Map reproduction (India, Jamaica, Philippines)

Orthophoto maps (India)

Space imagery (India)

AUSTRALIAN AWARDS TO FOREIGN TRAINEES*

Paper presented by Australia

The Australian Department of Foreign Affairs is responsible for the co-ordination of the technical aid given by the Australian Government, including Government-sponsored training awards offered to other countries. It is the official channel of communication with them. The Colombo Plan, the Special Commonwealth African Assistance Plan, the South Pacific Aid Programme and the Australian International Awards Scheme are administered by the Department of Foreign Affairs.

Colombo Plan

The Colombo Plan is one of several schemes of international co-operation which are helping to fill the gaps in the resources of many countries and to speed up the pace of development. Under the Colombo Plan, assistance is given only when the Government of a member country asks for it, by direct negotiations between the two Governments concerned.

Colombo Plan assistance is of two kinds: capital aid under which donor Governments provide grants and loans for national development projects, for commodities including food grains, fertilizers and consumer goods and specialized equipment; technical assistance, under which donor Governments provide the services of experts and technicians, technical and educational equipment and facilities for study for trainees. During the past 22 years, a large number of trainees have studied in overseas countries. By April 1972, Australia had trained over 11,000 people under the Colombo Plan.

Special Commonwealth African Assistance Plan

The Special Commonwealth African Assistance Plan was originated by the Commonwealth Prime Ministers Conference in May 1960. The Plan has as its objective to provide bilateral technical assistance in the form of training, experts and equipment to help in the development of African countries, including Botswana, the Gambia, Ghana, Kenya, Lesotho, Malawi, Mauritius, Nigeria, Sierra Leone, the Sudan, Swaziland, Uganda, the United Republic of Tanzania and Zambia. Training is offered in Australia for up to approximately 100 students at any one time.

Australian South Pacific Aid Programme

The Australian South Pacific Aid Programme was introduced in November 1965, to assist the countries and territories of the South Pacific. At the request of the recipient Government, the Australian Government may provide specialized training in Australia, or in Papua New Guinea; it may offer the services of Australian experts, or technical equipment for trade training, agricultural projects and research.

*The original text of this paper, prepared by B. P. Lambert, Director of National Mapping, Department of Minerals and Energy, Canberra, Australia, appeared as document E/CONF.62/L.2 and Add. 1.

Australian International Awards Scheme

The Australian International Awards Scheme was introduced in 1957. It replaced a smaller scholarship scheme under which the Australian Government had been offering training awards to countries in South-East Asia since 1948. The Awards Scheme provides for the offer of about 12 scholarships and fellowships each y to developing countries which are not included in otl aid schemes. Particular attention is paid to the needs Commonwealth countries which are approaching have recently attained independence, particularly th not provided for under other aid programmes.

Australia: tertiary-level courses in surveying and cartography

Teaching institution	*Course*	*Level*	*Duration (years)*	*Entry*
University of Sydney	Diploma in surveying science	Post-graduate	1	Appropriate professional qualifications
	Diploma in photogrammetry	Post-graduate	1	Appropriate professional qualifications
University of New South Wales	Bachelor's Degree in surveying	Undergraduate	4	Matriculation
	Master's Degree in surveying	Post-graduate	1	Appropriate first degree
	Master's Degree in surveying science	Post-graduate	1	Appropriate first degree
University of Newcastle	Bachelor's Degree in surveying	Undergraduate	4	Matriculation
University of Queensland	Bachelor's Degree in surveying	Undergraduate	4	Matriculation
	Master's Degree in surveying	Post-graduate	1	Appropriate first degree
South Australian Institute of Technology	Diploma of technology (surveying)	Undergraduate	3	Matriculation
	Master of Technology (surveying)	Post-graduate	1	Appropriate first degree or diplo
Tasmanian College of Advanced Education	Bachelor's Degree in applied science (surveying)	Undergraduate	3	Matriculation
University of Melbourne	Bachelor's Degree in surveying	Undergraduate	4	Matriculation
	Master's Degree in surveying	Post-graduate	1	Appropriate first degree
Royal Melbourne Institute of Technology	Bachelor's Degree in applied science (surveying)	Undergraduate	3	Matriculation
	Associate diploma in surveying	Undergraduate	3	Matriculation
	Fellowship diploma in surveying	Undergraduate	4	Matriculation
	Associate diploma in cartography	Undergraduate	3	Matriculation
West Australian Institute of Technology	Bachelor's Degree in applied science (surveying)	Undergraduate	3	Matriculation
	Graduate diploma in surveying	Post-graduate	N.A.[b]	N.A.[b]

Australia: tertiary-level courses in surveying and cartography (*continued*)

Teaching institution	*Course*	*Level*	*Duration[a] (years)*	*Entry*
Canberra College of Advanced Education	Undergraduate programme in cartography	Undergraduate	3	Matriculation

[a] Full-time study.
[b] Not available.

TRAINING AND CERTIFICATION OF CARTOGRAPHIC ENGINEERS*

Paper presented by Japan

OUTLINE OF THE PROBLEMS

With the diversification of maps as media of communication of information on regions and land, as well as the increase in demand for preparation of maps and cartographic innovation, well-qualified cartographic engineers are required and training for engineers is also needed. In dealing with the increasing amount of cartographic work handled not only by the organization as inside work, but by outside contractors, the qualifications and capabilities of the engineers in the employ of the contractor must be known in advance. It is desirable to impose on the award of a contract the condition that a certain number of qualified engineers should be confirmed to be charged with the scheduled work in the organizations. In order to encourage and foster fully qualified engineers, a standard for the certification of cartographic engineers is fundamentally needed.

The International Cartographic Association has published the following works which will be helpful in standardizing and improving the training level and certification of cartographic engineers:

(*a*) A catalogue of institutions providing instruction in cartography;

(*b*) Typical syllabi of instruction for the education of cartographers;

(*c*) An international bibliography for education in cartography (published through the Comité français de cartographie);

(*d*) An international multilingual cartographic manual.

PROFESSIONAL EDUCATION AND CERTIFICATION OF CARTOGRAPHIC ENGINEERS IN JAPAN

The education of cartographic engineers in Japan is divided into two categories: one conducted by private training institutions intended for secondary-school graduates; and one attached to the governmental organizations for cartography, intended for the same graduates. In both types of training, the first year is scheduled for the study of surveying and general cartography, and the next half-year or full year for specialized professional practices, including actual work. In the governmental educational programmes, the latter part of the training is conducted as on-the-job training. Those who have completed the first year of training are eligible for the post of assistant surveyor, which is equivalent to the primary level of qualification of surveying engineers.

As for the certification of cartographic engineers, the certification test, together with a short course intended for cartographers of private organizations, has been conducted by the Japanese Surveyor's Association since 1960.

This certification is required as the qualification of engineers in the employ of private organizations which are awarded contracts by governmental cartographic organizations.

The format of the test was revised in January 1972, and it currently is as follows:

I. *Cartographic compilation*

Category A: compilation planning (including process management); design of specifications and map projection; arts of compilation; compilation of basic map and its application; quality of map compilation practice;

Category B: map projections (calculation of tables and plotting graticules); map specifications; selection and evaluation of map data, generalization technique; map representation; theory and practice of layout;

II. *Map-drafting*

Category A: theory of drafting; process management; theory and practice of plane feature symbols; contours and letterings;

Category B: arts of drafting; practice on plane feature symbols, contours and letterings.

Qualifications of applicants

The qualifications required of applicants are as follows:

I. *Cartographic compilation*

Category A: Applicants should be eligible at least for the level of assistant surveyor and be certified for all the in category B;

Category B: applicants should be eligible at least for the level of assistant surveyor and be certified for the theoretical subjects and at least one practical subject.

*The original text of this paper, prepared by Kei Kanazawa, Geographical Division, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.62/L.21.

Those who are approved to be equivalently qualified to meet the above-mentioned requirements are given special consideration.

II. *Map-drafting*

Category A: applicants should be those who have had at least two years of practical experience after passing the examination for category B, map-drafting, or passing the examination in all the subjects of the certification test (excluding map compilation);

Category B: applicants should be those who have had at least one year of practical experience in map-drafting.

As a transitional treatment of the institutional chang those who have passed the former certification test drafting are eligible for the category of map-draftin Those who are assistant surveyors with certificates cartographic specialized technique courses which we conducted up to 1970 are eligible for category B of m compilation.

As of March 1973, the number of registered perso with those certifications was as follows: category B map compilation, 37; category B of map-drafting, 13

No registration has been made with respect to ca gory A in both cartographic compilation and ma drafting.

AGENDA ITEM 10

Small-scale mapping

APPLICATION OF TECHNIQUES IN AUTOMATED CARTOGRAPHY*

Paper presented by Australia

In Australia, the Division of National Mapping and the Department of Engineering Physics have been working jointly on two projects which are relatively inexpensive and easy to implement, yet which have important implications in the field of automated cartography. These two projects are the use of a simple digitizer to record data for a thematic-mapping data bank and a scanning technique for changing map projections. A third project on automated typesetting has been undertaken separately by the Division of National Mapping.

One objective in these projects has been to minimize investment in specialized hardware; some is extremely expensive, and it easily becomes out of date. Inexpensive and simple hardware, when suitably programmed, can achieve valuable economies in map production.

The first item developed was a "string" digitizer, which has been used as an interactive device for recording and editing data in the thematic-mapping data banks. The second item developed was a photo-scanning head, which fits in the pen carriage of a conventional *X-Y* drum plotter. It can scan maps which can then be redrawn on a different projection and at a different scale, saving much time.

In the third project, a gazetteer of Papua New Guinea has been merged with computer files of population, schools, hospitals, police-stations, etc. A series of computer programmes has been written to extract the place names in any given rectangular area; and, according to the attributes associated with each name, to list a probable type style and point size to be used for typesetting. After the draftsman has verified and corrected the computer listing, a magnetic tape is produced of the names, style and point size. The Division of National Mapping has access through the Australian Government Printer to an automatic typesetting-machine which is capable of producing the names on film directly from this tape. The name overlay is then produced in the usual manner. The main advantages of this system are the rapid classification of name, type style and point size, and the great reduction in draftsmen's time.

A THEMATIC-MAPPING DATA BANK

The objective of the thematic-mapping project was to produce automatically a compilation suited for fair-drawing. Many data are already stored in computer-readable files; for example, the population census is stored on magnetic tape. These data can be "married" to a computer file containing geographical locations of the collection areas to produce compilations of population dot distribution maps. Draftsmen may still have to verify or edit certain aspects of the output, but savings of up to 90 per cent in compilation time can be obtained. In many instances, the computer plot can be used to produce a guide image for scribing.

If the data bank is stored in a form suited for updating and editing, then up-to-date compilations can be prepared quickly, which is valuable if new editions of the same map are published periodically.

Census mapping

The activities of the Census Mapping Section of the Division of National Mapping were examined, and a data bank of the census regions of the Northern Territory was established to test the practicability of automating statistical map production. A population census is taken in Australia every five years. In 1971, there were 22,000 collectors districts (CD). Each collector required a map of his area, and the 22,000 maps were aggregated on to 3,000 sheets which form the permanent record of the geographical location of the data collection. A unique coding system exists for each CD, consisting of four numbers: the state; the local government area (LGA); the local government area part (LGAP); and the CD, e.g., 03-172-02-12.

A LGAP is a region consisting of between 10 and 20 adjacent CDs, which is the responsibility of an area manager or supervisor during the census. LGAs with small populations may contain only one LGAP.

A CD usually consists of about 100 families or 500 people and can vary in size from one tall building in Sydney to one third of Western Australia. The scales of the maps to be digitized vary from 1:1,000 to 1:2,000,000.

Mapping takes place both before and after a census. Pre-census mapping, known as field mapping, is concerned with the design of CDs and the production of maps for field collectors and area supervisors, and for record purposes. Each map shows CDs, LGAPs and LGAs. A typical field map and the inexpensive "string" digitizer used in this project are shown in figure 132.

Post-census mapping displays the information obtained by the census. Apart from the publication of a

*The original text of this paper, prepared by the Division of National Mapping, Department of Minerals and Energy; and Department of Engineering Physics, Australian National University, Australia, appeared as document E/CONF.62/L.44.

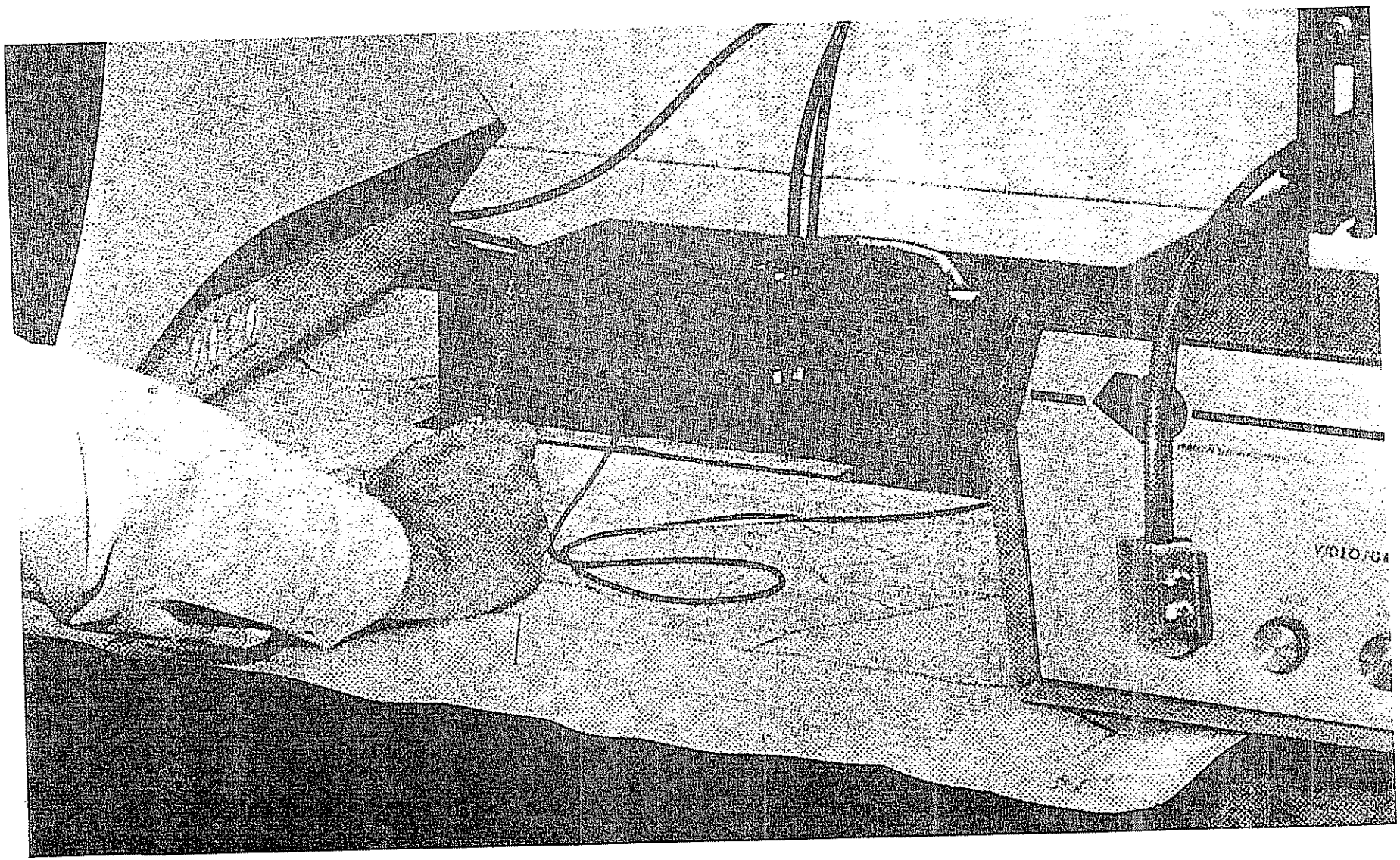


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Figure 132. Australia: digitizing a census map

series of maps showing the data collection boundaries in urban areas immediately after the census, population distribution, population density and other statistical maps are prepared. Base maps showing LGA and LGAP boundaries within Australia must first be prepared and kept up to date. They are commonly used as base maps for many other thematic maps produced by the Division of National Mapping for client departments and for the Atlas of Australian Resources.

The programming and testing of the thematic data bank has been performed on the PDP-15 computer and its associated peripherals in the Department of Engineering Physics at the Australian National University.

Co-ordinate system

Geographical co-ordinates were preferred to grid co-ordinate values, because the thematic maps produced by the Division are on various map projections and geographical co-ordinates can be readily converted from one projection to another.

Digitizing procedure

The input system has been designed around a single LGAP, which covers a map area about the size of the working area of the digitizer. An average LGAP contains about 50 boundaries. An operator can digitize this number of boundaries efficiently in about one hour, without omissions or recourse to more than one time-consuming plot. The programme allows the operator to obtain visual verification of his input at any stage on the plotter or graphic display. Sufficient data storage for a LGAP is available in the core memory of the PDP-15. A combination of disc and core storage will be used in a production system being developed when several digitizers will operate simultaneously.

Adjustment of junction points

One of the consequences of digitizing boundary data from a series of maps at various scales is that, at first, lines which should meet at a single point fail to do so. A feature of the programmes written for this project is that at the time of data-editing, the operator can call into core memory from disc all boundaries inside a given region and compute a weighted mean of the co-ordinates of the end points. The boundary segments will then all plot out neatly, without any overlapping. It is esential to adjust the junction point co-ordinates before computing any areas or joining CD boundary segments together to form LGAP or LGA boundaries.

Answering of questions

The answering of geographically based questions is simplified by storing the extremities and a centre-point value along with each collection of boundaries encompassing a CD. If a geographical question can be broken into a string of straight lines and arcs of a circle, it is a simple matter to decide if a particular CD falls within that region. Question-answering is not, however the main objective of these projects; and the development of intricate area intersection algorithms is not currently justified.

The time interval between a census and the publication of maps showing the information obtained will be reduced by using the thematic-mapping data bank. Valuable experience was gained by digitizing the census maps of the Northern Territory, and that small project clearly demonstrated the benefits of this type of approach to automated cartography. The Division of National Mapping plans to instal a special computer facility for this work early in 1974 and to begin digitizing immediately for the 1976 census.

Automation of map projection change

A new projection of an existing small-scale map is sometimes required, in which case it is usually easier to transform an existing map to the new projection than to compile afresh from raw data. The transformation distorts the original map non-linearly. The usual method of achieving the required transformation is to overlay the original with a graticule of lines of latitude, and longitude, and the individual "tiles" so formed are linearly distorted by a graphical process of iterative adjustment until they fit a corresponding graticule drawn in the new projection. The tile size has to be chosen so that the errors introduced by linear distortion of each tile are insignificant.

The manual technique described is slow and requires great care if the precision of the original map is to be maintained. The mathematical formulae involved in changing projection are well known. An automated system has been developed which uses a digital computer to transform detail from one projection to another by scanning the input material, storing the locations of black points and plotting these points in the new projection. The plotted output is used to prepare a guide image suited for scribing. A projection change task being undertaken by the Division of National Mapping was used as an example in the development of this system, which has been implemented on the Department of Engineering Physic's PDP-15 computer installation.

This task involved conversion and assembly of a set of International Map of the World (IMW) series maps, on the Lambert conformal projection on the scale 1:1,000,000, into a four-sheet map of Australia on the simple conic projection on the scale 1:2,500,000. Each IMW map covers 4° in latitude by 6° in longitude and is photographically reduced to 1:2,500,000 before processing. The IMW map information consists of four overlays: contours; drainage net and coastlines; roads; and railways with town centres. The distortion between the two projections ranges up to 8 per cent in longitude but less that 1 per cent in latitude.

Scanning

A picture scanner has been constructed by replacing the pen assembly of a Calcomp drum plotter with a scanning head see figure 133. The plotter drum is only 25 cm wide and the IMW overlays have to be processed in two 4° × 3° sections of about 19 cm by 13 cm. One of these sections is aligned with respect to previously plotted positioning crosses and is fastened to the plotter drum. The scanning head is moved across the overlay section using the Lambert conformal projection equations to drive the head along meridians of longitude. The grey levels of points along each scan line are examined, and the locations of black points are stored on disc in terms of the scan line number and the position in that line. The spacing between points along the scan line is 0.125 mm. The spacing between successive scan lines can be varied according to the nature of the overlay being scanned—a spacing of 0.25 mm may be required for the contour overlays, but 0.35 mm is usually adequate for

CALCOMP
2843.133 X

the road and railway overlays. With a scan line spacing of 0.25 mm, a 4° × 3° section takes about 50 minutes to scan, including the time required to write the locations of the black points on disc.

Plotting

The scanning head is replaced by a 0.1-mm pen, and a strip of acetate film is fastened to the plotter drum. The simplest method of plotting is to read the locations of black points from the disc, in the order stored during scanning, to convert the line and point numbers into latitudes and longitudes, and thence, by way of the simple conic equations, into plotter co-ordinates. The points are plotted out individually. This simple method of plotting takes up to 1¼ hours for a 4° × 3° section, and the continual lowering and raising of the pen leads to an excessive ink flow.

These problems have been overcome by writing routines which attempt to plot the points along lines in the original overlay, leaving the pen down between adjacent points. These routines plot connected sets of points by searching for adjacent black points as each point is plotted. There is only space for about 90 scan lines, each 4° deep, in the core memory of the PDP-15 computer, even when the scanned elements are represented by single bits. Plotting is therefore performed in several strips across the map. The output phase is completed by superimposing a graticule on the plotted points, to assist in relating overlays to each other.

A dramatic improvement in output time results from plotting connected sets of points; the time for plotting a typical 4° × 3° overlay is reduced to about 20 minutes. Including set-up time and data entry, the over-all time required to process a 4° × 3° overlay section is about 1½ hours, which compares favourably with the time required for manual techniques, especially when the limited amount of manual intervention is considered. Additional photo-detectors could be added to the scanning head so that several adjacent lines could be scanned with each traverse of the overlay. The scanning time will then be reduced from 50 minutes to perhaps only 10 minutes, thus nearly doubling the through-put.

Automated typesetting

Acquisition of data is often the most expensive item in a computer project. The Division of National Mapping was, therefore, fortunate to acquire a computer-readable file of a gazetteer of Papua New Guinea from the Department of Defence to initiate its automated-typesetting project.

In June 1972, work was begun on the design of a system, at first for the production of the 1:1,000,000 series covering Papua New Guinea, which would:

(*a*) Provide draftsmen with a print-out of all names falling within any map area;

(*b*) Give an indication of the type style and point size that should be used;

(*c*) Accept amendments;

(*d*) Produce a magnetic tape of the amended information suited for input to an automatic typesetting-machine, including codes for font, point size and capitalization.

Structure of the master file

The file, when received, contained over 26,000 entries, consisting of a reference number, the name, its source, a classification code, district and subdistrict codes; and, where available, map co-ordinates in latitude and longitude, census division number, population and date.

All entries on the master file are grouped into administrative areas, known as districts, and then subdivided into subdistricts. Each name is listed alphabetically within a subdistrict. This structure has two advantages: first, by using district and subdistrict names as a key, time is saved in locating particular names; secondly, the alphabetical listing is convenient for the draftsmen.

In the Papua New Guinea file, names are listed many times, once for each attribute. For example, Port Moresby has separate entries for populated place, airfield, harbour, district headquarters and so on. It is these attributes which gauge the importance of a place, and are used to select the font, point size and case.

Processing the master file

Programmes have been written to: (*a*) extract names falling within any specified area; (*b*) classify names by type font, point size and case; (*c*) correct, delete or add information to the file.

Extraction

Most maps produced by the Division of National Mapping have sheet lines defined by latitude and longitude, and the programme therefore lists all names between given latitude and longitude limits. In addition, in Papua New Guinea, it has been possible to minimize search time by specifying the districts and subdistricts falling within these geographical limits.

Classification

There are over 60 different classifications in the master file. Most classifications require a single point size and case. The Division of National Mapping has also adopted the Univers font as the standard type for the majority of its maps. However, populated places, rivers and mountains need a variety of point size and case to depict their relevant importance.

The importance of a populated place in Papua New Guinea is governed by the following attributes: population; communications; administrative importance. The population tends to determine the other two; however, a scheme was devised to account for the exceptions. The population was broken into groups: 0–200; 200–1,000; 1,000–5,000; 5,000–10,000; 10,000–50,000; and over 50,000. A weight was assigned to each. Weights were also assigned to communications, such as airfields and harbours; and to administrative headquarters, such as district headquarters, subdistrict headquarters, base camps and patrol posts. A programme was written to search the file for identical names whose co-ordinates were within a 5-minute square. It then assigned weights to each attribute, and the sum of these weights determined the point size and case to be used.

The importance of rivers in Papua New Guinea can also be measured by assigning weights to their hierarchical structure. Rivers entering an ocean may be assigned a weight of 10, and decreasing weights assigned to lesser streams. A distance function is added to the weights so that the point size will decrease in proportion to a name's

distance from the mouth and the number of "branches" from the ocean.

The importance of mountains can be judged in a similar manner by using height relative to surrounding relief and an area function.

These latter two classifications have not yet been fully developed by the Division of National Mapping, but it is planned to implement them towards the end of 1973.

The system

At the compilation stage of a map, the draftsman nominates the geographical co-ordinates of its area together with the district names falling within it. From this information, the programmes mentioned above retrieve all names falling within this area, select the appropriate font, point size and case; and provide simultaneously an alphabetical print-out and magnetic tape for the map area. The print-out is then checked by the draftsmen; and corrections, additions and deletions are fed back to both the master file and the map area tape. Any special type requirements for this particular map are only fed back to the map area tape. This tape is then run directly on an automatic typesetting-machine which provides film copy of the names. The map name overlay is then prepared in the normal manner.

The system being developed does not pretend to solve all the problems in the selection, classification and setting of type. It does, however do the following: (*a*) reduce type listing to corrections, deletions and addi tions; (*b*) reduce checking by half; (*c*) help the draftsme classify and select names.

Conclusion

These three projects demonstrate that by an appropri ate division of labour between man and computer substantial improvements over conventional manua methods can be achieved. The investment in compute hardware is not great, and the total programme develop ment time for all three projects has so far been less tha 18 man-months.

Three phases of map production have been examine and computer-oriented systems developed to help drafts men carry out their tasks.[1] The systems recognize tha the computer is better at repetitive operations, dat storage, retrieval and calculation, while the draftsman i superior in aesthetics and judgement. The automate systems can easily be introduced into a drawing office a they parallel the existing manual methods. Draftsme can operate the digitizers and photo-scanner, and extrac names from the gazetteer with little special training.

[1] For a detailed report of these automated techniques, see J. (Fryer, D. R. Smith and I. D. G. Macleod, "A rational approach t automated cartography", technical report No. 16, Division of Nation Mapping, Department of Minerals and Energy; and technical repo No. 36, Department of Engineering Physics, Australian Nation University.

SOME ASPECTS OF SMALL-SCALE MAPPING IN THE DIVISION OF NATIONAL MAPPING, 1970-1973*

Paper presented by Australia

The Division of National Mapping of the Department of Minerals and Energy is responsible for the production of World Aeronautical Charts (WACs) for the Department of Civil Aviation (DCA) at 1:1,000,000 scale covering the mainland of Australia and adjacent islands, including Papua New Guinea.

The Division of National Mapping compiles, fair-draws and prepares reproduction material (including machine plates) for each chart for printing by the Commonwealth Government Printer. Quality control of the final map is maintained by supplying, with the machine plates, detailed map-printing instructions, including strict colour controls. The method used is described below in the section dealing with colour control in printing World Aeronautical Charts.

In addition to the WACs produced to standards of the International Civil Aviation Organization (ICAO), the Department of Civil Aviation has a need for charts at a larger scale for use by pilots when approaching airports. These new Visual Terminal Charts (VTCs) at 1:250,000 scale also are described below.

All charts are continually revised. VTCs are updated and reprinted every eight months. WACs have a major revision cycle of from three to four years, with reprints (including minor revision) in between if required.

Information for these revisions is obtained from the most recent larger scale map coverage in Australia, supplemented by up-to-date information from agencie and departments involved in communications, develop ment projects etc. Another valuable source of ne material is the map correction reports sent in by cor scientious users of charts on the ground and in the air.

These sources do not always include new informatio such as cultural feature changes due to rapid develop ment of new roads, railways, mining projects, wate conservation, urban and suburban growth etc. Thes changes can be readily detected from the air, and office of the Division carry out regular visual inspection fligh of areas being mapped, in conjunction with the Depar ment of Civil Aviation Special Flying Unit, as describe below in the section on aerial inspections of aeronautic charts.

Colour control during printing of World Aeronautical Charts

One of the problems associated with the production a standard map series has been the maintenance specified colours during printing. In the past, colou were selected and specified in map specifications ar map-printing instructions, but it was always left to th printer to mix his colours to a formula and to mainta his colour strengths during the complete printing run.

The system adopted by the Division for colour stan ardization is the Pantone Matching System (PMS). Th system comprises 500 ink colours that can be matche from 10 basic inks. The sample colours are available coated and uncoated paper. The key formula on ea

*The original text of this paper, prepared by the Division of National Mapping, Department of Minerals and Energy, ACT, Australia, appeared as document E/CONF.62/L.80.

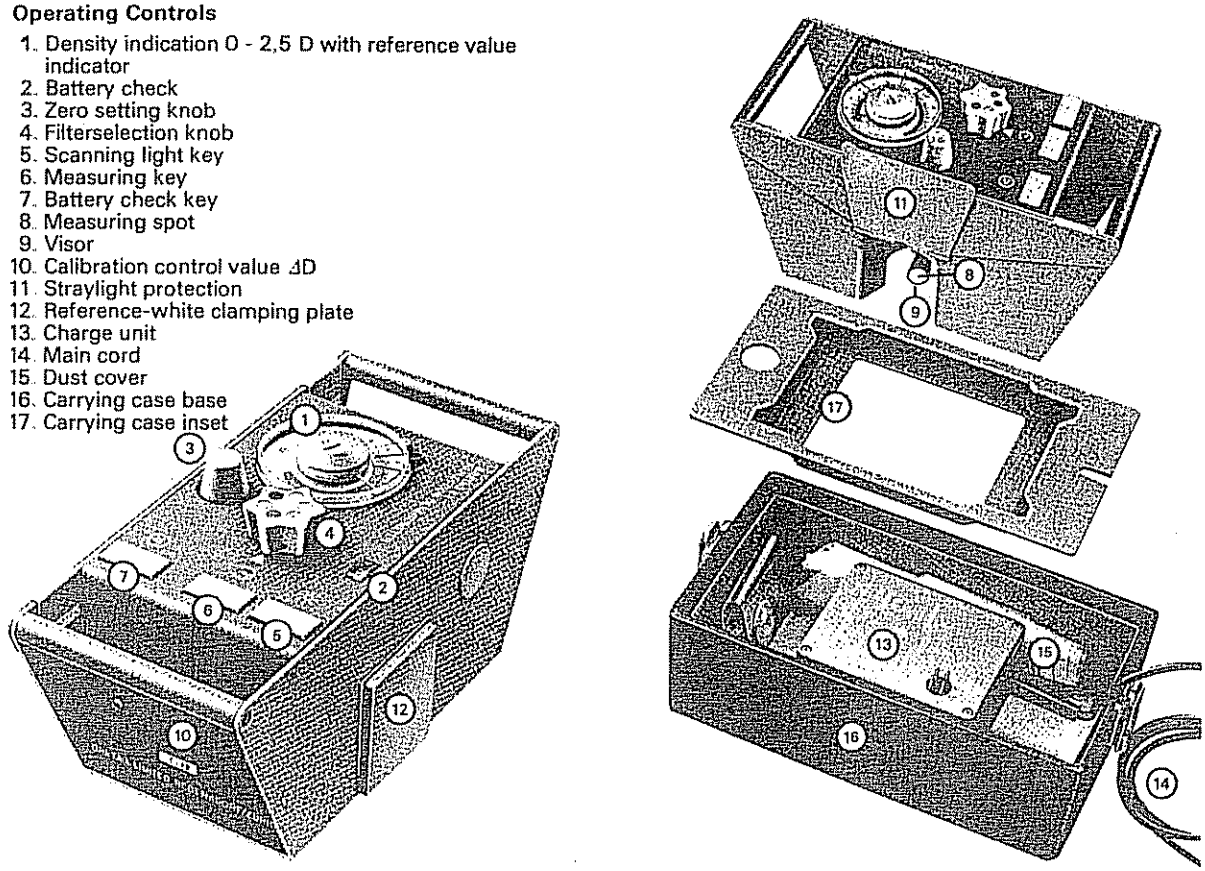
sample gives the exact proportion of various printing-inks required to achieve that particular colour.

But specification of colour-mix by itself is not sufficient to provide accurate colour control. The amount of ink applied to the printed image can cause wide variations in the final shade. This shading can only be controlled by testing colour patches on maps run on the printing-press. For this purpose, the Division uses a GRETAG D1 portable reflection densitometer (see figure 134).

Figure 134 also shows the colour-control strip which is printed on the trailing edge of the paper outside the trim marks. Each panel in the strip gives a printed image for the checking of line, half-tone and solid in each printing colour. These panels are repeated across the full width of the paper.

Operating Controls

1. Density indication 0 - 2,5 D with reference value indicator
2. Battery check
3. Zero setting knob
4. Filterselection knob
5. Scanning light key
6. Measuring key
7. Battery check key
8. Measuring spot
9. Visor
10. Calibration control value ΔD
11. Straylight protection
12. Reference-white clamping plate
13. Charge unit
14. Main cord
15. Dust cover
16. Carrying case base
17. Carrying case inset



COLOUR CONTROL STRIP



1 Circle and dot to detect roller pressures or "squash-out"

2 Halftone to detect sharpness of dot pattern

3 Solid for control of ink density by densitometer readings

Figure 134. Australia: GRETAG D1 colour reflection Densitometer

The Densitometer is placed on the litho-image of each control strip panel so that the coloured area to be tested is in the centre of a projected spot of light projected at 45°. Part of the light is reflected into the instrument, and the reading on the photo-detector records the degree of light absorption by the sample.

Test printings for a map or map series are made by the Division on a small offset press before final printing. When the desired result is obtained, Densitometer readings of the test printing are taken. These readings are included in the map specifications and map-printing instructions which are sent to the Government Printer with the reproduction material.

The machine room at the Goverment Printing Office is equipped with a GRETAG Densitometer identical to the model used by the Division. Both machines are periodically checked to ensure that there shall be no calibration differences, thereby enabling the printer to check the colour on the certification copies and subsequent copies selected at random during the printing-run.

A typical example of part of a map-printing instruction covering colour specifications for World Aeronautical Charts is given below.

Colour specifications

Plate/film pos No.	*Printing colour*	*PMS No.*	*GRETAG D1 Densitometer reading*	*Filter*[a]
1	Black	—	1.50	Black
2	Dark blue	285	1.04	Blue
3	Red	Warm red	1.08	Red
4	Dark brown	159	0.78	Red
5	Grey (relief)	423	0.44	Black
6	Yellow	101	0.40	Yellow
7	Light brown	474	0.28	Red
8	Light blue	290	0.20	Blue
9	Purple	265	0.74	Blue
10	Grey (back of chart)	401	0.20	Black

[a] Filters are specified because the Densitometer is equipped with four filters, each with a different zero setting.

VISUAL TERMINAL CHARTS AT 1:250,000 SCALE

Development

With the significant increase in Australian general aviation (i.e., private, business and general flying other than airline operations and military aviation) over the past 10 years, there has been predictable demand for maps and documents designed to make flight easier and safer for this large part of the Australian aviation industry.

One of the most insistent demands has been for visual approach charts covering areas around primary and international airports and those airports which are centres of general aviation activity. Such a chart needed to show in some detail the topography of an area of about 60 nautical miles around an airport, plus the details of the airspace and aeronautical facilities and services in the area. These details would materially assist general aviation pilots (particularly those limited to flying by visual methods) in their navigation and enable them to observe the conditions of entry into and flight within the various areas of controlled airspace, as well as warning them of restricted and danger areas. The incidence of general aviation pilots straying into or entering controlled airspace without obtaining a clearance to do so was serious enough to warrant the production of such charts.

The Department of Civil Aviation in association with the Division of National Mapping designed a chart which would meet these requirements, both in topography and in aeronautical information. Specifications for the topography are basically similar to the ICAO requirement for the WAC charts, showing roads, railways, lakes, rivers, towns and built-up areas, marine lights and coastal features; and easily identifiable man-made and natural features, including contours and spot heights.

All these details are clearly named in black, and the features themselves are portrayed in specified colours.

Overlaying this topographic base is the aeronautical information showing the limits of controlled airspace, details of selected radio navigation aids likely to be of use to a visual pilot (in electric blue); details of restricted and danger areas (in red); and the outlines of all aerodromes. Selected flight routes recommended for aircraft flying under Visual Flight Rules are also shown. Details of communications facilities and selected aerodromes are included on side panels.

Twenty locations were selected for these charts, based on the importance of the airport, the air traffic congestion around it and its use by general aviation traffic. These locations are: Adelaide, Alice Springs, Brisbane, Cairns, Canberra, Coolangatta, Darwin, Hobart, Launceston, Mackay, Melbourne, Mount Isa, Perth, Port Hedland, Port Moresby, Rockhampton, Sydney, Tamworth and Townsville. Of these locations, 13 are currently (May 1973) published, and the remaining seven should be available by early 1974.

A section of the Melbourne chart and the legend panel are shown in figures 135 and 136.

Scale

The Transverse Mercator projection was chosen for the small area to be covered. The scale selected was 1:250,000. This scale is similar to that recommended by ICAO for the Visual Approach Chart, which has some relevance to the Visual Terminal Chart. An additional help in the compilation of the topographic bases of these charts was the availability of the existing Australian 1:250,000 topographic series.

The scale of 1:250,000 is sufficiently large to present a clear picture of the topography of the area selected.

Compilation

The base maps are compiled from existing 1:250,000 and 1:100,000 map coverage, generalizing the detail to show only main streams and roads, and features of visual importance. No roads are shown through the smaller built-up areas, but main arterials are shown through large metropolitan areas.

A composite print on stable-base matte film with contours on a separate clear overlay are supplied to the Department of Civil Aviation for visual checking from the air before final drawing.

Fair-drawing

Guide images are obtained from the checked compilations, and these are scribed to specifications similar to

those for the WAC series. Type styles used are larger than WAC type to improve legibility for pilots flying into busy air-space.

Features easily identified in large built-up areas are shown—drive-in theatres, golf links, race-courses, large factories with high smoke-stacks etc.

The contour interval is 1,000 ft, with the first 500 ft also shown. There is no layer tint between sea level and 500 ft. The WAC hypsometric tints are used between other intervals.

Layer tints are supplemented with relief shading in areas where relief has significant landmark value and the features cannot be shown in sufficient detail by contours.

The drawing of the aeronautical detail overlay is done by the Department of Civil Aviation.

Revision and amendment

As with all charts, periodical revision of individual charts is necessary, particularly of the continual change in aeronautical information, and less frequently with the topography. The aeronautical information is updated regularly every eight months. It is envisaged that topographic information will be revised every two years, but sooner if significant changes occur.

Amendments to these charts arise from various sources, but primarily from the head offices of the Department of Civil Aviation and from individual general aviation pilots. Great attention is always paid to suggestions from the users of these charts, and the current edition incorporates many ideas put forward since the original Adelaide visual terminal chart was published in 1969.

Distribution

Visual Terminal Charts were designed for general aviation pilots who are limited to visual flight—a very numerous group. Of each edition, 21,000 copies are printed and distributed by the Department of Civil Aviation with other documents for visual pilots on a regular basis.

AERIAL INSPECTION OF AERONAUTICAL CHARTS

The cartographer, working within the confines of his drawing-office on the preparation of aeronautical charts, has little opportunity to examine his work under map-user conditions. Many of the decisions he makes on presentation, layout and symbolization may look fine on the printed map examined on an office table, but the pilot of a light aircraft flying over some remote area in adverse flying conditions may not feel so pleased.

When the Division produced the "new format" WAC chart on which relief shading was used for the first time to supplement contours and hypsometric tints, the cartographer considered he had produced a chart more useful and aesthetically pleasing than the old chart. Admittedly, the over-all effect was good; but isolated relief features sometimes appeared as little more than grey smudges. Pilots in the remote areas of Australia used these features for visual navigation and found it easier to recognize an isolated relief feature when it was portrayed by the previous crude method using hachures. It was necessary to add more character to these isolated relief features, over-emphasizing the air-brush tints and embellishing them where necessary with line work to show escarpments, eroded crests or cliffs. The cartographer would have been unaware of the deficiencies of the new maps if the pilots using them had not taken the trouble to complain.

The cartographers are currently given an opportunity to assess the value of the maps they draw and to become aware of deficiencies by flying with the Department of Civil Aviation Flying Unit when seats are available. In the past seven years, thousands of miles have been covered over every type of terrain.

In the air, the cartographers keep a flight log of ground detail visible from both sides of the aircraft, photographing detail of particular interest with hand-held 35-mm cameras. On the ground, they discuss the charts of the area with pilots of large and small aircraft, air traffic controllers, DCA personnel and administrators of commercial air firms. Written reports of these inspection flights are submitted to the Department of Civil Aviation with recommendations on map improvements. If adopted, these recommendations are included in the cartographic instructions for future editions.

The improvements in map presentation and completeness as a result of these flights have been remarkable. It is impossible to meet the particular needs of all map users, but the requirements of most are now being satisfied. A paper presented by Australia at the Sixth United Nations Regional Cartographic Conference outlined what had been achieved by 1970 in chart improvements as a result of these flights.[1]

Further flights have been carried out over remote areas of Australia, and some additional changes have been made to chart presentation. Inspection flights have also been carried out over Papua New Guinea, and a new format has been designed to cover the requirements of the rugged tropical landscapes encountered in this part of the world.

As many countries represented at this Conference are charting terrain similar to that encountered in Papua New Guinea, this paper outlines the more important observations and recommendations made by the Division of National Mapping as a result of these visual inspection flights.

Aeronautical charting of Papua New Guinea

Papua New Guinea presents a new set of problems to the maker and user of WAC charts. The terrain is extremely rugged and is covered with dense tropical vegetation.

Because of the number of layer tints required to show terrain up to a maximum height of over 14,000 ft, background colours are heavy.

The indigenous people live mostly in small villages connected by foot-tracks, and there are few large centres of population. Roads are few, and the chief method of communication is by air. From the air, the dense jungle hides many of the land features.

The pilots' problems of navigating under Visual Flight Rules are complex—quite different from those in Australia. Many landing-strips are in deep valleys and are often obscured by cloud. The approach to these valleys is often through gaps and passes in high ranges. These gaps are well known by the local pilots, but not to

[1] "Redesign of World Aeronautical Charts for remote areas of Australia", *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.72.I.20), p. 346.

the cartographers at Canberra. Existing WACs show major peaks, but few of the gaps which are so important.

With the pilot depending so much upon chart information for navigation, the cartographer is frustrated in his attempts to produce accurate WACs by the fact that most of the existing larger scale map coverage has not been recompiled since the original, war-time maps produced during 1939–1945; and, indeed, much of the country is still unsurveyed, though this is now rapidly being undertaken.

Recommendations for charts of Papua New Guinea

Following up on a visual inspection flight of Papua New Guinea, the following recommendations were made.

Relief

It was agreed that the relief-shading methods as used in the mountainous south-eastern corner of Australia could satisfactorily portray the rugged relief of Papua New Guinea. This would help to indicate the positions of the important gaps and valleys which could not be shown satisfactorily with 1,000 ft. contour interval. Local names and heights of the gaps will be shown on the map.

Habitation

The most important habitation features are those associated with aerodromes, even though they may be only small clearings in the jungle. Small villages without a strip are of little interest to pilots and can seldom be identified.

The importance of many settlements is related more to its administrative importance than to the size of its population. A black circle filled with yellow will be used for such settlements to make them more prominent.

Drainage

Main river systems will be shown without excessiv tributary detail. This will help to define the main valle systems which are so important to the pilot in locatin an air strip in cloudy weather. Minor stresses cannot b seen in mountainous areas covered by heavy jungle, par ticularly when viewed obliquely. On the other hand every bend, main junction, island etc. in the main water course is a valuable clue to identification.

Coast

If a pilot is lost in the interior of Papua New Guine he will head for the coast—the air distance from th central point is only 160 km. Navigating visually alon the coast is easier and certainly safer than over th rugged interior. There is a wealth of features with land mark value available along the shores of Papua Ne Guinea, and the charts will show as much as possible.

Commercial activity

In the heavy rainfall areas of Papua New Guine commercial activity removes the dense jungle cover an produces landmarks which are prominent from the ai Clearings by natives for the planting of subsistence cro are of a transitory nature only, but large tea and coffe plantations are excellent landmarks and will be show whenever possible.

CONCLUSION

This paper has described some aspects of small-sca mapping in the Division of National Mapping, relatin in particular to controlling quality during printing, c tering for the needs of the map user and maintainin accuracy of base mapping. As a result, the Division, i close collaboration with the Department of Civil Avi tion, is producing and maintaining aeronautical char which have made a major contribution towards the e cellent safety records of private and commercial flyin over a wide variety of terrain in this part of the worl

CARTACTUAL—PUBLICATION ADVISING OF CHANGES CONCERNING SMALL-SCALE CARTOGRAPHY*

Paper presented by Hungary

For the map-maker, it is most important that he be quickly informed about those changes affecting map content which took place after the publication of the cartographic documents serving as bases for the compilation of his envisaged new map; and that, in this way, his sources can be updated. Cartographers most frequently would like to be informed about the changes in population numbers, new roads, reservoirs constructed, railway lines recently completed or under construction (namely, closed); and the many other changes that took place after the publication of the relevant cartographic documents.

The map-makers may obtain knowledge of some of the changes from the press; but they cannot make use of the information received, because neither the sha nor the location of the changes concerned can be cart graphically represented. Therefore, the initiative of sor cartographic and geographical journals, to give textu information on such changes, has proved to be insuf cient.

In order to keep track of such changes on a worl wide scale and to ensure their cartographic coverage, enormous volume of work, proper organization a international co-operation is necessary. In Hungary, effort has been made by means of publication of t international cartographic documentation service, *C tactual*, to carry out this important task.

This periodical was published quarterly during t period 1965–1968. Since 1969, it has appeared monthly, printed in two colours. The text of the legend printed in English, French, German and Hungarian. this bi-monthly periodical, changes are represented

*The original text of this paper, prepared by Sándor Radó and Arpád Pap-Váry, National Office of Lands and Mapping, Budapest, appeared as document E/CONF 62/L 89.

means of maps. The base map is printed in grey; the changes are shown in red. Each issue contains, on average, 40–50 maps. To date, 42 issues have been published.

The scientific level of *Cartactual* is supported by the fact that this map service publishes exclusively such information as has been obtained from primary, authentic sources; the source and date of the information are always indicated.

Since 1971, with each issue of *Cartactual* has been enclosed an annotated list, called "CARTINFORM" of the most recent important cartographic and related publications (atlases, maps, technical books), with an average of 150–200 short annotations.

The editorial board of *Cartactual* also is striving to obtain the assistance of correspondents in the major countries. In the Asian countries, there are correspondents in Japan, India, Iran and Japan. There are also correspondents in the Union of Soviet Socialist Republics. It would be desirable to augment the number of countries represented by correspondents in the work of *Cartactual*

AGENDA ITEM II*

Thematic cartography (including national atlases) and photo-interpretation

EXPERIENCE WITH AUTOMATION IN THEMATIC MAPPING**

Paper presented by the Federal Republic of Germany

DEVELOPING OF A NEW CONCEPT

In 1971, systems planning was begun in the Bundesforschungsanstalt für Landeskunde und Raumordnung (BfLR). The main results of the analysis of the current organization of BfLR are given below.

Tasks to be automated

As had been expected, the first difficulties arose with respect to the definition of automatable tasks. To develop a concept of a system for electronic data-processing (EDP), one has to have far-sighted planning of tasks. The future projects of BfLR, therefore, had to be defined to a point from which it was possible to deduct a practical concept for the EDP system. The final concept comprises the following projects:

(*a*) Setting-up and updating of a topographic information system for the federal regional planning projects;

(*b*) Setting up and updating of a problem-oriented numerical information system;

(*c*) Storing of picture information (aerial photographs);

(*d*) Setting up of an electronic information system for scientific documentation in BfLR;

(*e*) Automation of the contact or public relation records;

(*f*) Statistical methods and model-building with EDP methods;

(*g*) Automation of thematic mapping.

The automation of thematic mapping is the main task, at least during the first phase of developing the EDP system at BfLR.

The task of a system that produces maps automatically is mainly to give to the research worker an effective instrument for analysing area relations and presentation of the results. This is true not only for the applications at BfLR, but for the earth and social sciences in general. For the programme system to be developed, this means: (*a*) great flexibility in the input of data; (*b*) great flexibility in the output of the drawing; (*c*) easy handling of t system by any interested scientist.

In future, therefore, it might be possible to return t map—which is nothing but an information-trai mitting medium, comparable to the written word tables of numbers—to the hands of the scientist.

System requirements

Beginning from the catalogue of tasks describ above, the EDP system at BfLR should be able to fu the processing of alpha-numerical information, geom rical information, numerical information and pictu information.

For the processing of alpha-numerical informatic data-collecting devices, mass storage devices and fi input-output devices are necessary. In this connexic the speed of the central processor unit is less importa than the transfer times to and from peripheral stora which are limited by mechanical properties.

In the processing of geometrical data, central pr cessor unit time and transfer time should have almost t same weight in the calculations. In addition, there ha to be devices by which geometrical data can be chang into digital values and vice versa. Picture informatic that is, data gained from pictures (aerial photograpl require great amounts of central processor unit time their processing. For an interactive process, rapid centi processor units with the possibility of parallel processi of matrices are necessary.

For the tasks of BfLR, an EDP system should m the following demands:

(*a*) Acceptable speed of processing alpha-numeri data;

(*b*) Acceptable central processor unit speed;

(*c*) Sufficient core capacity (512,000 bits for a sin programme);

(*d*) Sufficient supply with peripheral storage devi (several nine-trade tape units and disc drives);

(*e*) Sufficient supply with input and output devi (fast card-reader, line-printer, alpha-numerical displ units);

(*f*) Supply with graphic input and output devices (c ordinate reader, flat-bed plotter, graphic display unit

(*g*) Analogue-digital converter for aerial phot graphs.

*The following papers relating to the present agenda item appear under the agenda items indicated: "Training and certification of cartographic engineers" (E/CONF 62/L 21), agenda item 9; "Natural environmental maps in South and South-East Asia" (E/CONF. 62/L 48), agenda item 13; "Progress report on cartographic activities in Thailand" (E/CONF.62/L.100), agenda item 6.

**The original text of this paper, prepared by H. Schäfer, Bundesforschungsanstalt für Landeskunde und Vaumordnung, Bonn, appeared as document E/CONF.62/L.11

Financial situation

An EDP system that would meet all of the above-stated demands would cost between 10 million and 20 million Deutschemarks (DM). BfLR did not have this amount and would not have been able to use a system of that size to its full capacity, at least not during the first three to five years.

Personnel situation

Considering the poor personnel situation, the setting-up of the system had to be planned so that programmes from other institutions could be implemented and used first, and that the development of their own programmes would only be undertaken if no other way was possible.

Another aspect is the training of employees in EDP, which could be done through on-the-job training or an in-service training programme.

Proposed solution

In spite of the tense personnel and financial situation of BfLR, a solution had to be found. The basic system requirements could not be abandoned, and it had to be made certain that the project would not end up in a dead-end road due to personnel and financial difficulties.

Basic strategy

The set tasks, especially the automation of thematic mapping, required a computer installation of medium or large size together with special input-output devices. To have both system components was impossible because of the lack of funds, but a way has been found which promises to solve all the problems. It has been proposed to set up the system in three phases:

(a) *Setting-up of a graphic input-output system:*

(i) In the first phase, computer time at a large installation in the Bonn area should be acquired *gratis* or by purchase. At BfLR, a graphic input-output system under the control of a small process computer was to be installed;

(ii) At the university of Bonn, there was a suitably large installation with an IBM/370-model 165 which BfLR could use. Several things favoured this installation. It was designed for scientific applications, and it could be expected that most of the programmes designed for systems in the United Kingdom and the United States of America would run without greater difficulties. Because this installation did not have any special input-output devices, a co-ordinate reader and a flat-bed plotter could be installed at BfLR. In this phase of the set-up, an effort should be made to implement as many programmes from other institutions as possible. Much attention will have to be paid during the first phase to the training of employees in EDP;

(b) *Remote data-processing.* In the second phase, it has been planned to connect the large computer by a remote data-processing line with the process control computer at BfLR. The small computer will then be a terminal for the large one;

(c) *Scientific computing centre.* In a third phase, a larger computer should be installed which can also be used by other federal offices. What this installation will look like cannot yet be defined.

System configuration

The setting-up of the cartographic system will have absolute priority. The basic equipment for thematic mapping consists of two graphic devices. A co-ordinate reader or digitizer converts the analogue data in map form to numbers (pairs of orthogonal co-ordinates) and stores these on recording media. The output of graphic data is done by steering a drawing-table by the numerical co-ordinate values.

As a rule, digitizing has been done in such a way so that the co-ordinate values from the digitizer were directly transmitted by an electronic decoder to recording media (paper tape, cards, magnetic tape). Experience in the United Kingdom and in North America showed that it was more economical to have the digitizer run under the control of a small process computer; and to have a stored programme to the different variable functions such as scaling, shifting, rotation, zeroing, etc. This system would greatly enlarge the flexibility of the data recording and would allow, at the same time, application of the checking programme and routine for the data reduction.

The small computers currently on the market can be compared in their physical volume with the read-only electronic instrument which evaluates the encoder signals of the digitizer. Considering all the additional advantages, the combination digitizer/small computer with a magnetic-tape unit appears to be the optimal solution. Through stored programme evaluation, the system will become much more flexible since there are no restrictions of a read-only electronic device. The basic map, for example, does not have to be put on the digitizer exactly in the direction of the co-ordinate axis. By just recording the point of origin and a second point on an axis before beginning, digitizing is sufficient.

For the special applications at BfLR, an on-line digitizing control is absolutely necessary, e.g., recording and consecutive updating of the different kinds of administrative border lines of the Federal Republic. The volume of cartographic information to be recorded cares for a minimum of mistakes and the manual corrections caused by them. This accuracy can only be accomplished when, during digitizing, a checking programme in the computer checks every co-ordinate being recorded.

Another aspect favours a system configuration with a small computer. In thematic cartography, there are many cases where the human ability of recognizing area structures is by far superior to the computer. The solution of such problems by computer alone and without the possibility of human manipulation would mean a tremendous and costly effort of programming. Such cases include the erasing of lines when proportional symbols are drawn or the placement of names. A trained cartographer can solve these problems with one glance at the map. Instead of foreseeing all these problems and handling them in long and complicated programmes, it is simpler to get the right placement by having the machine draw the map several times.

A faster, cheaper and more elegant way is to change the map by interactive manipulation with a light pen or "joy-stick". The resulting display can be used as a terminal and as an input-output device for alpha-numerical characters, e.g., developing and testing of programmes,

controlling the remote data processing and as input for scientific documentation purposes (see figure 137).

Conclusion

The Government of the Federal Republic of Germany defines, in its second data-processing programme, the objectives "stronger and broader application of data processing in the economy and the sciences as an instru ment of rationalization and an increase of productivity' BfLR, as a federal research institute, tries to add it share to reach these goals by establishing a capable ED system. The problems are not in the technical field, bu in the field of problem analysis and programming. It i hoped to solve these problems co-operatively, whic could lead to close and intensive co-operation betwee the research worker and the EDP specialist.

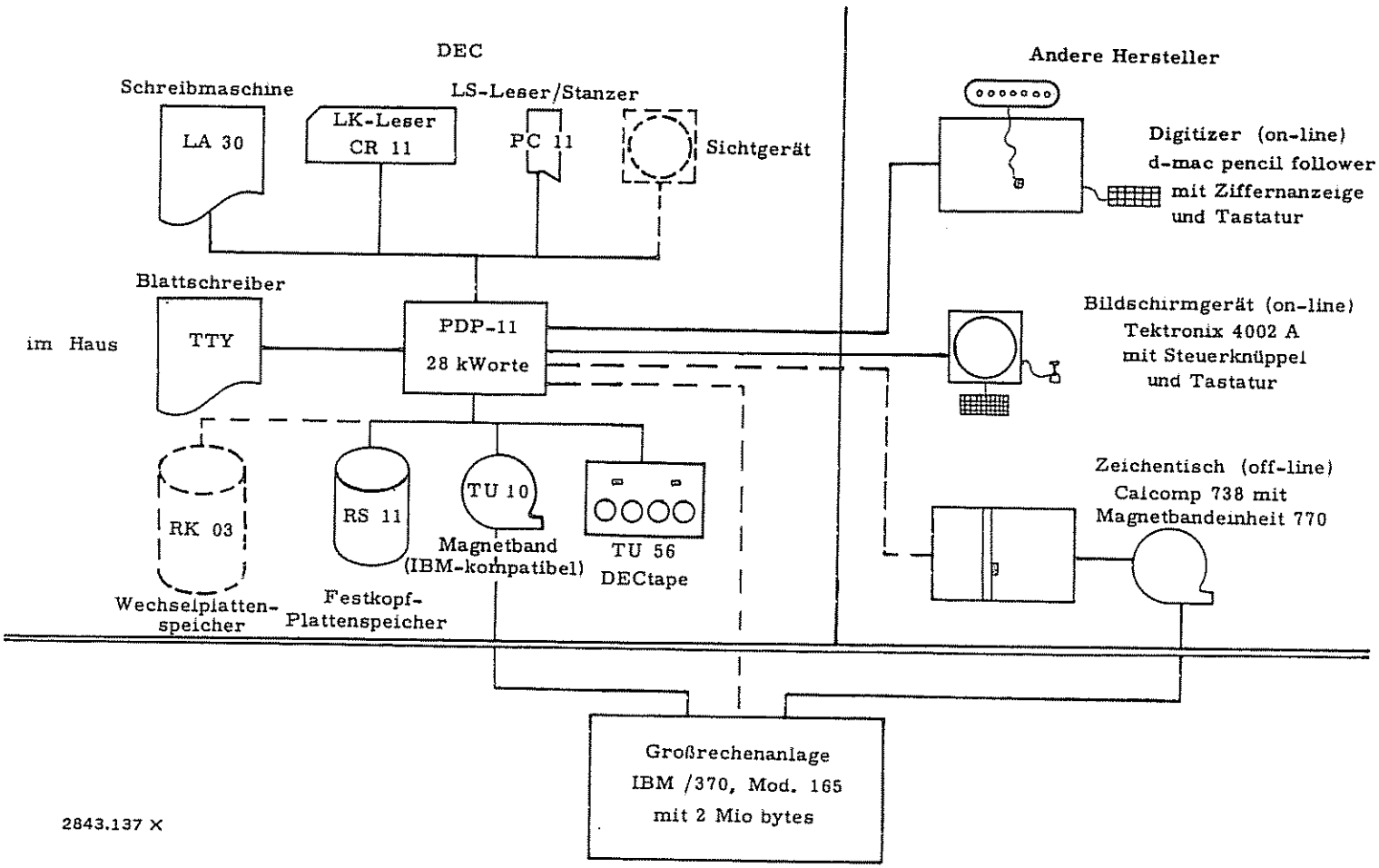
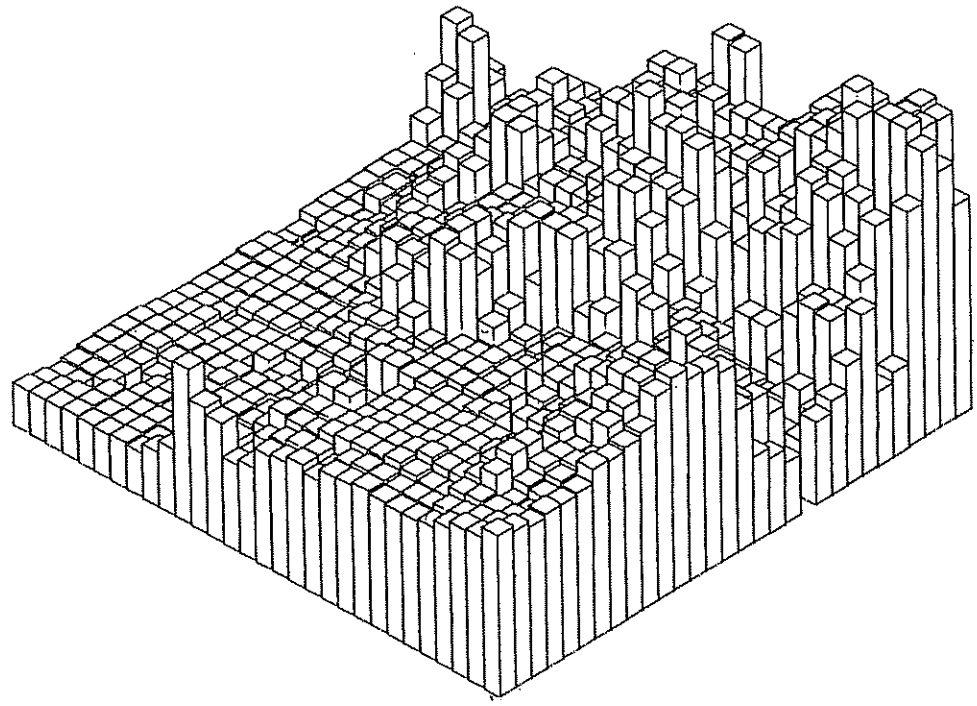


Figure 137. Federal Republic of Germany: flow diagram



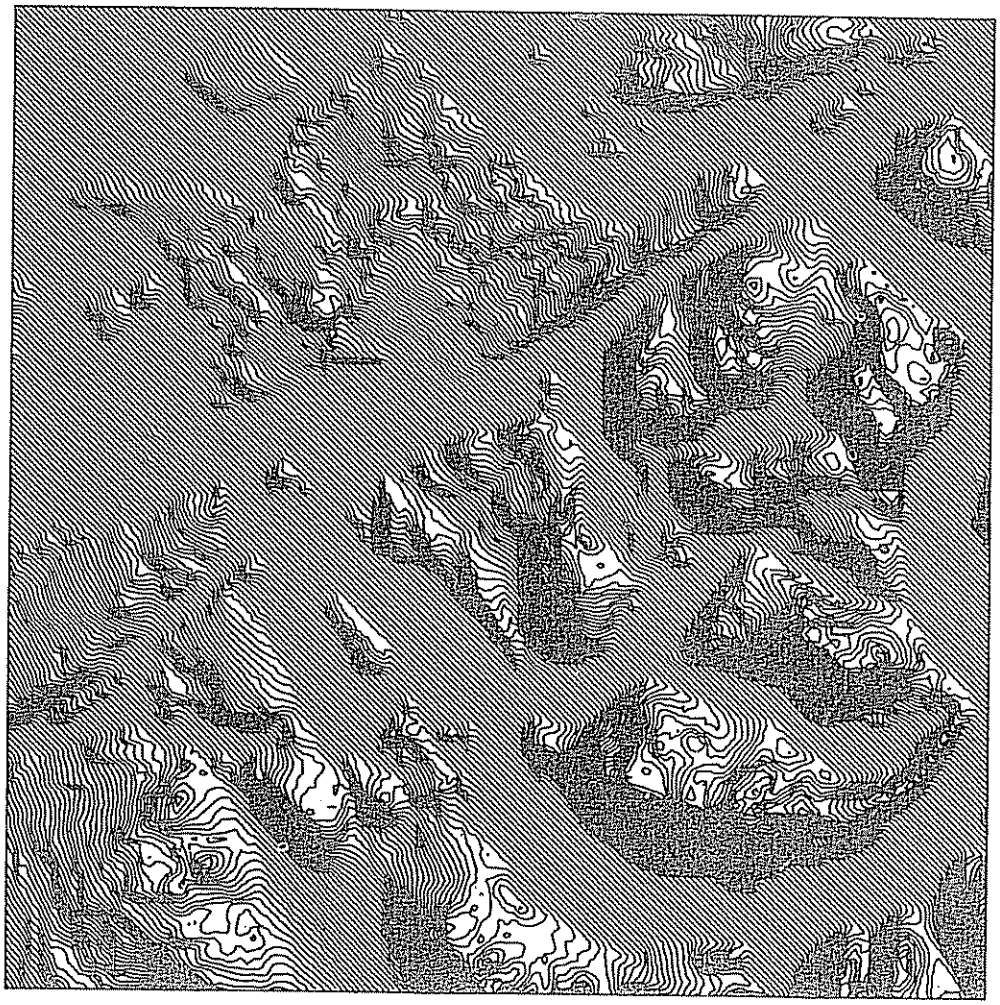
Input: matrix with 500 points of height

Figure 138. Federal Republic of Germany: automatically produced isolines based on spatial distribution of point



Input: matrix with 500 points of height

Figure 139. Federal Republic of Germany: automatically produced block diagram with columns of points



Input: matrix with 500 points of height

Figure 140. Federal Republic of Germany: automatically produced surface according to method of inclined intersection surfaces

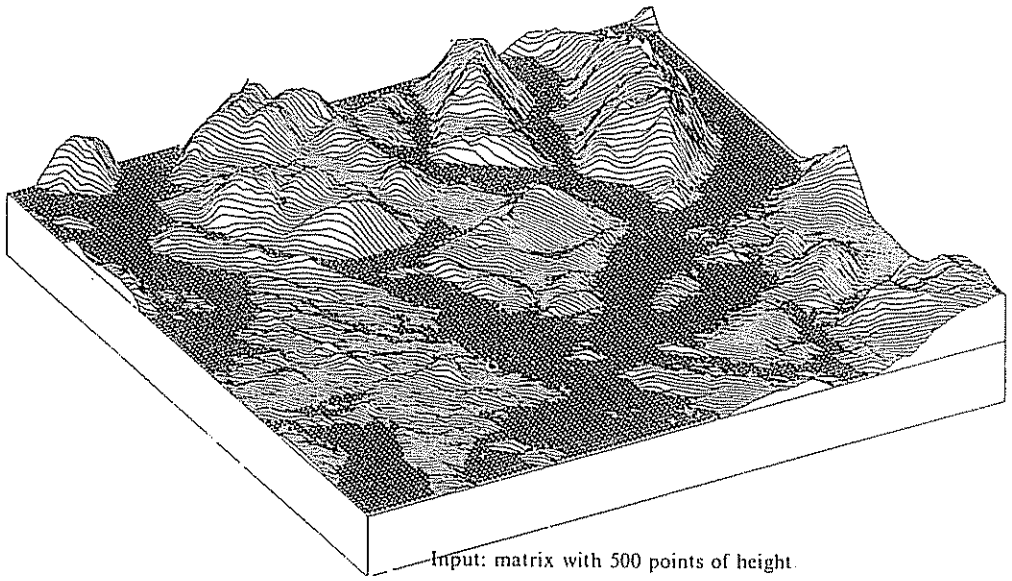


Figure 141 Federal Republic of Germany: automatically produced block diagram

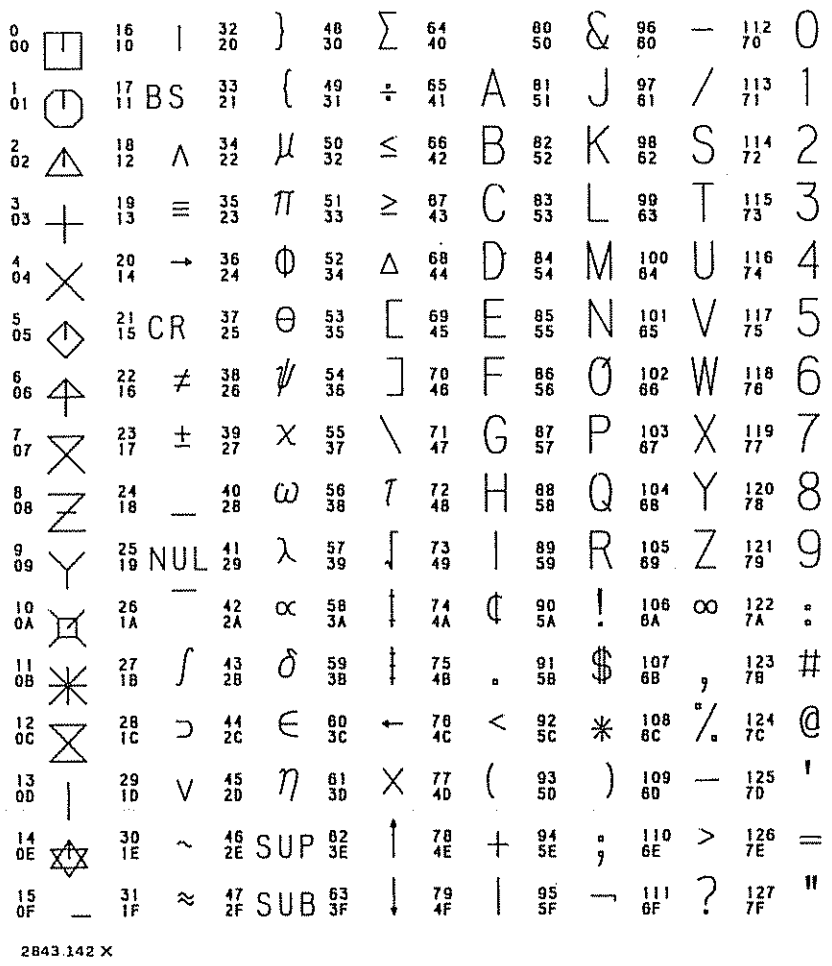


Figure 142. Federal Republic of Germany: symbols produced with Calcomp plotter 738

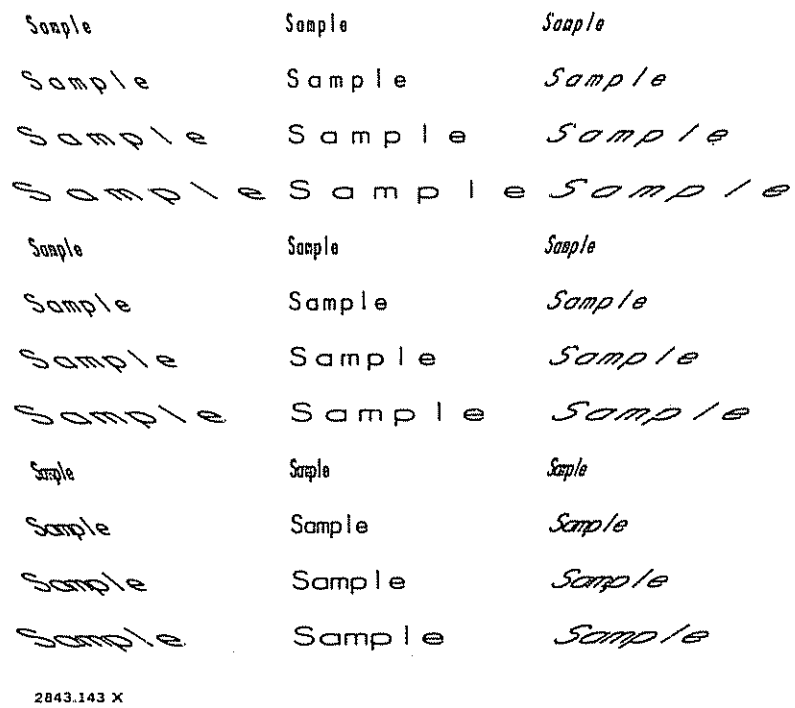


Figure 143. Federal Republic of Germany: variations of type used by Calcomp plotter 738

PREPARATION OF POPULATION DISTRIBUTION MAP BY LANDFORMS, 1970 POPULATION CENSUS OF JAPAN*

Paper presented by Japan

POPULATION DISTRIBUTION MAPS BASED ON CENSUSES

The Bureau of Statistics of Japan has prepared various kinds of maps on the basis of the populations of municipalities (*shi, ku, machi* and *mura*) obtained from the 1950 population census and subsequent censuses. The population distribution maps have been improved in each population census, in particular with respect to methods and forms of representation. The population distribution maps made on the basis of the results of the 1950 population census in one sheet was on the scale 1:2,000,000. It was based on the same scale map prepared by the Geographical Survey Institute of the Ministry of Construction. In the population distribution map, mountainous areas, lowland areas and uninhabited areas were represented by different colours; and the population distribution was expressed in dots, each representing 500 persons.

A map of population distribution and density by municipalities was prepared using the results of the 1955 population census, in which both an absolute distribution and a relative distribution of the population were shown at the same time. The scale of this map was 1:800,000. The density of population in each municipality was represented by different colours according to grades, and the population of municipalities was shown in sphere when it was above 30,000 persons; and in dot, representing 1,000 persons, when the population was less than 30,000 persons. The spheres had seven different diameters according to the size of population. The spheres and dots were printed in black, the base map (the topographic map on the scale 1:800,000) in blue and the boundaries of municipalities in brown. This map is characterized by the fact that both population distribution and density are expressed in the same map to make clear the relationship between the absolute distribution and the relative distribution of population.

As a part of the work to produce the World Population Map on the scale 1:1,000,000 as proposed by the International Geographical Union, the population distribution map by municipalities, based on the results of the 1960 population census, was made in principle according to the standards set by the International Geographical Union. Since the 1960 population census, both Densely Inhabited Districts (DID) with a population of 5,000 or more (a density of 4,000 or more persons per square kilometre) and quasi-DIDs with a population of 1,000–5,000 also have come to be delineated. Therefore, these districts were treated as communities with a population of 1,000 or more and were represented by spheres. Further, since Japan is one of the countries with the highest population density, the diameter of a dot was set at 0.4 mm. Dots, each representing 200 persons, were positioned in main communities on the map, on the basis of the topographic map on the scale 1:200,000 prepared by the Geographical Survey Institute and the enumeration district map of the 1960 population census:

The following revisions also were made in the population distribution map by municipalities of the 1965 population census, evaluating the population distribution map of the 1960 population census.

(*a*) The scale of the 1960 base map was reduced from 1:800,000 for the 1955 map to 1:1,000,000, and some modifications were made in the previous base map. For the 1965 maps, use was made of the new international map (1:1,000,000) produced by the Geographical Survey Institute, which was revised so that it was suited for a population distribution map;

(*b*) One dot in the 1960 map represented 200 persons; but on the map at 1:1,000,000 scale, one dot was designed to represent 500 persons, as it was feared that the dots would be too close to one another if the former method were used;

(*c*) As it was difficult to show a sphere on a map, circles were used to represent DIDs and quasi-DIDs. Since there is a close correlation between the population and the area of a DID, the size of a circle was determined on the basis of a formula obtained from a relationship between the area of a DID conceived in circle and its population.

However, in such large cities as Tokyo, Osaka, and Nagoya, and in their neighbouring areas, circles overlap so that it was very difficult to show the size of populations with circles and to visualize them in circles. In order to remove this defect, DIDs in these cities were represented by the actual shapes of such districts.

As explained above, the international map on the scale 1:1,000,000 was used as the base map for the 1965 population distribution map. As a result, it was characterized by the fact that the relationship between the distribution of population and topography was more clearly expressed.

METHOD OF PREPARING POPULATION DISTRIBUTION MAP BY LANDFORM DIVISION

The Bureau of Statistics and the Geographical Survey Institute jointly made a population density map on the basis of the results of the 1955 population census. As distinct from the conventional population distribution maps by municipalities, this map was prepared to make clear the distribution of population as seen from physical aspects. From the standpoint of landforms, the country was divided into "mountainous area" and "flat land"; and the "mountainous area" was subdivided into "mountain", "volcano" and "hill land", while "flat land" was subdivided into "piedmont gentle slope", "volcanic flank", "upland" and "lowland".

Where large expanses of land fell into one of the above-mentioned categories, such a large area was further subdivided into different divisions according to type of structure, shape and other aspects. One landform unit was required to have an area of more than 20 km^2, and areas of less than 20 km^2 were absorbed or merged into their neighbouring units. Division of the land according to landforms was made by the Geographical Survey Institute, on the basis of the landform classification map it had prepared, the geological map prepared by the Geological Survey of Japan, aerial photographs and other materials.

*The original text of this paper, prepared by the Bureau of Statistics, Office of the Prime Minister, Japan, appeared as document E/CONF 62/L 13/Rev 1.

The populations of divisions classified according to landforms were obtained by adjusting the population of municipalities as of 1 October 1955. In case a municipality stretched over two or more divisions, the population was distributed among these divisions in proportion to the number of dots in the population distribution and density map by municipalities of the 1955 census. Further, the populations of urban areas were excluded from the populations of divisions classified according to landforms in the calculation of population density in such divisions. Thus, in the population density map by landforms, urban areas were represented by circles or actual shapes. On the completed map, divisions with different landforms were represented by marks, and the population density was divided into eight grades represented by different colours.

This map is of great significance because no map of this kind has ever been made in Japan, and scarcely any maps of this kind have been made in other countries of the world. In this map, however, some problems still exist, particularly with respect to the process of its preparation. One of the problems is that as the DIDs were not set up in those days, the populations of "urban areas", which were excluded from the populations of the divisions classified according to landforms in the calculation of their population density, could only be estimated.

Method of preparing population distribution map by landforms

Method of expressing landform types

The landform types adopted for the populations density map of the 1955 population census were used for the 1970 map.

In the population distribution map by landforms, seven landforms were shown in different shades of green and brown, printed on the same modified international map at 1:1,000,000 scale that was used as the base map for the population distribution map of the 1965 census.

Representation of population distribution

In deciding on the method of representing population distribution for map by landforms based on the 1970 census, the method of representation used in 1965 was studied.

In the 1965 map, populations of DIDs and quasi-DIDs were represented by circles, and populations of other areas by dots, each representing 500 persons. As for the radius of the circle, the area of a DID was converted into a circle, and its radius was obtained. Then, a formula showing the relationship between the radius (r) and the population (p) was obtained. Further, the populations of DIDs and quasi-DIDs were classed into grades, and the corresponding radii were calculated to determine the size of circles according to different classes of population. However, the populations of DIDs with a population of 700,000 or more and the populations of their adjoining areas (within less than 1 km) were represented by their actual shapes.

As a result of examination, it was concluded that the use of dots, each representing 500 persons, was proper, in view of the gap in population distribution between the neighbouring areas of cities and the mountainous areas, and also in view of the availability of data, the scale adopted and the past experience. In the previous map, the populations of DIDs were represented by circles. In this case, as the radius of a circle becomes large, th distribution of dots in the neighbouring areas of DID does not reflect the actual distribution of population. I consideration of this factor, it was decided to bring dow the lower limit of the populations in DIDs which were t be represented by actual shapes.

As a result of examination of the relationship betwee the areas of DIDs classified into grades in the previou map and the populations of such districts, it becam clear that the areas of DIDs with a population of 100,00 or more were all more than 10 km² (10 mm² on the ma on the scale 1:1,000,000) and that those areas could b represented on the map according to their actual shape Therefore, it was decided to express the size of popula tions of DIDs with a population of 100,000 or more i their actual shapes. However, in the case of DIDs with population of 400,000 or more, the populations of DID in their adjoining (within less than 1 km) areas, with population of less than 100,000, were included in th former and were shown in their actual shapes. Th populations of DIDs with a population of less tha 100,000 were classed as follows as in the previous ma and were represented by circles with the correspondin diameters:

Population	*Diameter (millimetre*
1,000– 4,999	1.0
5,000–24,999	1.6
25,000–49,999	2.3
50,000–99,999	3.3

Dots were given with reference to the topograph map on the scale 1:200,000, the topographic map on th scale 1:50,000, the population distribution map of 19 and the enumeration district map of the 1970 census.

Base map and indications on the map

The international map on the scale 1:1,000,000 pr pared by the Geographical Survey Institute was used the base map for the population distribution map aft being modified to a certain extent for the purpose at th Bureau of Statistics. The base map has the followir indications: contours; administrative boundaries; ra ways; main national roads; main place names; river lakes and swamps; coastal lines; longitudinal and latit dinal lines; shading.

The colours used for these indications are as follow

(*a*) Contours, rivers, lakes and swamps, coastal line blue;

(*b*) Railways, main national roads, main place name longitudinal and latitudinal lines: brown;

(*c*) Administrative boundaries: red;

(*d*) Shading: pale grey.

Conclusion

This paper has outlined the method of prepari population distribution maps based on population ce suses, particularly with respect to the making of t population distribution map by landforms based on t 1970 census. This population distribution map makes possible to show the absolute distribution of populati by landform types in Japan more clearly than t

population density map by landform division made in 1955, and to grasp objectively the distribution of population by landform types. Further, as the map shows the administrative boundaries of municipalities, it—like the previous population distribution maps—makes it possible to grasp the distribution of population from the standpoint of administrative boundaries.

There are some problems, however, in using this map. The map is not one in which the number of dots is based on the populations of divisions classified according to landform types, but one divided into sections according to landform types on which the population distribution map is overlapped. Therefore, the number of dots in a division by landforms does not necessarily correspond to the actual number of population in the division. Further, as DIDs with a population of 100,000 or more are expressed by actual shapes, the correct number of populations of these districts is not shown, although it is clear that these districts have a population of 100,000 or more. At the same time, as populations expressed in circles or actual shapes of the districts stretch over two or more landform types, the population of each landform type cannot be known. These problems remain to be solved in the future.

REFERENCES

Kawai, Reiko. Method of making population density map by landform division and the accumulated results. Geographical review of Japan, 32, no. 10.

Kiuchi, Shinzo. Meaning and methods of a population map, with problems on locality statistics, rural and urban classification and cartographic techniques. Geographical review of Japan, 34, no. 10.

Otomo, Atsushi. Population maps of Japan, v. 1-4.

——— *and* Tsunemi Kosuge. Population distribution maps based on 1965 census results. (Research memoir of the Bureau of Statistics, v. 18.)

TECHNICAL CO-OPERATION BY THE GEOLOGICAL SURVEY OF JAPAN*

Paper presented by Japan

The importance of the development of mineral resources, including hydrocarbons, is now fully recognized as a significant means for economic and social progress in developing countries. As a fundamental measure for promoting exploration of mineral resources, most Governments in the region of Asia and the Far East have established a geological survey or a geological institute, which conducts basic geological, geophysical and geochemical surveys, including sheet-mapping and laboratory works, and provides basic information and services for testing minerals and ores. These geological surveys mainly extend their activities to hydrogeology, engineering geology; and, in some cases, environmental problems.

During the period from September to December 1971, a fact-finding mission of five highly qualified experts was organized by the United Nations Economic Commission for Asia and the Far East (ECAFE) to investigate requirements for a regional mineral resources development centre; the mission visited 12 countries in the ECAFE region. Although geological and/or mines departments were established in these countries, being staffed with technical personnel with high educational background, ineffective use was being made of geophysical and geochemical methods of exploration and laboratory support was inadequate, in addition to the lack of comprehensive and systematic planning and co-ordination of exploration and exploitation. The mission stressed in its report[1] the urgent needs of assistance in planning, implementation and evaluation of various modern sophisticated exploration methods, as well as in establishing facilities for accumulating and disseminating information, including a systematic mineral inventory.

Strengthening and expansion of the geological survey organizations in developing countries should be more emphasized, as well as other agencies relevant to land surveys and natural resources development; and further co-operation through bilateral or multilateral arrangements should be promoted in various fields, ranging from basic mapping to integrated surveys and feasibility studies.

Co-ordinating Committee for Off-shore Prospecting in East Asia

Owing to the increasing demand for minerals, including hydrocarbons, recent efforts have been directed considerably to exploring the sea and ocean floor, and the benefits from the mineral resources of the sea should be fairly shared by developing countries. Under the sponsorship of ECAFE, the Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Off-shore Areas (referred to briefly as the Co-ordinating Committee for Off-shore Prospecting and abbreviated to CCOP) was established in 1966 as an intergovernmental body for the promotion and co-ordination of planning and implementation of off-shore geophysical and other prospecting projects on the marine shelves of the member countries, currently comprising Indonesia, Japan, the Khmer Republic, Malaysia, the Philippines, the Republic of Korea, the Republic of Viet-Nam and Thailand. Australia, France, the Federal Republic of Germany, Japan, the United Kingdom of Great Britain and Northern Ireland, and the United States of America, as well as the United Nations Educational, Scientific and Cultural Organization (UNESCO), have provided high-level experts at the meetings of CCOP and other assistance to the work of the Committee.

A large number of geophysical and other surveys relating to off-shore mineral potentials have been co-ordinated and conducted with the assistance of the Governments of the Federal Republic of Germany, Japan, the United Kingdom and the United States of America. Systematic investigation of coastal deposits of

*The original text of this paper, prepared by Shunichi Sano, Geological Survey of Japan, appeared as document E/CONF 62/L 17.

[1] The report was included in "Progress report on the proposal for the establishment of a regional mineral resources development centre" (I&NR/164), submitted to the twenty-fourth session of the Committee on Industry and Natural Resources of the United Nations Economic Commission for Asia and the Far East, held at Bangkok, Thailand, 8-14 February 1972.

detrital heavy minerals has been carried out with assistance from the Australian Government. Reports of the results of the co-ordinated survey projects and scientific articles relating to marine geology and off-shore prospecting in the region have been published annually in the technical bulletin series of CCOP, which has been printed by the Geological Survey of Japan as a contribution to the work of the Committee. The publication is quite useful not only for disseminating information and knowledge gained through the medium of CCOP, but for encouraging indigenous scientists by giving them opportunities to submit their own papers and to participate in the preparation of joint reports.

Based on the discussions and recommendations made at recent sessions, CCOP is expanding its activities beyond the continental shelves of the member countries to the adjoining oceanic areas and is planning a regional scientific programme for investigation of the tectonic development of east and south-east Asia, and its relation to metalliferous ore and hydrocarbon genesis, which would form a part of the programme for the International Decade of Ocean Exploration (IDOE) being the acceleration phase of the Long-Term and Expanded Programme of Ocean Exploration and Research (LEPOR) of the Intergovernmental Oceanographic Commission (IOC).

The group training course in off-shore geophysical prospecting provided by the Government of Japan has continued since 1967; an account of this course is given below. Since 1967, the Government of Japan also has provided the services of a non-reimbursed expert as a full-time member of the technical support group, which was reorganized in April 1972 by financial support of CCOP activities contributed by the United Nations Development Programme (UNDP).

CCOP was successful in attracting risk capital to explore in more detail the prospects for mineral resources on the continental shelves of east Asia, particularly for petroleum; and, on the other hand, contributed to encourage the relevant organizations and raise the standard of technical personnel in member countries. As a matter of fact, the geological surveys or mines bureaux in a number of member countries now have geophysical equipment for off-shore survey and can begin their own off-shore survey projects.

Group training course in off-shore prospecting

The annual group training course in off-shore prospecting was inaugurated in 1967 in compliance with the recommendations made at the first session of CCOP. The Government of Japan entrusted the operation of the course to the Overseas Technical Co-operation Agency (OTCA), and the Geological Survey of Japan provided facilities and administrated technical matters. The technical sessions of the 1973 group training course were scheduled for the period from 9 July to 20 December. Participation in the course has been extended to developing countries outside the CCOP region, as is shown below.

The objective of the training course is to provide the participants with a fundamental understanding of off-shore prospecting for mineral resources; and to train them in basic techniques, with emphasis on geophysical surveys, through lectures, field and laboratory practices and observations. To attain those objectives, the Director of the Geological Survey of Japan sought the co-

Participants in group training course in off-shore prospectir

Area sending participant	*1968*	*1969*	*1970*	*1971*	*1972*	*19*
Brazil				1		1
Burma	1		1	1	2	1
Colombia				1		
Ecuador				2	1	
Egypt			1	1		1
India			1	1		
Indonesia	1	1	1	1	1	2
Khmer Republic					1	1
Malaysia	1		1		1	
Nigeria						1
Pakistan			1			
Peru				1		1
Philippines	1	1	1	1	1	1
Republic of Korea	1	1	1	1		1
Republic of Viet-Nam		1	1	1		
Saudi Arabia		1	1			1
Thailand	1	1	1	1	1	1
Turkey						1
TOTAL	6	6	11	13	8	13

operation of various organizations concerned, such universities and private firms. A steering committee w established, consisting of members of these organi tions; the committee also acted as an advisory boa The Director appointed a course leader to prepare t curriculum, conduct the sessions and evaluate the resu of the course. OTCA provided a co-ordinator to han the administrative and personal matters of the parti pants and to act as interpreter when required.

The curriculum of the training course has gradua changed since its inauguration as the techniques for c shore prospecting have rapidly progressed, and t technical standard of personnel in the member countr of CCOP also has been raised year by year. The curri lum of the recent courses laid emphasis on compu technology and processing of geophysical data, as well on geological interpretation of the data. On the oth hand, the geophysical methods mainly useful for pr specting on land occupied a considerable part of t curriculum due to the fundamental nature of the cour

For example, the lectures and practices given duri the 1972 course are as follows:

(a) *Lectures on geology and related subjects* (hours): geology of Asia; geology of the Middle Ea geology of Japan; marine geology; marine mine resources; petroleum geology; coal geology; metallif ous deposits; photo-interpretation; remote sensing;

(b) *Lectures on fundamentals of geophysical prospe ing* (47 hours): physics of the solid earth; mathemati physics; information theory; computers; electronics;

(c) *Lectures on geophysical prospecting methods* (1 hours): seismic methods; sonic methods; magnetic me ods; gravity methods; geothermal methods; geophysi loggings;

(d) *Lectures on miscellaneous subjects* (20 hou geochemical prospecting; electronic navigation; shore drilling;

(e) *Special lectures, including those by foreign gue* (13 hours);

(f) *Practices* (178 hours): processing and interpre tion of marine seismic data; seismic and electrical sur on land; processing and interpretation of sonic profil

data; processing and interpretation of aeromagnetic data; processing and interpretation of gravity data; rock magnetism; rock mechanics; radio-activity of rocks; chemical experiments.

The outline of observation trips and field training during the course in 1972 is as follows:

(a) *Trip to Hokkaido and coast of Sea of Japan near Honshu* (15 days): training in aeromagnetic survey at Hokkaido; observation of oilfields and gas-fields in Akita and Niigata areas, including inspection of an off-shore drilling rig and seismic survey on land;

(b) *Trip to Kyushu and western part of Honshu* (12 days): observation of Miike off-shore coal-field, including inspection of a drilling vessel; Ibusuki iron-sand deposit, Kushigino metallic mine and Kobe Shipyard of Mitsubishi Heavy Industries Co.;

(c) *Trip to northern part of Honshu* (9 days): observation of IP survey at Tashiro metallic mine and Matsukawa geothermal power-plant; training on board R/V *Bosei-Maru* of Tokai University on sonic survey and dredging;

(d) *Observation of research vessels at Shimizu* (2 days): observation of R/V *Tokai-Daigaku-Maru II* of Tokai University and R/V *Takuyo-Maru* of Japan Petroleum Exploration Co. Ltd. (Training on board *Takuyo-Maru* was originally planned, but it was subsequently cancelled due to an accident. A demonstration cruise of R/V *Tokai-Daigaku-Maru II* was held for half a day by courtesy of Tokai University)

At the final meeting, the participants were asked to submit evaluation reports in which they expressed their views on the content and conduct of the course and suggested further improvement. The participants appreciated the course for the useful knowledge they had gained, which would be of considerable value for future activities in their own countries. The hope was also expressed that an advanced course would be organized in future. The suggestions made by the participants for improvement of the course were carefully considered by the course leader in preparing the curricula of the subsequent courses.

For the time being, petroleum is the most important off-shore mineral resource; thus, the emphasis of the course is on petroleum exploration. Some participants in the past had interests in other off-shore mineral resources and even in those on land, and suggested possible separation of the course into two subgroups. However, it was thought that a new group training course on mineral exploration techniques should be considered rather than to diversify the current course.

In earlier times, the participants joined off-shore survey projects conducted by the Geological Survey of Japan; but with more than 10 trainees the survey operations were hindered, and participants were able to attend only a short period. Since the fourth annual course, the Geological Survey has contracted contractors to carry out marine geophysical and aeromagnetic surveys specifically for training purposes; these arrangements have considerably improved the practical field-work. The participants, however, requested that they should be given more opportunities to operate equipment during field-work. The course leader considered that this would be difficult unless the course maintained its own equipment and technicians, as the preparation before the survey might be more important than the operation itself. Some laboratory apparatus and some less sophisticated field equipment are maintained by the course for use by participants, and expansion of these facilities was strongly hoped for.

Effective control and administration of off-shore prospecting in developing countries will require more and better qualified personnel, so the need for the training course will continue. The professional level of the technical personnel in developing countries is improving, as indicated by the request for emphasis on computer processing and geological interpretation of geophysical data. With the strengthening of the lectures and practical work devoted to it, their appreciation of this training course and their expectations from it have also grown. It is important, therefore, that every effort should be made to upgrade the standard of the course and the effectiveness of the training provided.

Co-operation through research and development

During the First United Nations Development Decade of the 1960s, tremendous amounts of resources were spent by the developed countries and the international organizations for the provision of economic co-operation to developing parts of the world, and a large number of technical co-operation projects were undertaken. Economic and social advancement in developing countries was certainly achieved, but the results were not successful enough to narrow the gaps in economic growth and social conditions. In fact, the difference increased between the developing world and the industrialized countries

One of the important reasons may be the disregard of adequate and effective transfer of technology, which would generate and accelerate the activities and efforts by indigenous scientific and technological capacity. Therefore, international co-operation through science and technology has been strongly recommended in the Second United Nations Development Decade and has been discussed at various international meetings. Co-operation through research and development is a new channel to increase the technological potential of developing countries by directly influencing scientists and engineers.

The Institute for the Transfer of Industrial Technology (ITIT) was established in the fiscal year 1973 in the Agency of Industrial Science and Technology (AIST) of the Ministry of International Trade and Industry, in order to meet the requirement for international co-operation in research and development. The main role of ITIT is to co-ordinate and promote the technical co-operation made by the research institutes affiliated with AIST and to centralize domestic research and development resources currently scattered in various research institutes; and, then, to rearrange and reorient them to meet the demand for co-operation through research and development for developing countries.

As an affiliated body of AIST, the Geological Survey of Japan proposed a research project on regional tectonics of south-east Asia and will execute the research project jointly with the geological survey organizations in countries in that area.

Recent progress in exploration and exploitation of mineral resources in the world has gradually revealed the regional and systematic distribution of ore deposits and hydrocarbon accumulations. In east and south-east Asia, exploration for petroleum has been actively undertaken in recent years, and information on successful and

unsuccessful drillings has been accumulated. As concerns non-ferrous metals, tin-tungsten deposits of various ages are arranged along a belt running through the eastern margin of the Asian continent, while Cu, Pb, Zn, Au, Ag, As and Sb deposits of various ages were discovered over the island arcs lying off the continent. Tectonic processes associated with magmatism, and lateral and vertical movement of the crust controlled the distribution of mineral deposits.

Some discontinuites of zonal distribution are, however, pointed out: lack of porphyry copper deposits in Japan, notwithstanding the discoveries of those deposits in the Philippines and along the island arcs extending down to the south; sudden termination at Kalimantan of the tin-tungsten belt from Burma to the Indonesian tin islands through West Malaysia; and many years of unfruitful exploration for petroleum in the Philippines despite the discoveries of oil or natural gas in the adjoining countries. These circumstances could be understood in connexion with the geological framework and its evolution in this region.

On the other hand, recent progress in earth sciences provides new guides to interpretation of regional geological features based on global aspect and deeper processes. Earth scientists have begun to challenge ambitious researches of predicting mineral distribution and such natural hazards as earthquakes, and these researches mainly depend upon integrated interpretation of geological, geophysical and geochemical information.

The compilation of regional geological and related maps of Asia and the Far East, which certainly provides useful information for these researches, has been undertaken under the auspices of ECAFE and the Commission of the Geological Map of the World. However, further efforts in collecting information based on the new concepts of earth sciences, particularly geophysical and geochemical information, may be essential for understanding the tectonic history of this region. Processing and interpretation of geophysical data, including reinterpretation by up-to-date sophisticated means, may be important; whereas geophysical surveys should be conducted to supplement the existing data in this regior particularly over small oceanic basins, such as the Sout China Sea, the Sulu Sea, the Sulawesi Sea and th Andaman Sea. Even the existing geophysical data depos ited in institutions both in and outside this region wi very much contribute to picture regional subsurfac structures, if adequately compiled and interpreted.

A number of papers presented at the Consultatio Group Meeting for the Regional Tectonic Map, held a Kuala Lumpur in March 1972, indicated increase activities of tectonic studies in this region; and CCO decided at its ninth session, held at Bandung at the en of 1972, to initiate a regional research project concernin the tectonic development of east and south-east Asi and its relation to metalliferous ore and hydrocarbo genesis.

In order to promote integrated and co-operative re search efforts in this field of earth science and to facili tate the efforts made in the developing countries in thi region, important information obtained from regiona geophysical survey data should be made available; an the capabilities of scientists in these countries should b elevated and strengthened through co-operative re searches and transfer of technology.

The objectives of the ITIT co-operative project are: (*a* to study regional subsurface structures by compilatior processing and interpretation of the existing geophysica data over land and off-shore areas of south-east Asia; (*b* to contribute to the regional tectonic studies by inte grated interpretation in combination of the results o geophysical studies with geological and geochemica information; and (*c*) to transfer know-how and possibl software for geophysical interpretation to the counter part institute. The exchange of scientists is one of th main functions of the project.

Under the ITIT research project, the Geological Su vey of Japan will co-operate with the Geological Surve of Indonesia in compilation of a national gravity ma and will undertake joint research on geological interpr tation of regional gravity data.

LAND-CLASSIFICATION SURVEY OF NATIONAL LAND SURVEY*

Paper presented by Japan

The land survey provided for under the National Land Survey Law of Japan, enacted in 1951, consists of the land-classification survey, the water survey and the cadastral survey, in each of which maps and explanatory notes shall be made according to the said law. In the land-classification survey, current land use, natural elements and land productivity are surveyed.

The land-classification survey currently conducted consists of the fundamental land-classification survey undertaken by government (state) organizations, the developmental land-classification survey conducted by local governments (prefectures), the 1:200,000 land-classification survey and the detailed land-classification survey.

These surveys are explained with reference to the ma as follows:

(a) *Fundamental land-classification map* (survey cor ducted by government organizations). This map is base on the 1:50,000 topographic map (with a sheet area approximately 400 km^2, issued by the Geographic Survey Institute). The geomorphological lan classification map (12 polycoloured); slope-classificatio map (one polycoloured, overlay); drainage system an valley density map (one polycoloured, overlay); subsu face map (10 polycoloured) and soil map (eight polyco oured) are to be made. The standard of classification each map is provided by each survey standard regul tion, i.e., the geomorphological land-classification ma is illustrated by the genesis and character of geomorph logical land, the slope-classification map is shown b seven slope-classification maps, while the drainag system and valley density map is illustrated by th

*The original text of this paper, prepared by Hisao Yamazaki, National Land Survey Division, Development Bureau, Economic Planning Agency, Japan, appeared as document E/CONF.62/L.19 and Corr.1.

number of valleys within the area of 1 km². Furthermore, the subsurface geological map is classified into and illustrated by the degrees of consolidation, classification of rocks and hardness of rocks, while the soil map is classified into soil series;

(b) *Developmental land-classification map*. Survey conducted by the local government (prefecture) organizations. As for this map, each map listed in (a) above is indispensably required, while the water-use map, disaster-prevention map, classification map of soil productivity, land development limitation map, relative-relief map and land-use map are provided as optional maps;

(c) *The 1:200,000 land-classification map*. Each local government (prefecture) entrusted by the Economic Planning Agency draws this map for the entire area of the prefecture concerned; the map consists of the geomorphological land-classification map (12 polycoloured); slope-classification map (one polycoloured, overlay); relative-relief valley density map (one polycoloured, overlay); subsurface geological map (plane land-classification map, 12 polycoloured); subsurface geological map (vertical land-classification map, one polycoloured, overlay); soil map (12 polycoloured); classification of soil productivity map (one polycoloured, overlay); land-use map (12 polycoloured); and capability classification map of land use (10 polycoloured);

(d) *Survey unit*. A parcel of land is taken as the unit of survey when making the land-use map, land-condition map, classification map or principal characters of soil, land-conservation map and soil productivity classification map. The scale is 1:2,500, or a reduced cadastral map with a scale of 1:5,000. This map is made by cities, towns and villages.

The land-classification maps and other maps compiled and published by the Economic Planning Agency are listed below.

Land-classification maps, August 1973

Name of map	*Year commenced*	*Organization making map(s)*	*Progress*	*Completion year*
Fundamental land-classification survey map	1954	Geomorphological land-classification map; Geographical Survey Institute Subsurface map; Geological Survey of Japan Soil map; Government Forest Experiment Station, National Institute of Agricultural Sciences	46 planes (18,400 km²)	1973
Developmental land-classification map	1970	Prefectures	57 planes (22,800 km²)	1979
1:200,000 land-classification map	1967	Prefectures	36 Prefectures	1977
Detailed land-classification map	1966	Cities, towns, villages	644 km²	1977
1:500,000 land-classification map	1963	Economic Planning Agency	Nationwide	1969
Relative-relief map (scale: 1:1,160,000)	1966	Economic Planning Agency	Nationwide	1969

WATER-USE MAPS AT 1:50,000 SCALE IN JAPAN*

Paper presented by Japan

The water-use map at 1:50,000 scale is the compilation and mosaic of the results of the comprehensive surveys on water control, water use and hydrography in Japan. The map is made as part of the water survey prescribed by the Land Survey Law, and the survey of the main water-systems in Japan is being undertaken by both the Economic Planning Agency (EPA) and the Geographical Survey Institute (GSI).

*The original text of this paper, prepared by Toshitomo Kanakubo, Geographical Division, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.62/L.29.

Objectives of the survey

Japan, though favoured with abundant rainfall from the climatic and meteorological point of view, has been suffering from a serious water shortage both regionally and seasonally. The structural change of industries during the period of great economic growth promoted the rapid concentration of population in cities and the increase of industrial products. As a consequence, the demand and supply of water became unbalanced regionally, which imposes a serious barrier to regional development. This tendency is particularly conspicuous with respect to city water, such as industrial water and water-supply service. The current source of supply for industrial water is ground-water, due to the lack of river-water; but the excessive pumping-up causes ground subsidence, giving rise to a public nuisance which must be resolved immediately. The White Paper of Construction, 1972, states that the demand for city water increased 1.6 times during the five years from 1964 to 1969. In view of the coming social changes to be pushed by the increase of industrial products and by the betterment of the level of living, a considerable change in the water-use share other than industrial water is conceivable, and the water shortage problem apparently will be aggravated. To cope with the situation there is urgent need for the systematic development of rivers and the purposeful utilization of water resources, by means of dam construction overcoming topographic handicaps and of the preservation of water resources through the implementation and improvement of irrigation channels. On the other hand, the estimates of water demands, such as those for industrial water, agricultural water and water-supply service, which will be increased by industrial growth, agricultural modernization and a rise in the level of living, respectively, should be as accurate as possible.

The water-use map discloses systematically the balances between demand and supply for water use; and, with a check on the water-use register, summarizes in the form of a map the existing water-use situation for the main rivers throughout the country on the basis of the surveys, which are conducted to provide basic data conducive to the effective and widespread use of the constrained water resources.

The main objective of the Comprehensive National Development Law enacted in 1950 was to establish various infrastructures for industrial development. The comprehensive development plan based on this law is composed of basic policies to attain balanced regional development, with emphasis on the effective and rational use of domestic energy resources. As for water resources, the plan prescribes water conservation and water use from the national and comprehensive point of view, as well as improvement of maintenance facilities of the national land.

The National Land Survey Law, which was enacted in 1952, has as its objectives to conduct surveys on the existing conditions of the national land to ensure its development, conservation and intensive utilization. The survey of national land includes the control point survey, the land-classification survey, the water survey and the cadastral survey. The results are summarized in maps and in the index. As concerns the water survey, the survey of rainfall and groundwater, and the compilation of the observation list of water discharge, each on a water-system basis, were conducted during 1959-1963.

Following these surveys, the drawing of the water-use map was begun in 1965.

Specification of the survey area

In the comprehensive national development p based on the Law of 1950, various specific areas, nam new industrial cities, industrial consolidation areas industrial development areas, were designated throu out the country in order to avoid the excessive pop tion concentration in metropolitan areas, as well a promote regionally balanced industrial developm Moreover, in compliance with this Law, the compre sive local land development plan and the comprehen prefectural development plan were made, thus form the basis of the regional development.

Accordingly, as basic data for the regional deve ment, water-use maps of the main river system important areas designated by the law were drawn by one. The survey area was divided by the basin of main rivers, conforming roughly to the administra classification. As the first survey, the Kiso river sys (basin: 8,827 km^2) was surveyed in 1965-1966. The r systems that have been surveyed and are under surve are listed in table 1 (see also figure 144).

Table 1. Completed and ongoing water-use maps

Survey period	*River system*	*Main rivers*
1964-1965	Kiso river system	Kiso, Ibi, Nagar
1966-1967	Chikugo and Yoshino river system	Chikugo, Yoshin
1968-1969	Yodo, Yamato and Kino river water-systems	Yodo, Yamato, I
1970-1971	West-chugoku main water-systems	Ota, Go, Ii, Ashi
1972[a]	Mutsu River, Kitakami district	Kitakami, Narus Mabechi, Yon shiro, Omono
1973[a]	Suōnada district	Oita, Ono, Yamakuni

[a] Currently being surveyed.

Meihod of map drawing

The budget for the water-use map is supplied by Economic Planning Agency which gives GSI the resp sibility for compiling and drawing the maps on existing topographic map on the scale 1:50,000. E itself prepares the index.

Once the survey area is chosen, the ministries and prefectures concerned are requested to make surveys basic data. When that survey is completed, GSI coll the data, and compiles and draws the water-use map adjusting these data through aerial photographs a other materials. The observation data supplied by wa use facilities and hydrographic observation stations compiled into the index by EPA.

A flow sheet of water-use map production is show figure 145.

Composition of water-use map

The water-use map shows both the intake-discha canals and facilities of agriculture, industry, wa

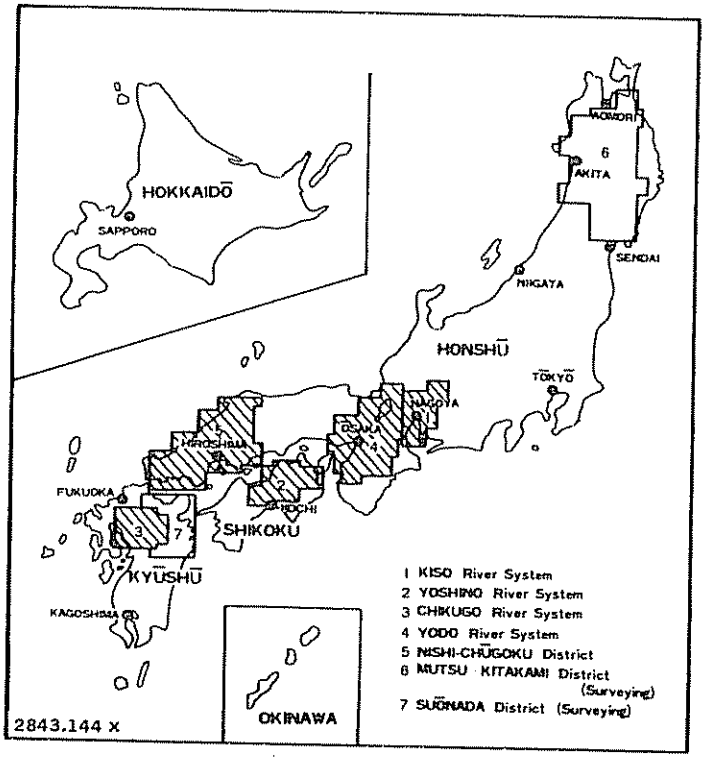


Figure 144. Japan: index map of the water-use map series

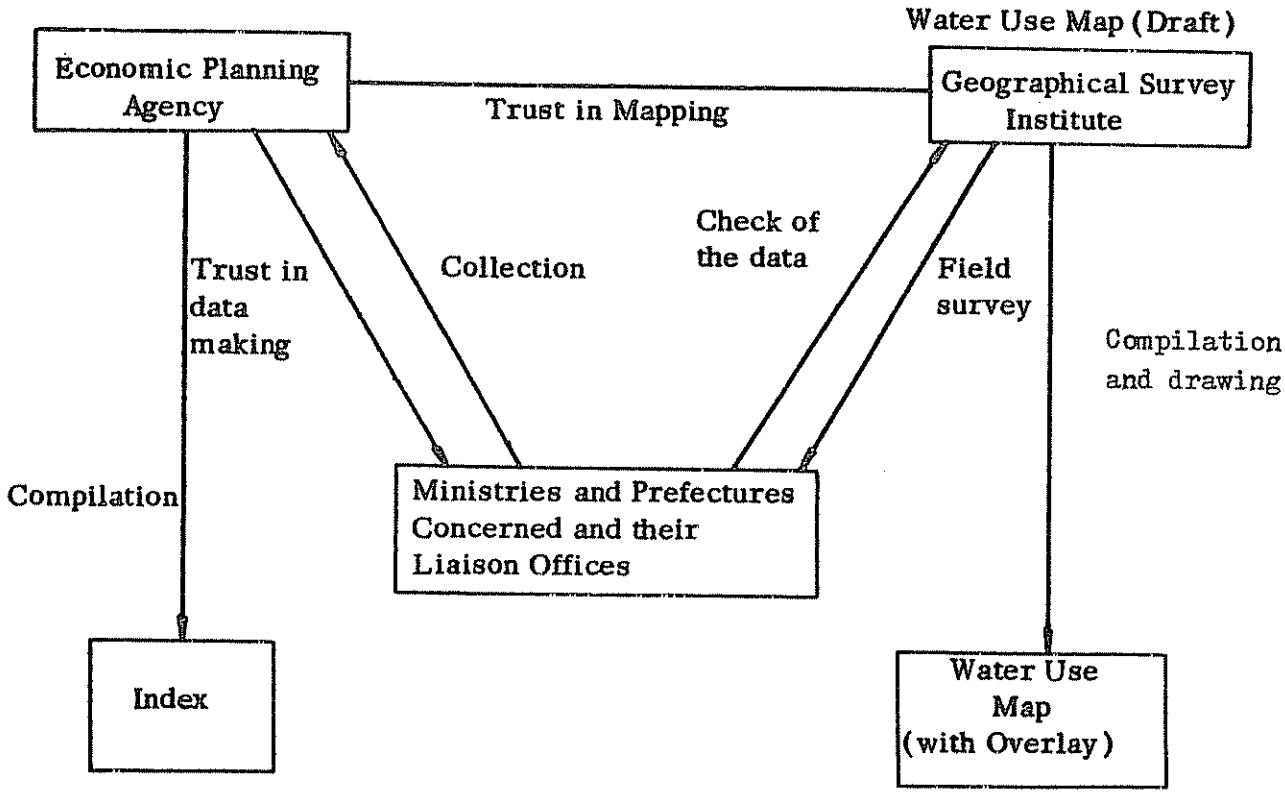


Figure 145. Japan: flow sheet of water-use map production

supply service and power, as well as its beneficiary areas in systematic legend. It also shows the names and numbers of each facility and classifies their capacities and scales.

The distribution of hydrographic observation stations, and soil and water conservation facilities are also drawn. For easier recognition of water-use classifications, nine colours are used all over the sheet, including the base map by water-use objective base. The overlay is adopted for agricultural areas benefiting from irrigation water and from land improvement to avoid excessive details in the map. The basic colour classification is given in table 2.

Table 2. Basic colour classifications for water-use maps

Objective classification	*Colour*
Agriculture	Green
Industrial	Red
Water-supply service	Orange
Hydroelectric power	Black
Multipurpose use and others	Violet
Rivers and their discharge	Indigo
Erosion and flood control	Brown
Observation facilities	Black

Content of the maps

Main map

The main map depicts the water-use systems by showing the use on an objective basis of the surface-water, composed of rivers, lakes and reservoirs; and of the ground-water (see figure 146);

(a) *Natural rivers and the basins.* The main rivers and their tributaries are divided into class A and class B rivers, according to their classification by the Ministry of Construction. The watersheds and basins are shown in order to facilitate the understanding of influx into rivers;

(b) *Lakes, reservoirs and irrigation ponds.* Lakes, reservoirs attached to dams and irrigation ponds for agriculture which are the resources for water use are shown;

(c) *Canals.* Unlike natural rivers, man-made canals are classified by objective and function into agricultural, industrial, water-supply service, electric-power supply and multipurpose canals. For those serving agricultural, industrial and multipurpose uses, the distinction between intake and discharge canals is shown. The main canals of the agricultural canals are expressed by the irrigation area (over 10 hectares) and those for industry and water-supply service by the size and capacity of pipes (over 1,000 mm in diameter or over 3 m^3 of discharge capacity). Such structures as canal bridges, tunnels and syphons also are shown;

(d) *Intake and discharge facilities.* Pump-plants, sluice-ways, infiltration galleries, intake weirs and dams, which are the intake and discharge facilities for the rivers and the canals, are shown both in colours on the objective basis and in the large and small symbols whose sizes depend upon the capacity scales. The symbols for intake and discharge capacity are divided into the following three categories in accordance with the capacity: (i) over 3 m^3/sec; (ii) between 3 m^3/sec and 1 m^3/sec; and (iii) below 1 m^3/sec. The flow direction of water taken in and water discharged is also given by arrow symbols;

(e) *Wells.* Wells, which are the means of obtaining ground-water, are classified into deep wells over 30 m in depth and shallow wells of less than 30 m in depth. Furthermore, they are classified by the quantity of water daily pumped: over 2,000 m^3; 2,000-500 m^3; and below 500 m^3. The kinds of wells are expressed separately as those for agriculture, for industry, for water-supply service (including small water-supply systems) and for other uses (such as air-conditioning);

(f) *Associated facilities for hydrography and water use.* The locations of observation stations for checking rainfall, water level, water discharge, tide level, water quality and ground-water, as well as treatment plants for water-supply, distributing reservoirs, hydroelectric plants and drainage treatment plants, are shown on the map;

(g) *Beneficiary areas and restricted areas.* The map depicts the areas benefiting from industrial water and water-supply service (including small water-supply systems). Similarly, the areas where the pumping of ground-water is restricted by law are shown;

(h) *Facilities for erosion and flood control.* Facilities for the maintenance of water resources and the prevention of disasters, such as those for flood control, water-discharge regulation and prevention of land collapses, are shown on the map together with the dangerous places. These facilities include sluices, dams, debris barriers, groundsels, reserved forests, landslides, designated areas for landslide prevention, crumbling earth areas and authorized sand prevention area ("Sabo" area);

(i) *Other designations.* The land-use classification clarifies the existing paddy-fields and irrigated fields in order to facilitate understanding of the relationship between water use and the agricultural base. The administration classification of prefecture, district, city, town and village is adopted.

Overlay

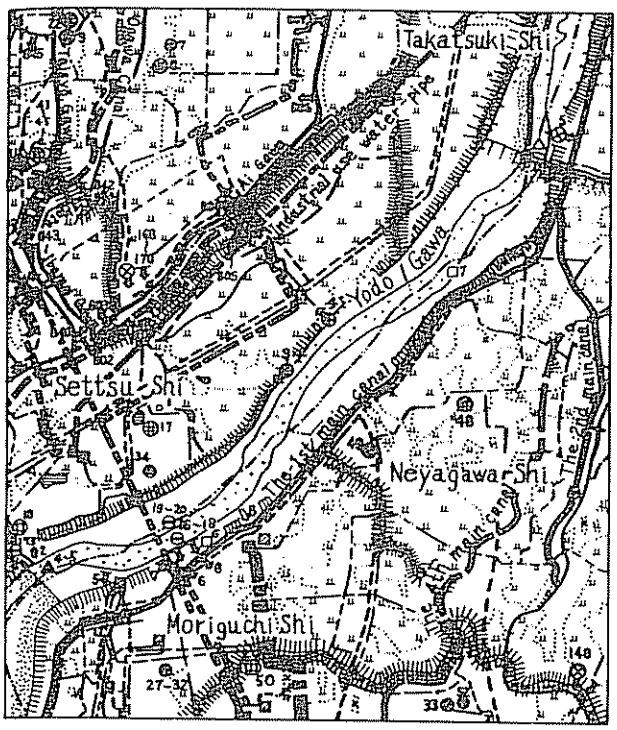
For easier visual observation, the map for beneficiary areas from agricultural water (intake, drainage and intake-discharge) and the map for land improvement areas are printed on the separate transparent sheet, and each can possibly be used by overlaying itself on the main map.

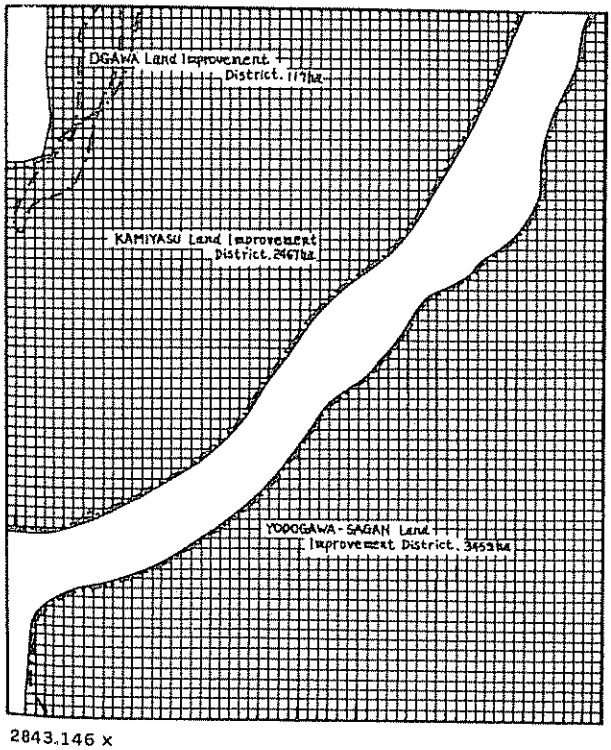
Index

In the index, the outline of the water system, observation data, and scales and capacities of various intake and discharge plants, reservoirs and irrigation ponds are compiled. The names and the numbers used are so arranged as to refer to the main map.

Conclusion

The water-use maps are composed of the main map, the overlay and the index which is supplied for use in water-use planning. However, the composition of the map is only relatively useful as concerns agricultural water. Since the trend in utilization of water resources is towards mass consumption of city water, the composi-





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L E G E N D

I River and lake
Class A river(designated section under The River Low)
Class B river(designated section under The River Low)
Other river
Lake, reservoir, and irrigation pond

II Canal or water-pipe
Agricultural irrigation
Agricultural drainage
Agricultural irrigation and drainage
Industry
Water supply
Sewerage
Multipurpose

III Facilities for water use
(Arrows show direction of flow)
Intake weir
Agriculture
Sluice wairs
Agricultural irrigation
Agricultural drainage
Agricultural irrigation and drainage
Industrial use
Water supply
Multipurpose
Pump plant
Agricultural irrigation
Agricultural drainage
Natural intake or drainage of surface water

IV Well
Deep well
Agriculture
Industry
Water supply

V Other facilities for water
Industrial filter plant
Water supply filter plant
Multipurpose filter plant

VI Benefited area etc.
Benefited area of water pipe
Industrial use
Municipal water supply
Sewerage
Restricted area for deep wells
Industrial use
Cooler use

VII Facilities and areas for soil and water conservation
Cemented river bed

VIII Land use
Paddy field

IX Observatories
Water-gauge station
Discharge observatory
Measurment station for water quality
Underground water-gauge station

X Administrative boundaries
Fu and Ken
Gun and Shi
Ku, Machi and Mura

XI Boundaries of drainage-basin
Boundary of irrigation and drainage system
Agricultural irrigation and drainage
Boundary of land imporvement district irrigation
Irrigation and drainage

Figure 146. Japan: water-use map and overlay at 1:50,000 scale, part of Yodo river system

tion of the water-use map has to include material that can respond to social needs. The legend has been partially changed; but the data that will permit the quantitative and qualitative comprehension of the movement of water resources are to be added to offer the basic information for the extensive planning of water use, for example, data on the reserved stock of river water and ground water and on water contamination.

THE NATIONAL ATLAS PROJECT IN JAPAN*

Paper presented by Japan

The compilation of the national atlas of Japan commenced in 1971 as a five-year project, in compliance with the long-standing requests and demands from governmental, educational, academic and business organizations.

School atlases, economic atlases and thematic atlases have been produced by private enterprises and by governmental organizations in Japan. However, the compilation of the national atlas, which summarizes natural, economic and social conditions of Japan in a single volume produced and published by a nationally authorized cartographic organization, is the first attempt of this type.

Organization of the work on the National Atlas of Japan

Producing organization

The planning, compilation and publishing of the national atlas of Japan are being undertaken by the Geographical Survey Institute of the Ministry of Construction.

Training of the staff

When the project was initiated in April 1971, the project team consisted of eight cartographers and geographers of the Geographical Survey Institute, and training of staff was conducted for three months.

The training included the following:

(*a*) Collection and analysis of statistical data and study of the problems pertaining to compilation of maps when using these data;

(*b*) Compilation of draft thematic maps by use of various expression methods;

(*c*) Study of duplication techniques and of designing.

Staff for editorial and compilation work

Seven staff members were engaged in the compilation work in 1971, and eight more were added to do compilation work in 1972. The staff was organized into seven two-man teams with one expert in each team; and in order to retain consistency, each team carried on its work from the preparation of the editorial scheme to the completion of the compilation draft.

During 1971 and 1972, basic studies on compilation and reproduction were made, together with the compilation of 28 maps. In 1973, the staff was increased to 22; and the system adopted was to divide the staff into two or three groups responsible for the planning, and the compilation and the preparation of the compilation draft, respectively.

Staff for reproduction work

Two experts of the reproduction division of the Geographical Survey Institute who were trained for three months in 1971 were mainly engaged in studies on trial and reproduction techniques. In 1972, the unit comprised four members; in 1973, it was increased to seven staff members.

Link between compilation work and reproduction work

In completing the atlas, the link between compilation and reproduction work is to be strengthened. To this end, staff engaging in both compilation and reproduction work are trained in the whole process from compilation to reproduction at the start of the project. Three staff members from each division are assigned to the other division in order to link smoothly the actual execution of the work.

Committee for the National Atlas of Japan

The Committee for the National Atlas of Japan was organized to collect various statistics and thematic maps prepared by governmental organizations, as well as to take into consideration opinions on composition, contents and expression of the atlas.

The Vice-Minister of the Ministry of Construction is the president of the Committee. The Committee has 42 ordinary members, composed of 26 officials from related government organizations and 16 academic scholars, and of 43 specialized members, composed of 31 officials and 12 academic scholars.

The Committee meets once a year as the National Atlas Council to discuss the project, its execution and progress, and the composition and contents of the atlas. Three or four times a year the Committee holds specialized conferences to evaluate technically the compilation draft and the expression of the thematic maps in each sector.

Outline of the project

Project period and the standard

The period of the national atlas project is five years, from 1971 to 1975. After the completion of the first edition, it will be revised every five or ten years.

The standard of the national atlas of Japan is as follows:

(a) *Size:* 84.1 cm × 59.4 cm (opened);

(b) *Volume:* approximately 400 pages;

(c) *Number of colours used:* 5-12 colours, depending upon type of map;

*The original text of this paper, prepared by Masayoshi Takasaki and Mutsuko Hoya, Geographical Division, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.62/L.30.

(d) *Scale*: the scales of thematic maps are 1:2,500,000, 1:4,000,000 and 1:8,000,000. The scales of regional maps and city maps are 1:1,000,000 and 1:100,000, respectively.

(e) *Language*: the edition for domestic use is in Japanese, and that for international use is in English;

(f) *Map projection*: oblique conformal secant conic projection;

(g) *Binding*: solid binding, but maps that are supposed to be used frequently are to be published separately before binding.

Composition of national atlas of Japan

The national atlas of Japan is to be composed of the 15 sections listed in table 1.

Table 1. Sections of national atlas of Japan

Section	*Number of pages*	*Number of maps*
General reference	4	2
Physical features	68	36
National development and conservation	20	11
Population	24	13
Agriculture, forestry and fisheries	44	28
Mining, manufacture and construction	40	25
Transport and communications	44	22
Foreign trade and commerce	28	18
Politics, finance and incomes	12	9
Social community	28	20
Education, culture and welfare	36	19
Regional maps	10	7
City maps	8	5
Old maps	8	4
Administration boundaries	4	1

The thematic maps are attached with complementary maps, graphs and explanatory notes, and with indexes of the names of places.

Current state of project execution

The maps that were tentatively printed in the fiscal year 1972 and those which were scheduled to be printed in the fiscal year 1973 are listed in table 2.

The maps that are to be compiled in the fiscal year 1973 comprise 7 maps of physical features, 7 of population, 18 of agriculture and forestry, 6 of mining and manufacturing, 11 of transport and 1 of culture. Of these maps, final drawings are to be completed for 4 of physical features, 7 of population, 10 of agriculture and forestry, 1 of manufacturing and 5 of transport.

Table 2. National atlas of Japan: maps printed in fiscal year 1972 and scheduled for printing in fiscal year 1973[a]

Map title	*Scale*
River systems[b]	1:2,500,000
Landform classification[b]	1:2,500,000
Physical regions and their names	1:4,000,000
Geology	1:2,500,000
Bathymetry[b]	1:8,000,000
Gravity anomalies	1:4,000,000
Epicentre of earthquakes	1:6,000,000
Mean temperature[b]	1:8,000,000
Daily ranges of temperature[b]	1:12,000,000
Mean monthly number of days with mean cloud amount less than 2.5/10 and mean monthly number of days with mean cloud amount of 7.5/10 and over[b]	1:12,000,000
Amount of precipitation[b]	1:8,000,000
Number of hours of bright sunshine	1:8,000,000
Mean relative humidity[b]	1:12,000,000
Normal sea-level pressure and wind-roses	1:8,000,000
Land use[b]	1:2,500,000
Population distribution[b]	1:2,500,000
Population density[b]	1:2,500,000
Percentage of population change 1965–1970	1:2,500,000
Sex ratio[b]	1:4,000,000
Transportation network[b]	1:2,500,000
Railway passenger traffic volume[b]	1:2,500,000
Railway freight traffic volume[b]	1:2,500,000
Traffic volume of passenger motor-cars[b]	1:2,500,000
Traffic volume of trucks[b]	1:2,500,000
Natural parks	1:2,500,000
Administration boundaries[b]	1:2,500,000

[a] Tentative printing.
[b] To be submitted to the Seventh United Nations Regional Cartographic Conference for Asia and the Far East.

COMPILATION PRINCIPLES AND PROBLEMS

Principles of compilation

The atlas is intended for academic study, education, administration and everyday work. The objective is the compilation in a single book of such basic information as the existing state and conditions of physical features, social community, economy and culture. When the current situation of Japan is known from this atlas, the inclusion of many themes in one map can be avoided. For the convenience of users, easy comparison and linkage between maps have been facilitated; and the expression and the plotting method are uniform not only within the section, but throughout the entire atlas.

Problems of compilation

Data and information

In the compilation of the national atlas, such basic data and information as statistical data and existing thematic maps, i.e., data and maps used for this atlas, are of uniform standard throughout the country, providing the most recent information, with minimum divergences in the survey timing of the different regions.

Existing thematic maps used as basic data are revised if newer data are available.

Formulation of the representing method

Attention is paid to the consistent use of expressions and symbols throughout the entire atlas.

Class distinction

In expressing the class distinction between statistical data by various methods, such as colouring or symbolizing, problems arise concerning the number of class intervals and the grouping of class intervals. Such problems often occur with respect to social community maps and economic maps.

In the national atlas of Japan, the number of class intervals is set at nine or so, in view of the scale of the maps and the unit of expressions. Moreover, the same

number and grouping of class intervals are made in the maps of the same section to facilitate easy comparison.

Expressions

Similar expressions are used in the same section or in the same kind of maps. For example, traffic volumes are all expressed in quantitative flow maps. Framings are also taken to present easy comparison even when the symbol representing a certain value cannot be used in all the maps throughout the same section.

Unit of representation

Even in maps showing the values on a regional basis, the representation of values is not considered on a specific regional basis for the specific themes, but on the administrative boundary basis for the benefit of comparison with other maps.

The distribution maps showing the range of distribution in configuration encompass the minimum unit of 0.3 mm width on the map for linear distribution and of 0.4 mm diameter for clustering distribution, excluding the lesser unit. If necessary, however, those items excluded in normal maps are expanded to the minimum unit and shown.

Problems of printing

Drafting and plate-making

Drafting work is mainly by the scribing method. To enhance the accuracy of the printing, less elastic polyester bases are used as the material for drafting and as the support for exposure materials. For registration, a punching method is adopted. The punching machine is of four-hole type designed by the Geographical Survey Institute.

All plates are made by printing the negative films on PS plates, and the printings are made in four colours by a rotary offset press.

Choice of colours

The choice of colours for the maps is closely related to the printing technique. Some specific problems arise, such as ink, paper and colour expression, from combining the solid printing and the screen.

In the execution process of the national atlas project, basic studies are made on: (*a*) the choice of basic colours; (*b*) the making of various screens; and (*c*) the colour range expressed by the combination of solid printing and screen. At the same time, an evaluation is made by printing the trial maps.

Choice of material

High-quality paper of physical strength, elasticity and non-transparency is needed for printing suitability. The map papers currently used by the Geographical Survey Institute are being used temporarily for trial purposes, since these papers have long been used for maps. Evaluations and tests of several kinds of papers have been undertaken for use in producing the national atlas of Japan.

SOME FEATURES OF THE AUSTRALIAN NATIONAL ATLAS OF RESOURCES*

Paper presented by Australia

Out of the needs of a country at war and the aspirations for a better managed post-war Australia, there arose by 1948, in the then Department of Post-War Reconstruction, the idea of preparing a set of national maps which would synthesize the rapidly growing knowledge of the continent's resources and its expanding economy. Envisaged first as an aid to administration for departments of the federal Government, this idea soon developed into a proposal to prepare and publish for all to use an Atlas of Australian Resources.

Australian resources

In 1950, K. Frenzel arrived from the Federal Republic of Germany to join the Department of National Development as editor of the atlas. He soon formulated a plan for 50 large map-sheets, each with a supplementary booklet. The maps were to be readily comparable by most of them being at 1:6,000,000 scale, or 94.7 miles to 1 inch, which was close to the scale of 100 miles to 1 inch, then used for the largest official general reference map of Australia on a single sheet.

The "national planning" theme of those early post-war years is evident in a programmatic article by the editor that was published in 1953. The first of the objectives he listed for the atlas was "to provide co-ordinated information on Australia in the form of maps for future National Planning".[1] Moreover, an important group of the 50 map-sheets proposed were 10 unspecified sheets showing potential development, to be produced by an evaluation of the maps of physical features and natural resources in relation to the economic and demographic maps.

First series of the Atlas of Australian Resources, 1952–1960

The first five map-sheets and their accompanying commentaries (booklets) were published in 1953, two years after work on the atlas had begun. It was a remarkable achievement for a very small group of people —the editor and his assistant, a professional geographer and four cartographic draftsmen—especially as the standard set was "to produce a cartographic work comparable with the best international standards".[2]

These maps exemplified several things characteristic of the atlas throughout its history so far. Some sheets have been made from existing maps contributed by people or organizations expert in the fields of knowledge covered, but redesigned by the atlas staff, for example, the sheets for soils (1952), rainfall (1952) and tempera-

*The original text of this paper, prepared by L. K. Hazlewood, Geographic Section, Department of Minerals and Energy, Canberra, appeared as document E/CONF.62/L.46.

[1] K. Frenzel, "The Atlas of Australian Resources"; *Australian Geography*, vol. 6, No. 2 (1953), p. 9.

[2] Ibid

tures (1953). Other sheets have been made from maps specially compiled by subject experts in collaboration with the atlas staff, for example, that for mineral deposits (1952). Yet other sheets, for example, that for underground water (1953), have been compiled by the atlas staff from various and not always readily compatible data, both published and specially provided, of which some at least have not been in map form.

Another noteworthy aspect of these first productions that has remained characteristic was the commentaries accompanying the map-sheets—booklets specially written by outside experts and edited by the atlas professional staff. These commentaries were considered necessary from the beginning, to sum up, interpret and add succinctly to the information dealt with on the map-sheets they accompanied.

Thereafter, five map-sheets of diverse subject-matter were published every year until the twentieth appeared in 1956. In 1957, it was decided to limit the atlas to a total of 30 sheets, in part by leaving out the final 10 sheets reserved for aspects of potential development. Other topics had been found unsatisfactory for lack of adequate Australia-wide data, such as the proposed sheet on areas liable to soil erosion, frost and flood; or the sheet on the history of settlement. Still other topics had been dropped because it had been realized that they were fairly pointless to map, such as the sheet proposed on postal telecommunications and broadcasting, which would, in large part, have been but a reflection of population distribution even in the maximum detail possible on an atlas sheet.

The last 10 sheets, including some essential topics which were among the most difficult to tackle, such as manufacturing industries (1960), appeared in 1958 and 1960 after appointment in 1956 of a new editor, an Australian-trained geographer, T. W. Plumb.

The topics of this first series of the Atlas of Australian Resources may broadly be summed up as dealing with physical features and resources (one third), the main primary and secondary industries (one third), and population, transport and services (one third). Some of the 82 maps appearing on these 30 map-sheets were the first ever made for Australia on their subjects, such as ports and shipping (1957); and some had never before been attempted in anything like such detail, at least not for more than part of the continent—for instance, those showing dominant land use (1957) or vegetation regions (1955). For a fuller discussion, see Plumb;[3] a list of the titles of the first series is given in the annex to the present paper.

Second series of the atlas, 1963 to date

Soon after publication in 1960 of the last sheets of the first series, an assessment of the finished Atlas of Australian Resources was begun by the editor. He was aided by a newly published book on national atlases produced for the Commission on National Atlases of the International Geographic Union[4] and by reviews of the atlas as a whole in a number of leading geographical journals, several of which reviews advocated an early start on revision.[5] As a result, it was decided in 1961 to make the atlas a continuing publication by preparing new and revised map-sheets and commentaries which would progressively supersede what then came to be called the first series of the atlas.

This meant that, as each sheet of this second series appeared, an old sheet would be withdrawn (whether superseded by a new edition or replaced by a new topic) so that the full atlas would always consist of 30 map-sheets plus commentaries. It was also decided that the new map-sheets (which would be of the same dimensions as those of the first series) would continue to be made available unfolded, folded to commentary size or folded in half with a mounting so they could be held in the atlas map-binder. Hence, pricing of atlas sets could be kept constant and existing owners could keep their atlases up to date at minimum cost.

The objectives of the atlas were reformulated, notably by omission of reference to national planning. Whatever that may have been intended to refer to in the late 1940s and early 1950s, such small-scale maps cannot do more than provide general orientation in framing government policy. The main objective, as stated by the editor, was that the atlas "should be outstanding as a first reference to the more important geographic information about Australia".[6] It had also been realized by then that a valuable additional function of some atlas map-sheets was to point up gaps in knowledge and thus provide a spur to filling in these gaps.

It followed from this policy of progressive revision that a major consideration in planning the order of production of the second series titles would be the extent to which the first series sheets were out of date or outmoded, and whether new data or new concepts would make possible any marked improvement or significant updating. Furthermore, as only a very small group of geographers and cartographic draftsmen could, as before, be made available for this work, production of the second series would have to be spread over a number of years—10 years was envisaged, but a longer period will be required.

This plan has had manifest advantages; and, despite slow progress in the earlier years, the atlas has continued to grow in popularity. A recurrent disadvantage of the plan has been that priority in the production of some sheets has been dictated by approaching exhaustion of stocks of the first series sheets they were to replace, in order to keep the total number of sheets currently in the atlas at 30. Another problem has been to keep owners of atlases informed of newly published sheets, especially if an entirely new topic has been introduced to replace one not considered worth retaining.

Standards of content have undoubtedly risen, accompanied by improvements in drawing, map design and printing. The Geographic Section of what is now the Energy and Water Division of the Department of National Development has continued to plan the topics, obtain and analyse the data required, and prepare it for cartographic drafting. The Department's Division of National Mapping has taken over the provision of cartographic services, and it has progressively introduced technical innovations and improved methods of quality control.

[3] T. W. Plumb, "Australia's Resources Atlas", *Cartography*, vol 4 (1961), pp. 60–65.

[4] K. A. Salichtchev, ed., *Atlas nationaux: histoire, voies de perfectionnement et d'unification* (Moscow and Leningrad, Academy of Sciences of the USSR, 1960).

[5] See list in T. W. Plumb and L. K. Hazlewood, "Planning the second series of the Atlas of Australian Resources", *Australian Geography*, vol. 9 (1965), ref. 17.

[6] *Ibid.*, pp. 299–300.

In the second series, a marked tendency, the beginnings of which became apparent during production of the first series, is a much greater use of multimap-sheets with maps of Australia at various scales smaller than 1:6,000,000. Sectional maps at larger scales, notably at 1:4,500,000, were also introduced. In the first series, 25 of the 30 map-sheets presented single maps of Australia at 1:6,000,000 scale, whereas only 11 of the 30 sheets of the second series will do so. This has generally meant that more aspects of a topic are dealt with on many second series sheets and not necessarily in less detail than on the corresponding first series sheets.

The map-sheets with sectional maps deal with topics for which the main information of national importance is distributed in eastern and south-west Australia—for instance, forests, irrigation and urban water-supply, electricity generation and distribution, and population distribution. Thus, more detail can be shown for such topics; or, at least, these maps have kept pace with the growing intricacy of some of these distributions as the economic development and population of Australia grew rapidly during the 1960s.

In general, the content of the second series does not differ greatly from that of the first series. Fourteen of the titles will have "second edition" written after them, but another five sheets have merely been retitled more aptly, for instance, "Livestock" (1970), which has replaced "Distribution of stock" (1954). Another six have involved so extensive a change in subject-matter, mostly by being broadened in scope, that they could not be issued under the name of the first series topic, for instance, "Water use" (in preparation, 1972), which will replace "Conservation of surface water". This leaves only five topics dropped or to be dropped from the first series—two sheets on intercensal population change (a subject combined with population distribution in the second series); the sheets covering educational facilities and health services (in Australia, both very largely reflections of population distribution at least in the detail possible on an atlas sheet); and that for major developmental projects (subject-matter well worth mapping, but changing far too rapidly for an atlas based on a 10-year replacement cycle).

As previously, a third of the second series of the Atlas of Australian Resources remains made up of sheets on the natural environment, but rather more than a third deals with basic industries and land use, and rather less than a third concerns population, transport and services.

For a country with so much hot, arid and semi-arid land, and with so much of its area devoted to extensive livestock raising and dryland grain-growing, three sheets on climate (on rainfall, temperatures and climate generally) seem as justified now as for the first series, as do three sheets on water resources and water use, including ground-water. The five sheets of the first series on rural land use and production have been added to by separate sheets on sheep and wool (1968) and grasslands (1970); and a new industry topic was added, fish and fisheries (1965). The introductory sheet covering physical features (1954) is being replaced by a more complex and thorough sheet which has been retitled "Landforms" (1972). In the second edition, the sheet on soils (1963) marked a great advance on the first series sheet of 1952, which was derived from a map produced in the early 1940s; and the sheet being prepared for natural vegetation will mark as great an advance on that covering vegetation regions (1955), as this first series sheet was on the existing continental map of the early 1930s. Once again, unfortunately, it has not been possible to include a sheet on wildlife, nor, except for some minor supplementary information in the industry sheet on fish and fisheries, anything on the Australian marine environment. Plans were being made in collaboration with several interested people to spread the revision of the data on manufacturing industries (1960) over two sheets, but a major and insuperable delay in the supply of data has meant that only one sheet can be produced in the time available. The four sheets on population characteristics in the first series have been reduced to two, by combining population growth (two sheets in the first series) with population distribution; the transport trio, vital for understanding the Australian economy, remains; and the two sheets covering educational facilities (1956) and health services (1957) have been or will be dropped, as mentioned earlier. The former sheet entitled "State and local government areas" (1953) is being replaced by the retitled multimap-sheet "Government", in which it is hoped to include a substantial treatment of federal electoral results. Lastly, another new sheet is being prepared, a specially devised general reference map, the commentary for which will largely comprise a gazetteer for the entire second series. A list of the second series titles is given in the annex.

Preliminary planning of third series

Towards the end of 1970, the continuing demand for revised maps and additional topics made it clear that production should continue beyond the second series. The Department of National Development then proposed that a first step in planning the continuation of the atlas should be the setting up of a National Atlas Advisory Committee to make a thorough assessment of the current atlas and to make recommendations on the objectives, content, format and mode of publication of the proposed third series.

The Committee, appointed by the Minister for National Development, has nine members, who, in the main, are representative of user interests and several of the main sources of supply of data—professional geographers and teachers of geography, earth scientists and social scientists. Members represent the Institute of Australian Geographers, the Australian Geography Teachers Association, the National Committee on Geography of the Australian Academy of Science, the Commonwealth Scientific and Industrial Reasearch Organization, the Academy of Social Sciences of Australia, the Commonwealth Bureau of Census and Statistics and the publishing industry. The Committee held its first meeting in February 1971, and since then has in various ways sought ideas and advice from a wide and numerous body of experts.

The forward planning and investigations of the editorial staff of the atlas have been concentrated on helping the National Atlas Advisory Committee prepare its report, which it hopes to submit in mid-1973. It is expected that the last sheet of the second series will be published in 1974, 11 years after publication of the first, and that, meanwhile, substantive work will have begun on the first sheets of the third series.

Comparison with other national atlases

When the first map-sheets of the Atlas of Australian Resources were published in 1953, it was one among a

dozen national atlases.[7] Ten years later, when publication of the second series began, there were national atlases for about 20 countries, though national atlases had still not appeared for such major countries as the United Kingdom of Great Britain and Northern Ireland and the United States of America.

The value of such publications was becoming increasingly widely recognized. In 1956, for instance, the International Geographical Union set up its Commission on National Atlases under the chairmanship of K. A. Salichtchev of the University of Moscow, with members drawn from other European countries, India and the United States of America. This Commission, which later came to include regional atlases in its scope, continued to be led by K. A. Salichtchev until the twenty-second International Geographical Congress at Montreal in August 1972.[8] By then, at least another 15 countries had national atlases; and, in addition, close to 10 new editions had been published or were in course of publication.[9]

One of the early achievements of the Commission on National Atlases was the publication of a small, but comprehensive, book on national atlases edited by K. A. Salichtchev—*Atlas nationaux* (1960). This book offered a conspectus of past achievements in the field, beginning with the pioneering first edition of the Atlas of Finland (1899), and went on to analyse the content and form of past national atlases and make practical recommendations on the objectives, content and degree of detail that national atlases should have.

On one aspect of the preparation of national atlases, however, the book said nothing: that aspect was the desirability (and problems) of revision. By then, the Atlas of Finland had had four editions, at widely spaced intervals (1899, 1910, 1928, 1960); and the Atlas of France had appeared in two editions (1931–1946 and 1953–1959).

Thus, new ground was being broken when, only a year after publication of the first series, progressive revision of the Atlas of Australian Resources was begun. By continuing serial publication in loose-leaf form of map-sheets and booklet commentaries of the same format, a first series title could be withdrawn from sale as each new title was published, and the total number of sheets in a set kept at 30.

By the meeting in 1972 of the Commission on National and Regional Atlases (as it is now called) at the International Geographical Congress, revision of national atlases was very much a live topic. Significantly, too, there was evident a trend away from producing the huge number of maps which were typical of many of the earlier national atlases. There was a growing recognition of the desirability of finding out more about users' needs and of reaching a wider audience. Continuing revision, in cycles of 10 years or so, was also being widely discussed.[10]

[7] The term "national atlas" has come to refer in particular to a thematic atlas which sums up contemporary scientific knowledge on the physical, economic and political geography of a single country. See Salichtchev, *op cit*, p 3.

[8] T. W. Plumb, editor of the Atlas of Australian Resources, has been a corresponding member of the Commission on National Atlases since 1962.

[9] Halina Tuszynska-Rekawek and S. Leszczycki, *National and Regional Atlases for 1968–1971: Sources, Bibliography, Articles* (Warsaw, Institute of Geography, Polish Academy of Sciences for XXII International Geographical Congress, 1972).

[10] Personal communication from T. W. Plumb.

Plans for third series of the Atlas of Australian Resources

These trends are reflected in, and perhaps have been influenced by, the Atlas of Australian Resources. As already mentioned, a searching examination of the achievements of the first series and the partially completed second series of the atlas began in early 1971 with the first meeting of the Australian National Atlas Advisory Committee. The work the Committee has done and is doing to prepare its recommendations for presentation to the Minister for National Development in mid-1973 marks a step towards a more systematic and comprehensive collaboration between those responsible for producing the new atlas (in Australia, a group of geographers employed by the national Government); and a wide range of users' interests, as already mentioned. Some of the non-government groups responsible for producing national atlases for other countries, such as national committees on geography, also are moving towards this middle ground of close co-operation with government agencies.

Early in its work, the National Atlas Advisory Committee began to favour a much smaller and handier format for the new atlas; but, unlike the new edition of the National Atlas of Canada (1971–), not at the cost of a considerable reduction in detail. The sheets envisaged would be large enough for a single map of Australia at 1:10,000,000 scale; or for several maps at smaller scales, such as four maps at 1:20,000,000 or nine maps at 1:30,000,000, all scales which have been used successfully for the second series. If a scale larger than 1:10,000,000 is necessary to present the detail required, sectional maps at 1:5,000,000 could be used.

By setting up working groups including a considerable number of other people, the Committee has been able to submit possible subject-matter to a very thorough scrutiny. In addition, several "thousand postal questionnaires on users'" needs and preferences were printed and distributed to all buyers of atlas sheets from September 1971 to December 1972, and a modification of this questionnaire was sent out in the first half of 1972 to the 2,500 members of the school geography teachers' associations and the Institute of Australian Geographers.

One advantage of the smaller size of sheets would be greater flexibility in the amount of map material that can be presented in a topic (title). Thus, topics can be included that would fall well short of filling one of the present large map-sheets (72 × 75 cm) and others that would require significantly more space. The net effect would be a doubling of the map material in the third series.

Various other innovations are under consideration. One of the Committee's guiding principles has been that the new atlas should contain all material considered essential in a national atlas, recognizing that the first and second series of the Atlas of Australian Resources have not covered all the subject-matter usually found in national atlases. There are now more topics on which available data permit national generalizations in map form to be undertaken with some confidence. Also, the significance of certain aspects of the Australian environment and economy has been increasing rapidly. For example, consideration is being given to the preparation of maps on the history of settlement and on land potential, both of which were proposed in the original

list of topics for the first series;[11] on the marine environment; and, perhaps most notably, on detail within the 10 cities of Australia with over 100,000 people (in which live 65 per cent of the total population).

Nevertheless, many topics that have appeared in other national atlases will not appear in the expanded and refurbished third series of the Atlas of Australian Resources, or, at least, will not appear in the same relative detail. This situation derives in part from the characteristics of Australia, its people and their general level of living. Thus, there are no proposals for maps showing incidence of snow, languages spoken, or various welfare services, such as elementary schools and hospitals.

One clear-cut finding from the answered questionnaires received is that users value the booklet commentaries that have always accompanied map-sheets and with virtually no exceptions want commentaries in the third series. The Committee has in mind that commentary material should be interleaved with map-sheets on sheets of the same size. However, the very much thicker new atlas would be overburdened with text if commentaries remain at their current usual length, so it is likely that commentaries will be briefer.

Thus, a more comprehensive third series, or third edition, of the Atlas of Australian Resources is being planned, to appear in a new and much more convenient format. Current proposals are for the new sheets to be published serially, as were those of the first and second series, over a period of about seven or eight years. Preparation of the new sheets is expected to begin as soon as completion of the second series permits, and the first batch of topics may be issued in 1975.

[11] Frenzel, *op cit*, p 9

ANNEX

Atlas of Australian Resources — Contents

First series: 1952–1960

Physical features (1954)
Geology (1958)
Mineral deposits (1952)
Climatic regions (1954)
Temperatures (1953)
Rainfall (1952)
Drainage systems (1955)
Conservation of surface water (1954)
Underground water (1952)
Soils (1952)
Vegetation regions (1955)
Dominant land use (1957)
Croplands (1958)
Agriculture production (1953)
Distribution of stock (1954)
Forest resources (1954)
Mineral industry (1959)
Power and fuel (1955)
Manufacturing industries (1960)
Population density and distribution (1953)
Population increase and decrease, 1933–1947 (1954)
Population increase and decrease, 1947–1954 (1957)
Immigration (1959)
Railways (1954)
Roads and aerodromes (1953)
Ports and shipping (1957)
Educational facilities (1956)
Health services (1957)
State and local government areas (1953)
Major developmental projects (1953)

Second series, 1962

Published:

Landforms (1972)
Geology, 2nd edition (1966, reprinted 1969)
Mineral deposits, 2nd edition (1965, reprinted 1967, 3rd imprint with amendments 1969, 4th imprint with amendments, 1970)
Temperature, 2nd edition (1972)
Rainfall, 2nd edition (1970)
Surface water resources (1967, reprinted 1969)
Soils, 2nd edition (1963, reprinted 1970)
Croplands, 2nd edition (1970)
Crop production (1968)
Livestock (1970)
Sheep and wool (1968)
Grasslands (1970)
Forest resources, 2nd edition (1967)
Fish and fisheries (1965, reprinted 1970)
Mineral industry, 2nd edition (1969)
Electricity, 1st edition (1962); 2nd edition (1969)
Population distribution and growth (1964)
Immigration, 2nd edition (1970)
Roads and aerodromes, 2nd edition (1967)
Ports and shipping, 2nd edition (1971)

In preparation:

Climate
Water use
Ground water
Natural vegetation
Land use
Manufacturing industries, 2nd edition
Railways, 2nd edition
Major urban areas
Government
Locational index

A SCHEME FOR PREPARATION OF 1:25,000 LAND-USE MAPS IN JAPAN*

Paper presented by Japan

BRIEF HISTORY OF LAND-USE SURVEY IN JAPAN

Initial stage of land-use survey, 1946–1952

The post-war land-use survey in Japan was initiated in 1947, when the Geographical Survey Institute (GSI) of the Ministry of Construction completed a land-use map at 1:800,000 scale covering the whole country, as the basic data for implementing rehabilitation of war devastation. This undertaking was followed by the Institute's plan to prepare, in co-operation with the Planning Bureau of the Ministry, a land-use map at 1:200,000 scale, also covering the whole country. However, in the course of land-use surveys conducted in a number of comprehensive development districts, it was determined that a 1:50,000 land-use map should be prepared instead of the said 1:200,000 map, due to the higher accuracy of the larger scale, as well as its suitability for use in individual development projects. Hence, a few press-proofs of that map were produced.

Period of 1953 map symbols, 1953–1967

In 1953, the symbols for the 1:50,000 land-use map to be prepared by GSI were officially determined and detailed budgetary rules were enforced whereby the Institute embarked on the task of preparing several tens of that map each year.

The 1953 map symbols were intended for consolidation of the basic data of development plans to be implemented in specially designated districts in accordance with the Multiple Purpose Land Development Law of 1950. Hence, stress was placed on the development of resources and effective land use for agricultural and forestry production in undeveloped areas, with consideration also given to conservation of national land and prevention of disasters. Map symbols relating to cities and villages, on the other hand, were expressed in a rather simple way. To be brief, the symbols were established with primary account taken of the specially designated districts embracing undeveloped areas.

During the 1962–1966 period of this stage, a 1:200,000 land-use map of Hokkaido was compiled and published from the intensified manuscript on the scale 1:50,000. In addition, during 1958–1967 land-use maps of a few other districts, prepared from preliminary surveys on the scales 1:20,000, 1:22,500 and 1:25,000, were printed and published.

Period of 1967 map symbols, 1967–1969

In the 1960s, the economy of Japan achieved rapid growth, particularly in the Pacific belt area, inviting marked population convergence in large cities. Concentration of industries in the belt area gave rise to larger regional disparities.

In 1962, the Comprehensive National Development Project was mapped out. The prime objective of the project was to redevelop existing industrial zones in each locality with local cities as their core in order to check expansion of large cities, correct regional differences and materialize efficient redistribution of industries.

With the changes effected by the regional development policy of the Government, the land development and conservation works shifted from undeveloped areas to urban areas. As a consequence, the districts previously covered by the land-use survey, as well as the survey items, were likewise changed, with the result that the symbols for the map at 1:50,000 scale were revised in 1967.

In the 1967 revision, the symbols relating to urban areas were subdivided and increased, whereas those relating to agriculture and forestry were subjected to omission and unification. In addition, considering the fact that GSI had begun publishing, as from 1960, the land-condition map (a thematic map intended chiefly for disaster prevention and indicating land classification and ground elevation, as well as organs and facilities relating to land and disaster prevention), the symbols of organs and facilities already shown in that map were simplified.

In short, the 1967 map symbols reflected the trend towards urbanization.

Period of 1970 map symbols, 1970 to date

In the latter part of the 1960s, various difficulties which developed as a result of the rapid economic growth posed a serious problem, and it was necessary to alter the economic policy of the Government so as to give preference to the protection of human life and living environments over industrial development.

In 1969, the new comprehensive national development plan was formulated. With 1985 set as the target year, it was envisaged by the plan that the central control functions would be strengthened in each locality by establishing a nuclear city; and proper distribution of industries and population would be attained by consolidating the transportation and communication networks. This scheme was called the "network system". The objective of the plan was to bring about a radical remedy for the problem of urbanization which had progressed to excess; and to establish, for each locality of the country, a new and large-scale development project incorporating various local characteristics.

Consequent on the formulation of the new plan, land-use surveys came to be conducted in areas covered by large-scale development projects; and in addition, the rapid supply of many land-use maps was demanded in order to determine the details of the plan. The map symbols were therefore simplified to the maximum extent, with efforts exerted for making best use of the symbols for the topographic map at 1:50,000 scale, which was to be used as a base map.

The 1970 symbols, to be brief, were the result of simplification which was intended to make possible the mass production of maps to meet the demands of the development plan, and they were devised from the symbols for the 1:50,000 topographic map to be used as a base map.

The past production of land-use maps is shown in table 1 and in figure 147.

*The original text of this paper, prepared by Eiichiro Torii, Geographical Division, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.62/L.49.

Table 1. Production of land-use maps at 1:50,000 scale

Period	Number of maps
1953–1966 (1953 symbols)	305
1967–1969 (1967 symbols)	22
1970–1973 (1970 symbols)	95
TOTAL	422

NEED FOR 1:25,000 LAND-USE MAPS AND REVIEW OF THEIR PRODUCTION

Need for land-use maps at 1:25,000 scale

As is described below, it is expected that topographic maps at 1:25,000 scale will be continuously prepared and published to cover the whole country in the coming few years. Consequently, both the Government and the local public bodies tend to employ 1:25,000 topographic maps

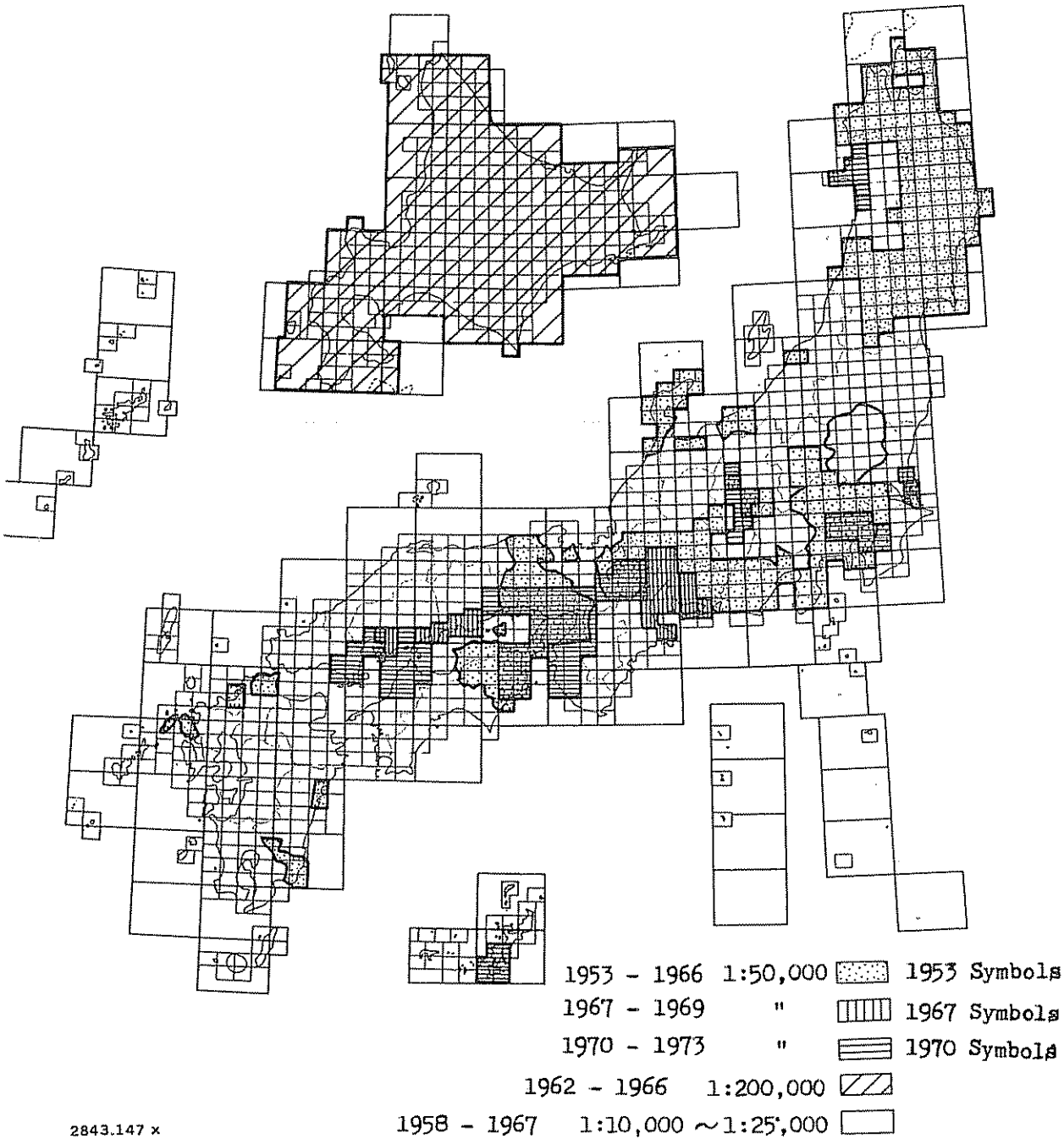


Figure 147. Japan: production of land-use maps, 1953–1973

rather than 1:50,000 topographic maps in formulating the master plans for various types of development, land conservation, disaster prevention, improvement of environmental conditions, etc., for clearer and more detailed presentation of the area covered and for improvement of the quality of the master plan itself.

This trend brought about the need for making more positive use of the land-use map which had been the source of basic data indispensable for preparation of master plans. In other words, it became essential that the land-use map be prepared with the 1:25,000 topographic map as the base map so that it would provide detailed information required on the scale 1:25,000.

Plan for revising 1:25,000 topographic maps in parallel with preparation of 1:25,000 land-use maps

GSI is currently engaged in map production activities along the lines of its second-phase long-term plan (1964–1973). Preparation of 1:25,000 topographic maps for coverage of the whole country is one of the important works included in the plan, and it is in general, progressing smoothly, as is shown in table 2, though somewhat behind the schedule.

Table 2. Production of topographic maps at 1:25,000 scale

	Number of completed intensified manuscripts	*Ratio (Percentage)*	*Number of printed and published maps*	*Ratio (Percentage)*
March 1973	3,937	88.3	3,093	69.4
March 1974 (estimate)	4,264	95.7	3,454	77.5

Note: **Total number of maps for full coverage: 4,455.**

Hence, the Institute has now definite prospects of full coverage of the country with 1:25,000 topographic maps, though part of the work may have to be carried forward to 1974.

In the third long-term plan (1974–1978), which is in the planning stage, revision of completed 1:25,000 topographic maps constitutes an important part. GSI is planning to undertake the new task of preparing land-use maps at 1:25,000 scale during the period of the third long-term plan, with close co-ordination maintained with the revision of 1:25,000 topographic maps.

Revision of these topographic maps calls for such activities as aerial photography, collection and review of relevant data, and field surveys. The Institute plans to carry out these activities not just for the purpose of revising the topographic maps, but for the preparation of the land-use maps at 1:25,000 scale.

Needless to say, the symbols for the 1:25,000 topographic map do not coincide with those for the 1:25,000 land-use map, the latter requiring some additional symbols. By exerting ingenuity in limiting the additional symbols to a minimum, however, it will become possible to produce land-use maps in parallel with the revision of 1:25,000 topographic maps, which, undoubtedly will contribute largely to the reduction of cost and the number of personnel and working days.

Considerations in preparing land-use maps at 1:25,000 scale

In studying the content of 1:25,000 land-use maps, it is necessary to be fully acquainted with the history of the land-use survey and the demand of the times.

What is expected of the various plans of the Government and the local public bodies owing to the prevailing political and social situation is, in brief, the checking and correction of urbanization which has already become excessive. The first task in meeting this expectation is the rapid establishment of a land-use plan covering the entire country. This step should be followed by a re-examination of the city planning involving urban and suburban areas, as well as by formulation of a detailed remodelling plan designed, on the basis of the above-mentioned land-use plan, to achieve balanced and harmonized development, conservation, disaster prevention and environmental consolidation of the whole Japanese archipelago.

With the Environment Agency established in 1971 from this viewpoint, the Government is eager to prompt environment administration; and it presented before the 1973 ordinary session of the Diet an omnibus bill proposing, on the one hand, amendment to the Multiple Purpose Land Development Law and suggesting, on the other, establishment of a multiple-purpose land development agency to be charged with the execution of the amended law. It merits attention that if the bill is passed, the amended law will oblige prefectural governments to draw up a land-use plan without delay.

If one is fully cognizant of such trends of the times, one would readily see the points to which due consideration should be given in conducting land-use surveys in future, as described below:

(*a*) The survey should be so conducted as to permit mass production of maps. Naturally, classification of current land-use conditions throughout the country is an essential prerequisite of the establishment of a land-use plan covering the entire Japanese archipelago. The land-use survey can never fulfil its purpose unless an extensive area is covered within a specified time. A land-use survey covering a small area or requiring several years in a single locality is meaningless no matter how highly it can be evaluated in terms of quality because land-use conditions in Japan are changing year after year. Hence, it is an imperative that the land-use survey, if intended for establishment of a nation-wide land-use plan, should adopt a method that permits the mass production of land-use maps. For these reasons, GSI is planning to conduct the land-use survey in parallel with the revision of topographic maps under its third long-term plan;

(*b*) Urban functions should be suitably classified. The progress of the land-use plan in Japan is more impeded by cities than by anything else. A topographic map indicates the morphological land use in urban areas (e.g., individual buildings, built-up areas, built-up areas with edifices), but its indication of the functional land use in urban areas (e.g., commercial district, public district, industrial district, residential district) is not satisfactory. Classification of urban functions is the basis of city planning and can never be dispensed with for working out a land-use plan of an urban area. The functional classification should be indicated minutely according to the scale of the map.

Concurrent revision of 1:25,000 topographic maps and survey of 1:25,000 land-use maps

Outline and effects of concurrent work

Revision of the topographic maps at 1:25,000 scale is planned to be conducted in parallel with the land-use survey on the same scale, as shown in figure 148.

The benefit of this simultaneous work can be summarized into the following points:

(*a*) An integrated system can be established under which collection and review of data and field survey can be carried out both for revision of topographic maps and for survey of land-use maps;

(*b*) The most recent land-use condition can be indicated, almost simultaneously, in both topographic maps and land-use maps;

(*c*) The most recent and abundant data on land-use condition can be conveyed to users quickly;

(*d*) In addition to the above-mentioned points, both the revision and the survey activities can be made highly rational and efficient.

Relationship between parallel implementation of work and survey items

If the parallel implementation of the revision survey and land-use survey activities is reviewed with respect to the survey items, it becomes clear that the 117 symbols (including notes) for the topographic map are all required for the land-use map, the latter having an additional 23 symbols of its own.

The contents of the additional 23 items for the land-use survey comprise: (*a*) functional classification of buildings and other structures; (*b*) landscape classification of vegetation.

For the land-use survey to be conducted for the purpose of item (*a*), necessary data can be obtained from the functional buildings classification map which is being prepared by the City Bureau of the Ministry of Construction in co-operation with local public bodies (the map is on the scales 1:25,000–1:3,000 and is expected to cover built-up areas by the end of 1973).

Item (*b*) is intended for classification of vegetation into broad-leaf forest land, coniferous forest land and mixed forest land; and practically the entire vegetation area can be classified by aerial photo-interpretation.

Hence, it is expected that inclusion of some extra work in the revision survey will suffice to meet the purpose of the land-use survey.

The symbols and sample of the 1:25,000 land-use map are as shown separately.

Future policy for preparation of the 1:25,000 land-use map

As described above, preparation of the third long-term plan, which will be put into practice in April 1974, is in the stage of final brush-up.

The size of the 1:25,000 topographic map is A2, and the total number of maps required for full coverage of the country is 4,455. Revision of these maps is one of the major activities to be undertaken under the Institute's third long-term plan. GSI officials in charge are planning to prepare new 1:25,000 land-use maps in parallel with the revision of several hundred topographic maps on that scale each year, so that it is expected that the land-use maps will be produced at the same rate.

In undertaking the revision of topographic maps and the land-use survey, GSI intends to give priority to important districts expected to be covered by development projects.

GSI is currently engaged, on an experimental basis, in simultaneous implementation of the revision and the land-use survey in an area covered by about 30 topographic maps at 1:25,000 scale for the purpose of collecting various data which will facilitate revision and land-use survey activities under the new long-term plan.

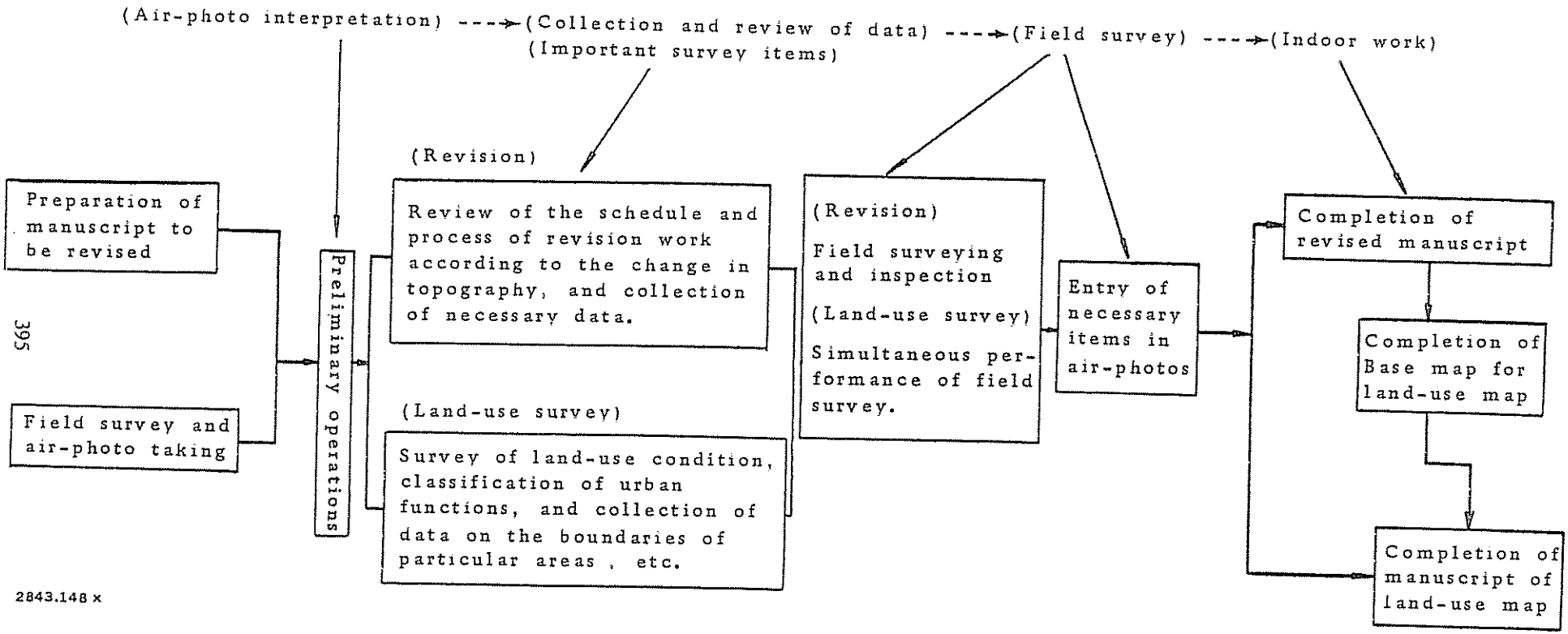


Figure 148. Japan: flow chart of revision of 1:25,000 topographic maps and land-use survey

AUTOMATED PRODUCTION OF HIGH-QUALITY THEMATIC MAPS AND MAP SERIES*

Paper presented by Israel

The "discovery" of computers by geographers and cartographers has led, over the past decade, to the automation of certain cartographic processes in two types of thematic maps. Isolines interpolated between random or regular-grid data points can be drawn by computer-driven plotters of both the drum and the flat-bed type, but problems of storage beset many of the experiments in this direction. One of the attempts to reduce the storage requirements involves the reduction of an irregular curved line from a (large) set of n points specified by their $2n$ plane co-ordinates to a polynomial specified by its $k < 2n$ coefficients.

However, the type of automated map that undoubtedly has brought computer maps to the masses (though "masses", it should be stressed, is still a relatively small proportion of cartographers) is the line-printer map. This type serves both for isoline maps where line-printer or typewriter characters in their rigid row-and-column positions form the contours—and for chorographic maps, where the same characters are used (both separately and with overprinting) in covering areas.

The best-known package programme for producing line-printer maps is Synagraphic Computer Mapping (SYMAP), developed at the Harvard Center for Computer Graphics.[1] However, it must be remembered that a line-printer map is at best a crude affair, and the term "quasi-map" is proposed for describing this type of graphic product. Line-printer maps should be the geographer's ephemeral tool, and the fact that some cartographers rather uncritically use this medium for producing final maps[2] only stresses their limitations. These limitations derive not only from the discrete or discontinuous method, but from the fact that line-printers are a poor substitute for the drafting-pen, and, moreover, are not uniform in their (monochromatic) printing quality.

The current relatively widespread availability of high-precision automated drafting instruments enables cartographers to assume a rather different attitude towards automated map production. Conventional "manual" cartography has by now reached a very high standard of precision, on the one hand, and of graphic and aesthetic quality, on the other. The introduction of the computer should not lower the level of these two attributes, precision and aesthetics, as it currently does,[3] but should reduce both time and effort spent in producing maps of a predetermined quality. Indeed, with the standard reached by automation in cartography, it appears that the time has come for a reorientation of thought by cartographers, with the goal of improving map appearance (and therefore legibility) by increasing the graphic value of computer maps.

Conversely, one can state the objective as the need to automate, at least partially, the production processes of maps of a given graphic quality.[4] With this objective in mind, the International Cartographic Association has put the topic "Methods for increasing the graphic quality of computer-derived maps" on the agenda of its Seventh International Conference, to be held at Madrid in 1974.

One type of map that has not yet been widely adopted as a suitable subject for automation is that of point symbol maps and cartograms. Yet, these maps are especially amenable both to computerization—the processing of crude basic data as well as actual drafting—and to graphic improvement. The cartographic package programme, KOMPLOT, produced by the author,[5] was designed specifically for the automated production on a drum plotter of 13 types of thematic point and line symbol maps and their numerous combinations, from the geographer-user's crude input. Although drum-plotter maps are reproducible, a high-quality map, if automated, should be produced on a flat-bed plotter. The present paper describes the production of a series of pie-diagram maps of highest graphic quality on a flat-bed plotter utilizing (besides a ball-point pen) an optical exposure head, in which a beam of light of controlled width draws directly on photographic film.

Since programme development, as well as digitizing and punching—automated or manual—of data and programmes consume a not inconsiderable amount of time, automation will be employed to best advantage where the production of a series of maps is involved or in cases where updating is anticipated. In such cases, the background map often exists and can be printed from extant originals, so that only the thematic overlay has to be produced by automation. In the following treatment, therefore the background map is assumed as given, and concentration is on the diagrammatic symbols and thematic script.

The main steps for producing automated pie-diagram maps have been described in the *Cartographic Journal*.[6] The first consideration in designing the map is the selection of the generating function of its symbols and the thematic scale, i.e., the number of units of the statistical variable represented by the unit area of the symbol (e.g., the circle). As no universally accepted valid conclusions have as yet been drawn by either perceptive psychology or cartography on this issue,[7] direct proportionality between value and area is assumed, so that the generalized generating function of the map will be:

$$A = k - S$$

or

$$r = \sqrt{S/a}$$

where S is the statistical variable, A is the area of the representative circle (of radius r), and k and a are constants.

*The original text of this paper, prepared by Naftali Kadmon, Survey of Israel, appeared as document E/CONF.62/L.51.

[1] Harvard University, Laboratory for Computer Graphics. *User's Reference Manual for Synagraphic Computer Mapping. "SYMAP" Version V* (Cambridge, Massachusetts, 1968).

[2] See Mei-ling Hsu and P. W. Porter, "Computer mapping and geographic cartography", *Annals, Association of American Geographers*, vol. 61, No. 4 (December 1971), pp. 796–799.

[3] See, for example, K. E. Rosing and P. A. Wood, *Character of a Conurbation: A Computer Atlas of Birmingham and the Black Country* (London, 1971).

[4] Royal College of Art, Experimental Cartography Unit, *Automatic Cartography and Planning* (London, Architectural Press, 1971).

[5] N. Kadmon, "KOMPLOT—Do-it-yourself computer cartography", *Cartographic Journal*, vol. 8, No. 2 (December 1971), pp. 139–144.

[6] *Ibid.*

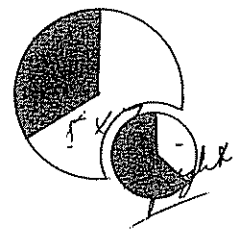
[7] See, for example, H. W. Castner and A. H. Robinson, "Dot area symbols in cartography: the influence of pattern on their perception", in *Papers of the Twenty-ninth Meeting of the American Congress on Surveying and Mapping* (Washington, D.C., 1969).

The latter factor, a, constitutes the thematic-scale factor, and one of the advantages of automated cartography is that it is easy to select the best value for a in a number of pre-production plotting runs. By "best" is meant a value that not only ensures good legibility throughout the range of S, but necessitates the least number of displacements of overlapping symbols.

Another important step is objective point generalization, achieved by specifying two limits. The first is the minimum value S_o of the statistical variable S to be included in the map; all smaller values are omitted. The second states r_{min}, the minimum radius to be plotted, corresponding to a value of S_{min}; values represented by smaller radii but larger than S_o are plotted with constant radius r_{min}. All larger values are plotted so that the area of the circle is directly proportional to statistical value. If a is the area proportionality factor, then the specific generating function of the map is:

$r = \sqrt{S/a}$	if	$S > S_{min}$
$r = r_{min}$		$S_{min} \geqslant S \geqslant S_o$
$r = O$		$S < S_o$

Another cartographic consideration should be the treatment of overlapping symbols where these occur in spite of the proper selection of the constant a. In conforming with accepted practice, the larger ("intersected") circle will be interrupted, while the smaller ("intersecting") circle will be produced in full. For best graphic effect and legibility, the intersecting circle will be surrounded by a white circular band of width d_{rad} where it cuts through the larger circle, as shown in figure 149.



2843.149 x

Figure 149. Israel: intersecting pie-diagrams with white dividing band

All the foregoing considerations have been taken into account in programme PIEGRAM, described in schematic form in figure 150. Input data, such as coordinates, names and statistical values of data points, are prepared either by manual punching on cards or directly on a digitizer (the programme caters for both options). In the present case, an Instronics "Gradicon" free cursor digitizer with paper-tape output was used for input preparation, while a Gerber 1132 system, driven off line by means of an IBM 1130-processed paper tape, plotted the final graphic output.

As a first step, a run with trial parameters and thematic scale produces a preliminary ink or ball-point pen plot, which is then edited by the cartographer, who readjusts the thematic scale as well as other graphic parameters in a series of iterative runs, still using pen output. A second feature of cartographic editing is the repositioning of circles or names as necessary. As this task is considerably easier if done on punch-cards, provision is made in programme PIEGRAM to generate a card file from the digitizer-produced paper-tape data input, if used.

After obtaining a satisfactory layout, final line widths are selected separately for circles, names, map title and legend script; and the programme and data are again run on the computer, generating a paper tape for producing the map on the plotter. However, before removing this tape from the computer tape punch, the width of the white intersection band is selected and the programme run once more on to the same paper tape, but this time only with the data for the intersecting circles. This tape is fed into the plotter, with the optical exposure head plotting the entire map—pie-diagrams (including intersection bands), names, colour codes, map title and legend—on photographic film under dark-room conditions.

On developing this film, a master positive is obtained. This requires one manual operation: scraping out those arcs of the circular intersection borders which do not cut through the intersected circles. However, cartographic editing has already reduced the number of overlaps to a minimum, as explained above.

The final positive for printing the pie-diagram outlines, names, map title and legend script, e.g., in black or dark blue, can be made from the master positive by producing a contact negative and, with masking fluid, masking out the colour code numbers which were embodied in the original plot in order to identify the pie-diagram colours. A contact positive can then be produced for making the printing-plate.

For the production of colour-separation masks, the programme is rerun with an indicator to leave out all script. This process produces a positive plot of pie-diagrams only, which again requires scraping out of superfluous lines. Alternatively, if these lines are relatively numerous, a contact negative of the master positive is produced; and on this negative all script is masked out. The resulting positive is then used for producing separation masks for all colours by etching into peel-coat in the usual way, the number of peel-coat masks required being normally less than the number of colour masks. In the case of the map illustrated here, four masks only were used for producing 10 shades of five colours, by covering and uncovering suitable portions of the mask with masking fluid. The respective colour masks are now used in conjunction with lithographic screens to produce combined final Astralon positives for plate-making and offset printing.

Lastly, it should be stressed that the automated production of repro stages is not only precise and fast in itself, but it overcomes queueing problems in production control and thus reduces both actual job time and overall elapsed time.

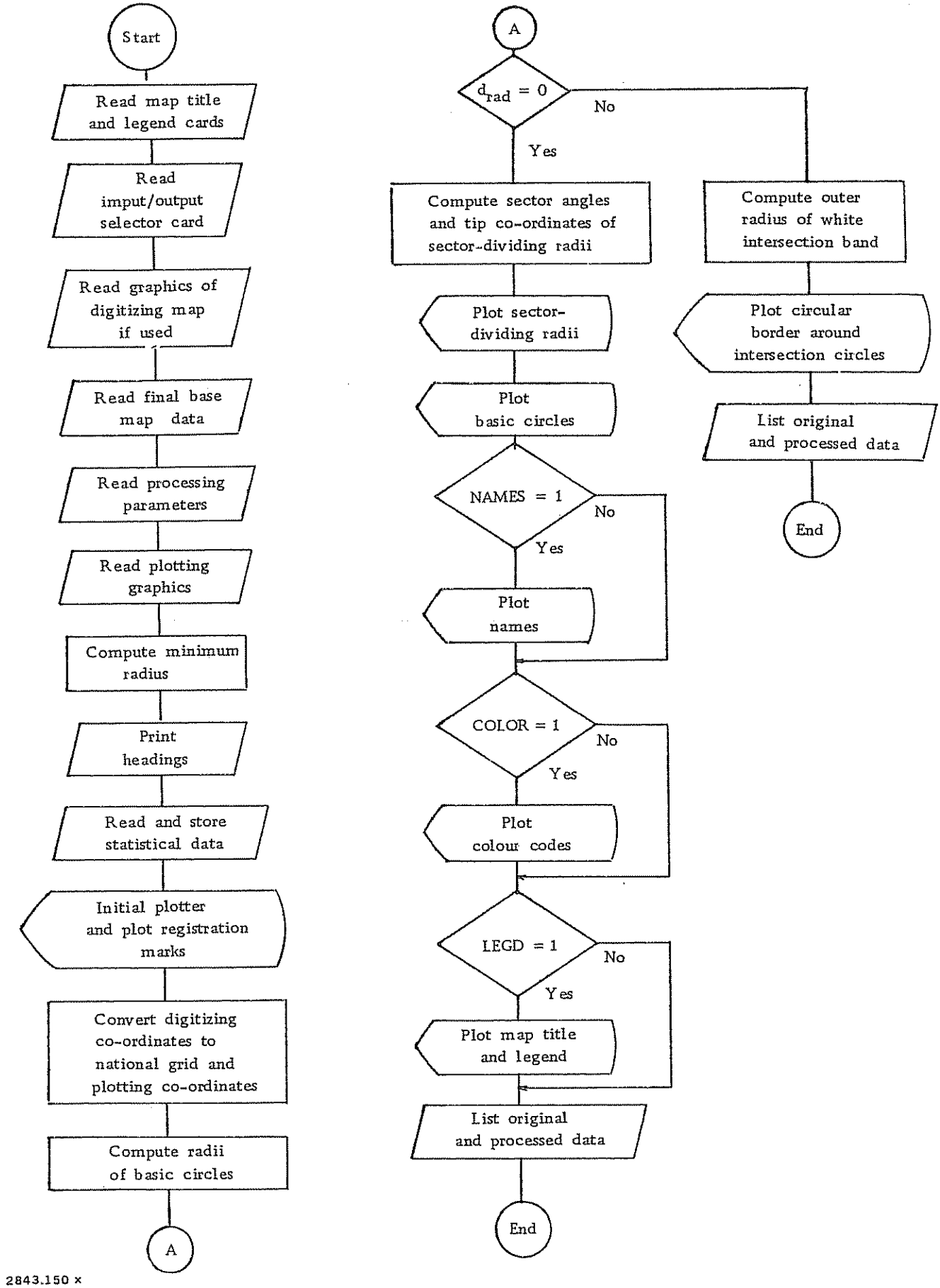


Figure 150. Israel: flow diagram of programme PIEGRAM

THE NATIONAL ATLAS OF THE UNITED STATES OF AMERICA: IMPACT OF BINDING*

Paper presented by the United States of America

The National Atlas of the United States of America was published in January 1971 by the United States Geological Survey (USGS) of the Department of the Interior. This noteworthy accomplishment was the result of a complex, long-term, high-cost, planning and production effort involving more than 80 federal agencies; city, state and regional planning agencies; and scores of professional societies, commercial firms, institutions and individuals. A 431-page, 14-lb, solidly bound volume, the atlas contains 765 maps and related information describing the salient historical, physical, socio-economic and cultural characteristics of the country.

The national atlas was planned primarily as a reference and research tool for practical use by decision-makers in government and business, planners, research scholars and others requiring high-quality, graphic overviews for the study and analysis of the distributional patterns and relationships between environmental phenomena and human activities, information that is particularly essential in guiding decisions related to orderly planning on national and broad regional levels.

In a secondary role, it was designed to be effective in creating a better informed citizenry. Knowledge of his country, its character and diversity helps the citizen to understand the multifaceted elements that have shaped the nation and are responsible for its achievements and its contemporary structure. With this understanding, he can view more objectively public issues and other matters of national concern. The significance of its value as an educational tool is expressed in the dedication by President Richard M. Nixon:

> "This comprehensive documentation of the nation's physical features, resources, and human activities, is dedicated to the people of the United States of America as an aid in the development of a better understanding of our environment and man's impact on it".

Attainment of these broad, utilitarian publication objectives depended largely upon the foresight of the planning staff and the thoroughness of their work. An advance analysis of all aspects of design, organization, production, distribution and use can substantially influence the time required for preparation, the efficiency of the production programme, the over-all cost, the quality of the publication and its utility. A major issue in planning for the national atlas was the problem of selecting the method of binding that best supported publication objectives and the diverse needs of the users.

Prior to the establishment of the national atlas programme in the United States Geological Survey, the loose-leaf form of binding was advocated by many professional geographers and cartographers. The later history of these activities is important to a discussion of binding because it serves as a basis for the initial investigations by the USGS national atlas planning staff.

The publication of a National Atlas of the United States has had support from various federal agencies, professional groups, commercial firms and individuals for many years; but the task was so great and the research and funding requirements so broad that it was virtually impossible for any one group to attempt production. In 1954, at the request of the Association of American Geographers, the United States National Academy of Sciences/National Research Council (NAS/NRC) set up an interagency National Atlas Committee composed of representatives from various federal agencies. The primary functions of the committee were to draft basic specifications and to co-ordinate the cartographic work of co-operating agencies so that copies of special-purpose maps normally produced for other uses could be collected and eventually form a loose-leaf national atlas. Although the co-operating agencies donated some 80 sheets to the atlas between 1954 and 1961, it soon became apparent that there was a need for greater uniformity, a more comprehensive approach to subject-matter and a centralized distribution for map-sheets. Consequently, in 1961, the NAS/NRC committee proposed its own termination and recommended through the president of the National Academy of Sciences that responsibility for the National Atlas be placed in a single federal agency, preferably the United States Geological Survey of the Department of the Interior. This recommendation was accepted by the Secretary of the Interior; and in 1963, the national atlas programme was established in the Geological Survey under the leadership of Arch C. Gerlach. Work on the NAS/NRC loose-leaf predecessor was discontinued and the task of planning a new national atlas was begun.

The NAS/NRC Committee recommended, at the time of transfer of responsibility for the national atlas to USGS, that a loose-leaf binding be employed on the new national atlas. The committee had studied the bindery problem thoroughly in connexion with the earlier attempt to produce a national atlas, and it was convinced that the loose-leaf form was the most flexible approach to meeting the needs of a broad spectrum of users. An *ad hoc* committee organized by USGS to study the feasibility of the Geological Survey producing the national atlas echoed the findings of the NAS/NRC Committee in its final report to the Director, stating:

> "National Atlases produced in recent decades for major countries have had demountable bindings of some sort so the contents have not been fixed by the initial printing of core items; additions and revisions are possible; and the user or buyer can be selective in his modifications of the atlas. The sheets of the atlas should be held together in a simple, durable, and economical device which will make the atlas easy to use while permitting the owner to add new sheets and to remove superseded sheets".

The national atlas planning group, consisting of eminent geographers and cartographers from universities, commercial firms and government agencies, reviewed the recommendations by the former Committee of the National Academy of Sciences, the conclusions of the Geological Survey *Ad Hoc* Committee and the recommendations for content by the International Geographical Union Commission on National Atlases. They also studied the methods used in binding or boxing existing national atlases; researched new forms of binding, packaging and boxing; and conducted a survey of the potential market interest for a national atlas

*The original text of this paper, prepared by C. William Beetschen, United States Geological Survey, Washington, D.C., appeared as document E/CONF.62/L.75.

Existence of the "Lumbeck" and "Perfect" bindings, which had proved to be strong, durable and flexible, and of less cost than some of the loose-leaf bindings, and reaction to the results obtained from the marketing survey greatly influenced the national atlas planners and brought about the final decision to publish a solidly bound atlas. Their final report on binding listed some of the advantages of solid binding:

(*a*) It gives a psychological impression of prestige because of its finished form;

(*b*) The cost is usually less than that for substantial unbound atlases;

(*c*) Both sides of the sheet may be printed, thereby reducing the thickness of the volume;

(*d*) Content may be better organized, making it easier to locate maps and related information within the book;

(*e*) Taper from spine to opening edge, a characteristic of many loose-leaf atlases is eliminated. This feature, combined with greater compactness, will make it easier to handle and store;

(*f*) Greater security is possible with respect to theft of pages or their disarrangement through careless use;

(*g*) It is highly popular with librarian, distribution and sales organizations.

The marketing survey conducted prior to the decision on binding was important to the development of the national atlas programme for several reasons. Not only was it largely responsible for the decision to produce a permanently bound atlas, it also provided special insights to buyer preferences for content; it was used as the basis for predicting initial sales and it provided the support for the organization of a modest separate sales programme.

Assuming that the greatest demand for a national atlas would be from the various library groups in the United States, questionnaires were sent to the five largest groups and to selected institutions abroad. Included in the sampling were all of the college and university libraries, all special libraries consisting of technical libraries and libraries in large business firms, about 20 per cent of the public libraries, 20 per cent of the foreign libraries and universities, and about 5 per cent of the public high-school libraries. The questionnaire was designed to determine the demand for the completed atlas if sold at $50.00 per copy, the demand for separate sheets at $1.00 per copy, the degree of interest in the various categories of proposed special subject maps and the type of binding preferred—solid or loose-leaf.

The returns from the survey showed that:

(*a*) Of the respondents, 95 per cent would purchase one or more copies of the atlas at the price of $50.00;

(*b*) Public libraries constituted the largest potential purchaser, followed by high-school libraries, college and university libraries, special libraries, and foreign libraries and universities;

(*c*) If they were sold at $1.00 per copy, 70 per cent were interested in purchasing separate sheets;

(*d*) Interest in special map groupings was, in order of preference, economic, physical, socio-cultural, historical, all types, administrative and general reference;

(*e*) Solid binding was favoured over loose-leaf by 84 per cent of the respondents.

It was conceded at the time that the survey was too limited in its coverage and should have been extended to other potential buyer or user groups. Individual scientist, bookstores, commerical and trade associations and publishing houses were considered for sampling; but the extensive time required to conduct the additional marketing studies and the need to complete the initial planning work to coincide with the scheduled start of production combined to terminate further research.

A preliminary study of the impact of the solid binding on the production programme, on sales and on the current atlas maintenance programme has been completed. The findings from this brief appraisal, coupled with the representative comments of reviewers, offer evidence that a subsequent edition of the national atlas should be published in unbound form.

Design of binding

A principal requirement was for a binding that would be durable and sufficiently flexible to permit the atlas to open flat without a noticeable channel or separation along the spinal fold. Extensive testing by the Chicago Paper Testing Laboratory, at Chicago, Illinois, proved that a modified "Perfect" binding would meet the requirements. Unfortunately, the final product exhibits a slight, but annoying, "gutter" on the larger scale maps extending across the spinal fold. This channel effectively hides information and makes it virtually impossible to overlay the map and copy information.

Impact on production programme

Compilation of maps and related information began in 1963 and extended over a seven-year period. This lengthy preparation time affected the production programme in many ways, of which some of the more important were:

(*a*) A significant number of sheets prepared during the early compilation period were based on data collections available at that time. When it was learned that newer data would become available prior to the completion of the atlas, those first sheets had to be recompiled. This repetition of work interrupted the established working schedule for other compilations, increased the cost and was partially responsible for the deletion of some sheets because of the lack of time and personnel for their completion. Had the atlas been designed in unbound form, sheets would have been published as they were completed;

(*b*) Only a limited capacity existed for the publication of separate sheets. Most funds allotted each year were increments of total cost estimates for the completed volume and had to be applied for that purpose. Monies derived from the sale of separate sheets could not be used to sustain a separate sales programme since those funds were not returned to the project. The high cost of the bound volume severely limited the publication of separates. A few were issued to test their cartographic design and reproduction, and to obtain public reaction to the product;

(*c*) The preparation of a large assemblage of atlas manuscript and reproduction materials that could not be dispersed until most atlas sheets were completed gave rise to a need for additional storage facilities which would not have been necessary if the sheets could have been published in advance.

Impact on sales

Two factors, cost and the growing obsolescence of much of the atlas content, are combining to affect sales. The cost of the volume, at $100.00, is twice that indicated to correspondents in the early library survey which served as a basis for the prediction of sales. This figure was established of necessity so that a Congressional commitment for the return of programme costs through sales could be honoured. Many public libraries, high-school and elementary-school libraries and a few libraries associated with local governments have found the price to be too high for their limited budgets and are unable to purchase the atlas.

The high price has also accounted for a more evenly spread distribution than first predicted. An analysis of about 8,000 orders for the atlas shows the distribution to be:

(*a*) University and college libraries, 30 per cent;

(*b*) Industrial and commercial firms, 16 per cent;

(*c*) Individuals, 15 per cent;

(*d*) Public libraries, 14 per cent;

(*e*) High-school and elementary-school libraries, 12 per cent;

(*f*) Federal, state and local agencies, 12 per cent;

(*g*) Foreign sales, 1 per cent.

While sales to libraries have accounted for a major portion of the initial orders, bearing out the early assumption of the atlas planners, their importance in the total distribution has been less than the early estimate. Of surprising importance, in view of the high cost of the volume, is the share of sales to individuals.

Impact on current programme

The release of a few separate sheets of the atlas prior to publication of the bound volume had revealed a sizable demand for the individual sheets, a demand as large as that indicated in the library survey. In response to this potential market, an atlas maintenance programme was organized following publication of the volume. A primary objective of this programme is the preparation of new separate sales sheets and the revision of many contained in the bound volume. However, the objectives of the separate sales programme have not been fully realized. Restrictions on funding the hiring of personnel and the higher priorities accorded to other programmes have been principally responsible for a low-level programme activity.

A large number of sheets were left over following the binding of the atlas. These untrimmed, folded, bindery remainders have been made available for purchase at low prices in an effort to satisfy requests for separates and to test the market for sales of sheets in sets corresponding to the major topical divisions in the atlas. Sales of sets and single sheets have been excellent, proving the popularity for atlas materials in unbound form.

Comments by reviewers

A large number of persons reviewed the National Atlas of the United States of America, and their comments were recorded in various journals, newspapers and other kinds of publications. Many of them referred to the form of binding; and the majority of these references, 13 out of 15 reviewers, showed preference for an unbound atlas. Typical comments of many reviewers are contained in the following statement by Nathaniel Abelson, of the Dag Hammarskjöld Library at United Nations Headquarters:

> "Despite the compactness, ease of shelving, and greater security of the individual maps which the solid bindings afford, I should have preferred a ring binder, pin binder or a box. I do not agree that the solid binding is more impressive than loose-leaf binding. One has only to look at the atlases of Germany, the Netherlands, Peru, Sweden, or Switzerland to see how impressive a loose-leaf binder can be. The solid binder is neater, more compact, less expensive, and has a more finished appearance on which its selection might be based. It is easier to handle, easier to file and easier to find a map in, but against these advantages is the fact that you cannot remove the map. A removable map can be laminated, more easily exhibited, more easily reproduced, and more easily used to compile other maps. It is also easier to make measurements on a map that will lie absolutely flat. Of course it can be misfiled, lost, or stolen more easily, but maps in solid bindings disappear too. A loose-leaf map can be replaced and it can be revised without having to replace the entire atlas".[1]

Arnold Court states:

> "The possible second edition . . . perhaps it can be issued loose-leaf so that those who wish may purchase only the climatic (or other) section. Such format, too, would permit removing the individual maps for display, and eliminate the annoying distortion in the centers of the double-page spreads".[2]

Solid binding was selected for the National Atlas of the United States because of the factors of cost, compactness, ease in handling, storage and shelving, greater security of content and impressiveness because of its finished appearance. The loose-leaf, or unbound, atlas also has many obvious advantages:

(*a*) Individual sheets can be published as they are completed, bringing a quick return on investment, placing materials in the hands of users while the information is current and eliminating the need for an additional programme for publication of separates;

(*b*) New sheets may be added as changes occur in national interests or in the availability of data. The atlas is, therefore, not limited to a fixed number of maps, as would be the case with a hard-bound volume;

(*c*) Maps or sheets of text containing supplementary information can be added at any time and placed in proximity to the materials they supplement;

(*d*) Out-of-date maps can be easily replaced by revised editions, eliminating the need for purchase of an entire revised atlas if solidly bound;

(*e*) Individual sheets may be removed to help facilitate research; or for use at conferences, as exhibits, or for reproduction;

(*f*) Persons who could not afford to purchase a large bound atlas and those who do not have a need for all materials in a bound atlas could purchase only those sheets desired;

(g) Great flexibility is possible in the manner of assembly of a national atlas. This matter can, in fact, be

[1] *Special Librarian* (March 1972)
[2] *Weatherwise* (October 1971)

left to the individual user to determine according to his personal preference.

The published volume has many attributes. It is an attractive book, easily handled, shipped, stored and displayed. It is comprehensive and uniformly organized. The thematic and general reference maps are designed to communicate information in a straightforward, intelligible manner.

However, it has some major short-comings. As the content is "locked in", out-of-date sheets cannot be replaced nor can new materials be added. Furthermore, the growing obsolescence of much of the content combined with the high price of the volume produces an adverse effect on sales.

The flexibility present for the user of loose-leaf, or unbound, atlases appears to outweigh heavily the advantages noted for a solidly bound atlas. Ease in handling, shipping, storing, shelving, displaying, etc., are keyed more to service organization requirements than to the needs of the user. The two important attributes of the loose-leaf or unbound atlas—the ability to revise existing sheets and add new materials—are of direct benefit to the user. The characteristics should be accorded the highest significance in any future planning programme where binding is an issue.

In view of the complexity of the planning and production effort for national atlases, the high cost of the programme in the United States and the many different requirements of potential users, planning for a future revision of the first edition of the National Atlas of the United States should consider its publication in loose-leaf or unbound form. The choice of the method of binding, boxing or packaging should be made dependent upon the preferences of an appropriate cross-section of current users and a thorough investigation of the advantages and disadvantages of the many options available.

VEGETATION MAP PREPARATION PROJECT FOR PRESERVATION OF VEGETATION AND PLANT AND ANIMAL SPECIES*

Paper presented by Japan

In Japan, man's influence has been largely destructive in replacing natural plant communities, which fully exploit the climatic potentials, by other plants which do not so, and in displacing or exterminating native species of plants and animals. Complete information about the biologically important areas and outstanding plant and animal species is urgently needed to determine methods of preserving and safeguarding them. Recently, the Agency for Cultural Affairs, in co-operation with each prefecture, completed a project to prepare prefectural vegetation maps and distribution maps of native plants and animals, with short comments attached.

To the topographic base maps on the scale 1:50,000, issued by the Geographical Survey Institute, information was transfered from aerial photographs at 1:20,000 scale and the land-use maps at 1:50,000 scale. The base maps were then field-checked. As a result, the prefectural vegetation maps and the plant and animal distribution maps were completed on the scale 1:200,000. Such maps have been issued for 27 prefectures out of 47.

Each vegetation map gives precise information about the quality, location and extent of natural, semi-natural and cultural vegetation in the prefecture. Natural vegetation is decreasing strikingly through the country. The destruction is extremely serious in prefectures of the warm temperate climate, compared with those of the cool temperate one.

The analysis and comparison of the prefectural vegetation maps serve the purpose of preserving natural vegetation as a natural monument worthy of protection against destruction by current human environmental practices.

So far, natural monuments were selected for rare and peculiar vegetation and outstanding specimens of plant and animal species. Now, however, it is especially urgent to preserve the standard, climatic vegetation in each prefecture which is being threatened with virtual destruction and eventual extinction.

*The original text of this paper, prepared by Kuniji Yoshioka, Faculty of Science, Tohoku University, Japan, appeared as document E/CONF.62/L.83.

ON A GEOMORPHOLOGICAL SURVEY MAP OF THE RIVER BASIN INDICATING AREAS SUBJECT TO FLOODING*

Paper presented by Japan

Demand for geomorphological flood analysis since Second World War

After the Second World War, two problems facing Japan were food shortages and flood damage. The staple food of the Japanese is rice, which is produced only in the alluvial plains, and in order to increase the yield of rice, it was necessary to improve the rice field.

The Resources and Science Technology Bureau organized the Commission on Geomorphological Flood Analysation. The Commission included a civil engineer, an agricultural engineer and a geographer. Before the war, topographic study was strongly influenced by studies of Europe and the United States of America, almost all of which had been done in mountainous regions formed by erosion. In contrast, the alluvial plains in Japan were formed by depositions, and some geographers wanted to begin research on the topography of the depositional areas under the leadership of a

*The original text of this paper, prepared by the National Institute of Resources, Science and Technology Agency of Japan, appeared as document E/CONF.62/L.84.

technical expert of the Resources Council, Fumio Tada. The main work of the Commission was to make the geomorphological survey map of river basins indicating areas subject to flooding. The mapping has been done by a technical expert of the Resources Council, Masahiko Oya.

Purpose and method of the geomorphological survey map

The geomorphological survey map of the river basins indicating areas subject to flooding is intended to permit the estimation of the nature and extent of floods not only in the past, but in the future, with respect to extent of the area submerged by floods, length of time an area would be under water, depth of the standing water, direction of flood current, changes in the course of flood current, possibility of erosion, deposits and other details that may help define the types of floods likely in the area.

Such a survey map serves the purpose of indicating the types of floods because the relief features of a plain, however slight, and its sand and gravel deposits have been formed by repeated floods over the areas affected. Consequently, the microtopography of the plain and the state of the sand and gravel accumulation can indicate the history of floods in the past years.

Geomorphological features, such as plateau, terrace, valley plain, alluvial fan, natural levee, back-swamp and delta, influence the extent and nature of flooding. For example, in the case of the alluvial fan, erosion and deposition of sands and gravels are common, changes of river channel are frequent and flood waters drain off quickly; on a natural levee, changes of channel are less frequent, flood waters drain off readily and depositions are mostly of sand. On the other hand, in a back-swamp area, the water is generally deep and remains for a long period, with deposition of silt and delta area; the water is generally shallow and remains for a long period, with deposition of clay. The area is a dangerous zone of flooding caused by high tide.

Therefore, by classifying the geomorphological configuration of areas subject to flooding, one can define not only the types of flooding that occurred in the past, but the types likely to occur in the future.

From this point of view, geomorphological survey maps indicating areas subject to flooding have been prepared over the past 20 years for the basins of the Kiso, Chikugo, Honmyo, Ishikari, Yoshino and Kuzuryu rivers in Japan.

In preparing the said map, say, on the scale 1:50,000, the target area is first classified by major topographic elements by means of aerial photographs at approximately 1:40,000 scale. The provisional map thus prepared is to be put into final form by checking it against the results of the field survey of the area.

The standard for classification of topography is based on the Law of Country Research (see table given below). The topography is first classified into the following factors: mountain and hill land; upland and terrace; and lowland. Secondly, it is classified by its altitude, structure, form and so forth. The upland and terrace areas were classified into gravelly terrace, rocky terrace and so forth; the lowland into valley plain, fan, delta, tide land and so forth.

Landform classification by Government of Japan

Classification		
Primary classification	*Secondary classification*	*Definition*
Mountain and hill land	Gentle slope on mountain ridge	Gentle slope surrounded by steep slopes
	Gentle slope on mountain side	Gentle slope on mountain side like stairs
	Piedmont gentle slope	Piedmont gentle slope that was formed by erosion or gentle slope at foot of a volcano that was formed by lava or pyroclastic flow
	Steep slope	Slopes having none of the gentle slopes mentioned above
Upland and terrace	Gravelly terrace	Terrace that was formed by deposition of thick sand and gravel
	Rocky terrace	Terrace that was formed by bed-rock or one covered thinly by sand and gravel
	Karst upland	Upland that was formed by limestone
	Pyroclastic plateau	Plateau that has been covered thickly with volcanic ash or volcanic products
	Lava plateau	Plateau that has been covered by lava
Lowland	Valley plain	Flat area situated in the valley bottom and formed by fluvial deposition
	Fan	Area that is fan-shaped and is situated at foot of the mountain
	Delta	Delta that is situated at the river mouth and was formed by sand, silt and clay

Example of flood-forecasting based on the geomorphological land-classification map

Figure 151 shows the microtopographic classification of the lower course of the Kiso River, indicating the flood types of the region. There are fans formed by the Kiso River and the Nagara River in the northern part of the Nobi plains. Three or four distinct natural levees exist from the fan to the city of Nagoya and to the city of Tsushima. These natural levees show the ancient main course and branch courses of the Kiso River before the fifteenth century. Back-swamps occupy their spaces between natural levee and natural levee, between natural levee and terraces, and between natural levees and fans. The map shows the delta from the natural levee to the south, the reclaimed lands constricted from the sixteenth century downwards along the coast of Ise Bay and the artificial field of Nagoya port. The ground level of the delta is almost all sea level, and the area of the ground in the Nobi plains below sea level covers 185.4 km^2. The map was prepared in 1956.

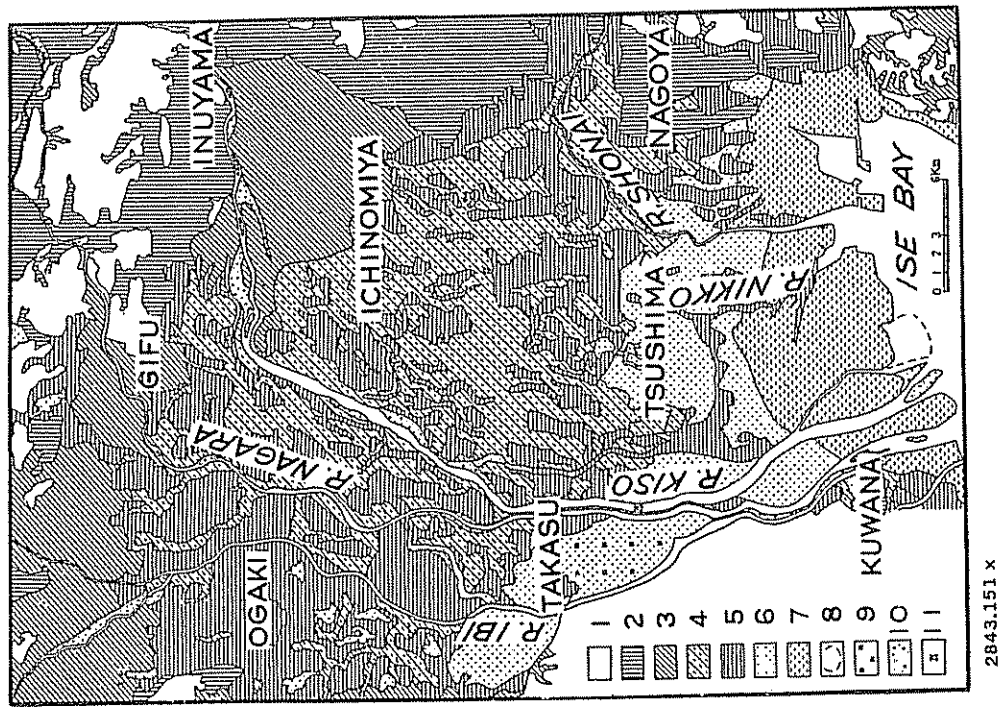
The area had been attacked by high tides caused by the Isewan typhoon (Typhoon Vera) in 1959, three years after the preparation of the above-mentioned map. The flood proved to be a good test of such maps, on a very large scale and one of the greatest value. The effects of

the flooding were found to be almost exactly the same as those predicted in the map.

The coast of Nagoya port was hit by the high tide, which was 3.89 m above sea level.

The high tide intruded on to the inland area with high velocity. It did not proceed far, but instead disappeared and was found at the boundary of the reclaimed land, that is, the coastline of the sixteenth century. Beyond this line, the sea-water flowed on more slowly. The point of the inflow of the sea-water seen at spring tide the next day was as high as 1 m above sea level. The extremity of the influx was seen at the boundary of the delta, which may be clearly seen in figure 151.

Furthermore, it may be seen that the regional differences of the flood type and the main routes of the high tide are determined by the landforms.



Legend:

1. Mountains
2. Terrace
3. Fan
4. Natural levee
5. Back marsh
6. Delta
7. Reclaimed rice field
8. Sunken agricultural land into the sea
9. Swamp
10. Dry river-bed
11. Tidal limit

Figure 151. Japan: microtopographic classification of lower course of the Kiso River, showing flood types of the region

Depending upon the stage in the cycle of erosion and the mountain region in a drainage area, distinct regional differences on geomorphology will be found in the plain. If the stage of the cycle of erosion is young, the volume of sand and gravel that will be transported from the upper reaches is large; and building of the alluvial plain will still be in process. On the other hand, if the stage is old, the volume of the sand and gravel is small; and building of the alluvial plain has already ceased and erosion has begun.

At the young stage, the natural levee is still built up by flood deposition along the river course and the river-bed has a rising tendency. Thus, the nearer to the river the land is, the higher it will be. When a flood occurs, the flood water overflows from the mainstream to adjacent low-land areas.

At the old mature stage, the building of the plain has been nearly completed and the erosion process has begun. In this case, the nearer to the river the land is, the lower it becomes, and the mainstream flows down a deep channel in the lowest part of the alluvial plain. Thus, when floods occur, the flood water flows from the higher surrounding area into the mainstream. Even if flood water should overflow from the mainstream, it is not dispersed widely, but flows down near the mainstream course in a narrow width.

Generally speaking, in the case of the young stage, the area and depth of inundation, velocity of flood current, period of stagnation and volume of deposition are large. Furthermore, the river has a good possibility of shifting its course. On the other hand, in the case of the old mature stage, velocity of flood current, area and depth of

inundation, period of stagnation and possibility of shifting of the river course are much smaller. Erosion predominates over deposition in and near the river-bed and banks.

An example of the former may be seen in the Kiso River, of the latter in the Chikugo River. Figure 152 is the geomorphological survey map of the Chikugo River basin, indicating areas subject to flooding. If one compares figure 151 with figure 152, large differences in topography may be seen.

In the Kiso River, a large alluvial fan and natural levees may be seen. In the Chikugo River, on the other hand, large fans are formed by the tributaries coming from the mountains north and south of the main course, but a tiny fan is formed by the main course, and the natural levees, which are to be seen along the lower course from the fan, are seldom seen here. This aspect shows that the quantity of the transportation of the sand and gravels of the main course of the Chikugo River is smaller, and the area of deposition is smaller than that of erosion. During a flood in 1953, the flood water flowed into the main course with sand and gravels, and not from the main course to the adjacent regions (see figure 152).

Application in other countries

The Mekong Committee of the United Nations Economic Commission for Asia and the Far East (ECAFE) has formulated a plan to construct the Pa Mong Dam in the upper reaches of the Vientiane Plain. If the dam were constructed, the nature of flooding in the Vientiane Plain will be changed artificially. The variation of the flooding is very important for farmers in the Vientiane Plain. The Mekong Committee then wanted to know the current state of flooding in the area. However, there was no frequent flooding overflowing banks; major floods have occurred once in several decades. The Mekong Committee had to research the flooding without seeing the inundation, and it considered the utilization of a geomorphological map of the river basin indicating the areas subject to flooding.

At the request of the Mekong Committee of ECAFE, Masahiko Oya researched and prepared a geomorphological survey map of the Mekong River Basin indicating areas subject to flooding. When he visited the area in 1966, he encountered the greatest amount of flooding in his way; and he also prepared a map of the Mekong River Basin indicating the inundation of 1966.

The Vientiane Plain is classified as follows: mountain slopes, gentler mountain slopes, piedmont gentle slopes, terraces, lower terraces, alluvial fan, natural levee, lower natural levee, valley plain, delta or back-swamp, lower delta, former river courses, dry river-beds and marsh.

Almost all the terraces are covered with a layer of laterite. These terraces are covered by forest, and some of their area is occupied by villages and used for the cultivation of upland crops.

The alluvial fan is very small in this region, and the amount of gravel transported from the mountains and terraces was very small, in part because the mountains are not high and their slopes are gentle, and in part because the rock was weathered to laterite rather than to gravel by high temperatures and a high level of precipitation.

On the other hand, there are large natural levees along the river courses. Above all, the natural levees are particularly broad at the meandering parts of the Mekong. The city of Vientiane, the pilot farm of the Food and Agriculture Organization of the United Nations (FAO) and the city of Nongkhai are located on natural levees.

Back-swamps occupy the area between one natural levee and another, and between a natural levee and a terrace. Almost all the back-swamps are utilized for paddy.

When one compares the map of the Mekong River Basin showing the inundation of 1966 with the geomorphological survey map of the Mekong River Basin indicating areas subject to flooding, one finds that almost all the natural levees, back-swamps, former river courses and some parts of the lower terraces were covered by flood water, which shows that the flood was one of the largest in the Holocene period.

Two different types of flooding were seen on the Vientiane Plain. One was seen from the uppermost parts of the Vientiane Plain to the junction of the Huai Kham Van and the Mekong. With this type, deposition was more important than erosion. The other was seen from the junction down stream. With this type of flood, erosion was more important than deposition.

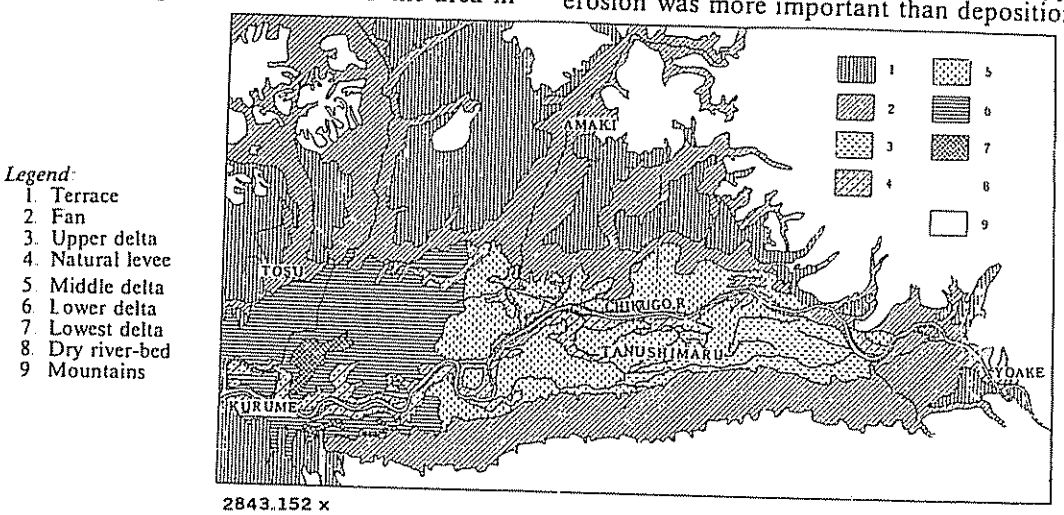


Figure 152. Japan: microtopographic classification of Chikugo-gawa basin, showing flood types of the region

If the construction of protective dikes along the Mekong River in the Vientiane Plain is undertaken in the future, dikes should definitely be built between the uppermost part of the plain and the junction of the Huai Kham Van and the Mekong, but they are not as essential from the junction to the lower reaches.

The cities of Vientiane and Nongkhai are located on natural levees, which indicates that those cities would not be affected by a normal flood, but would be affected by an extraordinary flood like that of 1966.

REFERENCES

Japan. Resources Council. Reconnaissance topographical study on areas subject to flood. Part I; The relationship between geomorphology and flooding in the Kiso River basin. 1956.

_____. Science and Technology Agency. Resources Bureau. Reconnaissance topographical survey on areas subject to flood. Part II; The relationship between geomorphology and flooding in the Chikugo River basin. 1957.

_____. Science and Technology Agency. Resources Bureau. Reconnaissance topographical survey on areas subject to flood. Part III; The relationship between geomorphology and flooding which visited in 1959 on the city of Isahaya and its vicinity.

_____. Science and Technology Agency. Resources Bureau. Reconnaissance topographical survey on areas subject to flooding. Part IV; The relationship between geomorphology and flooding in the Ishikari River basin. 1961.

_____. Science and Technology Agency. Resources Bureau. Reconnaissance topographical survey on areas subject to flooding. Part V; The relationship between geomorphology and flooding in the Yoshino River basin. 1963.

_____. Science and Technology Agency. Resources Bureau. Reconnaissance topographical survey on areas subject to flood. Part VI; On the geomorphology, land use and flood which visited in 1958 on the Kano River basin. 1968.

_____. Science and Technology Agency. National Institute of Resources. Reconnaissance topographical survey on areas subject to flood. Part VII; The relationship between geomorphology, flooding and land use in the Kuzuryu River basin. 1968.

Oya, Masahiko. Geographical study of flooding immediately down stream from Pa Mong in the Mekong River Basin. Report prepared for the United Nations Economic Commission for Asia and the Far East. 1967.

Tada, Fumio *and* Masahiko Oya. The flood type and the classification of the topography. Proceedings of International Geographical Union regional conference. Japan, 1957.

UTILIZATION OF THE 1:2,500,000 WORLD MAP AS A THEMATIC BASE MAP IN CARTOGRAPHY*

Paper presented by Hungary

The survey, the scientific analysis of phenomena indicating territorial distribution, the exploration of the ties and relations existing between the phenomena deriving from territorial differences and spatial situations of the quantitative and qualitative factors, the illustration of the starting-points, and the well-arranged, clear-cut publication of research results can be attained only by means of the map. The map is, therefore, a working tool, the materialization of the research method and, at the same time, a form of communication. This triple function explains the ever-growing importance of maps in the domain of the natural and social sciences.

The specialists have become aware of the advantages of maps and are applying them more and more extensively in both regional and country-wide research efforts. The extension of the study of the phenomena to larger areas (to groups of States or to continents), or to the earth's entire surface, has been hindered up to now because no adequate base maps and working maps were available for the researches.

The need for a map compiled according to uniform principles and covering the earth's entire surface in the same system of measures and on the same scale was recognized by geographers towards the end of the nineteenth century. In 1891, the necessity of making such a world map was included in the resolutions of the International Geographical Congress at Bern. After lengthy preparations, the principles of making the International Map of the World (IMW) on the uniform scale 1:1,000,000 were approved in 1913 by the International Geographical Congress at London. The progress of works was rather slow. Even now only a part of the IMW sheets has been published. Because of the slow progress of the programme to produce the IMW on the scale 1:1,000,000, seven socialist countries (Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, Romania and the Union of Soviet Socialist Republics) decided to produce the 1:2,500,000 map of the earth.

The objective and the function of this mapping have been established by the participants of this programme as follows:

(a) *General geographical map.* This map covering at uniform scale the entire surface of the earth (including oceans) in the same system of measures, with the same contents and in the same execution, is to provide general information for the geographical study of large areas;

(b) *Base map and working map for thematic mapping covering large areas.* The uniform structure permits these maps to serve as a uniform chorographical base for the various branches of thematic mapping. In the choice of the scale, this point has been of importance, due to the fact that, according to the judgement of the editorial board of the 1:2,500,000 map, the materials currently available do not make possible the compilation of more detailed thematic maps covering continents, or especially the entire earth. In the choice of the projection, a crucial point has been that sheets covering as large an area as possible could be assembled to uniform base maps.

The projection, the sheet layout and the contents of the world map have been discussed in several papers, and it is, therefore, intended here to examine only the use of the world map as a base map in the cartographic work. This point is of topical interest, as it is expected that the work on the world map will be completed by 1974. There will be available, for whatever part of the earth, maps that could serve as bases for thematic maps.

The base maps are intended to represent surface objects and phenomena to such a degree of detail that:

(*a*) The main features of the physical peculiarities and economic characteristics of an area will be expressed in

*The original text of this paper, prepared by Sándor Radó and Arpád Papp-Váry, National Office of Lands and Mapping, Budapest, appeared as document E/CONF.62/L.88.

such a way that the elements serving the orientation do not spoil the legibility of the special content;

(*b*) For quick and precise compilation of survey data and of observed phenomena, sufficient information should be available;

(*c*) Spatial identification and recompilation of particulars represented on other maps should be made possible;

(*d*) The area, the limits on the earth's surface of the represented special content, should be unambiguously rendered;

(*e*) The ascertainment of the relations existing between the special content and the surface physical geographical peculiarities and economic objects will be facilitated.

Considering the probable density of special thematic contents at the given scale, the development of the following three kinds of base and working maps has been proposed by the editorial board.

Types of base and working maps

First variant

The first type is a general working map intended for all kinds of thematic mapping research and a base map for the compilation of maps representing those economic phenomena which are greatly influenced by the physical environment. Coverage will include, without relief colours, the full and very dense contents of the world map. This map will serve the purpose, among others, that the research worker could indicate on the working map the various data; and by means of preparing several variants, the phenomena could be analysed and synthetized; spatial reconstructions, namely, development prognoses, could be established.

A further function of the map is to provide a cartographic base for the representation of the phenomena closely related to economic activity and influenced by the relief. This variant will provide a clear and easily analysable base for the compilation of land use, agricultural and medico-geographical maps.

Second variant

The second variant is intended as a base map primarily for the natural sciences. On this map, the relations existing between the represented phenomena and the special relief features will be emphasized. Therefore, this variant will contain the physical geographical elements of the world map. Unlike the first variant, the railway and road networks, boundaries of national parks, names of locations and administrative boundaries will not be represented.

This base map can well serve for the compilation of geophysical, geological, soil science, meteorological, hydrological, oceanographic, phyto- and zoogeographical maps dealing with various subjects. In the field of social sciences, this variant can well be used for the compilation of archaeological, historical and ethnographical maps.

Third variant

The third variant is intended for use as a base map in the field of social sciences. On this map, the localization of public projects (settlements, roads, railways and reservoirs) and their spatial situations will be emphasized. Unlike the second variant, the contour lines will not be represented. This variant can serve as a base map for the compilation of industrial, commercial, transportation, public-utility coverage and population maps.

In addition to the above-mentioned variants, by means of a slight modification, quite a number of further base maps can be developed.

The base maps can be used not only in the existing sheet layout, but, by means of mounting different sheets or some parts of sheets, in modified size. In this way, maps covering countries (e.g., Japan), groups of States (the Far East), continents (Asia), and charts of seas or oceans can also be developed.

By means of comprehensive modifications of the contents and of the size in the given scale, uniform base maps which are best suited for the given purpose can be provided for all kinds of thematic mapping.

In the course of the past decade, several thematic map works have been published in the field of natural sciences. These map works covering large areas are prepared under the terms of international co-operation and also are effectively sponsored by the United Nations Educational, Scientific and Cultural Organization (UNESCO). In the course of preparing map works sponsored by various international organizations, individual base maps are prepared each time. Due to the production of the base maps, the time required to complete them must be extended, the costs of production are multiplied, and the quick and easy collation of various maps is obstructed.

Therefore, the authors would like to draw the attention of national and international organizations to the use of the base-map variants of the 1:2,500,000 world map in such cases, when thematic maps covering larger areas are to be compiled. Due to the use of sheets of uniform structure, one can provide to the users base maps in which the content and layout are best adjusted to the thematic material.

The utilization of the world map as a thematic base map would be of double advantage:

(*a*) The compilation of the thematic content on a base map of uniform projection, scale and structure would greatly facilitate the collation of various maps, and on the basis of this collation, the performance of the necessary examinations;

(*b*) The saving in costs and time resulting from the quick, cheap production of base maps could be utilized for the acceleration of further development of the thematic mapping.

By means of the world map, even quite special requirements in base maps can be met more quickly and more easily than they can by making new base maps. For instance, in maritime and aerial navigation, conformal projections are employed. The world map could be simply transformed in conformal projection. Eliminating the time-consuming work of compilation, base maps having a proper fullness of detail could be made in a rather short time for navigational purposes.

In the authors' judgement, the scale of 1:2,500,000 would comply with the requirements of both domains.

In maritime navigation, the scale of the actual 1:10,000,000 bathymetric charts has already proved to be insufficient. Taking into account the long-range development of shipping, the increasing number of bathymetric soundings, the economic effects and the time-saving due to the use of available maps, the preparation of

1:2,500,000 navigational base charts would require consideration.

As concerns aerial navigation, due to the recent rapid increase of speed, the 1:1,000,000 charts have begun to be superseded by the 1:2,000,000 navigational charts. But the development currently taking place is going to necessitate the elaboration of a chart series of smaller scale, which will, nevertheless, ensure the necessary orientation. In the formulation of a new aerial navigation chart series, utilization of the world map is advantageous because of the uniform structure of the map work, in addition to its suitable scale.

As mentioned above, in order to meet the requirements in maps of the natural sciences, several international efforts have been made. Unfortunately, this situation does not apply to economic-geographical mapping. The methodology and the techniques of representation of the economic-geographical maps are not yet properly developed. Therefore, the experience gained in the course of preparation of an international economic-geographical map of the world would definitely facilitate the development of economic-geographical cartography.

As a result of examination of the available statistical data, the possibility of detailed representation on the scale 1:2,500,000 could be realized with respect to population maps covering the entire world. Therefore, the preparation of such a map would be of topical interest. The territorial distribution of the population and the network of populated places is greatly influenced not only by relief features but by the range of forests. At the same time, the forests also exercise an influence on other branches of the national economy. The representation of the forests is, moreover, motivated by the fact that on a number of thematic maps the marking of forests is necessary, for instance, agricultural, medico-geographical and hydrological maps. The uniform representation of forests on a global scale can be estimated as a prospective demand on the base maps of thematic content.

The purpose of this paper is to draw attention to the possibilities of the utilization of the sheets of the 1:2,500,000 world map in the field of thematic mapping. The makers of the world map are prepared to offer the film negatives of the individual sheets for use as bases of thematic maps, because they are convinced that in this way they would be facilitating the development not only of cartography on the whole, but especially of thematic mapping, and in this way would contribute to the strengthening and widening of friendship and understanding between countries in this scientific domain.

Some sheets of the 1:2,500,000 map covering Asia and the Far East, as well as some variants, were on display at the technical exhibition of the Seventh Conference.

SOIL-CLASSIFICATION PHOTO MAPS OF PEÑARANDA AND GUIMBA AREAS—A RESEARCH PROJECT*

Paper presented by the Philippines

The purpose of this paper is to present the methods used in the preparation of the photo base map and the subsequent reproduction of the soil-classification photo maps and other thematic maps necessary for the irrigation feasibility study of the Peñaranda and Guimba areas of the Philippines. The Bureau of Soils had been using, to a large extent, existing topographic maps as base maps in its various soil survey work. Only very recently did the Bureau begin to use aerial photographs in some of its projects. In the survey of the Peñaranda and Guimba projects, aerial photographs were extensively utilized to update the soil-mapping procedures and to meet the requirements of the project areas for an accurate and efficient method of soil survey and land classification.

The methods discussed herein in the production of photo base maps and thematic maps by means of combined screened positives were planned and standardized by Heinrich Engeler, a cartographic consultant of the Food and Agriculture Organization of the United Nations (FAO).

Joint projects of the Bureau of Soils and the United Nations Development Programme

The current project on the irrigation feasibility study of the Peñaranda and Guimba areas is an extension of the soil fertility and research project of the Bureau of Soils and the United Nations Special Fund, a United Nations development project completed in 1969; and is a joint undertaking of the Bureau of Soils and the United Nations Development Programme (UNDP). The objective is to carry out and establish the soil survey and land-classification methodology of the organization to meet future needs of the agency. The counterpart staff and personnel received on-the-job training on the new research methods, new cartographic procedures and soil survey methods under the supervision of soil experts from the United Nations and FAO. The land-capability classification system was developed in consultation with the team from the United States Bureau of Reclamation, which was working on projects in the vicinity.

Intergovernmental agency co-operation was developed, as the project counterpart was not completely equipped nor sufficiently trained in all the aspects involved in preparation of the photo base maps. The field survey was done by the Bureau of Soils survey teams. Photographs and photographic material for the controlled mosaic were procured by the National Irrigation Administration (NIA) and UNDP. Preparation of the controlled mosaic and production of mosaic negatives of 2 × 2 min grid at 1:20,000 scale were done by the University of the Philippines Training Centre for Applied Geodesy and Photogrammetry; and the major part of the reproduction process from the mosaic negatives was done by the Research and Development Division of the Board of Technical Surveys and Maps. Preparation of the frame and grid and the soil map overlaps was undertaken by the Cartographic Section of the Bureau of Soils.

*The original text of this paper, prepared by Rufino L. Santos, Supervising Soil Technologist, Bureau of Soils, Philippines, appeared as document E/CONF.62/L.91.

Soil survey and classification

Aerial photographs of the area enlarged to an approximate scale of 1:8,000 on a semi-matte double-weight paper were used as field-sheets. Partial photo-interpretation was done either on the enlarged copies or on the contact prints. Elements of interpretation were mainly on slope, physiography, vegetation or land use and drainage. A greater part of the work was done during the field completion survey. Delineations of soil boundaries and other symbols were drawn directly on the photographs in pencil and subsequently inked after correlation work.

Soil classification was based on the *Soil Survey Manual* of the United States Department of Agriculture (USDA) and the Comprehensive System—7th Approximation at the series level. Soil profile descriptions for a complete characterization of the soil are based on the FAO *Handbook on Guidelines for Soil Profile Descriptions*. These were done on intensive deep soil borings and exposures of typical or representative soil-profile pits.

The soil characteristics and other external features formed the basis for the land capability classification based on the system of the United States Bureau of Reclamation.

Photo base map and thematic map production

The method and procedure discussed in this paper are based on the duty mission report of the FAO cartographic consultant, who visited the country in April and May 1971 to assist the project in the development of quality maps. He organized the procedures to be followed and established quality standards and controls.

Mention was made earlier that the project counterpart in the Bureau of Soils was not completely equipped nor sufficiently trained in some of the aspects involved in map production and that the photographic work was done by the Research and Development Division of the Board of Technical Surveys and Maps.

Several reproduction methods can be used to produce photo base maps, and one must decide the best procedure according to the available equipment and materials to obtain quality results. These special requirements led to the development of a unique system of production, which provided a striking demonstration of the adaptability of different photo and offset processes.

Production of base map

Production of the base map involved the following steps:

(1) The negative of the mosaic of 2 × 2 min grid at 1:20,000 scale was scrutinized on the contrast range density, using an electronic Densitometer for correct measurement. This measurement served as a guide in establishing the required lens openings, exposure and development time. Enlargements in the camera were made from the negatives on Kodak bromide paper on the scale 1:10,000 for the base;

(2) From the bromide copy, a continuous-tone negative on Kodak commercial film was produced in the camera. At this stage, it is very important to fix the range of density. A medium density was chosen in order to facilitate the screening. The negative was made by opening the lens to f32, for an 8-second exposure, and developed for 1 minute and 40 seconds in Kodak D-11 developer at 20°C or 68°F;

(3) From the bromide copy, an overlay for the frame and grid was made using stable transparent material (acetate paper), from which a negative was produced in the camera on Kodalith ortho-film. The same was done for the marginal text. The camera flood-light was used for exposure through the lens at an opening of f32, 20-second exposure, and 1½-minute developing time in Kodak Super Developer A and B;

(4) Retouching on the continuous-tone negative of the hydrographic features with Kodak red opaque was done so that they were flat white on the final base map;

(5) From the negatives of step 2 and 3, a combined reverse reading positive was printed on Kodalith ortho-film, using a contact magenta screen positive in the camera-back vacuum frame. Both negatives were reversed and register-punched, and placed emulsion side up. A pin system was used for registry control in interexposures. In the absence of any standard light source, testing was necessary to establish the required standard of contrast of 10 per cent in the highlights and 85 per cent in the shadows. Exposure with the magenta screen and continuous-tone negative was 10 seconds. A normal white light-bulb of 25 watts was used at a distance of approximately 1.5 m, and development was 2 minutes in Super Developer A and B.

The master positive was made for use by the NIA-UNDP project (PHI-31) as a neutral base map of which working copies can be printed by means of diazo or offset process.

Production of soil map

Production of the soil map entailed the following steps:

(1) From the master-positive reverse side, a contact negative right reading from the emulsion side was made. This negative was used as the base component in the production of the combined thematic positives;

(2) The soil-classification boundaries, symbols and other information were transferred by free hand from the field-sheets to working copies produced from the master positives printed by diazo process. The boundaries in turn were traced on stable transparent overlay material from which a negative was produced;

(3) The soil map negative and the contact negative must be register-punched. The pin system was used for registry control in the interexposure production of the second combined screened positive showing the incorporated soil boundaries and symbols in solid lines in the screened photo base. From this positive, paper copies may be printed by either the diazo or the offset printing process; depending upon the number of copies required.

The step-by-step production of these maps is illustrated in figure 153.

Conclusion

The process of photo-map production has been discussed as it was actually done, including the field-work phase of the project activities. Viewing the whole process, the programme of work should have the controlled mosaic prepared prior to the field-work. Duplicate paper prints at the desired scale are produced from the 2 × 2 min mosaic negatives; one copy should be used as the field-sheet for thematic information, and the other

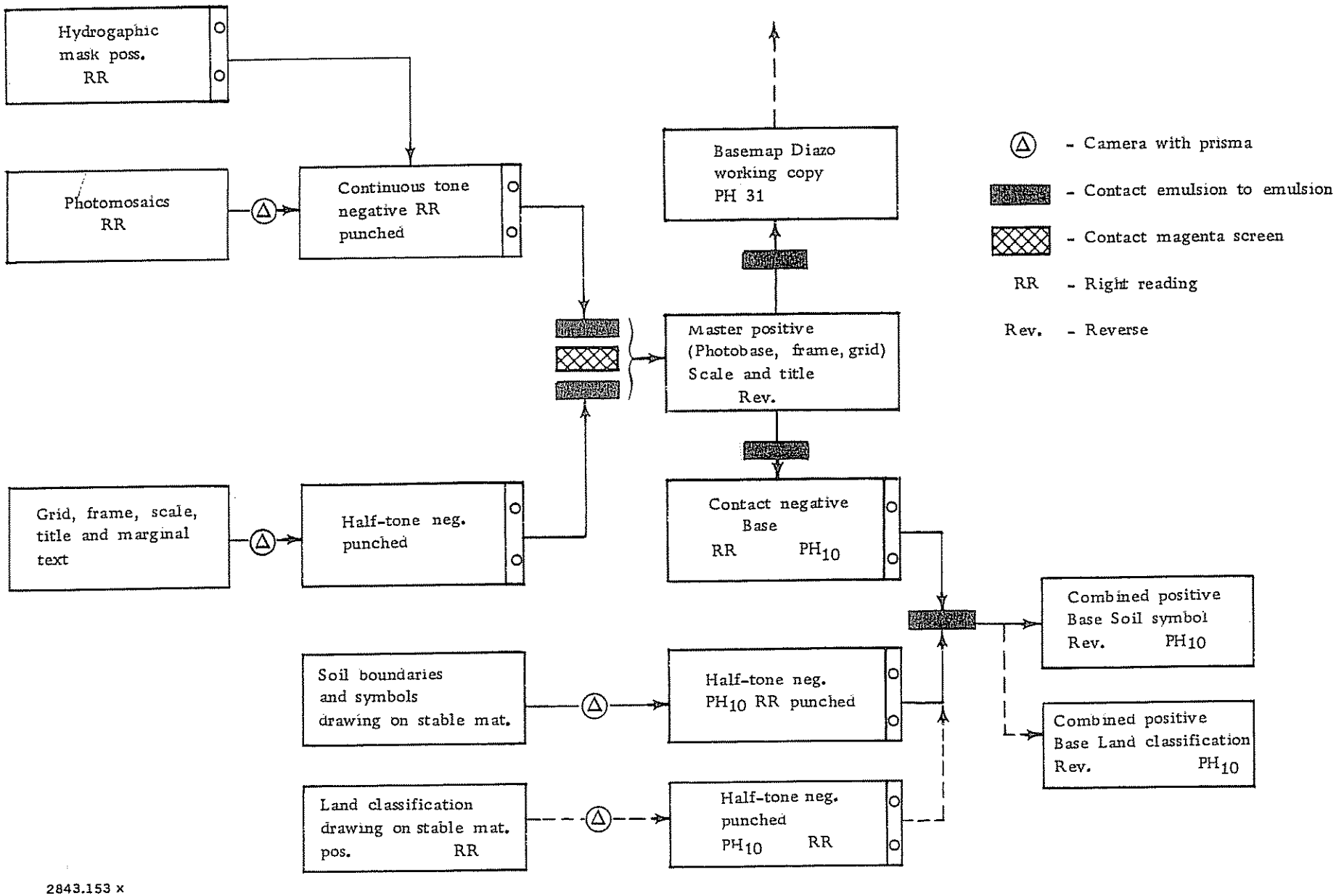


Figure 153. Philippines: photo-map production step by step

copy should be used as the base in production of the photo base map.

The master positive, which is a neutral base map, should be stored for any future needs in the area. From the master positive, a number of thematic maps can be produced accurately and efficiently in a short time, and economically in the long run.

THE PHILIPPINE NATIONAL ECONOMIC ATLAS, SCALE 1:4,000,000*

Paper presented by the Philippines

In the Philippines, several government agencies undertake various facets of surveying and mapping activities. Liaison among the mapping and surveying agencies generated interest and co-operation among them so that agencies readily agreed to make their data available and to allow their personnel to collaborate in the preparation of the Philippine National Economic Atlas. Invaluable data gathered through the years have been evaluated, collated and translated into maps, and effectively presented so that they could be readily understood, fully appreciated and effectively utilized by government agencies, planners, *entrepreneurs,* economists, investors, businessmen, students, tourists and the general public. At a meeting of the National Committee on Geographical Sciences (NCGS) at the National Science Development Board (NSDB) in early 1971, the Board of Technical Surveys and Maps (BTSM) presented a project proposal on the compilation, funding and publication of the National Economic Atlas and requested financial assistance for the project. NSDB approved the project and granted financial assistance for cartographic and reproduction materials. When the executive branch of the national Government was reorganized in pursuance of Presidential Decree No. 1 dated 24 September 1972, and implemented in accordance with Presidential Letter of Implementation No. 19 dated 31 December 1972 and Department Order No. 737-A dated 24 January 1973, of the Department of National Defense, BTSM was abolished and most of its functions and necessary personnel were assigned to and assumed by the Bureau of Coast and Geodetic Survey (BCGS) effective 1 February 1973. At that time, work on the National Economic Atlas was already under way; and BCGS continued and completed the work on the project.

Objectives

The National Economic Atlas is intended to provide and make available pertinent information, already accumulated by many government, semi-government and private agencies, in map form for the use in the study, planning and implementation of economic development projects of the Government and to supply data needed by many government agencies, private offices, groups and individuals in varied activities of national development. Recent developments have generated new interest in investment opportunities in the Philippines and opened new horizons for both local and foreign capital. It is hoped that the National Economic Atlas will be of assistance in hastening the growth and accelerating the developing of the country and its people.

Source materials

Almost all the basic data compiled and analysed in this atlas were obtained from various government and private agencies, whose surveying and mapping activities were being co-ordinated by BTSM. These offices provided excellent statistical services. However, they could meet only to a limited extent the increased demand for detailed and/or particular economic information. The available data or information are either compiled generally for the whole country and therefore provide little or no information on the characteristics of individual regions and provinces; or, if they are compiled by region, deal only with a particular economic aspect and give little idea of other economic characteristics or their relevance to particular needs or requirements. Moreover, some comprehensive and detailed economic data were scattered among separate sources in a wide variety of presentations. Hence, the data had to be collated, evaluated, digested and presented in readily understandable media, as in this atlas.

In the Philippines, the following atlases and thematic maps have been previously prepared by several agencies:

(*a*) Philippine Agricultural Atlas, by the Agricultural Economic Division of the Department of Agriculture and Natural Resources (DANR), 1957;

(*b*) Philippine Economic Atlas, by the Presidential Economic Staff, 1966;

(*c*) Water Resources Atlas at scale 1:25,000 and smaller, compiled by the Water Resources Committee, 1969;

(*d*) Meteorological, Geophysical and Climatological Atlas, compiled by the Weather Bureau;

(*e*) Individual thematic maps, compiled and published by government agencies, on such subjects as geology, soils, population, surface water and political subdivisions;

(*f*) Water Resources Atlas of the Philippines, compiled by the Presidential Advisory Council on Public Works and Community Development, 1969;

(*g*) Maps, charts and information brochures, issued by private agencies.

Preparation of the atlas

Base map

The base map is a reduction of the three sheets of the 1:2,000,000 reproducibles of the jet navigational chart of the United States Air Force, mosaiced to compose the Philippine coverage. The Lambert conformal conic projection is used. The dimension of each map sheet is 17½ × 22 inches.

*The original text of this paper appeared as document E/CONF. 62/L.94.

Contents

The data presented fall under the following general groupings: general reference maps; special-subject maps dealing with the physical, economic and social characteristics of the country; and indexes showing the extent of coverage. There are 37 map-sheets, 23 of which are printed in multicolours, using the Philippine Color-Trol System.[1] Their general meaning is immediately evident; the more important a region is in some economic activity, the more is it emphasized. Some technical statistical presentation or explanation or detailed information is also included on the preceding page of each individual map.

Compilation standards

Standard specifications for research, compilation, colour separation and reproduction of national atlases were adopted, taking into consideration local conditions and resources. Pictorialization and symbolization were also adopted to illustrate distinctly the economic resources and information.

Reproduction negatives

Source materials were either reduced or enlarged to the compilation scale 1:4,000,000 by photographic process. Statistical materials furnished by agencies were collated and evaluated and corresponding symbols and pictorials prepared. The negatives of the maps and charts sources were compiled and waxed on lumirror sheet, from which a compilation positive was made. The positive was then contacted to scribe coats for scribing of the required physical and economic features. The scribe-coat paints used, as well as the graph strips, were developed, formulated and produced from local materials by the Research and Development Division of the Board of Technical Surveys and Maps. Scribing was done as per specification for each type of map. The scribed sheets were then exposed to produce a positive for preparation of window negatives for colour separation.

The symbols and pictures were drawn and reduced photographically to the proper size. Positives of the illustrations were then reproduced on stripping films for use as stick-ups. Other textural and marginal information was type-set on photo-typesetting equipment, and stick-up positives for each individual map were prepared. When all the required positives/negatives were completed for each map, a colour proof was prepared. This proof served as the basis for editing and correcting the compiled maps. In some instances, composite negatives/positives were made.

After the corrections were applied, the final colour proofs were presented for approval before the preparation of printing-plates.

Printing

The printing-plates used were pre-sensitized. The printing was done on an offset press, utilizing previously requisitioned base maps.

[1] For detailed description of the uses of the Color-Trol system, see "Specifications for a regional economic atlas", and addenda 1-16 to that paper, in *Fourth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II: *Proceedings of the Conference and Technical Papers* (United Nations publication, Sales No. 66.I.3), pp. 440-472. The Color-Trol chart may be found in the pocket of the same volume

ANNEX

The Philippine National Economic Atlas: list of maps

1. Cadastrally surveyed areas
2. National parks and wildlife
3. Surface-water resources
4. Manpower resources
5. Sugar-rice-corn, area and production
6. Ground-water resources
7. Trade centres and trade areas
8. Commercial and rural banks
9. Income distribution
10. Mineral distribution (metallic)
11. Domestic water-supply
12. Population distribution
13. Climate
14. Areas covered by aerial photographs
15. Metallogenic provinces
16. Coconut-abaca and timber production
17. Relief
18. Cultural-linguistic map
19. Non-metallic minerals
20. Health facilities distribution
21. Livestock and poultry production
22. Index of topo maps
23. Political subdivision
24. Literacy
25. Power resources
26. Irrigation
27. Industrial distribution
28. Regional subdivision
29. Index to nautical charts
30. Geological
31. Land use (soil cover)
32. Soil
33. Fishery resources
34. Transportation
35. Communication
36. Industrial distribution (steel, plywood, mining)
37. Index of aeronautical charts

AGENDA ITEM 12

Hydrography and oceanography

RECENT DEVELOPMENT OF HYDROGRAPHIC SURVEY INSTRUMENTS IN JAPAN*

Paper presented by Japan

The Hydrographic Department of Japan has long engaged in work primarily concerned with production of nautical charts of the seas and oceans surrounding Japan, but its sphere of work is now expanding to comply with new and increased demands.

In recent years, human activities at sea have become more remarkable, not only with respect to development of shipping and fishery activities, but in connexion with exploitation of resources in the sea, at the sea-bed and beneath the sea-bottom, as well as utilization of the vast space of the sea and sea-bed.

To cope with the demand derived from these movements, the development of techniques and instruments for multipurpose surveying of the sea and ocean has been advanced. In addition, the development of hydrographic survey instruments has been accelerated to meet the rapid construction and consolidation of harbour facilities due to the increase in size and volume of ships and shipping traffic.

Some of the newly developed instruments have already been put into practical use and have been adopted for routine work under the new conception of hydrographic survey, while others are still at the initiative stage of development.

In this paper, the development of some of the instruments related to hydrography is outlined by giving the gist of past, current and future trends.

SOUNDING INSTRUMENTS

Precise echo-sounder of narrow-beam type

An ordinary echo-sounder for deep-sea use emits sonic waves in rather a wide beam, considerations being given to pitching and rolling of a survey ship. However, this feature has a disadvantage in that the portion of the sea-bed where the sonic wave is reflected is a rather wide area so that the exact spot where the sounding is made becomes ambiguous. Ideally, emitting sonic waves in an extremely narrow beam results in the advancement of accuracy in sounding, which will make it possible to obtain a more detailed sea-bottom configuration. However, when a transducer for emitting and receiving sonic wave is fixed to the bottom of a survey ship, the sounding is occasionally made to obtain a slant distance due to the movement of the ship. Accordingly, errors may rather become larger than in the case of ordinary echo-sounders.

Now, it may become possible to overcome this disadvantage at minimum cost by detaching the transducer from the hull of the survey ship and installing it in a stabilized towed body. On the other hand, in order to obtain a sharper beam of sonic wave, a larger sized transducer is required. As the transducer should be installed in a towed body, equipment that is too large and heavy cannot easily be handled aboard a survey ship.

Considering these problems, a compact transducer capable of emitting a sharp beam has been developed. This device, which is expected to be completed in 1974, is designed to fulfil the above-mentioned requirements by electronically summing up the output of a certain number of transducers. The particulars of the device will be as follows:

(*a*) Total beam angle: 3°;
(*b*) Maximum sounding: 7,000 m;
(*c*) Frequency of supersonic wave: 12 kHz;
(*d*) Recording: electric-spark marking on dry paper;
(*e*) Width of recording paper: 485 mm;
(*f*) Digital reading: four figures.

SIDE-SCANNING SONAR

With side-scanning sonar, the topography of the sea-bed of a wide range can be seized as a plane by simultaneous use of two different frequency waves, as in the way where shades of bottom configurations are drawn on the recording-paper as if the topography were seen on a radar screen. The instrument can be used in waters up to about 50 m in depth. The survey ranges are 150 m with the higher frequency (150 kHz) using a fan beam and 600 m with the lower frequency (40 kHz). With the higher frequency, a bottom configuration within a short range can be identified by high resolving power (undulations of 0.2 m can be resolved), while with the lower frequency, moderate undulations can be surveyed in a wider area. Figure 154 illustrates this instrument.

Side-scanning sonar is being successfully used in the surveys of sand-waves and wrecks, its capability being quite sufficient to fulfil the requirements of such surveys.

BOTTOM PROFILER

Seismic profiler for deep-sea use

In order to make clear the geological structures of the sea-bed, or to exploit the mineral resources there, a

*The original text of this paper, prepared by Takao Uchino and Mitsugu Okada, Hydrographic Department, Maritime Safety Agency, appeared as document E/CONF.62/L.22.

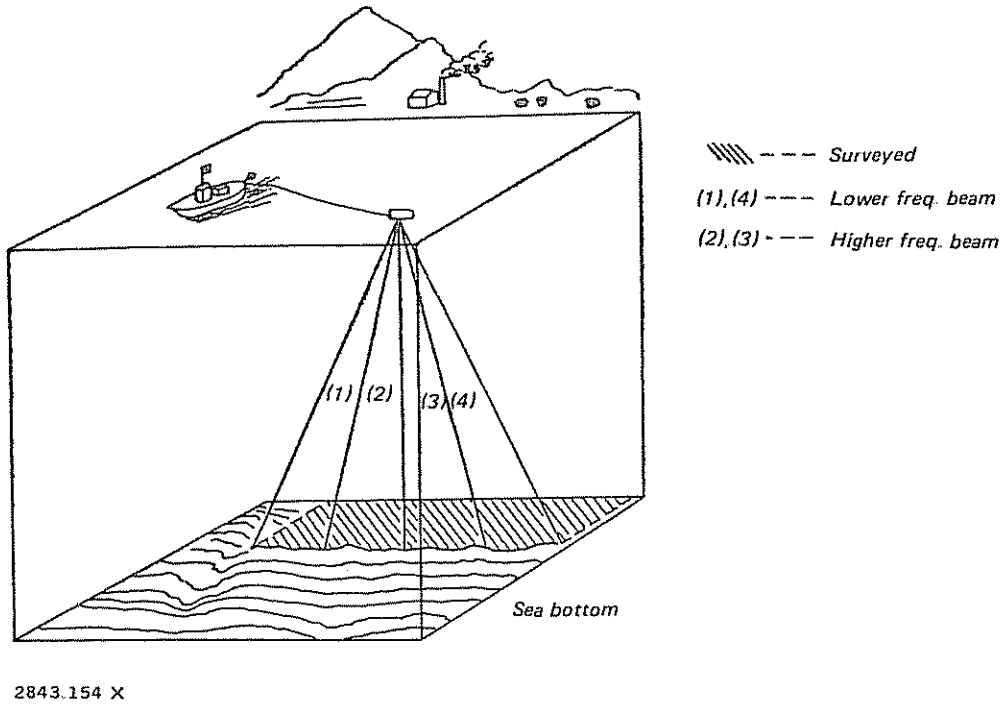


Figure 154. Japan: side-scanning sonar

seismic profiler is used for continuous recording of submarine structures. It utilizes reflections of high-power, low-frequency sonic waves at the borders between different subbottom layers. Recordings can be obtained of 1-2 seconds of sound-travel time below the sea-bottom surface at a sea depth of about 2,000 m.

The transmitter and receiver of the sound-waves are towed behind a survey ship. The receiver is quite identical to that of the echo-sounder for deep-sea use, and they are interchangeable.

In addition to the so-called "reflection profiling method" mentioned above, the refraction profiling method (where the velocities of sound in the subbottom layers are measured, by which the nature of the layers can be judged) is concurrently used with the reflection method; thus, fresh data for elucidation of submarine structure are being obtained.

Position-fixing instruments

Electronic distance-measuring device

The electronic distance-measuring device is that with which the distance between the ship station and land slave-station is measured and put out digitally in metres. If another land slave-station is established at a different place, the position of the ship can be fixed by the distances from the two land slave-stations. As the device has extremely high accuracy in position-fixing and also is easily portable, it is most suited for high-density sounding in shipping routes, harbours and coastal waters. Particulars of the device are as follows:

(*a*) Effective range: 100 km (within line of sight);

(*b*) Accuracy in position fixing: within 2 m;

(*c*) Digital output: 99,999.9 m (maximum).

This device uses microwaves (3 GHz) having the similar characteristic of light-waves which are easily reflected. Therefore, at the master station, two waves, one directly from the slave station and the other reflected at the sea surface, are both received as combined, which results in errors of measurement. Not only this problem exists; it also has a defect in that measurements cannot be done at such a place where the phases of those two waves differ by 180°, at which both waves cancel each other.

In order to overcome these disadvantages, improvements have been made by using a special antenna and removing about 80 per cent of the reflected waves, thus advancing the reliability of measured values.

When one expresses by probable error the results of measurement of distance between fixed points, the errors are from ±50 cm to ±70 cm for the device not using a special antenna; while with the one equipped with a special antenna, the error becomes ±20 cm, which is an extremely good result.

In Japan, three manufacturers are producing this type of device and more than 20 sets are currently employed by both governmental and private agencies. Furthermore, a linear guiding device which can convert the distance values obtained by the two-range system into *XY* rectangular co-ordinates has been developed and put into practical use.

Sonar beacon type of position-fixing system

When carrying out topographic and geological surveys in a limited area of the ocean, position-fixing can be done by using landmarks, electronic-positioning systems or others if the survey area is rather close to the coast; but in the offing area, there are no compatible facilities for position-fixing. Although LORAN, DECCA,

OMEGA, etc. are in operation, their accuracies in position-fixing are on the order of from one hundred to several thousands metres, which are insufficient for a precise survey.

The system proposed is a kind of position-fixing method by distance and bearing, utilizing supersonic waves. The characteristics of the system are as follows:

(*a*) The transponder set at the sea-bed automatically surfaces by the signal from the survey ship when the survey is completed. After surfacing, it transmits radio signals so that it may be recovered by the survey ship;

(*b*) The sound-ray between the interrogator and the transponder does not become a straight line. Therefore, consideration should be given to correcting measured values on the basis of vertical distribution curves of sound velocity. It further should be converted into the horizontal distance;

(*c*) The transducer of the interrogator is of a towed type so that it may be relieved from noises.

The system is illustrated in figure 155.

HYDROGRAPHIC SURVEY SYSTEM

Data-accumulation system

The data-accumulation system has been developed for the purpose of reducing labour and standardizing the results of hydrographic surveys carried out in coastal waters, passages and harbours. The data of sounding, position-fixing and heights of tides are accumulated aboard the survey ship by this system for off-line processing by an electronic computer.

As digital output can be obtained by use of the position-fixing instrument described above, that instrument can easily be adapted to this system. It is considered that the function in which some difficulties may arise is the digitization of sounding data. In particular, in reading the sounding record of a rugged sea-bottom immediately after dredging completed therein, even an experienced technician cannot tell which is the true echo from the sea-bottom and which is that from some other materials either sunken or suspended.

The following characteristics may assist him in discriminating the true echo from the false ones:

(*a*) For a short duration, the signal of a true echo has the distinctive feature of periodicity and continuity;

(*b*) The true echo signal rises sharply and continues for a certain duration;

(*c*) The signal of a true echo has a comparatively strong signal strength. These characteristics, of course, would not completely prevent misreading. Hence, a certain measure is necessary to ascertain any misreading as quickly as possible. For this purpose, a comparison of the analogue record and the digital record of sounding is the most reliable way. This method, however, is time-consuming, which is against the policy of reducing manpower.

Therefore, a method is now conceived in which digital sounding values are transformed into analogue values and recorded on the same recording-paper separately from the original sounding record in order not to hamper the original one. In other words, if the record is drawn completely in parallel with the original one, judgement can easily be made of the correct reading. The

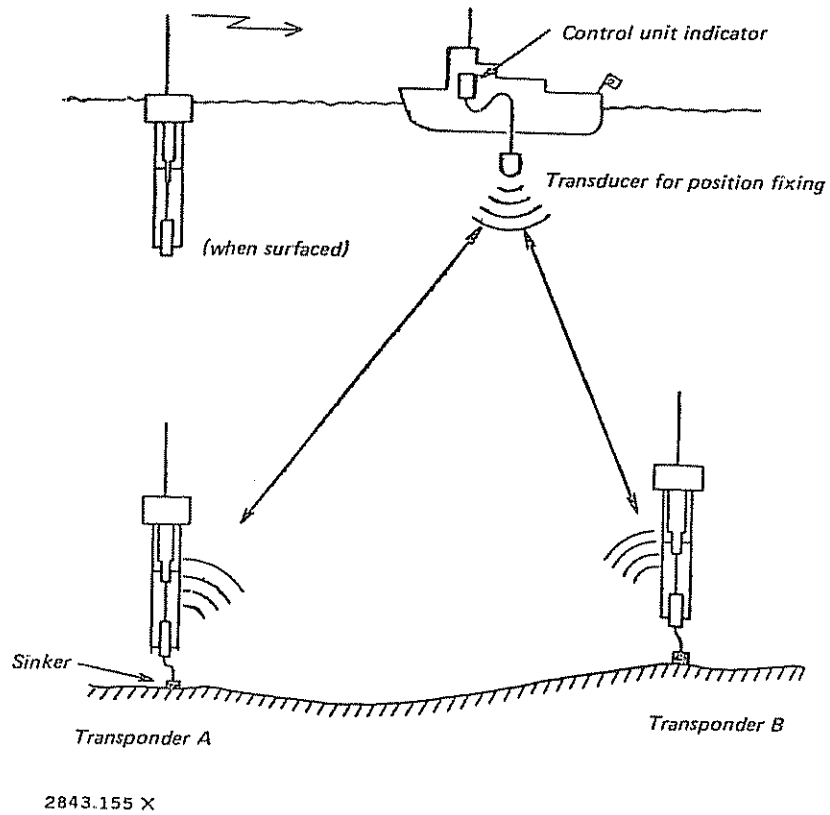


Figure 155. Japan: sonar beacon type of position-fixing system

data thus obtained (on paper tape or magnetic tape) are sent to the Computation Centre of the Hydrographic Department, where they are processed and then fed back to the survey site to be used as a reference material for examining the necessity of carrying out supplementary surveys or resurveys.

The special feature of this system is that its weight is light, so that it can be carried aboard a survey boat of any size.

Based on the above-mentioned idea, automation of sounding has just made a start.

Survey system aboard survey ship Shoyo

The survey system installed on board the survey ship *Shoyo* was selected on the basis of the following considerations:

(*a*) The fundamental composition should be the same with that aboard the *Meiyo*, another survey ship of the Hydrographic Department, in order that the system may have the same capability or more for carrying out the survey for the Basic Map of the Sea;

(*b*) When a computer is housed on board at a later date and on-line processing becomes feasible, various instruments concerned should be digitized; and output levels, shapes of waves and connectors standardized;

(*c*) If the digital circuit becomes out of order, the same survey and measurements should be continued by the analogue circuit.

Thus, the following survey instruments are installed aboard the survey ship:

(*a*) LORAN A/C combined receiver, including auto-tracking system and track plotter;

(*b*) Deep-sea echo-sounder;

(*c*) Shallow-water echo-sounder;

(*d*) Deep-sea seismic profiler;

(*e*) Proton magnetometer;

(*f*) Ship gravity meter;

(*g*) Analogue to digital (A-D) converter for sounding (used as combined with (*a*) or (*b*) above; sounding values are digitized and expressed by five figure-tubes and at the same time put out by binary coded decimal (BCD) system);

(*h*) Navy Navigational Satellite System (NNSS) positioning equipment;

(*i*) Control unit of survey instruments (controls type-written letters and punched holes on paper tapes concerning such values as station numbers, month, date, hour, minute, second, LORAN, sounding and total magnetic intensity);

(*j*) Narrow-beam precise echo-sounder (to be mounted in 1973 fiscal year).

The block diagram of the survey system mentioned above is shown in figure 156.

As has been explained, survey items have become manifold and survey accuracies have been raised to a higher level, which has made the survey instruments more complicated and upgraded. Consequently, excellent engineers are now increasingly demanded for handling and maintaining those instruments.

Apart from this aspect, it is considered an important factor that duplicate instruments should be held in reserve so that they may be put into operation at once when the main instruments become out of order, thus avoiding any lack of survey data.

Future trend

As concerns position-fixing, the general tendency for the past decade has been that the method of positioning by sighting landmarks has been replaced by the method of electronic position-fixing. In particular, it is not too much to say that position-fixing in the ocean is now completely entering the era of electronic-positioning.

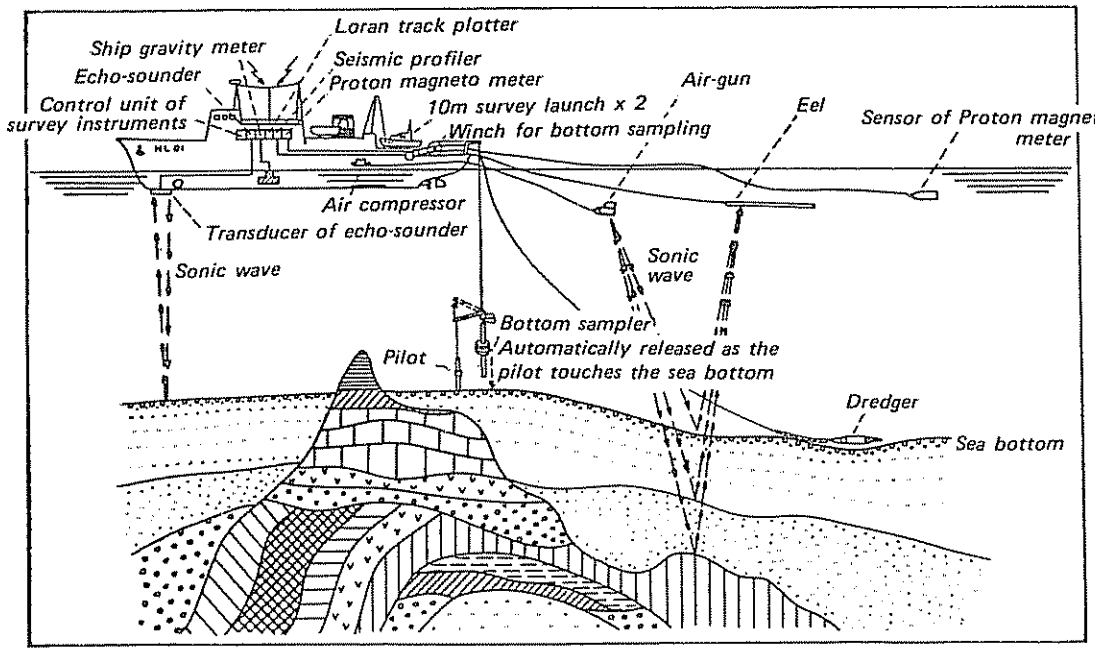


Figure 156. Japan: survey system aboard survey ship Shoyo

However, various electronic-positioning systems have some peculiar weak points. Therefore, the current trend is to use as many different systems as available to eliminate those weak points.

Recently, a position-fixing system having global coverage has become available. The most important problem in this development is the standardization of geodetic datum and the earth's spheroid. It is hoped that this difficulty will be solved in the near future.

As concerns sounding, in some cases, digitized s sounders are put into use on the premise that the s will be automated as explained above.

It is expected that the hydrographic survey wi further expanded quantitatively in future. There reduction of manpower and automation of surv undoubtedly will be the general trend, which wi related to the standardization of the quality of coll data and the unification of accuracy at a higher le

GROUP TRAINING COURSES FOR HYDROGRAPHIC AND PHYSICAL OCEANOGRAPHIC SURVI BY THE GOVERNMENT OF JAPAN*

Paper presented by Japan

There has long been recognized a growing need for hydrographic services, including a demand for well-trained personnel in the Asia and Far East region. The demand explicity appeared in certain resolutions of the previous United Nations Regional Cartographic Conferences for Asia and the Far East.[1]

In Japan, this need has also been made clear by the fact that various requests for training of personnel in the fields of hydrography and oceanography have frequently been made from certain countries in the region.

In view of the demand, the Government of Japan has been making efforts to map out a programme to realize the training, *inter alia,* to implement the training along the lines made clear by resolution 18 of the Fourth Conference.

In 1970, it made inquiries and investigations on this subject to some countries in east Asia, with the objective of inaugurating group training courses in these fields as part of the Government's technical co-operation project.

In 1971, a pilot course for the proposed group training courses was held at the Hydrographic Department of Maritime Safety Agency for 35 days in September-October. The participants were mostly staff officers of hydrographic offices or other governmental offices related to hydrography or oceanography of countries in east Asia.

Based on the findings of the investigation, replies to the inquiries as well as various suggestions and experiences obtained through the pilot course, the group training courses for hydrographic survey and for physical oceanographic survey were organized as regular courses, and began in 1972.

These courses are conducted by the Government of Japan as part of its technical co-operation programmes for developing countries, with a view to contributing to their upgrading of techniques in the field of hydrographic or physical oceanographic surveys mainly by introducing to participants modern techniques in these fields through lectures, practical training, observation tours etc. The languages used are English and Japa through English interpretation.

Details of the training courses carried out in 197 given below.

Table 1. Group training course for hydrographic survey,
Duration of course: 29 May–4 November (23 weeks)
Participants: Indonesia, 1; Malaysia, 1; Philippines, 2 Republic of Korea, 1; Thailand, 1

Subject	*Dur (d*
Geodesy	
Map projection	
Photogrammetry	
Control survey	1(
Coastlining	1
Electronic survey	13
Smooth sheet of survey and data processing	1
Sounding	5
Astronomical observation	5
Field operation of harbour survey	5
Data processing of harbour survey	5
Marine topography and geology	5
Gravity measurement at sea	2
Geomagnetism	2
Field operation in oceanic survey	21
Data processing of oceanic survey	8
Survey planning	1

In addition to the above listed lectures both in t class-room and in the field, the participants made va ous observation tours to visit institutions, manufactur or places related to the subjects of the training.

Table 2. Group training course for physical oceanograph survey, 1972/1973
Duration of course: 6 November 1972–27 February 197 (17 weeks)
Participants: Indonesia, 1; Malaysia, 1; Philippines, 1; Republic of Korea, 1; Singapore, 1; Thailand, 1

Subject	*Durati (days*
Physical properties of sea-water	3
Chemistry of sea-water	4
Dynamics of ocean current	7
Field training in oceanographic observations	8
Data processing of oceanographic observations	4
Waves	3

*The original text of this paper appeared as document E/CONF. 62/L.23.

[1] *Second United Nations Regional Cartographic Conference for Asia and the Far East,* vol. I, *Report of the Conference* (United Nations publication, Sales No. 59.I.9), p. 9, resolution 10; Fourth Conference, vol. I, *Report of the Conference* (United Nations publication, Sales No. 65.I.16), p. 13, resolution 18; Fifth Conference, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.68.I.2), pp. 12–13, resolutions 20, 21 and 25; Sixth Conference, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.71.I.15), p. 17, resolution 13.

Table 2. Group training course for physical oceanographic survey, 1972/1973 *(continued)*

Subject	Duration (days)
Tidal current	7
Tides	5
Field training in tide and tidal current observations	7
Data processing of tide and tidal current observations	4
Processing and exchange of oceanographic data	4
Optional curriculum: calibration of thermometer; how to set up a tidal station; investigation of water pollution[a]	2

[a] Participants were divided into three groups according to their selection.

In addition to the lectures and field operations listed above, the participants made observation tours to visit institutions, manufacturers and other places related to the training subjects.

For the 1973 year fiscal also, these two courses are being conducted at the Hydrographic Department. The curriculum and schedule are similar to those of the 1972 courses, but the content has been considerably improved on the basis of the experiences of the previous courses.

PREPARATION OF THE BASIC MAPS OF THE SEA ON VARIOUS SCALES*

Paper presented by Japan

MARINE CARTOGRAPHY

The map of the sea has long been none other than the nautical chart. As human activities in the ocean were in the past restricted to marine transportation and fishery, maps of the sea have developed in the scope of navigation. Recently, various kinds of marine surveys have been made in connexion with ocean development, which, in other words, means that the human activities have expanded from land to sea. In several developed maritime countries, exploration or exploitation of mineral resources in the sea-bottom, as well as construction of harbours and other oceanic engineering projects, have become real problems. In the near future, basic surveys and researches in many branches of marine sciences will become increasingly necessary both for the prevention of marine pollution and for the effective and harmonized utilization of the ocean. As the result of those surveys and researches, more kinds of thematic maps of the ocean, other than nautical charts, will become necessary in a way similar to the needs on land.

The Hydrographic Department of Japan has carried out numerous bathymetric surveys around the Japanese islands during the past 100 years since its establishment. Although scientific surveys were included in no small numbers in those surveys, almost all of them were made for the purpose of nautical charting.

In 1967, the Hydrographic Department began the project of the Basic Map of the Sea, the purpose of which is quite different from the usual survey for nautical charts.

The project consists of various kinds of scientific surveys, such as bathymetry, continuous seismic profiling, total magnetic intensity measurement, gravimetry and sampling of the sea-bottom. As a result of these surveys, the following four kinds of thematic maps are made: bathymetric chart; submarine structural chart; total magnetic intensity chart; and gravity anomaly chart. They are called "Basic Maps of the Sea", because they are the most fundamental of the various kinds of thematic maps for utilization and scientific research of the sea.

It may be said that the surveys currently being carried out by the Hydrographic Department of Japan are twofold, one of nautical charting and the other for basic mapping of the sea.

Marine cartography has a broader scope including various kinds of thematic maps other than the Basic Map of the Sea and the nautical chart.

In this paper, the purpose, general plan, methods of survey and results of the Basic Map of the Sea project of the Hydrographic Department of Japan are explained.

OUTLINE OF THE PROJECT

The project can be divided into the following three groups: ocean; continental margin; and coast (see table 1).

The oceanic project is divided into four kinds, according to the scales of maps:

(a) *The 1:500,000 series.* This series, which has not yet begun, is scheduled to be put underway in 1976. The results will be compiled into the four kinds of thematic maps mentioned above;

(b) *The 1:1,000,000 series.* This series is the project of the General Bathymetric Chart of the Oceans (GEBCO). The A III and B III areas under the responsibility of Japan are divided into 59 sections for which three kinds of maps are to be prepared with respect to each section; plotting sheet; source overlay; and bathymetric overlay. Thus far, 13 sections have been completed. The A III area will be completed by the end of 1973, and the compilation for B III area will be begun in 1973;

(c) *The 1:3,000,000 series.* This series is the reduction of the 1:1,000,000 bathymetric overlays of GEBCO, of which four sheets have been published; other sheets will be issued in accordance with the progress of the GEBCO project;

*The original text of this paper, prepared by Takahiro Sato and Yoshio Iwabuchi, Hydrographic Department, Maritime Safety Agency, appeared as document E/CONF.62/L.24

Table 1. Outline of the Basic Map of the Sea project

Subproject	Scale	Purpose	Schedule	Method	Bathymetry	Geology	Geomagnetism	Gravity
Ocean	1:8,000,000	Education, research, planning	None	Compilation	In progress	None	None	None
	1:3,000,000	Research, planning	None	Compilation	In progress	None	None	None
	1:1,000,000	Research, planning, survey	GEBCO[a] schedule	Compilation	In progress	None	None	None
	1:500,000	Planning, survey	1976–	Survey	Under planning	Under planning	Under planning	Under planning
Continental margin	1:200,000	Planning, survey	1967–1976	Survey	In progress	In progress	In progress	In progress
	1:50,000	Planning, survey	1971–	Compilation, survey	In progress	In progress	None	None
	1:10,000	Survey, field operation	1971–	Survey	In progress	In progress	None	None

Note: "Survey" in the column of "Purpose" means an intermediate case between "planning" on desk and "field operation" at sea.

[a] General Bathymetric Chart of the Oceans.

(d) *The 1:8,000,000 sheet.* This sheet covering the Western Pacific was published in 1972. No further plan in this connexion is scheduled for the time being.

The continental-margin project currently in progress consists of four kinds of thematic maps on the scale 1:200,000. It was begun in 1967 and will be completed in 1976.

The coastal project is divisible into two sections, according to the scale:

(a) *The 1:50,000 series.* This series was begun in 1971 and will be continued for many years around the Japanese islands. The results consist of bathymetric charts and geological maps;

(b) *The 1:10,000 series.* This series also was begun in 1971 and will be continued for many years in particular areas where special requirements arise due to industrial activities. The results consist of bathymetric charts and geological maps.

Table 2 shows the principal items of the bathymetric charts of every series. The detailed information of the series accompanying the surveys is described below.

Continental-margin project

The Basic Maps of the Sea on the scale 1:200,000 are being prepared for use in various researches, planning etc.

Methods of surveys and analyses

The survey for the project will cover the entire continental shelves and slopes around the Japanese islands. The spacing of surveying lines is 2 nautical miles, along which bathymetric survey, continuous seismic profiling, total magnetic-intensity measurement and gravimetry are done continuously.

Although the method of positioning depends upon the location of the area, in principle, the best method for the area in question is selected from among the following: ground sight-positioning; LORAN A; LORAN C; DECCA navigation system etc. Soundings are obtained by a specially designed echo-sounder which can measure up to about 3,000-m depth in 1-m units, and by another one for deep-sea use which can measure up to 10,000-m depth in 10-m units. The correction of soundings are made in 1-m units for those depths shallower than 1,000 m, and in 10-m units for deeper soundings. The correction of sound velocity in sea-water is calculated according to the oceanographic observation data.

Geological survey is made by a continuous seismic profiler of the air-gun type along all lines with dredging at several points for the sake of the correlation of profiling records and rock. Geomagnetism is observed by a proton magnetometer. Observed values are corrected according to daily variations continuously recorded at a land station. Gravity is measured by the Tokyo Surface Ship Gravimeter and punched out on a tape which is processed with an electronic computer in a laboratory for the Eötvös correction.

Representation of results

The continental shelves and slopes around the Japanese islands are divided into 80 districts of 63 × 46 cm size on the scale 1:200,000, for each of which four kinds of thematic maps are prepared. The Lambert conformal conic projection with two standard parallels is used. The bathymetric chart is expressed by every 10-m isobaths on the continental shelves and every 100-m ones on the continental slopes, as well as the deepest and shallowest soundings with isolated closed isobaths, geographical names of submarine features, abbreviations of bottom sediments etc. The expression of the land area is as follows: contour lines in coastal parts; main river systems; and geomorphological names.

The geological structural chart shows the relief of acoustical basement in the form of every 0.1 sec (= 75 m) contours, the axes of anticlines and synclines, faults in sediments and basement, and subbottom profiles along a few lines in the sheet.

The total magnetic intensity chart shows the intensity by the 50 gamma contours, and the gravity anomaly chart indicates free-air anomaly by 10 mgal contours, together with measured points.

Table 2. Elements of bathymetric charts of the Hydrographic Department of Japan

Scale	Subdivision	Number of sheets issued	Projection	Size	Colours	Area covered	Sea			Land		
							Contour	Bottom sediment	Geographical name	Contour	River system	Geographical name
1:8,000,000		1	Normal polyconic	Full	3	Western Pacific	500 m (relief)	—	Main feature	500 m (relief)	Main	—
1:3,000,000		4	Mercator	Full	3	GEBCO A III and B III	500 m	—	Main feature	—	Main	In preparation
1:1,000,000	Plotting sheet	13	Mercator	Full	1	GEBCO A III and B III	Soundings	—	—	—	Main	In preparation
	Bathymetric overlay	13	Mercator	Full	1	GEBCO A III and B III	500 m	—	—	—	Main	In preparation
1:500,000	In plan	—	Lambert conformal conic	Full	—	Western Pacific	100 m	—	Main feature	—	Main	—
1:200,000		15	Lambert conformal conic	One half	2	Continental shelf and slope	10 m on shelf; 100 m on slope	In preparation	Main feature	100 m	Main	In preparation
1:50,000	Compilation	40	Lambert conformal conic	Full	1	Within 12 miles off coast	10 m (auxiliary 5 m)	In preparation	All	—	Main	In preparation
	Survey	1	Transverse Mercator	Full	3	Within 12 miles off coast	10 m (auxiliary 5 m)	In preparation	All	In detail	In detail	In preparation
1:10,000	Compilation	8	Transverse Mercator	Full	1	Coastal sea	1 m	—	All	—	Main	In preparation
	Survey	2	Transverse Mercator	Full	3	Coastal sea	1 m (auxiliary 0.5 m)	In preparation	All	In detail	In detail	In preparation

COASTAL PROJECT

Series at 1:50,000 scale

The coastal sea area within 12 miles around the Japanese islands is divided into 428 districts which are 96 × 63 cm in size at 1:50,000 scale. Although the coastal sea area has already been sounded by means of lead and echo during the 100-year history of the Hydrographic Department of Japan, the area sounded by echo occupies only about 70 districts. The Department is preparing bathymetric charts by re-examining original echograms. About 40 sheets have been published thus far, and another 30 sheets will be prepared in a few years. These are compiled bathymetric charts without conducting surveys. The Lambert conformal conic projection is also used in this project. Bathymetric charts are expressed, in principle, by every 10-m isobaths with auxiliary isobaths of 5-m interval, the shallowest soundings with isolated closed isobaths, a number of abbreviations of bottom sediments, geographical names of submarine features etc. The land portion is expressed by main river systems, coastal lines shown by symbols according to the nature of the coast, geographical names, triangulation points etc.

On the other hand, bathymetric charts and geological maps will be produced for those areas where surveys should be conducted. The method of the bathymetric survey is the same as that for the usual hydrogra survey, but the continuous seismic profiling of magnetostriction type is newly adopted. The expres of the bathymetric chart surveyed is nearly the sam that of the compiled ones except that the former sh detailed contour lines on land. The geological r shows the relief of the acoustical basement by conto axes of anticlines and synclines, faults, distributior bottom sediments and schematic profiles of subbott structure.

Series at 1:10,000 scale

As for special areas where such development plans harbour construction, improvement of fishery groun exploitation of mineral resources or oceanic engine ings are intended, bathymetric and geological surv will be carried out by precise echo-sounder for shallo sea use and by continuous seismic profiler of the magr tostriction type. To date, 10 bathymetric charts and t geological maps of such kinds have been published. T projection of the sheets is Transverse Mercator. The si is 96 × 63 cm on the scale 1:10,000. The expressions the bathymetric chart and the geological map are t same as those of 1:50,000 series mentioned above, exce that the interval of isobaths is 1 m with auxiliary isoba of 0.5-m interval.

COMPILATION OF THE GEBCO PLOTTING SHEETS BY THE HYDROGRAPHIC DEPARTMENT OF JAPAN*

Paper presented by Japan

Under the international co-operation programme of the General Bathymetric Chart of the Oceans (GEBCO) sponsored by the International Hydrographic Organization (IHO), the Hydrographic Department of Japan, as one of the volunteering hydrographic offices of 19 member States of IHO, commended the work of preparing GEBCO plotting sheets, for the most part, of the A III area, in 1962. Upon the request of the International Hydrographic Bureau (IHB), co-ordinator of the GEBCO programme, the Department assumed the responsibility for preparation of the plotting sheets for a part of B III area in 1969. Thus, the Department will eventually prepare and update 58 plotting sheets which will provide the latest bathymetric information covering the western part of the north Pacific Ocean and its adjoining seas.

In this paper, the current procedures for preparing the plotting sheets are described, featuring some measures taken for upgrading the accuracy and reliability of the charted information.

GEBCO COMPILATION IN JAPAN

In accordance with GEBCO regulations, plotting sheets, source overlays and bathymetric overlays are being prepared at 1:1,000,000 scale.

Data used

All oceanic soundings collected by the Hydrographi Department have been exchanged with responsible hy drographic offices, and soundings in the A III area hav been received from colleague hydrographic offices. Con cerning the collection of data in responsible areas, th Department requested exchange soundings from sucl research vessels visiting Japan as *Vitiaz, Argo, Vema* and *Conrad*. Oceanographic institutions and organiza tions in Japan also were asked to submit unpublishec soundings to the Hydrographic Department.

Corrections

The submitted soundings include those of corrected and/or uncorrected fathoms. Fathom depths are converted to metric. The uncorrected depths are always corrected according to Matthews' table. There was a problem about the correction of sound velocity in seawater. Certain countries are of the opinion that uncorrected soundings should be shown on the plotting sheet because the correction table of sound velocity is inadequate for current knowledge; a ship at sea does not measure corrected depths, but uncorrected ones so that the sheet with uncorrected depths is more convenient, and the labours for correction are saved. The Hydrographic Department, on the contrary, does not agree with this proposal. The echo-sounders made in countries using the metric system are designed according to assumed sound velocity of 1,500 m/sec, and those in

*The original text of this paper, prepared by Yoshio Iwabuchi, Surveying Division Hydrographic Department, Maritime Safety Agency, Japan, appeared as document E/CONF 62/L.26.

countries using the fathom systems are usually designed according to 800 fathoms/sec (1,463 m/sec) so that there are two kinds of uncorrected soundings. The Department also recognizes the inadequacy of the existing correction table, but this is not a reason to permit the omission of correction. It is, rather, necessary to examine the correction tables in the scope of international co-operation. The standardization of echo-sounders of assumed velocity of 1,500 m/sec is desirable.

The quality of soundings is checked and incorrect data are eliminated as follows:

(*a*) According to GEBCO regulations, the overlays indicating the source of soundings, such as the ship, age and kinds of positioning, are prepared, which is useful for the elimination of incorrect soundings in the updating of the plotting sheet;

(*b*) The older soundings are worse in their accuracy of depth and position so that some of them are indicated at 100-m order. These soundings are eliminated in the area containing many modern soundings;

(*c*) During the process of data exchange, the following errors occur: those due to the copying position; twice correction of sound velocity; and conversion from fathoms to metres and from metres to fathoms again;

(*d*) Checking of the cross-overs between tracks of high-quality soundings and of low-quality soundings is always done. The cross-overs between tracks of wrong tracks are also checked and bad lines are eliminated;

(*e*) Geomorphological checking is very effective. Topography is considered, in principle, to be based on soundings so that surroundings are never eliminated solely by geomorphological check. However, geomorphologically abnormal tracks are usually not good at cross-overs;

(*f*) The reliability of contours is understood in the examination of the source over-lay in detail. Generally speaking, the density is very high in seas adjacent to Japan, but scarce in the north-western Pacific basin.

Some problems in compilation of Japanese GEBCO plotting sheets

Collection of soundings

The Hydrographic Department had circulated a document in Japan requesting that oceanographic institutions and organizations submit soundings. However, it was very laborious work to obtain data from those organizations. Staff members of the Department visited them and borrowed data from smoothed charts, and corrected soundings were prepared. The oceanographers should co-operate in the submission of sounding data.

Publishing of collected data

The soundings in the Department are not secret. Anyone wanting sounding data can obtain them by paying the price. The Department publishes and distributes the data according to requests. There is a plan to publish plotting sheets on which bathymetric overlays are printed in blue colour.

Updating

The national hydrographic offices should collect soundings and keep the plotting sheet up to date. Since 1970, however, the Department has stopped updating due to the shortage of personnel. When the plotting sheets in the A III have been completed and sent to IHO, updating will begin again as routine work.

Contouring

In the conventional way of drawing contour lines from soundings, contouring is made by means of interpolation on the basis of soundings taken at fixed time intervals. At the Hydrographic Department of Japan, however, a new method has recently been adopted whereby geomorphologically important soundings are used instead of soundings at fixed time intervals. Namely, the Department has adopted on the echogram those soundings which indicate the transition point of slope and the shallowest and deepest portions of bottom undulations, as well as the point where a depth contour should pass, taking into account all correction values (for example, adopt the point of 1,021-m sounding, which will become 1,000 m with correction value of −21 m; thus, the 1,000-m depth contour is to pass through this point). When isobaths are drawn on the basis of soundings thus adopted, one obtains more accurate bathymetric charts than those prepared by the conventional interpolation contouring method.

Future work on Japanese GEBCO plotting sheets

As concerns the progress made in the areas for which the Hydrographic Department is responsible, 11 sheets in the A III area have been completed thus far and were sent to IHO by June 1972; 19 sheets are under compilation and 36 sheets under co-ordination, i.e., checking of the connexion of coastlines, isobaths, sounding lines, etc. between adjoining sheets prepared by different hydrographic offices. These works will be completed by the end of 1973. Regular compilation of the B III area plotting sheets will begin in 1973.

HYDROGRAPHIC SURVEY OF SANDWAVE AREAS*

Paper presented by Japan

There are various types of sandwaves, some of which develop in an intertidal zone and are formed almost in parallel with a coastline owing to tidal currents along the coast where the tidal range is large. Some others develop at the sea-bottom where strong currents flow, while still others develop in a trough of a breaker zone, being formed at right angles to the coast due to coastal stream. The size of the waves varies, ranging from a wave length of several tens of metres to several hundred metres and

*The original text of this paper, prepared by Kazuhiko Sato, Hydrographic Department, 7th Regional Maritime Safety Headquarters, Japan, appeared as document E/CONF.62/L.27.

from a wave length of several centimetres to several tens of metres.

Recently, as deep-draught vessels have increasingly entered service owing to expanding maritime transportation, it has become important to ensure their navigational safety by making clear the existing status of sandwaves and investigating their shapes and mechanism.

At the Tenth International Hydrographic Conference in 1972, there was considerable discussion with respect to sandwaves, and a resolution was adopted, recommending "that known areas of seabed mobility characterized by large sandwaves be indicated by the accompanying symbol or by an appropriate legend on charts".

The Hydrographic Department of Japan has carried out several investigations of sandwaves in Bisan Seto, Seto Naikai, as well as in Kanmon Kaikyo. Furthermore, it carried out the investigation in the Malacca and Singapore Straits jointly with the hydrographic offices of Indonesia, Malaysia and Singapore.

This paper describes some findings that may be useful to the safety of navigation and remarks pertinent to a hydrographic survey to be carried out in sandwave areas, based on the results of those investigations.

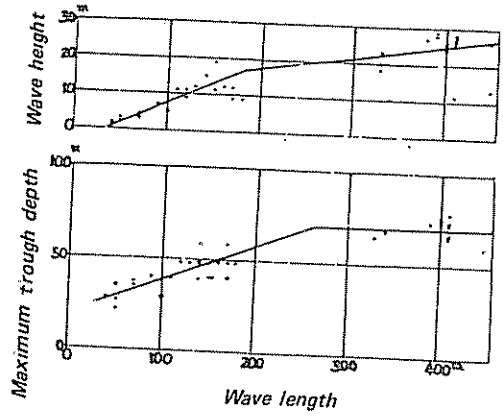


Figure 157. Japan: relation between wave length and wave height, and between wave length and maximum trough

Results of investigations of sandwaves

Several reports have been made concerning the existence of huge sandwaves in particular areas, as well as sandwaves found in inlets and passages where strong tidal currents flow. Moreover, various studies have been made on sandwaves with respect to their mechanism of origin, size, mechanism of movement and relations with the quality of the bottom and with the flow of current. However, there are a number of problems yet unsolved which should further be studied.

Sandwaves in Bisan Seto, Seto Naikai

The maximum velocity of the tidal current in the area of Bisan Seto, Seto Naikai, was observed as 4–5 knots at the surface and 1 knot at a layer 1 m above the sea-bottom. Distribution of sandwaves is limited to those places where the quality of the bottom is sand, coarse sand or granule, and is not seen in those areas where the bottom is of gravel, fine sand or mud.

The size of sandwaves varies according to the location; and even in the same place, their sizes are various. In general, heights of waves are 0.5–2.4 m and wave lengths are 10–250 m; they are distributed at depths of 5–30 m.

Other characteristics are as follows:

(*a*) The relation between the length and height of the sandwave and the grain diameter of the quality of the bottom is such as that the greater the length and height, the greater the grain diameter, and vice versa, being in proportion to the square root of the grain diameter;

(*b*) There is a remarkable tendency that the shallower the water, the shorter the wave length, and vice versa;

(*c*) As for the relation between the wave length and the wave height, they show different aspects between shorter and longer wave lengths, bordered at the length of 200 m. As for the shorter wave lengths, a high positive correlationship is observed between the wave length and wave height, as well as between the wave length and the water depth of the trough (see figure 157). On the longer wave length side, the gradient of the correlationship becomes gentle; and the depths of water at troughs become almost the same value irrespective of the increase in the wave length;

(*d*) They are formed in a linear arrangement, and the direction of the arrangement is almost at right angles to the direction of the tidal current at its stage of maximum velocity;

(*e*) Movements are seen amounting to 5–10 cm per month, with a maximum of 30 cm. The movement is a repetition of a back-and-forth movement. For over a long span of time, however, it may be quite possible that they would gradually move in a certain direction;

(*f*) As for the relation between the movement of sandwaves and the velocity of tidal current, the movement occurs when the velocity of current corresponds to the competent velocity peculiar to the grain diameter of the quality of the bottom;

(*g*) In case a sandbank is artificially dredged, the balance in supply of sand is collapsed and sandwaves begin to develop in other areas;

(*h*) There was an example in which, after a sandbank where sandwaves existed had been artificially dredged, the depths at the dredged portion resumed their original values in a short period of time as sandwaves redeveloped there;

(*i*) Areal investigation of sandwaves by sonar is greatly useful (see figure 158).

Sandwaves in Kanmon Kaikyo

The maximum velocity of tidal current in the strait was observed as 2–5 knots at the surface. Sandwaves are distributed in places where quality of the bottom ranges from fine sand to medium sand to gravel. Their sizes are different according to the place, but, in general, their wave heights are 0.6–4.0 m, wave lengths are 8–50 m and depths of water are 5–18 m.

Other characteristics are:

(*a*) Even in places where the grain diameter is as Gr or G, sandwaves can be formed if the velocity of current is adequate;

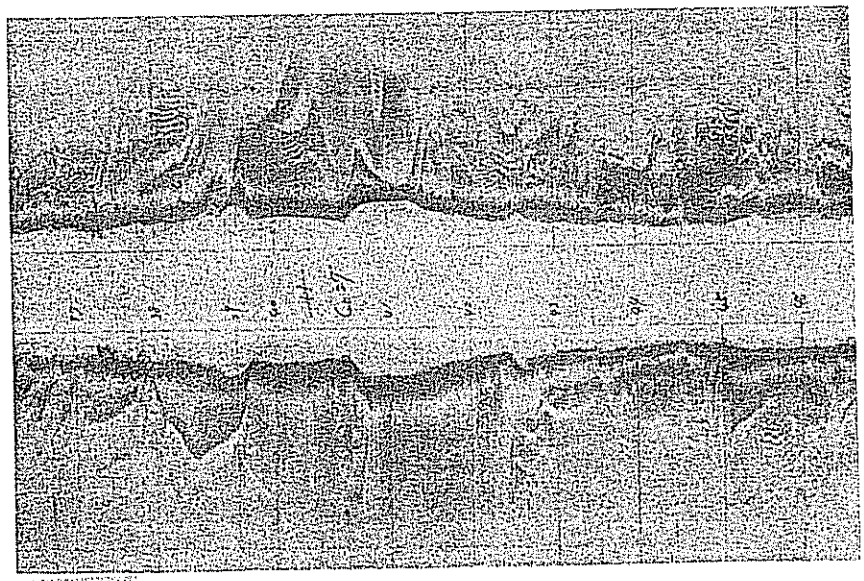


Figure 158. Japan, sonar record of sandwaves

(*b*) In a large-scale countercurrent area, the accumulated volume of sediments is large and sandwaves tend to develop;

(*c*) Their sizes are comparatively smaller than those in Bisan Seto;

(*d*) No investigation has been made as to their movements.

Sandwaves in the Malacca and Singapore Straits

In the Malacca and Singapore Straits, sandwaves are distributed in those places where the quality of the bottom is fine sand, medium sand or coarse sand, i.e., almost all over the area; but they are not seen in such limited places where the bottom quality is clayey or rocky.

Their sizes vary according to the locality, and even in the same place various sizes are seen. In general, the wave heights are 5–20 m and wave lengths are 100–350 m. The highest wave height measured was 20.6 m with a wave length of 267 m.

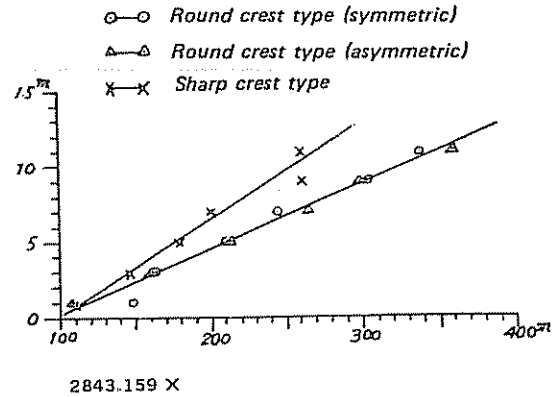
Other characteristics are described below:

(*a*) On those bottoms where depths decrease gradually in the direction of the current, sandwaves tend to develop; and on bottoms where depths increase in the direction of current or in places behind a shoal, sandwaves tend to attenuate;

(*b*) The correlation between the length and the height of waves shows almost a linear variation (see figure 159);

(*c*) Development of sandwaves can be explained as follows: crests of small-scale sandwaves are first formed by the movement of ripple marks towards the directions of tidal currents which are constantly changing; then, by accumulation of these individual small-scale sandwaves, larger-sized sandwaves develop (see figure 160).

(*d*) Movement of sandwaves: sandwaves are the waves of sand originated by currents and tidal currents. In such areas as the Malacca Strait where the current flows constantly in one direction, it cannot be considered that sandwaves stand still at the same place, nor move



SOURCE: Kawamura, Yamada. 1969

Figure 159. Japan: relation between shape of wave and wave lengths of various types of sandwaves

sometimes back and forth in opposite directions during the time of their occurrence and disappearance.

In 1969 and 1972, hydrographic surveys were carried out in areas where sandwaves were prevailing, but the amount of movement could not be confirmed as sounding lines were different between those surveys.

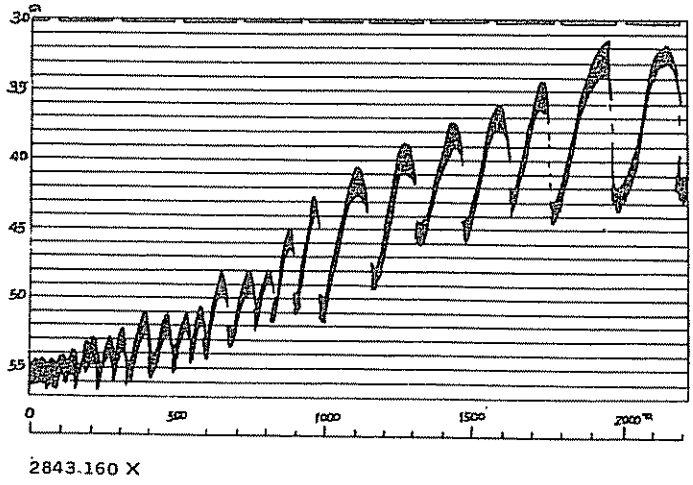
HYDROGRAPHIC SURVEY OF SANDWAVE AREAS

The following points will be useful in conducting a hydrographic survey in a sandwave area:

(1) Investigate the state of distribution of sandwaves by areal survey using sonar;

(2) Carry out sounding so as to make clear the bottom configuration;

(3) Carry out sounding to obtain the shallowest portions of sandwaves on the basis of the investigations in (1) and (2) above;



SOURCE: Kawamura, Yamada, 1969

Figure 160. Japan: example of development of sandwaves

(4) Use an electronic position-fixing system for positioning and an echo-sounder for sounding. Survey launches should be guided on the sounding lines either linearly or circularly;

(5) Take sounding lines along the direction of currents so as to cross sandwaves;

(6) Measure velocity of the current both at the surface and at the bottom layer;

(7) Carry out sea-wave observation;

(8) Collect bottom samples for such investigations as analysis of grain size, measurement of specific gravity and degree of concentration;

(9) Investigate condition of sediments by bottom profiler;

(10) Establish fixed sounding lines and carry out sounding along those lines to obtain the amounts of movements of sandwaves;

(11) Carry out surveys mentioned above as condition of the sea changes in order to find any occurence or disappearance of sandwaves, as well as to measure the amounts of movements;

(12) Based on the data obtained from the foregoing steps 1-11, make an estimation of development and decay of sandwaves, as well as the amounts of their movements.

MARINE BOUNDARIES AND POSITIONS*

Paper presented by the United States of America

THE PROBLEM

In 1580, Queen Elizabeth wrote to the Spanish Ambassador: "The use of the sea and air is common to all; neither can a title to the ocean belong to any people or private persons, forasmuch as neither nature nor public use and custom permit any possession thereof". Yet, today, some countries have extended their spheres of influence to the 12-mile limit, and others exercise sovereign control as far as 200 miles from shore. Furthermore, there have been suggestions that national boundaries should be established where the water column reaches a certain fixed depth or where the geology changes from continental to oceanic structure.

Such legal and political definitions of off-shore boundaries are stated in exact terms and have been so interpreted by many countries. But engineering operations, and positioning and boundary determinations are engineering problems, must allow for an error budget. The establishment of a line a fixed distance off shore or at a fixed depth is technically unattainable. However, a line 5 km ± 15 m off shore or where the depth is 200 m ± 2 m is a technically attainable boundary today. As technology improves, the error budget can be reduced without altering the boundary definition. Another consideration should be the rate at which the parameter that defines the boundary changes. If this parameter changes slowly with distance, it poorly defines a boundary. Depths of 200 m ± 2 m may exist over tens of kilometres; needless to say, a depth could be a most inappropriate boundary parameter. A geological boundary, the continental-oceanic interface, is inadequate for the same reason; the transition from continental to oceanic structure is not finely defined. Probably, the most suitable definitions are those based either on distance or on geographical positions (which depend upon distances). In either case, however, the definition should include an error budget.

*The original text of this paper, prepared by Hyman Orlin, Acting Chief Scientist, National Survey, United States of America, appeared as document E/CONF.62/L.54

An important aspect of the establishment of national boundaries is the delineation of the low-water line. The importance of this tidal datum cannot be overstated, for it is, in many cases, the basis of the legal boundary, separating local, national or international jurisdictions. The economic significance of this boundary is indicated by the off-shore leasing in the Santa Barbara Channel in California, United States of America, where approximately 360,000 acres drew over $600 million in bids.

Of as great significance as the declarations of national exclusive rights are the accuracy requirements in navigation and position data in ocean regions for scientific investigations and economic exploration and development. For merchant marine navigation—where a ship may blunder across the ocean by any means available until a landfall is made—the "half-dollar" philosophy is adequate. That is, a merchant vessel needs to know its position within the region covered by a half-dollar on the chart by which it is navigating. This area is equivalent to a circle of radius less than 0.5 km on a chart at 1:24,000 scale, well within the accuracy of most positioning systems. For the exploitation of lease blocks on the continental shelf, developers generally operate at least 50 m from the limits of their lease blocks due to uncertainty in boundary demarcation. For scientific and management decision-making purposes, the position requirements depend upon the type of data and the interpretative techniques available. Thus, for time-dependent parameters, such as water temperature, wind and wave characteristics, and for the distribution of dissolved gases, a realistic position accuracy is one proportional to the rate of variation in the parameter. An accuracy of a few kilometres will suffice for most purposes. However, it is in the measurement of the time-independent parameters that the accuracy of position control becomes important. These parameters include bottom topography, gravity and magnetic fields, and characteristics of the lithosphere. Of interest for time-independent parameters is their spatial distribution; and, therefore, a position accuracy inversely proportional to their variation is desirable. Thus, hazards and bottom features that are a danger to navigation must be positioned within 50–100 m. Gravity and seismic operations present unique problems, in that velocity information must be deduced from relatively closely spaced position data which must be known to better than 30 m.

These are formidable requirements, especially in a hostile environment, which modern technology does not satisfy in their entirety.

Before proceeding, three terms should be defined: accuracy, precision, and resolution. Accuracy indicates how well a single measurement or the average of a set of measurements of the same item agrees with an adopted standard or, if known, the true value. Precision indicates how well the individual measurements of the same item agree with one another. Resolution indicates the smallest unit to which an item can be measured. These definitions are presented pictorially in figure 161. Assuming that the true position of a station is at the centre of each circular plot and that each dot represents a single measurement of this position, the left plot indicates that the measurements are precise and that the average of all the measurements is accurate; the middle plot indicates that the measurements are precise but not accurate; and the right plot indicates that the measurements are far from precise, but that the average of all the measurements is accurate. The middle plot also shows a scale which divides each circular ring into 10 equal parts. This scale can be used to measure the distance of each dot from the centre of the plot, possibly estimating the distance to the nearest one half of each division; this one half of one tenth represents the resolution of the measurements on the plot. It is important to realize that without prior knowledge of the true value of a quantity, the precision of a series of measurements may be all the information it is possible to determine. However, by repeating the measurements with many different instruments and using different procedures, and by averaging all of these measurements, one may approach an accurate value. At this point, a word of caution is appropriate. If only one measurement of a quantity is available, one cannot know with certainty which measurement has been obtained; therefore, one cannot say that a single measurement is accurate or precise.

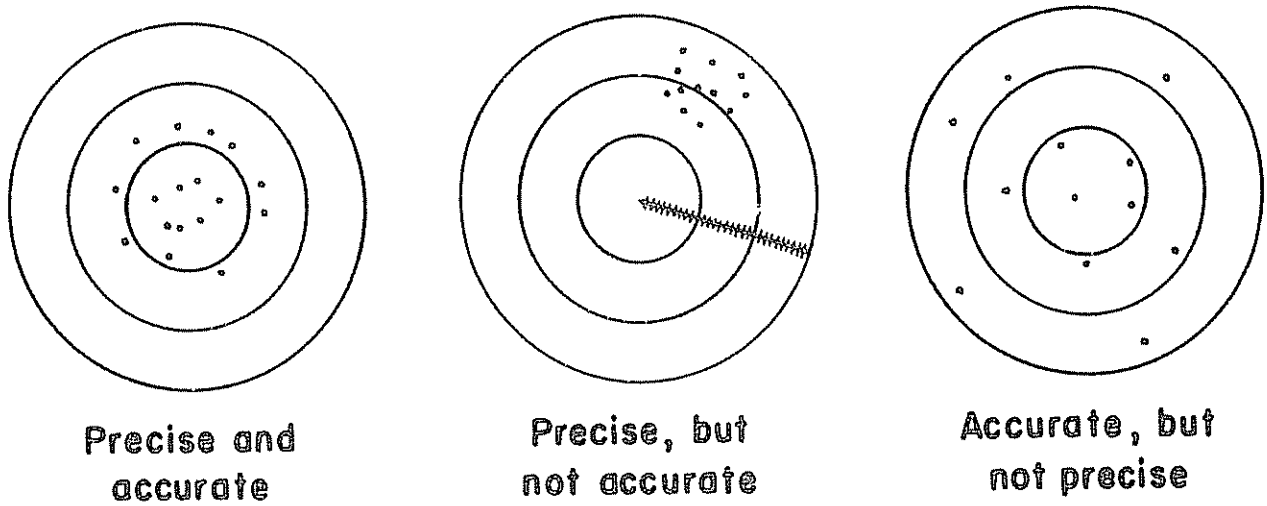


Figure 161. United States of America: pictorial definition of "precise" and "accurate"

A PRECISE MARINE POSITIONING SYSTEM

Positions in marine areas are obtained by either extension of classical land-based triangulation or by some variation of either of two methods: the three-point fix, or the intersection of two lines of position. Classical triangulation is possible where stable supports are available upon which angle- and distance-measuring equipment can be mounted. This procedure was followed in the extension of geodetic control into the Gulf of Mexico. Survey lines were measured by electronic means; the average correction to these measurements was 1 part in 59,400, with a maximum correction of 1 part in 10,400 on an uncertain line. The precision in position is better than 0.1 seconds, or better than 3 m. These are amazing figures when one considers that observations were made from drilling-rigs, many of which were unstable platforms unless the waters were calm.

This type of survey gives the highest precision. However, it is a terribly high price to pay for control. This survey established the positions of about 100 off-shore points at a cost of slightly under $200,000, excluding charges for transportation, for erection of the drilling platforms and for the depreciation of equipment. One may well ask who but the most affluent could afford such an expenditure for the entire continental-shelf region.

ADDITIONAL MARINE POSITIONING SYSTEMS

Visual methods

Positions within sight of shore can be obtained by visual methods, where angles are observed from lines between fixed points to points off-shore or from a point off-shore to fixed points on shore. In the former cases, positions of a moving target, such as a ship, within 5–10 km from shore, can be determined to better than 3 m in clear weather; for fixed targets, positioning data comparable in precision to the Gulf of Mexico survey are possible. In the latter case, angle observations are made from the ship; within 5–10 km from shore, positions can be determined to about 8 m in calm seas and under clear skies.

Electronic methods

Electronic positioning systems either measure distances, or differences in distance, between stations by measuring the transit time of electromagnetic waves. The path of an electromagnetic wave depends upon its frequency. The lower the frequency (the longer the wave length), the closer the path follows the curvature of the earth, and the greater is the distance that can be observed. The higher the frequency, the closer the path follows a straight line, and the closer the method becomes one of "line of sight". The velocity of electromagnetic waves is affected by temperature, humidity and barometric pressure; the effect of these quantities is lumped together in the refractive index, n, which is computed from data generally obtained at the transmitting and receiving stations and is assumed to be constant over the entire path. Such an assumption may be far from the truth; and, hence, the greater the distance to be determined, the greater is the error to be expected. For some systems, the position error may vary from 300 m to 4 km. For short-range systems, positions within 0.5 m are possible.

In order to determine the feasibility of establishing and recovering passive markers on the continental shelf with geodetic precision by means of line-of-sight electronic control, an underwater geodetic marker was implanted in the Gulf of Maine about 25 km off shore from Jonesport, Maine. The marker was a 1-m steel sphere suspended about 25 m from an anchor on the ocean floor and about 25 m beneath the ocean surface. The marker was located by intersecting the mast of the ship from three triangulation stations ashore and by observing distances electronically (using AutoTape equipment) from two of these stations. A comparison of the location established by triangulation and AutoTape distances agreed to within 0.7 m; and by coning the vessel with the AutoTape readings, the vessel could be navigated back over the marker. A very satisfactory echo return was obtained with the 723 fathometer when directly over the marker.

The project showed that markers could be located with geodetic precision by electronic positioning devices, at least where line-of-sight observations are possible, and that a return could be obtained on a fathometer. However, it would have been practically impossible to find the marker without an accurate positioning device aboard the vessel, as a strong fathometer signal was obtainable only when directly over the marker. A fathometer signal expands as a cone, similar to a light beam, from the ship and is reflected from the object intercepted. To obtain a clear return, the object intercepted should cover more than 50 per cent of the area from which a return is possible. When a wide-beam echo-sounder is used in depths exceeding 4 km, the uncertainty of the sounding with respect to the ship is greater than a 2-km positioning error. This situation is not generally true in shallow-water surveys where narrow-beam echo-sounders are used.

Another application is the measurement of long distances by the "line-crossing" method. A plane crosses the line to be measured a number of times at a predetermined altitude. During flight, the distances to two ground points, or two ships, are continuously observed. The minimum sum of these distances is reduced to sea level to give the distance between the two ground points. Distances of the order of 1,000 km have been measured with a precision of 4 m by this method, which is well within the requirements for geodetic control.

The precision attainable with modern electronic equipment decreases as one leaves the line-of-sight range. Some of the problems inherent in these systems are described below for a hyperbolic location system, where for each point on a given position line, the difference in the distances from two known stations is a constant. The distance between the hyperbolic lines (the lane width) on the base line (the line joining two transmitting stations) is one half the wave length of the transmitted signal. Lane widths vary from 50 to 800 m for systems currently in use. The resolution (reading precision of a system and not precision of position) of most systems is 0.01 of a lane width, or 0.5–8 m on the base line. However, due to the divergence of the hyperbolic "lines of position", the average lane width 200 km from the base line, for systems approaching geodetic precision, is of the order of 300 m with a resolution of 3 m. If lane width were the only problem, the task would be simple, but, as mentioned above, there is the difficulty due to unknown variations in the propagation velocity. The data are further degraded by errors due to distortion

in the hyperbolic pattern caused by islands or other land masses in the path between the ship and shore stations, non-linearity in the electronic systems and drift (variation in the same direction of measurements with time) in the system which increase the uncertainty to 15 m or more. Furthermore, errors are also introduced due to the geometry of the system. For example, if the intersection of hyperbolic lines some 200 km from the base line was at a small angle, and the position with respect to these lines could be determined no better than 15 m, the error in determining the position of this point could be as great as 50 m, due primarily to the small angle of intersection of the hyperbolic lines. If the hyperbolic lines were perpendicular to each other, the best possible configuration, an error of 20 m would still be possible. When one adds to this uncertainty that of the propagation velocity of electromagnetic waves, errors of the order of 80 m would not be uncommon, even for the better "geodetic" electronic systems.

To minimize the propagation error, one would need to monitor the meteorological conditions along the wave path. It has been recommended that an aircraft sample the necessary data along the path from shore to ship at the same time that the distance measurements are under way. The aircraft would also serve another useful purpose. The electronics of these systems measure the fractional part of a lane and keep track of the number of lanes by an incremental counter. That is, as the fractional part of a lane changes from 0.99 to 0.00, the increment counter increases by one unit; and as the fractional part of a lane changes from 0.00 to 0.99, the increment counter decreases by one unit. Frequently, due to mechanical difficulties and various types of interference, the increment counter loses its count. Using the electronic positioning equipment of the aircraft, the number of lanes from the shore stations can be carried to the ship. Such a technique has been found necessary by oil firms surveying in the Gulf of Mexico, where ships are in operation for many days. The aircraft brings the "lane count" to the ship every morning.

The field of electronic distance measurement is replete with claims and counter-claims for high accuracy. To resolve these claims, the United States Navy and the National Oceanic and Atmospheric Administration are planning a test and evaluation programme. These agencies expect to define precisely their position requirements; and to determine, by examination of manufacturer literature, which systems might satisfy such requirements. The systems will then be tested electronically and evaluated under operating environmental conditions. At the early stages, only those systems which can satisfy continental-shelf requirements will be tested.

Satellite methods

The use of artificial satellites for position determination is emerging as a geodetic tool. The most precise technique is the simultaneous method. Essentially, the position of the satellite is determined by the three-point method from stations with known geodetic positions. Observations are simultaneously obtained at each of these stations and at the unknown station. After a series of such measurements, the position of the unknown station with respect to the known stations can be determined with a mean square error of ±5 m. These observations require elaborate cameras and extremely precise timing mechanisms, and are not the type of measurements that are normally possible in the marine environment.

A more satisfactory technique for these purposes is the orbital method. Here, the satellite orbit is known or predicted from observations undertaken at known positions, and by three-point method observations at the unknown site, the position of that station is determined. If the ship is anchored or reasonably motionless, observations of this type have given positions within 100 m of the known geodetic position. This precision will certainly improve; the major problem at this time is that, due to the insufficient number of satellites in orbit, positions in some regions can only be determined at intervals of approximately 100 minutes.

Inertial systems

An inertial system depends upon gyros for detecting angular motion, upon accelerometers for detecting variations in linear velocity and upon computers to process these data to provide position information. The system uses a platform, which can be levelled, upon which the gyros and accelerometers are mounted; the platform itself is suspended in a gimbal frame to permit levelling independent of the motion of the transporting vehicle. A simple system requires that the platform be perpendicular to the local plumb-bob (the direction of the earth's attraction at a location) and oriented along a north-south line. If these spatial directions are established at some time and place, the gyros will maintain them. However, as the earth rotates on its axis, the spatial direction of the plumb-bob and of the north-south line at any place will change at a rate proportional to the earth's rotation. Therefore, to maintain these latter directions on a rotating earth, the gyros must be continuously forced to adopt these new orientations; this is done by inserting into the system a motor which changes the direction of the gyros in accordance with a theoretical model of the earth's rotation. In addition, the plumb-bob and the north-south spatial orientation vary from place to place on the earth's surface, and forces are required to maintain the proper orientation as the ship moves over the earth's surface.

Among the major problems are drift of the gyros (variation in orientation with time not associated with the earth's rotation) and the local variation of the direction of the plumb-bob from that of the model earth adopted to provide this direction. To resolve the drift problem, the gyros must be periodically reoriented by position information obtained outside the system. The accumulated effect of the local variations in the direction of the plumb-bob is corrected by the same method. To correct for the effect of the local variation in the direction of the plumb-bob would require perfect knowledge of the shape of the earth everywhere.

Hard data on the precision of the inertial navigation systems are not generally available. However, the systems are expensive and probably out of reach for most commercial users.

Acoustic method

Although the acoustic method, Sound Fixing and Ranging (SOFAR), where the transmission time of sound-waves is measured, has been proposed for long-range navigation and position-fixing at sea, the uncertainties in the velocity of propagation of sound-waves and the sound-path limit its use to short ranges. Even

over short ranges, a knowledge of sea-water temperature, pressure and salinity along the sound-path would improve the results.

For acoustic positioning, a ship transmits a signal which is picked up and retransmitted by three transponders, which have been emplaced on the sea floor. One half of the travel time of these signals, from transmission to reception, is converted to distance. If the positions of the transponders have been previously determined in some geodetic system, the position of the ship can be computed by the three-point method. Ultimately, with improvement of transponders and more knowledge of the physics of sea-water and the velocity of propagation of sound-waves, ships can be located with respect to the transponder array with a precision of under 8 m. Practically, however, errors in the range of 15–30 m are what should currently be expected.

CURRENT SITUATION

It is obvious from the foregoing statements that the position and distance accuracies to be expected, at least in the near future, are much lower in the marine environment than the geodesist has been accustomed to dealing with on land. However, research and development are moving at a rapid pace. It is entirely possible that new equipment has been developed about which no one has heard because of military classification. The author is especially enthusiastic over the proposal to combine an inertial navigation system with a gravity-sensing device. But it is unlikely that there is a major breakthrough in the offing for the day-to-day user.

The most practical technique would combine acoustic transponders for local positioning with inertial, satellite and electronic methods for positioning of the transponders. One could expect a precision of 100 m or better anywhere on the continental shelf. The shipboard acoustic devices would be inexpensive and would serve the smallest vessel. The transponders could be positioned by a federal agency or by some commercial concerns. However, the question arises as to whether bottom markers of known position are acceptable in consideration of national security.

The oceans, from time immemorial, have provided natural boundaries behind which countries could develop in security. Today, technology has changed this situation. All countries, even those which are land-locked, have developed an intense interest in exploiting the immense oceanic natural resources. To prevent chaotic conditions from developing, there is need for oceanic charts as accurate as those prepared for land areas, and the international law of the seas must be strengthened so that these riches may benefit all mankind.

OCEAN MAPPING, OR WHO DRAWS THE ISOBATHS FOR NOAA'S BOTTOM CONTOURS?*

Paper presented by the United States of America

A need for systematic mapping of the geophysical properties of the oceans was recognized some time ago. Significant efforts are currently being mounted to display marine geophysics through maps and other mapping outputs, particularly in the United States of America, and specifically in continental margin areas as a high priority. The feasibility of conducting such mapping operations was, perhaps, spurred by instrumentation developments allowing more than one property to be measured simultaneously. But the single factor causing acceleration of these programmes was the realization that certain work in or concerning the oceans could not be accomplished effectively in the absence of knowledge of geophysical effects and relationships.

It is apparent that there are degrees of importance placed on the various uses of marine geophysical mapping data. Such efforts as petroleum exploration, mining and off-shore engineering of one kind or another are obvious beneficiaries. In recent years, while the importance of these applications has scarcely decreased, other more intangible needs have been identified that necessitate marine geophysical knowledge. These needs relate to pollution problems, waste disposal needs, recreation and general coastal-zone planning and management. Not the least of these new needs is the means to exploit resources in keeping with environmental safeguards.

For the foregoing reasons, a formal programme of marine geophysical mapping was begun several years ago at the National Ocean Survey (NOS) in the United States. The NOS is a component of the National Oceanic and Atmospheric Administration (NOAA) in the United States Department of Commerce. While NOS is only two years old, those familiar with the organization of marine affairs in the United States will recognize that it represents a 197-year old agency. The National Ocean Survey is the new name for the former Coast and Geodetic Survey, although the composition of the present NOS is much enlarged (see figure 162).

The NOS, as part of NOAA, joins other related offices involved in weather analysis and prediction, fisheries work, atmospheric and satellite work, minerals work and other efforts. Many large and well-staffed laboratories and data centres are also part of NOAA. This is obviously the briefest description of a complex agency involved in numerous interrelated efforts in the oceans and atmosphere. The major civilian efforts in oceanography are found within NOAA (see figure 163).

Geophysical mapping uses and applications include coastal-zone planning, engineering and construction, research, fishing, resources, environmental relationships, pollution control, defence, and recreation. These uses and applications are determined periodically through studies and are kept current. An effort is made to meet needs in some reasonable order of priority, and it has been found useful to develop absolute priority systems. One such priority scheme is shown in figure 164,[1] which relates to the continental margin of the United States. The need for geophysical maps can be said to be independent of availability of means to satisfy those

*The original text of this paper, prepared by Philip M. Cohen, Chief, Marine Geophysics Group, Office of Marine Surveys and Maps, United States of America, appeared as document E/CONF.62/L.55.

[1] Figures 164-170 are annexed to this paper.

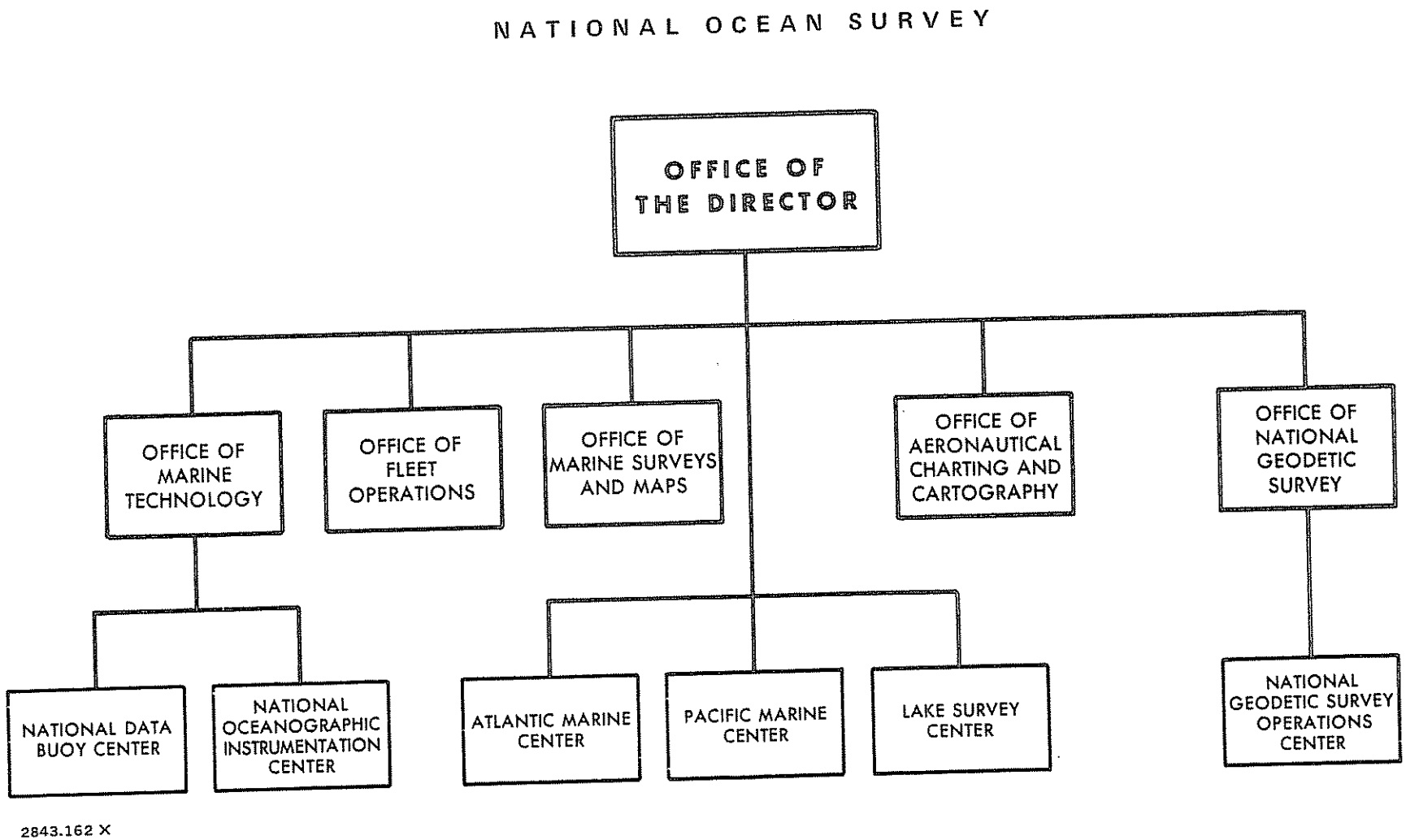


Figure 162. United States of America: organization of National Ocean Survey

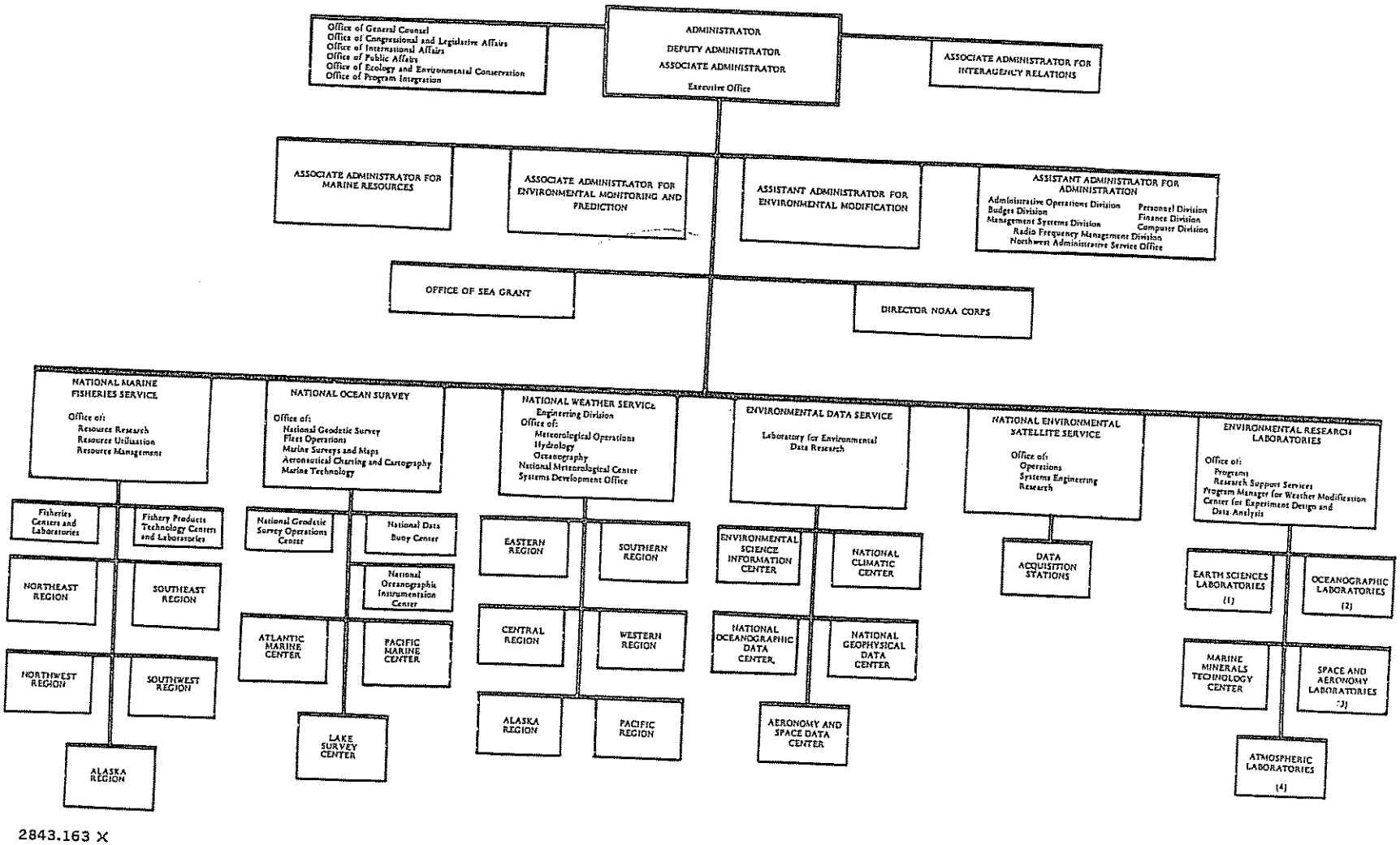


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Figure 163. United States of America: organization of National Oceanic and Atmospheric Administration

needs. This principle implies that programmes to collect data cannot always be compatible with the priorities established. If a four- or five-year programme of data collection were to be compared with figure 164, there would be no complete correlation because many external factors cause work to be performed not in exact consonance with priorities. Of these factors, one may mention seasonal considerations, official commitments, special programmes and the ever-present fact of limited ship and manpower resources. This situation does not detract from the importance of developing priorities based upon requirements alone as a starting-point. In any event, the areas in which NOS operates are carefully thought out, simply because in the presence of these other factors one must be certain that limited resources are applied against the most important needs. Inherent in this approach is that lower priority needs do not necessarily mean non-essentiality for certain uses in certain areas.

The data collected at this time are bathymetry, gravity, magnetic and seismic. These properties are measured simultaneously in an under-way mode, with the need to tow air-guns and hydrophones for seismic work sometimes limiting ship speed (to about 6-8 knots). Newer seismic gear (low-frequency sounding systems) allow collection at higher speeds because they preclude the need to tow gear behind the ship, and NOS hopes to equip more of its ships with these systems soon. The four properties mentioned above are collected because additional ones would necessitate slowing or stopping the ship. This is the case with core work and sediments. These data are also of importance, but the matter of time and economics dictates the limitation of the kinds of data collected. The major kinds of equipment in use at NOS are illustrated in figures 165-168.

Horizontal control during the survey is paramount; the proper interpretation of the data is directly dependent upon the reliability of the control system used. In the absence of proper control, data would be collected to instrumentation accuracies which are frequently superfluous. This aspect is particularly true for bathymetric and gravimetric data. It is almost useless for mapping purposes to measure depth values to ±1 m in 3,000, when horizontal accuracy is not known to equivalent tolerances. Many different kinds of control systems are used, depending upon accuracy desired and whether given areas are covered by the system. Typically, NOS uses LORAN-C and/or satellite navigation in deep areas, and Raydist or similar systems on the continental shelf. The accuracy sought (ideally) is about 500 m in deep areas and 50 m in shelf areas.

The NOS has two basic subprogrammes (see figure 169). One is on the continental shelves and margins to about the 2,500-m depth curve, where the data are produced on maps on the scale 1:250,000. This subprogramme is called "CONSHELF" work. In deeper areas, the maps are produced at 1:1,000,000 scale; this subprogramme is called "SEAMAP", an acronym for Scientific Exploration and Mapping. Survey-line spacing is generally 9,000 m at 1:250,000 scale, and 18,000 m at 1:1,000,000, with cross lines at perhaps one fourth the primary spacing.

At spacing of 18,000 m (SEAMAP), quite adequate maps of bathymetry, gravity and magnetics can be produced. At the 9,000-m spacing (CONSHELF), proper bathymetric maps cannot be constructed at the scale involved (except in rare cases), although gravity and magnetics do not present this difficulty. None the less, NOS does produce a bathymetric map based on 9,000-m spacing, because it is still valuable as a base to relate to the gravity, magnetics and seismic data. It is recognized, however, that better maps can be produced at denser spacing, so NOS occasionally assigns a small ship to collect bathymetry only, at about 1,800-m spacing after the primary geophysical work has been done, which allows excellent portrayal at 1:250,000 scale. Directional echo-sounding transducers are used where possible since this procedure yields more accurate depths and shape, and aids echogram interpretation. But some discretion is necessary, for these things are obtained at the expense of bottom coverage and a balance is necessary. It would be best to use two transducers at the same time, one directional and one wide-beam, and NOS ships may yet be equipped to operate in this mode.

It is planned shortly to concentrate certain efforts on specific environmental problems, e.g., on dump-site delineation and analysis, in which seismic, high-density bathymetric and side-scan sonar techniques will be applied in given localities. The mapping data thus generated will be at large scale.

Processing of the collected data is accomplished using computers for merging; for application of such corrections as sound velocity, eotvos, station errors, etc.; and for plotting. The net result of the computer phase is a series of numerical data plots with corrected digitized values which are then contoured.

Contouring is performed manually. While automatic contouring is quite feasible, the density of collection at the scale used requires too much interpretation to be accomplished properly by computer. Interpretation is crucial, and the contouring phase is one upon which much of the previous efforts will stand or fall. It is here that the judgements of the geophysicist and the cartographer come to the fore.

Similar to what is true of land areas, the character of submarine terrain helps to interpret underlying structures and, therefore, processes that shaped and continue to shape the earth. The proper graphic expression of terrain on maps depends upon the relationship of data-point density and the horizontal scale on which it is portrayed. Depiction of anomalies is enhanced when density is increased or scale decreased, or both. This is further compounded by scale being a function of end-use of the map, and density of the extent of anomalies found per given area. The adequacy of oceanographic data (compared with land topography) when graphically displayed is consequently less fixed by standard criteria than one might wish. One could well ask if the map should be accurate, correct or merely satisfactory. All that one can say is that any map of the oceans is adequate if it can be counted upon to do the job expected of it.

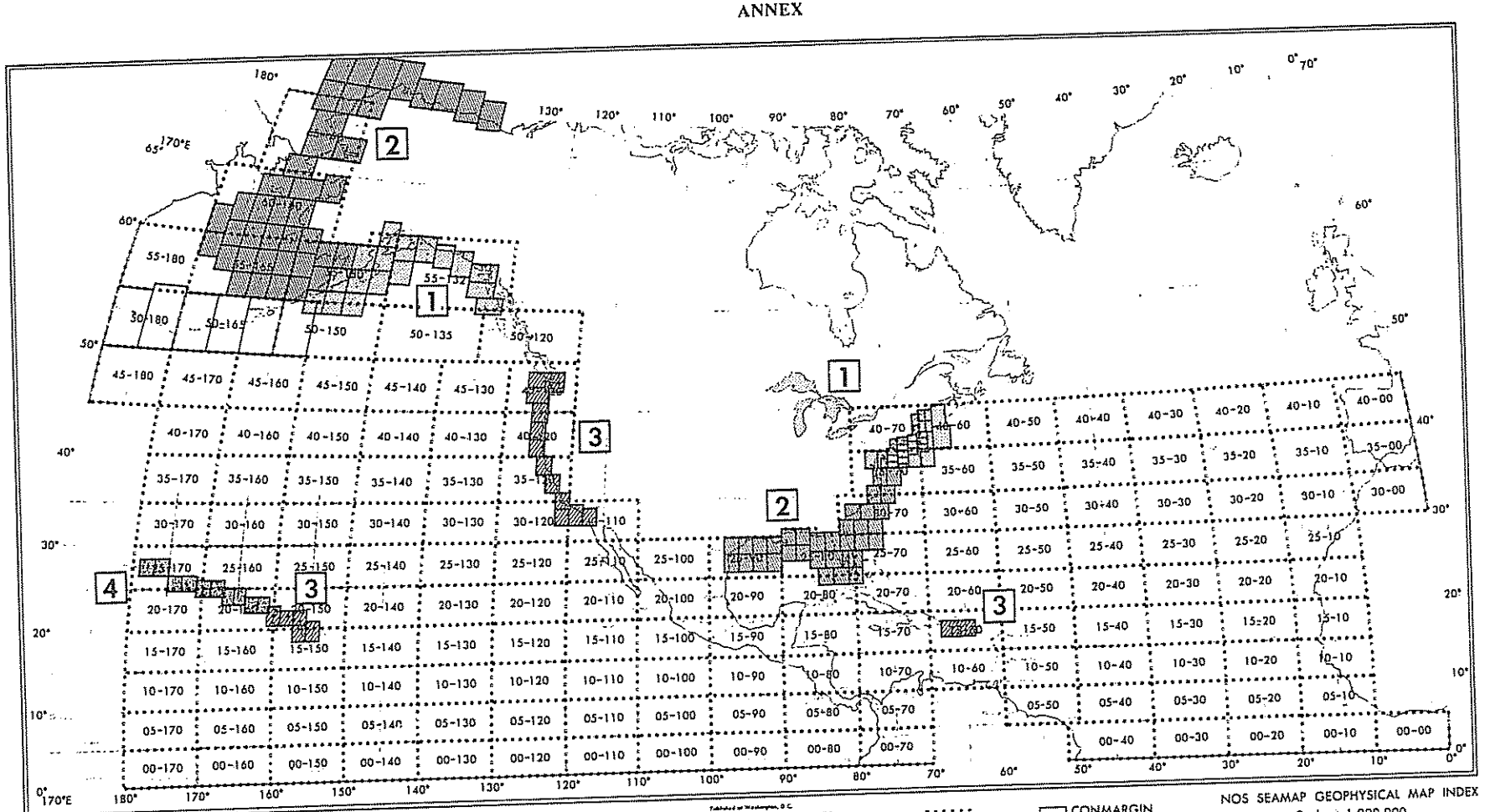
It is axiomatic that mapping programmes undertaken for any length of time soon accumulate very large amounts of data. No insurmountable problem in the processing of hundreds of thousands of data points was foreseen, and this has been essentially confirmed through use of third-generation computers, such as the Control Data 6600 and IBM 360 series. Some colleagues would pale at such glossing-over of certain programming difficulties; but, by and large, these problems have not been formidable. Processing compatibility as between collection techniques at sea and direct amenability to computer programming is a different matter; this factor is a constant problem.

The hard-copy lithograph, the common map with which everyone is familiar, is but one result of the manipulation of these data. It can be and usually is an important result; witness the relative ease with which spatial information can be portrayed and its familiarity to most users. But it is a common misconception that mapping data must be displayed solely upon maps as such. The NOS is manipulating data points using automatic processes and, therefore, can produce many different yields. Such is the case, in fact, and information in the form of tabular lists, numerical track plots, merged magnetic tapes, stacked (positionally aligned) profiles, evaluated analogue prints (e.g., seismic), data reports, and special papers and analyses are produced, all in addition to the map itself. These products are illustrated in figure 170.

The question of fullest possible exploitation of geophysical data is relevant. From the point of view of current utilization, no issue can be taken with the fact that a difficult job is being done well. By this is meant that the functions to which use of the data are currently assigned are carried on adequately. This being true, one may still lament the sophomoric attempts to use current techniques when it is realized that more extensive use of the data is entirely feasible. Given that one must describe effects in ways so that users can obtain special meaning or understanding, this can be done in ways limited only by resources and imagination. To cite several examples, modern computers in conjunction with ancillary gear can develop special profile analyses, spatial distribution graphics, statistical extension data, answers to statistical queries, probablistic models and so forth. It remains only to say that the basic unambiguous data that make such goals possible are now available. A working balance needs to be struck between satisfying a requirement in which there is a measurable sense of urgency and demonstrating more ambitious capabilities. However, implicit in the desire to exploit computers and automated processes to the fullest is the belief that this undertaking will accelerate the steady improvement of marine geophysical knowledge.

The management of coastal resources, in the broadest sense, is infinitely more complex today than it might have been a generation ago. An increase in the ability to understand natural processes must also be achieved to assist the interaction of man's activities. Ecological effects must be ascertained or predicted, together with expected benefits of certain priority activities. No one is naïve enough to believe that particular benefits can be gained without paying some ecological penalty; this much has been learned. What are the penalties? Can they be quantified? How extreme are they in certain circumstances? These are large problems of modern times. The need is to comprehend, to conclude and to make difficult decisions. This task is enhanced by the availability of marine geophysical mapping data, which plays one small part in providing rational choices and probable consequences.

ANNEX


1
2
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Priority
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY
00-00 SEAMAP
CONMARGIN
NOS SEAMAP GEOPHYSICAL MAP INDEX
Scale 1:1,000,000
January 1972
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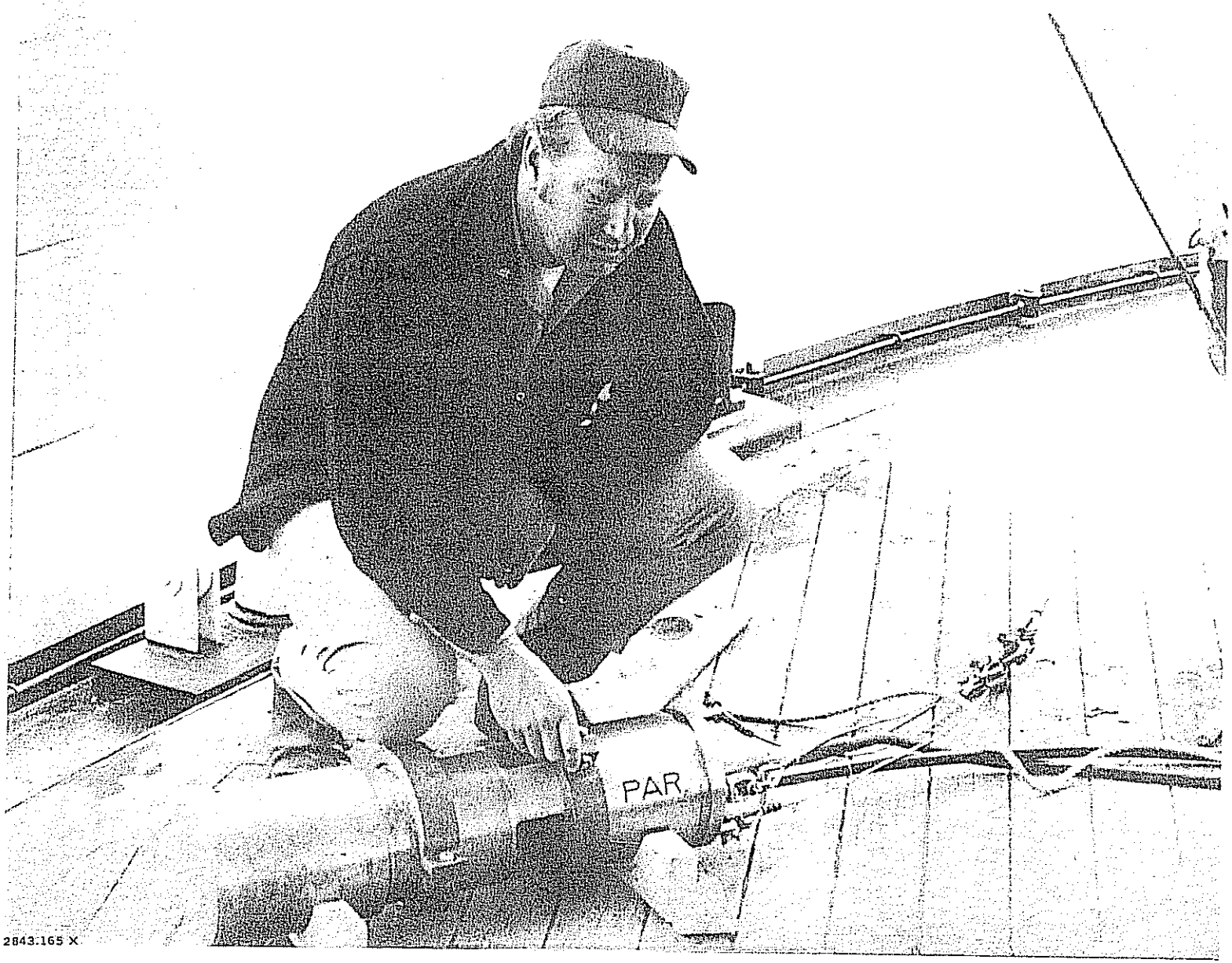


Figure 165. United States of America: air-gun used in seismic work

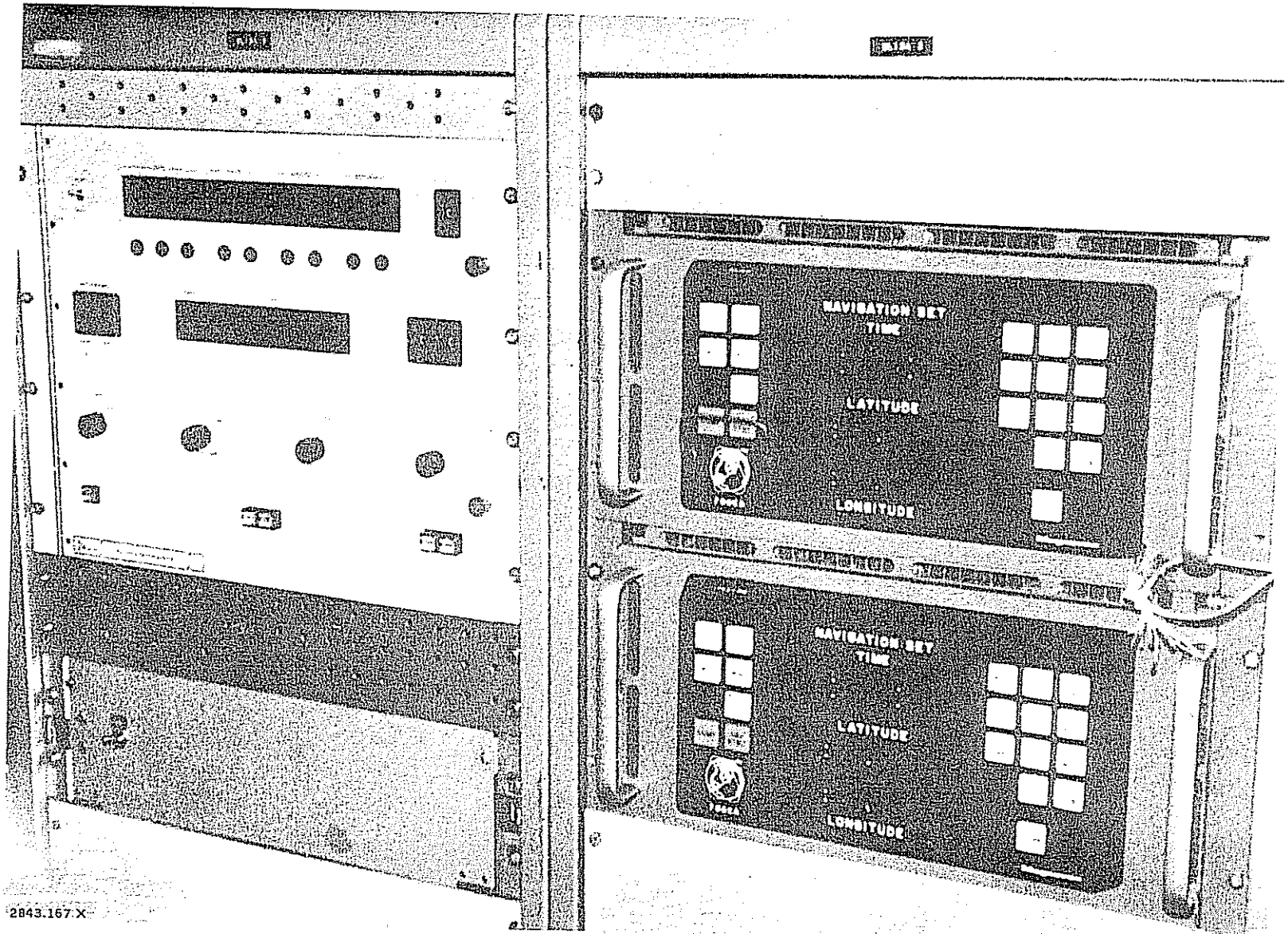


Figure 167. United States of America: satellite receiver

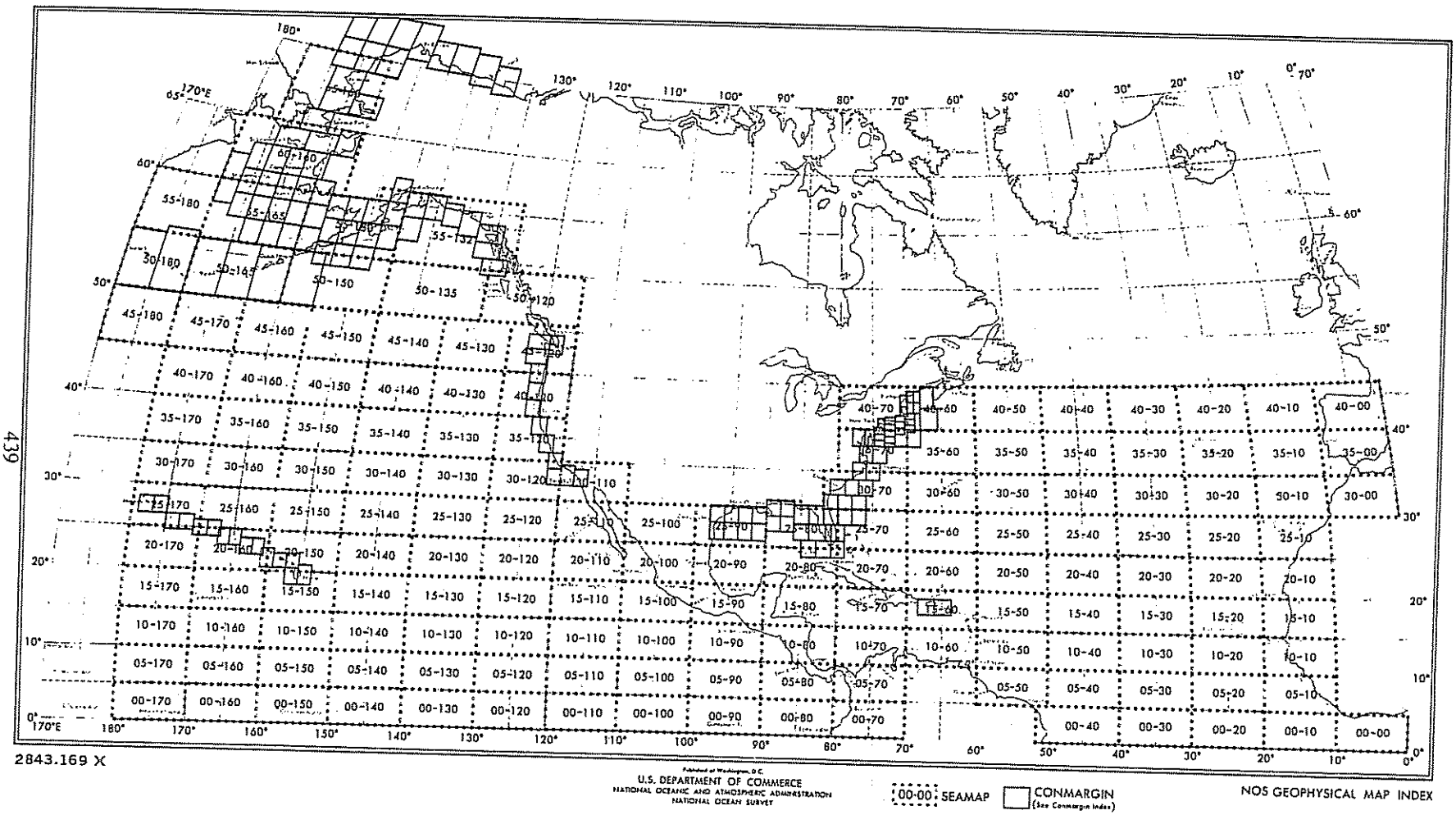
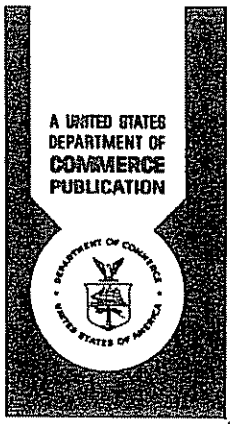


Figure 169. United States of America: major subprogrammes of National Ocean Survey



NOAA Technical Report NOS 46

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Survey

Pacific SEAMAP 1961-70 Data for Area 15530-10

LONGITUDE 155°W TO 165°W, LATITUDE 30°N TO 36°N
BATHYMETRY, MAGNETICS, AND GRAVITY

J. J. DOWLING
E. F. CHIBURIS
P. DEHLINGER
H. J. YELLIN

ROCKVILLE, MD.
January 1972
2843.170.a X

Figure 170. United States of America: products of National Ocean Survey

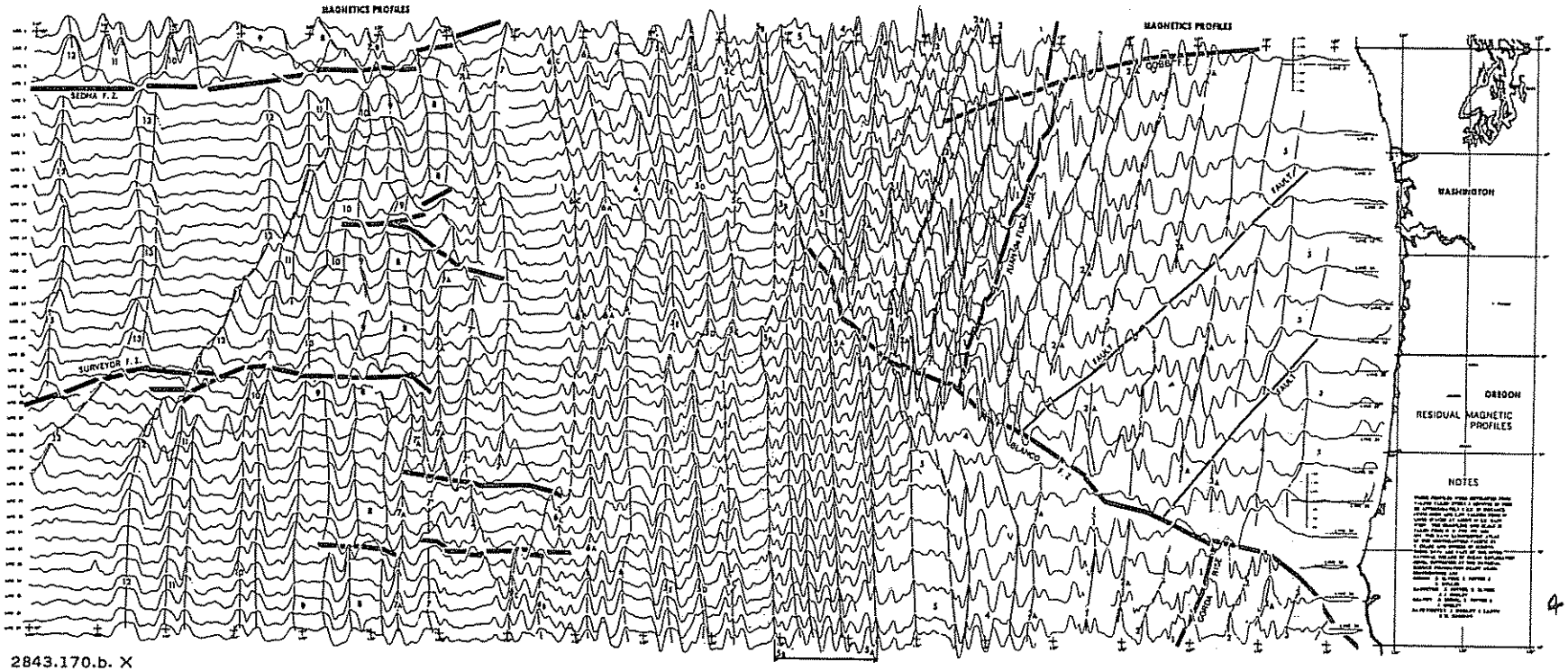


Figure 170. (continued)
(b) *Aligned magnetic profiles*

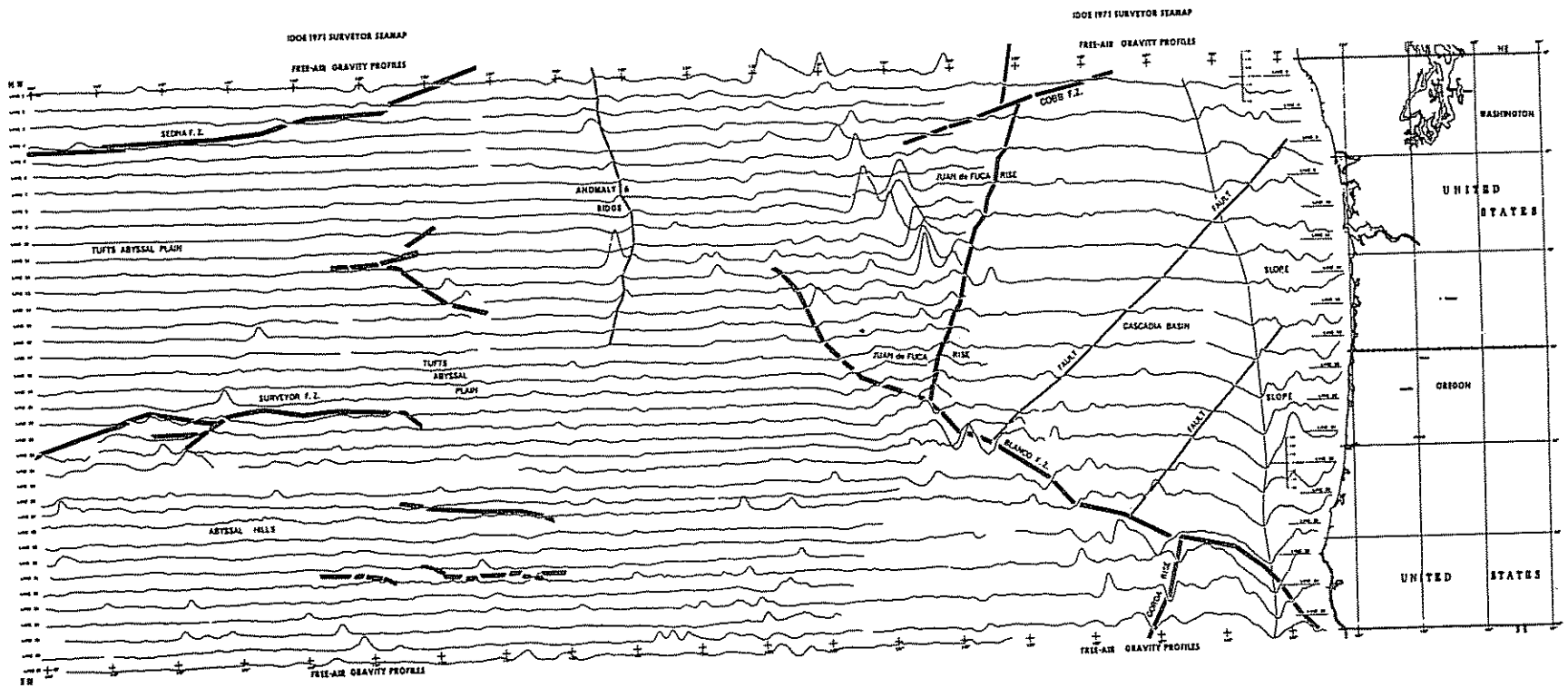


Figure 170. (continued)
(c) *Aligned gravity profiles*

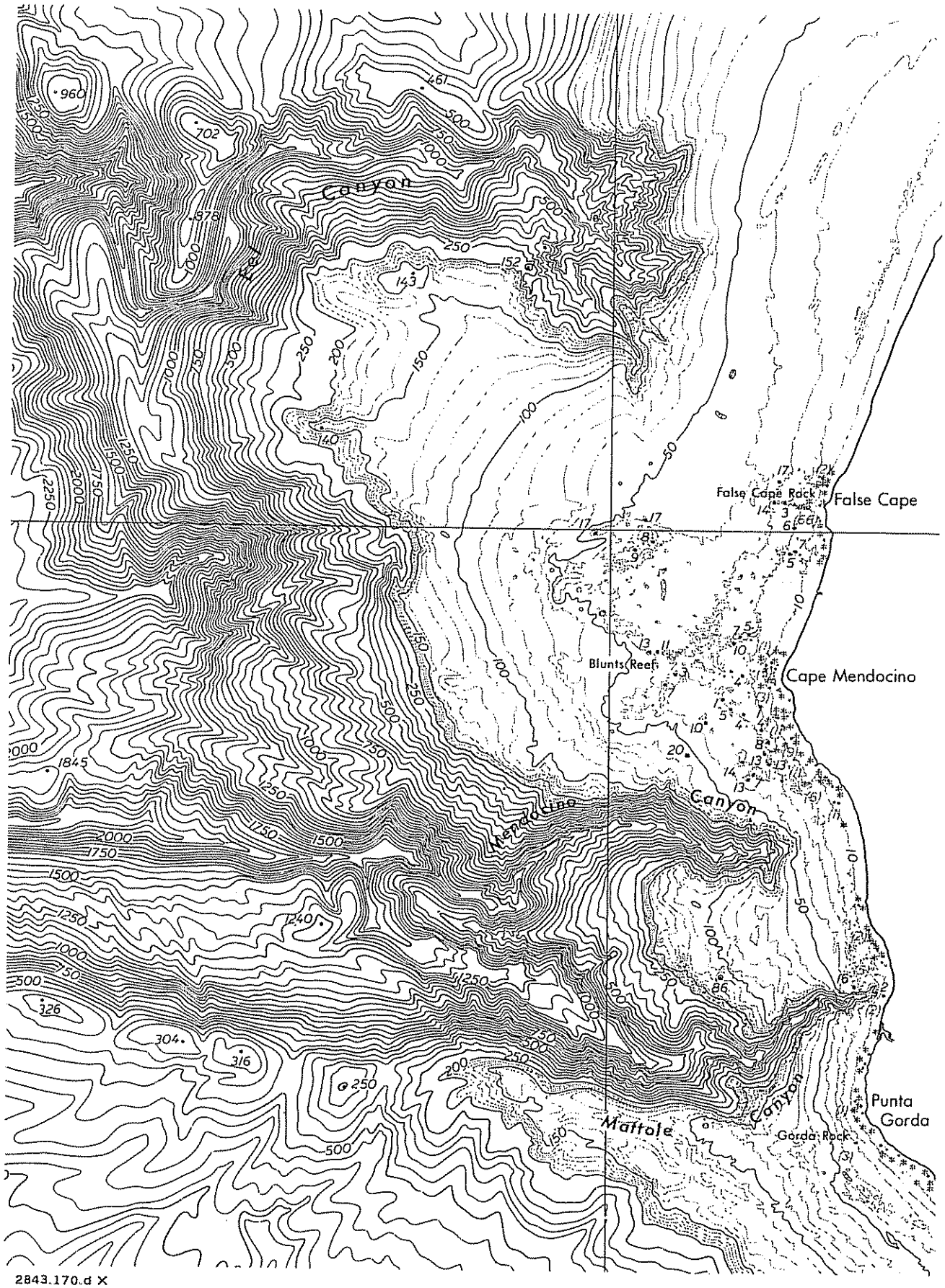


Figure 170. (continued)
(d) *Bathymetric map*

THE AUTOMATION OF LARGE-SCALE COASTAL HYDROGRAPHY*

Paper presented by the United States of America

Initial steps in the application of automation equipment and techniques to its hydrographic survey activities were taken by the United States National Ocean Survey (NOS), formerly the Coast and Geodetic Survey, in 1963. These steps included installation of digital data-recording equipment aboard survey vessels and establishment of a computer-supported survey data-processing system ashore. The vessel equipment included hard-wired, manually operated, semi-automated and/or automated loggers having punched paper-tape and hard-copy listings as output products. The shore-based system, which was card-oriented, included an IBM 1620 computer and a Gerber incremental plotter having point-plotting capability only (i.e., no line-drawing capability).

These initial steps were successful in showing that the application of automation to hydrographic surveying was both practical and useful, and were followed by the installation of computerized data recording and plotting systems (the NOS Hydroplot/Hydrolog System) aboard a 164-ft coastal survey ship and a high-speed (22-knot) 60-ft launch in 1967 and 1969, respectively. In 1971, a much improved hydrographic survey data-processing system was established at a second shore location, and three 231-ft medium survey ships and six of their auxiliary launches were equipped with the Hydroplot/Hydrolog System.

AUTOMATED DATA-ACQUISITION SYSTEM

System hardware

Figure 171 is a block diagram of the NOS Hydroplot/Hydrolog system installed aboard nine vessels of the National Oceanic and Atmospheric Administration (NOAA) in 1971. Hydroplot, the shipboard system, includes the incremental plotter. Hydrolog, the launch system, is a precise duplicate of Hydroplot, but without the plotter.

The computer is a Digital Equipment Corporation PDP-8/E with a capacity of 8,000 12-bit words of memory. Peripherals, all of which share a common I/O bus, include the following: (*a*) an eight-channel paper-tape reader/punch capable of a read rate of 300 characters per second (CPS) and a punch rate of 50 CPS; (*b*) two ASR/33 teletype units which provide keyboard and paper-tape input, as well as paper-tape punch and printer output at 10 CPS; (*c*) a crystal-controlled interrupt clock located within the computer; and (*d*) a Houston Instrument Complot DP-3-5 incremental roll plotter having 22-inch plotting surface width, effectively unlimited plotting surface length, an increment size of 0.005 inch and a maximum plotting speed of 300 inches per second.

The Hydroplot controller is illustrated in figure 172. This special-purpose I/O interface, designed to NOS specifications and manufactured by Digital Equipment, is the "heart" of the Hydroplot/Hydrolog system hardware. It provides the following five functions: (1) a digital multiplexer for up to 32, 12-bit data input wor (2) a 12 input interrupt system; (3) four relay closures; an analogue output to drive a steering indicator; and two pulse outputs.

All data from the echo-sounder, positioning equ ment and 49 controller panel thumb-wheel switcl enter the system under programme control by means the 32-word multiplexer. The operator can select eitl of two echo-sounders, any of several positioning devi and input various survey parameters and infrequen changing data through the panel switches. Contro design provides for the addition of up to 33 bin coded decimal (BCD) digits of input information allow for future expansion.

The interrupt system, which includes seven manua operated momentary contacts located on the contro front panel and five electrical connexions on the r panel, provides a means by which both the operator a the sensor equipment can communicate with the cc puter. The interrupts are used for time synchronizati system start and stop, etc.

The four relay closures are used to put marks analogue records (e.g., the echogram) and to gene audible or visual signals and alarms as needed.

The controller contains digital to analogue conver the computer controlled output of which drives a m type of steering indicator. By following the steer indicator, the helmsman keeps the sounding vessel c predefined survey track.

The two pulse outputs are used to inhibit the cha of depth and position information while they are be sampled by the computer.

The echo-sounder is a complete subsystem wh provides an analogue depth record, a visual digital de display and parallel BCD depth input to the system. shoal-water digital echo-sounder used with the syste illustrated in figure 173.

The navigation interface, designed by NOS, is use convert the outputs of Hastings Raydist, Decca Hi- and the NOS digital sextant to parallel BCD infor tion acceptable to the system. Any navigation devic which an incremental encoder can be attached can be used as an input to the navigation interface wh provides a considerable degree of versatility to system. In addition to Raydist, Hi-Fix and dig sextant, two models of super-high-frequency, microw equipment have been used with the Hydroplot/Hyc log system to date.

Typical ship and launch Hydroplot/Hydrolog sys equipment installations are illustrated in figures 174 175.

System software

Approximately 55 computer programmes, the ma ity written in assembly language, are currently avail for use with the Hydroplot/Hydrolog system. T programmes fall into the following four basic groups preliminary and utility programmes; (2) acquisi programmes; (3) off-line data edit/plot program and (4) pre-processing programmes.

*The original text of this paper, prepared by Clinton D. Upham, Captain, National Oceanic and Atmospheric Administration; Manager, Marine Data Systems Project, Office of Marine Technology, United States of America, appeared as document E/CONF.62/L.56.

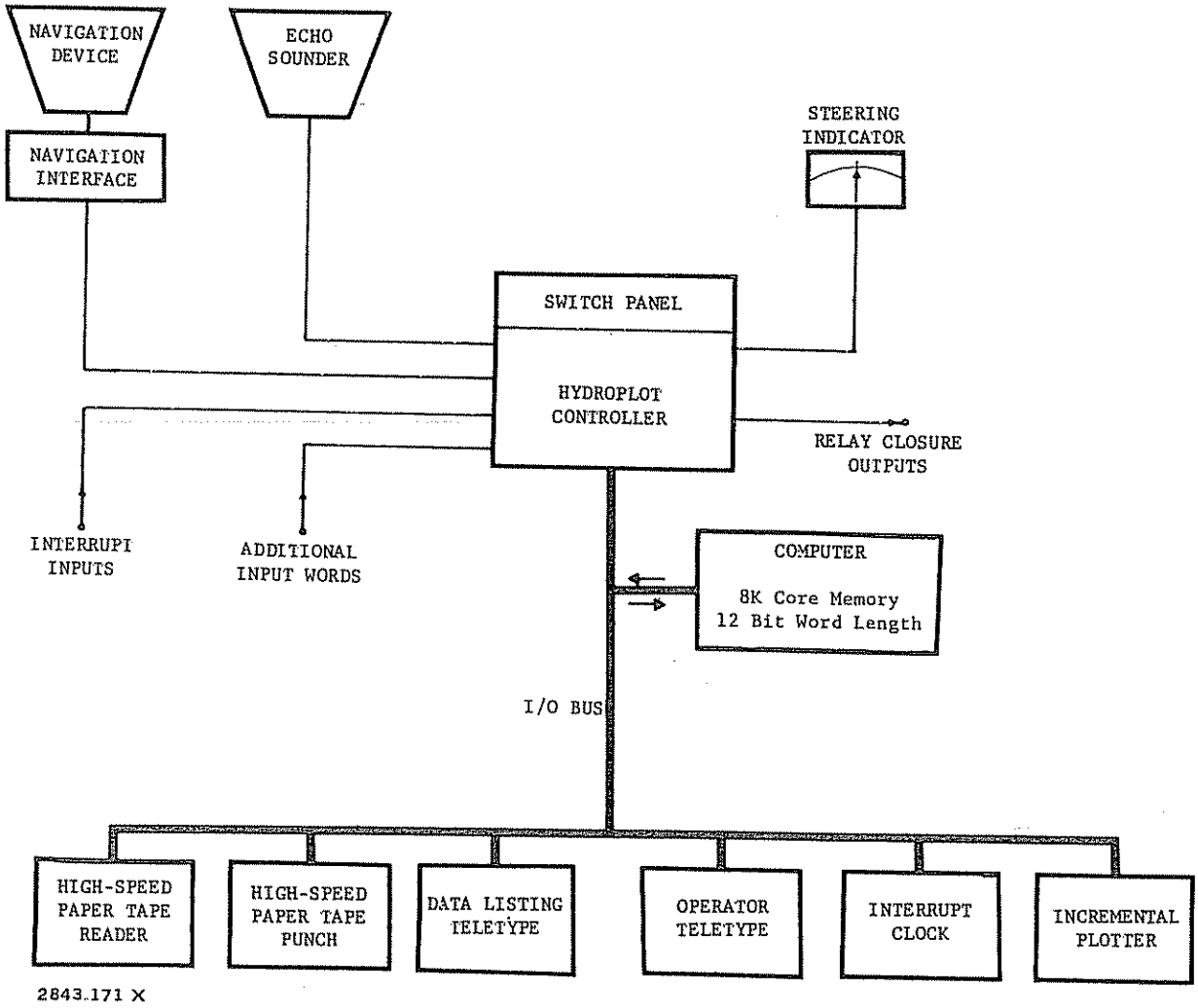
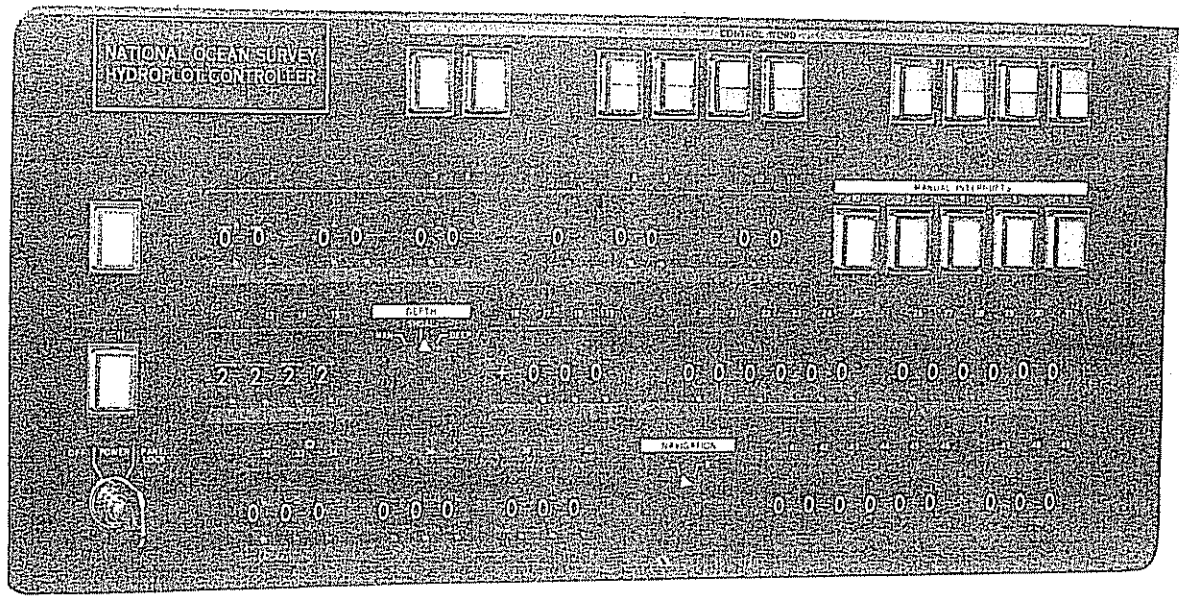
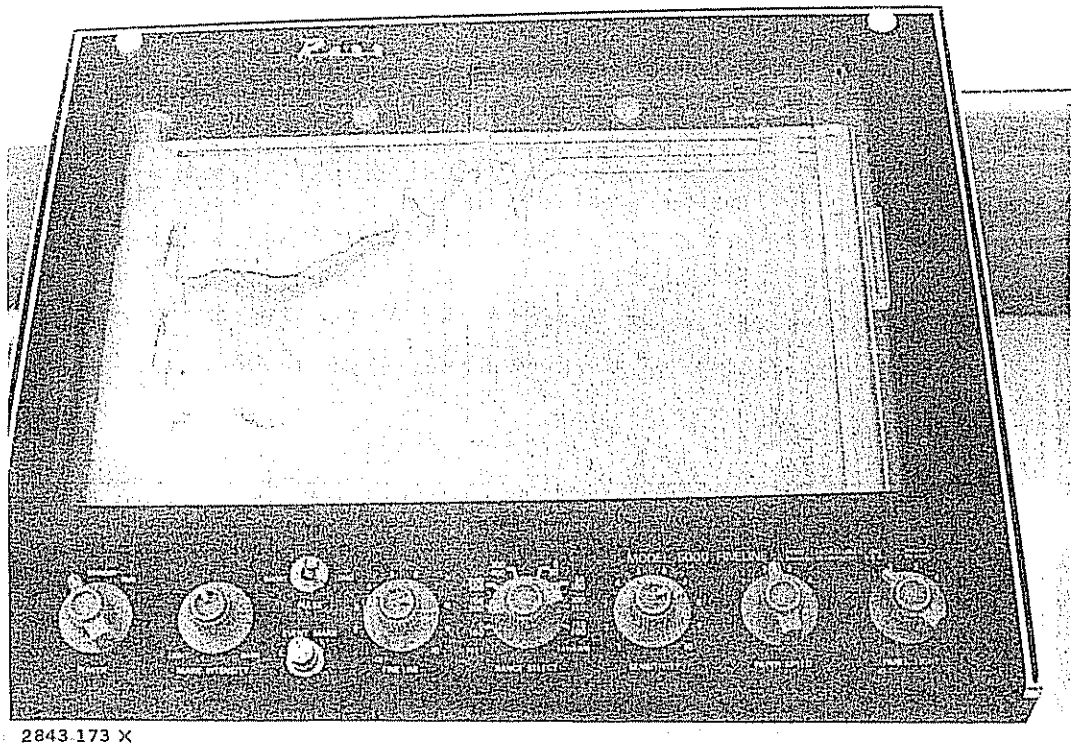


Figure 171. United States of America: block diagram of Hydroplot/Hydrolog system



2843.172 X

Figure 172. United States of America: Hydroplot controller



2843.173 X

Figure 173 United States of America shallow-water echo-sounder



Figure 174. United States of America launch Hydrolog system equipment

The first group includes programmes used in the construction of the Universal Transverse Mercator (UTM) grid (both *x-y* and geographical co-ordinates); in the construction of range/range and hyperbolic navigation lattice plots; for conversion of navigation lanes to *x-y* to *GP* and vice versa, three-point sextant fix to *x-y* to *GP* and vice versa, etc.; for generation of predicted and actual tide corrections; for calculation of direct and inverse geodetic positions; for compilation of parameter input (based on the UTM projection) for the real-time data acquisition system etc.

The second programme group includes the Hydroplot/Hydrolog data-acquisition programmes. These programmes allow for either manual or automated real-time input of depth, position (either range/range or hyperbolic electronic navigation, sextant angles, combination sextant angle-hyperbolic lanes or combination sextant angle-range/range lanes) and predicted tide correction information. All programmes allow the input of real-time tide data by means of a digital radio telemetry link when such is available. Echo-sounder transducer draft, navigation system corrections, sounding interval, position fix interval etc., are entered manually through the controller; sound velocity corrections are not input in real-time, but are compiled in digital format for application during follow-on processing ashore. Such data as sounding-line spacing, the co-ordinates of the starting-point of the first sounding line, the heading of the first sounding line and the orientation of the plotted sounding, are entered through the teletype keyboard. System outputs include a real-time plot of depth and position (hydroplot only), left/right steering commands by means of meter display, digital data file on punched paper-tape and print-out, and print-out of operator messages. Skewed projections may be used for both real-time and off-line position and sounding plots. Examples of the various data formats used are shown in figures 178-181 in the annex. It should be noted that position information is recorded for each sounding.

Use of the third group of programmes allows the hydrographer to edit the raw survey information, prepare final correction information and prepare data plots useful in evaluating the work prior to leaving the survey area.

The fourth group of programmes is used to pre-process specially certain data prior to follow-on processing ashore with the IBM 1620 computer. This pre-processing is not required for data input to the shore-based IBM 1130 supported system described below.

System operation

System operation is discussed briefly below in terms of Hydrolog as its operation entails virtually all of the activities of Hydroplot operation while requiring additional considerations due to the unavailability of a real-time automated plot.

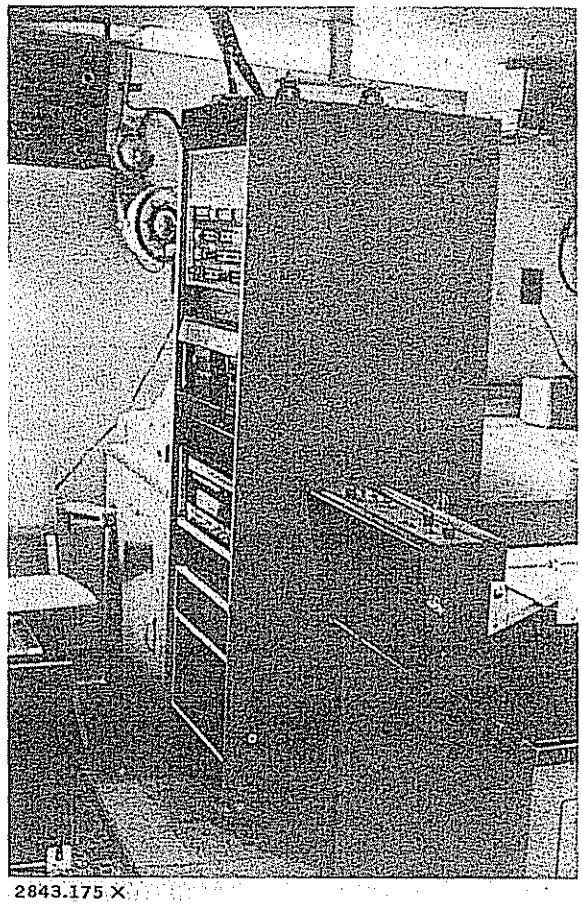


Figure 175. United States of America ship Hydroplot system equipment

Prior to beginning work, the hydrographer prepares a work-sheet (UTM projection) of the area containing the *x-y* grid, the latitude-longitude grid and an electronic navigation lattice (if applicable). He also prepares a survey limits tape containing the latitude and longitude of each corner of an *n*-sided polygon (*n* may be as great as 100) enclosing the survey area. Following system start-up (loading of Hydrolog programme, survey parameters, survey limits etc., into the computer memory and the controller switches), the sounding vessel is manoeuvred towards the sounding line (the steering meter is now operating under programme control); during movement to the sounding line, the hydrographer manually plots the vessel's *x-y* position from data made available by means of teletype print-out on demand. When the vessel enters the survey area, the message "INSIDE" is printed by teletype, and the Hydrolog system data sampling and recording system is placed in operation. When the vessel crosses the opposite survey area boundary line, the message "OUTSIDE" is printed, data sampling and recording operations are stopped, the steering indicator begins tracking with respect to the next sounding line, the vessel is manoeuvred to the next sounding line (see figure 176), and the sounding operation resumes. The launch Hydrolog data are plotted aboard ship at the end of each day through the Hydroplot system of the ship.

Automated shore-based processing system

System hardware

The shore-based automated hydrographic survey data-processing system is schematically illustrated in figure 177. The central processing unit is an IBM 1130 computer with a capacity of 16,000 16-bit words of memory and a cycle time of 3.6 microseconds. This subsystem has the following additional capabilities not indicated in figure 177: (*a*) paper-tape read at 300 CPS; (*b*) paper-tape punch at 50 CPS; (*c*) magnetic tape read/write at 22,000 CPS; (*d*) average disc storage access time of about 50 milliseconds; (*e*) card read at 300 cards per minute; and (*f*) card punch at 80 cards per minute.

The plotter subsystem utilizes a PDP-8/E computer for control purposes. Communication with the controller is available through magnetic tape, paper tape, keyboard and hard-copy listings. All operational plotter input is done with magnetic tape. The Calcomp 618 plotter has a 24-vector input command format, an increment size of 0.05/0.025 mm and plot speed of about 200 increments per second. Any one of four pens are available for selection under programme control. Both the hardware and the software are available to allow alternative transfer of the plotter control function to the IBM 1130 if required.

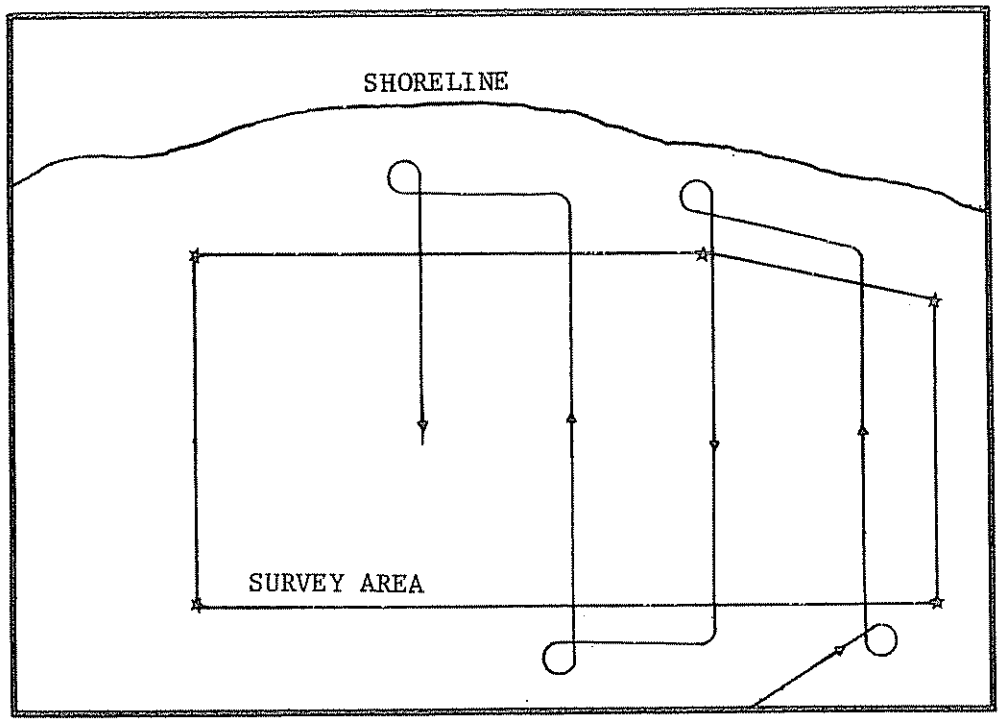


Figure 176. United States of America: Hydrolog system survey operation

System software and operation

Approximately 75 operational programmes have been prepared by NOS personnel for use in the processing of hydrographic survey information with this system. The vast majority of these programmes are written in Fortran IV, assembly language being utilized only in those areas where the use of Fortran was not feasible or where significant increases in processing speed could be achieved through use of the assembly language. System software currently allows the processing of surveys utilizing the following five positioning techniques: (1) electronic navigation-hyperbolic; (2) electronic navigation-range/range; (3) visual three-point sextant fix; (4) combination of range/range electronic and visual sextant angles; and (5) combination of hyperbolic electronic and visual sextant angles.

The processing of hydrographic survey data from the intial paper-tapes and listings provided by the survey ships through the final smooth-sheet plot is accomplished in nine phases:

Phase 1. The paper tape is simultaneously read into the system and examined for possible errors (time errors, invalid characters and/or formats, etc.); errors are listed through the printer; and the entire survey is written on two disc files—one for the uncorrected survey data and one for corrector data (i.e., tide reducers, sound velocity corrections, position corrections etc.);

Phase 2. The list of errors identified during phase 1 is manually examined, appropriate corrections are keypunched on to cards and the disc files made in phase 1 are updated to reflect these corrections;

Phase 3. The two corrected disc files are merged to form one master disc file; geographical positions for each sounding are computed; a polyconic projection containing a preliminary plot of all corrected position fixes is prepared (see figure 182 in annex); a navigation lattice plot (either range/range or hyperbolic) is prepared (see figure 183 in annex); and a listing of all geographical positions is produced;

Phase 4. This phase consists of a manual examination (verification) of the preliminary position plot (overlay) and associated position listing (see figure 184 in annex); the keypunching of corrections and an updating of the master disc file;

Phase 5. During this phase, the echo-sounder transducer draft, sound velocity and smooth tide corrections are applied to the uncorrected soundings on the master disc file and the reduced soundings are computed;

Phase 6. During this phase, an excess removal programme is executed. In this process, the entire master disc file is analysed, soundings that will either overprint when plotted or are in excess of requirements are selected out, the shoaler soundings are retained for plotting and the remaining soundings are labelled on the disc as excess information;

Phase 7. A preliminary smooth sheet sounding overlay (see figure 185 in annex) and an overlay containing excess soundings are prepared during this phase;

Phase 8. During this phase, the preliminary sounding overlay is manually examined and corrections are applied to update the master disc file as required;

Phase 9. The final position overlay, sounding overlay, excess sounding overlay and listing are prepared and given a final manual verification. After verification, the final smooth data are copied from disc to magnetic tape for submission to NOS headquarters along with the smooth sheet overlays for final review and application to the nautical chart.

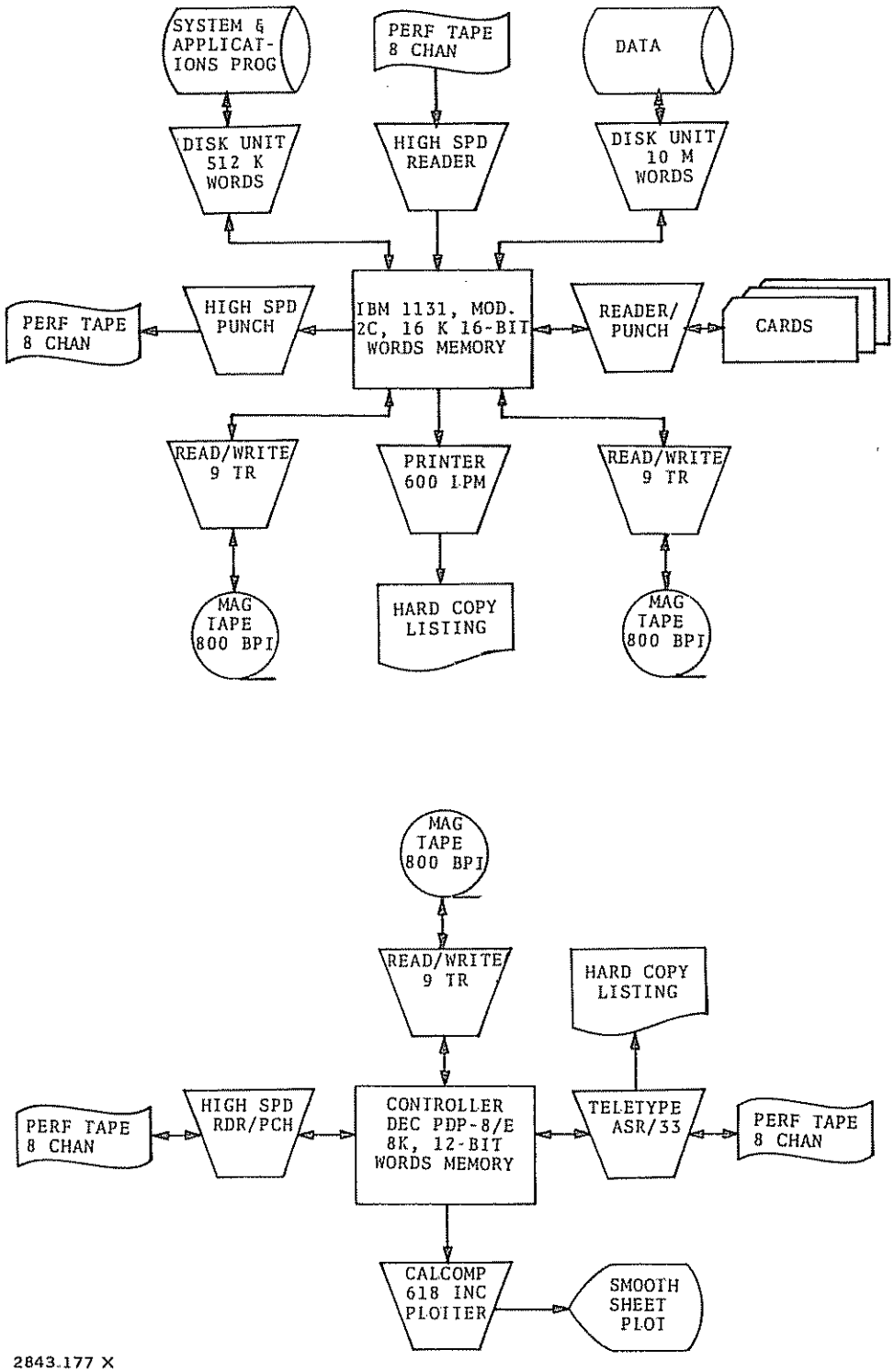


Figure 177. United States of America: automated hydrographic survey data-processing system of National Ocean Survey

Conclusion

The automated data acquisition and processing system described herein has increased the speed and efficiency with which a completely verified hydrographic survey can be produced.

Hydroplot/hydrolog, the data acquisition system, was designed and developed by hydrographers; and, therefore, the high degree of operational flexibility characteristic of manual (i.e., non-automated) surveying has been retained while most of the time-consuming manual drudgery has been eliminated. Features deemed unique

to Hydroplot/Hydrolog include: (*a*) digital sextant capability; (*b*) capability to combine simultaneously visual sextant and electronic navigation data; (*c*) real-time telemetered tide data input; (*d*) the use of both normal and skewed projections; (*e*) capability to rotate plotted sounding orientation; and (*f*) a very large repertoire of off-line computing and data-processing programmes.

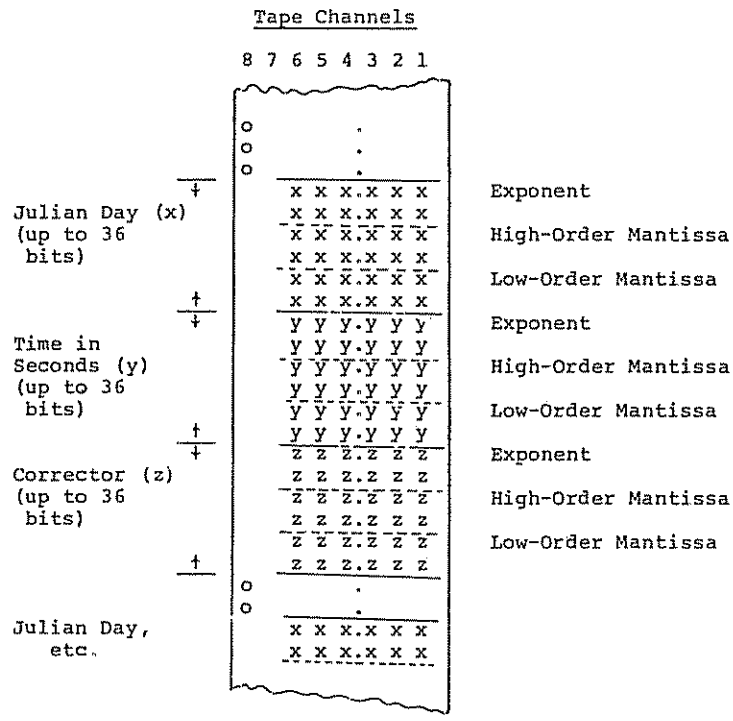
The shore-based data-processing system design is founded entirely upon functional requirements provided by personnel experienced in hydrographic survey verification. Its use eliminates virtually all of the tedious, time-consuming manual data reduction and plotting previously associated with the verification task; thus, the verifier is at last allowed to pursue his rightful role as a cartographer.

ANNEX

FEST=2ØØØØ	False Easting (meters)
CLAT=4ØØØØØØ	Control Latitude (meters)
CMER=76/1Ø/Ø	Central Meridian (deg.,min.,sec.)
GRID=15	Grid Interval (Sec.)
PLSCL=1ØØØØ	Survey Scale (1:10,000)
PLAT=36/54/4Ø	Latitude of Plotter Origin
PLON=76/15/2Ø	Longitude of Plotter Origin
MLAT=36/55/44.78	Latitude of Master Station
MLON=76/1Ø/58.86	Longitude of Master Station
S1LAT=37/ØØ/Ø4.8	Latitude of Slave 1 Station
S1LON=76/18/19.Ø9	Longitude of Slave 1 Station
S2LAT=36/55/32.44	Latitude of Slave 2 Station
S2LON=76/Ø2/39.Ø3	Longitude of Slave 2 Station
Q=33ØØ.4	Navigation System Frequency (KHz)
VESNO=293Ø	Vessel Identification Code
YR=7Ø	Year of Survey

2843.178 ×

Figure 178. United States of America: Hydroplot/Hydrolog system, parameter format (hyperbolic Hi-Fix control)



2843.179 X

Figure 179. United States of America: Hydroplot/Hydrolog system, predicted tide format

Time	Depth	Pos. No.	HI-FIX P1	HI-FIX P2	Plane Coordinate X	Plane Coordinate Y
293Ø	7Ø	17Ø Ø Ø1 *				
1Ø3745	-ØØ6	-Ø1Ø	-ØØØ41	ØØØØ38 **		
1Ø3745	ØØ43Ø	ØØ199	Ø11Ø1Ø	Ø19Ø2Ø	ØØ5921	ØØ2672
1Ø38ØØ	ØØ54Ø		Ø11Ø12	Ø191ØØ		
1Ø3815	ØØ532		Ø11Ø15	Ø1921Ø		
1Ø39ØØ	ØØ52Ø		Ø11Ø17	Ø19315		
1Ø3915	ØØ513	ØØ2ØØ	Ø11Ø23	Ø1954Ø	ØØ6Ø16	ØØ2691

NOTE: * Day Word - from left to right-- Vessel Identification, Year, Julian Day, Sounding Indicator, Velocity Table No. Number.

** Corrector Word - from left to right - Time, Tide Reducer, Draft Correction, HI-FIX Corrections.

2843.180 X

Figure 180. United States of America: Hydrolog system, data format

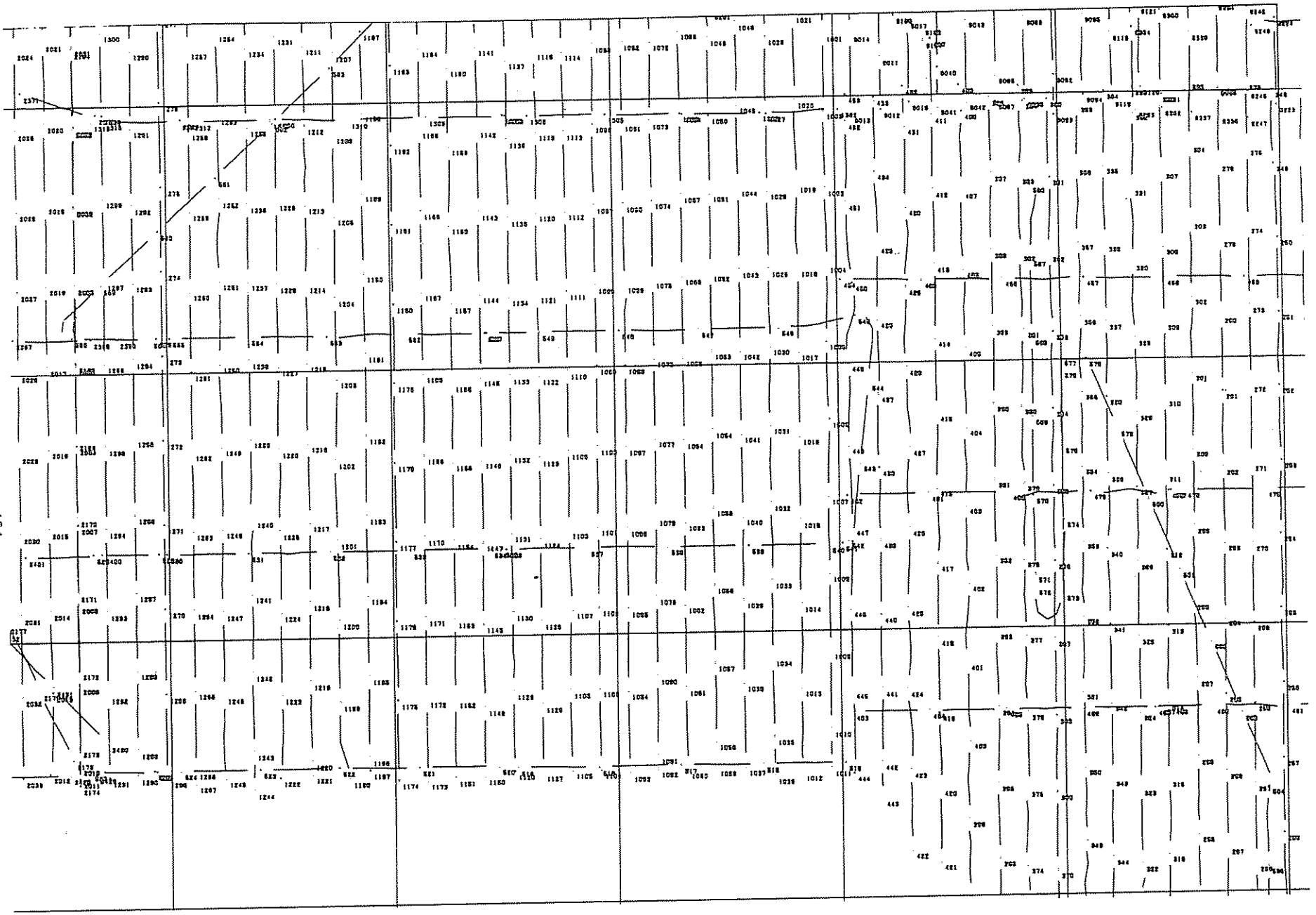
Time	Depth	Pos. No.	HI-FIX P1	HI-FIX P2
293Ø 7Ø 17Ø Ø Ø1 *				
Ø8292Ø Ø46 ØØ3 ØØØØ51 ØØØØ51 **				
Ø82922 ØØØ94 Ø5969 Ø16786 Ø22386				
Ø82932 ØØ988 Ø1686Ø Ø22385				
Ø82942 ØØ984 Ø15933 Ø22384				
Ø82952 ØØ981 Ø17ØØ7 Ø22383				
Ø83ØØ2 ØØ978 Ø17Ø8Ø Ø22382				
Ø83Ø12 ØØ977 Ø17154 Ø22381				
Ø83Ø22 ØØ974 Ø597Ø Ø17228 Ø2238Ø				
Ø83Ø32 ØØ973 Ø173Ø2 Ø22379				
Ø83Ø42 ØØ97Ø Ø17376 Ø22377				

NOTE: * Day Word - from left to right- Vessel Identification, Year, Julian Day, Sounding Indicator, Velocity Table.

** Corrector Word - from left to right - Time, Tide Reducer, Draft Correction, HI-FIX Corrections.

2843.181 X

Figure 181. United States of America: Hydroplot/Hydrolog system, master data format



2843.182 X

Note: The Hydroplot system of the National Ocean Survey was used in the conduct of this survey at a speed of 20 knots.

Figure 182. United States of America: automated smooth sheet position overlay

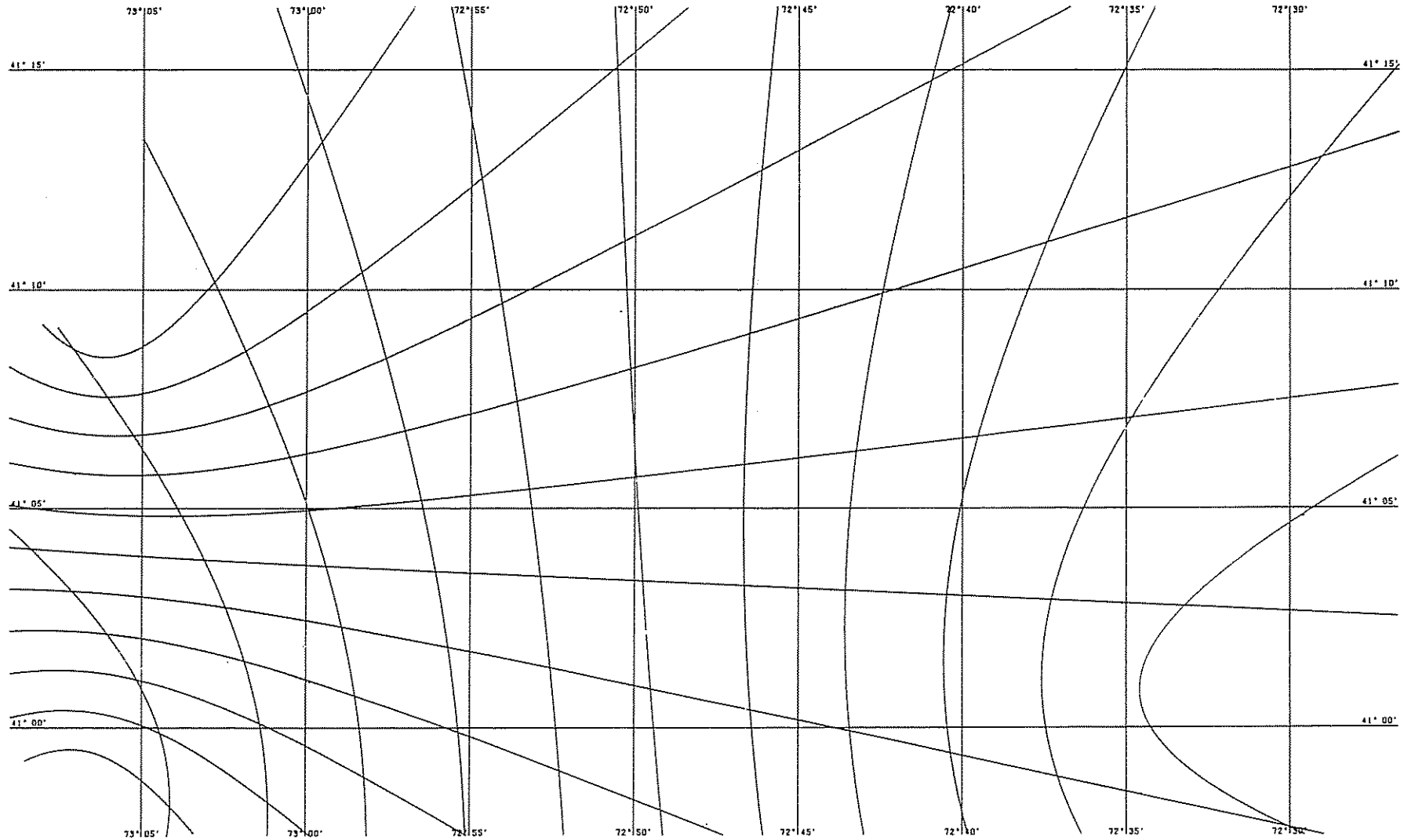
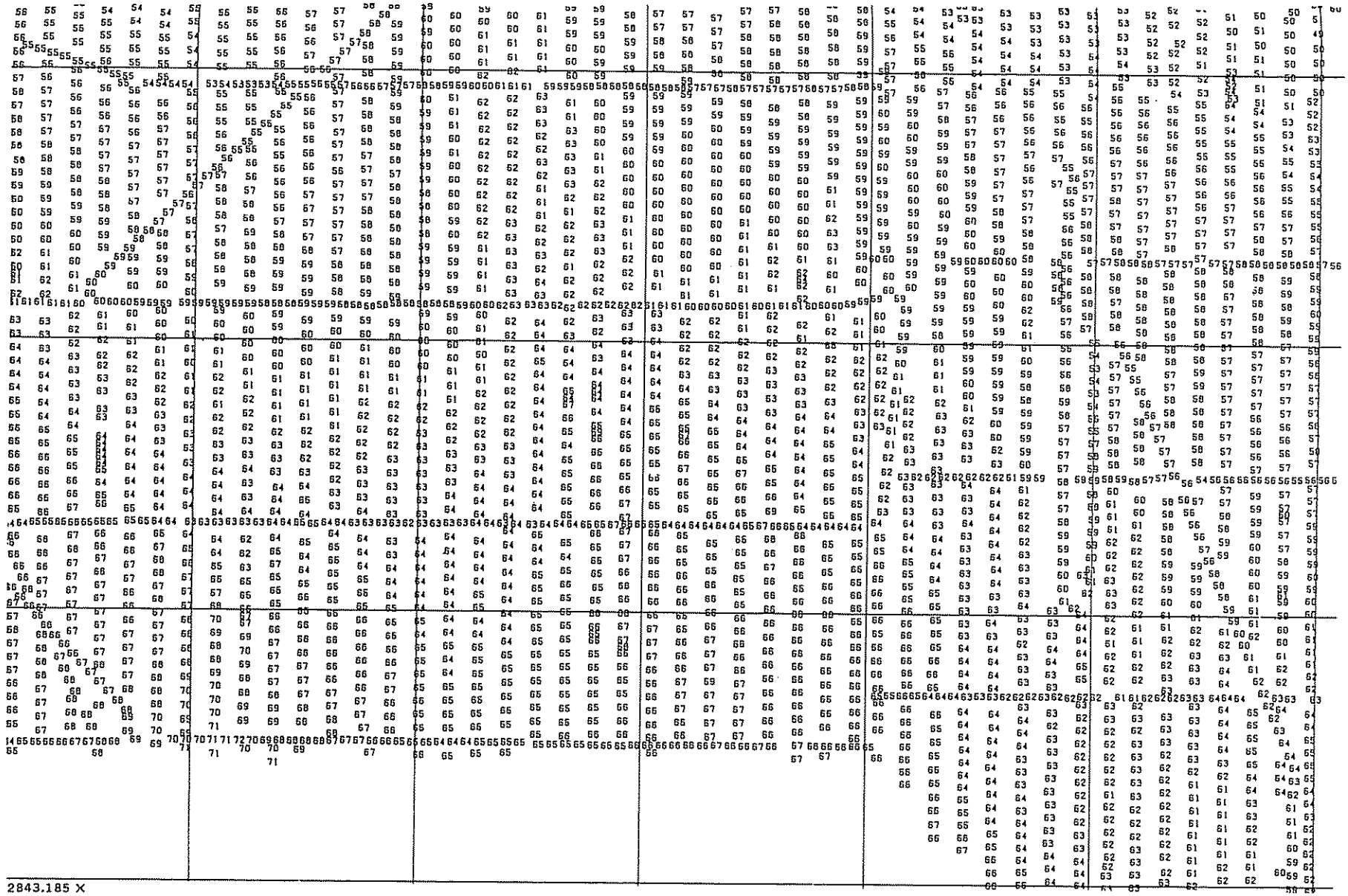


Figure 183. United States of America: automated polyconic projection with Hi-Fix lattice

VES ID	YR	DAY	TIME	POS NUM	TYP	P1CR	P1C	P2CR	P2C	COORDINATES LAT	COORDINATES LONG	RECORD NUMBER
2930	70	064	232806	3028	11	76.11	-0.45	279.28	-0.13	33 43 49.05	78 23 18.52	2305.
2930	70	064	232836	0	11	75.25	-0.45	279.32	-0.13	33 43 54.62	78 23 18.64	2306.
2930	70	064	232906	0	11	74.43	-0.45	279.35	-0.13	33 43 59.94	78 23 18.80	2307.
2930	70	064	232936	0	11	73.57	-0.45	279.47	-0.13	33 44 5.56	78 23 18.66	2308.
2930	70	064	233006	0	11	72.72	-0.45	279.63	-0.13	33 44 11.14	78 23 18.38	2309.
2930	70	064	233036	0	11	71.90	-0.45	279.91	-0.13	33 44 16.56	78 23 17.67	2310.
2930	70	064	233106	3029	11	71.06	-0.45	279.98	-0.13	33 44 22.12	78 23 17.73	2311.
2930	70	064	233136	0	11	70.24	-0.45	279.92	-0.13	33 44 27.56	78 23 18.24	2312.
2930	70	064	233206	0	11	69.40	-0.45	279.91	-0.13	33 44 33.16	78 23 18.60	2313.
2930	70	064	233236	0	11	68.56	-0.45	279.92	-0.13	33 44 38.79	78 23 18.89	2314.
2930	70	064	233306	0	11	67.75	-0.45	280.16	-0.13	33 44 44.28	78 23 18.37	2315.
2930	70	064	233336	0	11	66.93	-0.45	280.35	-0.13	33 44 49.86	78 23 18.04	2316.
2930	70	064	233406	3030	11	66.14	-0.45	280.37	-0.13	33 44 55.23	78 23 18.30	2317.
2930	70	064	233436	0	11	65.35	-0.45	280.36	-0.13	33 45 0.62	78 23 18.68	2318.
2930	70	064	233506	0	11	64.51	-0.45	280.44	-0.13	33 45 6.40	78 23 18.77	2319.
2930	70	064	233536	0	11	63.72	-0.45	280.65	-0.13	33 45 11.90	78 23 18.40	2320.
2930	70	064	233606	0	11	62.91	-0.45	280.77	-0.13	33 45 17.54	78 23 18.36	2321.
2930	70	064	233636	0	11	62.13	-0.45	280.75	-0.13	33 45 22.98	78 23 18.80	2322.
2930	70	064	233706	3031	11	61.31	-0.45	280.76	-0.13	33 45 28.72	78 23 19.16	2323.
2930	70	064	233736	0	11	60.54	-0.45	280.89	-0.13	33 45 34.18	78 23 19.10	2324.
2930	70	064	233806	0	11	59.76	-0.45	281.08	-0.13	33 45 39.76	78 23 18.84	2325.
2930	70	064	233836	0	11	58.99	-0.45	281.30	-0.13	33 45 45.31	78 23 18.49	2326.
2930	70	064	233906	0	11	58.23	-0.45	281.60	-0.13	33 45 50.85	78 23 17.87	2327.
2930	70	064	233936	0	11	57.46	-0.45	281.65	-0.13	33 45 56.42	78 23 18.13	2328.
2930	70	064	234006	3032	11	56.69	-0.45	281.59	-0.13	33 46 1.98	78 23 18.76	2329.
2930	70	064	234036	0	11	55.94	-0.45	281.66	-0.13	33 46 7.47	78 23 18.95	2330.
2930	70	064	234106	0	11	55.20	-0.45	281.79	-0.13	33 46 12.94	78 23 18.95	2331.
2930	70	064	234136	0	11	54.47	-0.45	281.95	-0.13	33 46 18.39	78 23 18.84	2332.
2930	70	064	234206	0	11	53.74	-0.45	282.11	-0.13	33 46 23.87	78 23 18.75	2333.
2930	70	064	234236	0	11	53.00	-0.45	282.27	-0.13	33 46 29.45	78 23 18.67	2334.
2930	70	064	234306	3033	11	52.28	-0.45	282.39	-0.13	33 46 34.91	78 23 18.73	2335.
2930	70	064	234336	0	11	51.55	-0.45	282.47	-0.13	33 46 40.47	78 23 18.94	2336.
2930	70	064	234406	0	11	50.83	-0.45	282.57	-0.13	33 46 45.99	78 23 19.09	2337.
2930	70	064	234436	3034	11	50.11	-0.45	282.76	-0.13	33 46 51.59	78 23 18.94	2338.
2930	70	065	000135	3035	11	50.76	-0.45	287.21	-0.13	33 46 48.51	78 23 3.63	2339.
2930	70	065	000205	0	11	51.46	-0.45	287.05	-0.13	33 46 43.06	78 23 3.66	2340.
2930	70	065	000235	0	11	52.20	-0.45	286.85	-0.13	33 46 37.32	78 23 3.82	2341.
2930	70	065	000305	0	11	52.95	-0.45	286.67	-0.13	33 46 31.56	78 23 3.91	2342.
2930	70	065	000335	0	11	53.70	-0.45	286.54	-0.13	33 46 25.85	78 23 3.84	2343.
2930	70	065	000405	0	11	54.47	-0.45	286.42	-0.13	33 46 20.04	78 23 3.74	2344.
2930	70	065	000435	3036	11	55.25	-0.45	286.30	-0.13	33 46 14.18	78 23 3.65	2345.
2930	70	065	000505	0	11	56.03	-0.45	286.15	-0.13	33 46 8.36	78 23 3.67	2346.
2930	70	065	000535	0	11	56.81	-0.45	286.00	-0.13	33 46 2.58	78 23 3.70	2347.
2930	70	065	000605	0	11	57.61	-0.45	285.96	-0.13	33 45 56.72	78 23 3.35	2348.
2930	70	065	000635	0	11	58.41	-0.45	285.93	-0.13	33 45 50.89	78 23 2.98	2349.
2930	70	065	000705	0	11	59.21	-0.45	285.80	-0.13	33 45 45.08	78 23 2.97	2350.
2930	70	065	000735	3037	11	60.03	-0.45	285.64	-0.13	33 45 39.14	78 23 3.05	2351.
2930	70	065	000805	0	11	60.84	-0.45	285.47	-0.13	33 45 33.31	78 23 3.19	2352.

2843.184 X

Figure 184. United States of America: automated data listing available to cartographer during verification of smooth sheet position overlay



Note: Same survey as figure 182; depths in feet.

Figure 185. United States of America: automated smooth sheet sounding overlay

SURVEY H 9116 DATE 03/29/72 PAGE 1

VES ID	YR	DAY	TIME	DEP IND	DEPTH	VTAB	VEL	TIDE	TRA	RED DEP	EXS IND	PLOT DEP	POS NUM	COORDINATES LATITUDE	COORDINATES LONGITUDE	RECORD NUMBER
2930	70	064	232806	0	38.0	2	0.6	0.6	11.4	50.6	0	50	3028	33 43 49.05	78 23 18.52	2305.
2930	70	064	232836	0	38.8	2	0.6	0.6	11.4	51.4	0	51	0	33 43 54.62	78 23 18.64	2306.
2930	70	064	232906	0	39.1	2	0.6	0.6	11.4	51.7	0	51	0	33 43 59.94	78 23 18.80	2307.
2930	70	064	232936	0	38.7	2	0.6	0.6	11.4	51.3	0	51	0	33 44 5.56	78 23 18.66	2308.
2930	70	064	233006	0	38.5	2	0.6	0.6	11.4	51.1	0	51	0	33 44 11.14	78 23 18.38	2309.
2930	70	064	233036	0	39.8	2	0.6	0.6	11.4	52.4	0	52	0	33 44 16.56	78 23 17.67	2310.
2930	70	064	233106	0	39.0	2	0.6	0.6	11.4	51.6	0	51	3029	33 44 22.12	78 23 17.73	2311.
2930	70	064	233136	0	38.0	2	0.6	0.6	11.4	50.6	0	50	0	33 44 27.56	78 23 18.24	2312.
2930	70	064	233206	0	37.5	2	0.6	0.6	11.4	50.1	0	50	0	33 44 33.16	78 23 18.60	2313.
2930	70	064	233236	0	37.5	2	0.6	0.6	11.4	50.1	0	50	0	33 44 38.79	78 23 18.89	2314.
2930	70	064	233306	0	37.0	2	0.6	0.6	11.4	49.6	1	49	0	33 44 44.28	78 23 18.37	2315.
2930	70	064	233336	0	37.2	2	0.6	0.6	11.4	49.8	0	50	0	33 44 49.86	78 23 18.04	2316.
2930	70	064	233406	0	38.0	2	0.6	0.6	11.4	50.6	0	50	3030	33 44 55.23	78 23 18.30	2317.
2930	70	064	233436	0	38.2	2	0.6	0.6	11.4	50.8	0	51	0	33 45 0.62	78 23 18.68	2318.
2930	70	064	233506	0	38.5	2	0.6	0.6	11.4	51.1	0	51	0	33 45 6.40	78 23 18.77	2319.
2930	70	064	233536	0	38.5	2	0.6	0.6	11.4	51.1	0	51	0	33 45 11.90	78 23 18.40	2320.
2930	70	064	233606	0	38.1	2	0.6	0.6	11.4	50.7	0	50	0	33 45 17.54	78 23 18.36	2321.
2930	70	064	233636	0	38.5	2	0.6	0.6	11.4	51.1	0	51	0	33 45 22.98	78 23 18.80	2322.
2930	70	064	233706	0	38.2	2	0.6	0.6	11.4	50.8	0	51	3031	33 45 28.72	78 23 19.16	2323.
2930	70	064	233736	0	38.0	2	0.6	0.6	11.4	50.6	0	50	0	33 45 34.18	78 23 19.10	2324.
2930	70	064	233806	0	38.2	2	0.6	0.6	11.4	50.8	0	51	0	33 45 39.76	78 23 18.84	2325.
2930	70	064	233836	0	38.8	2	0.6	0.6	11.4	51.4	0	51	0	33 45 45.31	78 23 18.49	2326.
2930	70	064	233906	0	37.5	2	0.6	0.6	11.4	50.1	0	50	0	33 45 50.85	78 23 17.87	2327.
2930	70	064	233936	0	39.0	2	0.6	0.6	11.4	51.6	1	51	0	33 45 56.42	78 23 18.13	2328.
2930	70	064	234006	0	38.5	2	0.6	0.6	11.4	51.1	1	51	3032	33 46 1.98	78 23 18.76	2329.
2930	70	064	234036	0	37.5	2	0.6	0.6	11.4	50.1	0	50	0	33 46 7.47	78 23 18.95	2330.
2930	70	064	234106	0	36.2	2	0.6	0.6	11.4	48.8	0	49	0	33 46 12.94	78 23 18.95	2331.
2930	70	064	234136	0	37.2	2	0.6	0.6	11.4	49.8	0	50	0	33 46 18.39	78 23 18.84	2332.
2930	70	064	234206	0	37.1	2	0.6	0.6	11.4	49.7	1	49	0	33 46 23.87	78 23 18.75	2333.
2930	70	064	234236	0	35.2	2	0.5	0.6	11.4	47.7	0	47	0	33 46 29.45	78 23 18.67	2334.
2930	70	064	234306	0	35.3	2	0.5	0.6	11.4	47.8	0	48	3033	33 46 34.91	78 23 18.73	2335.
2930	70	064	234336	0	34.5	2	0.5	0.6	11.4	47.0	0	47	0	33 46 40.47	78 23 18.94	2336.
2930	70	064	234406	0	35.0	2	0.5	0.6	11.4	47.5	0	47	0	33 46 45.99	78 23 19.09	2337.
2930	70	064	234436	0	34.2	2	0.5	0.6	11.4	46.7	0	46	3034	33 46 51.59	78 23 18.94	2338.
2930	70	065	000135	0	37.0	2	0.6	0.6	11.4	49.6	0	49	3035	33 46 48.51	78 23 3.63	2339.
2930	70	065	000205	0	37.1	2	0.6	0.6	11.4	49.7	0	49	0	33 46 43.06	78 23 3.66	2340.
2930	70	065	000235	0	37.3	2	0.6	0.6	11.4	49.9	0	50	0	33 46 37.32	78 23 3.82	2341.
2930	70	065	000305	0	37.3	2	0.6	0.6	11.4	49.9	0	50	0	33 46 31.56	78 23 3.91	2342.
2930	70	065	000335	0	38.1	2	0.6	0.6	11.4	50.7	0	50	0	33 46 25.85	78 23 3.84	2343.
2930	70	065	000405	0	38.6	2	0.6	0.6	11.4	51.2	1	51	0	33 46 20.04	78 23 3.74	2344.
2930	70	065	000435	0	38.5	2	0.6	0.6	11.4	51.1	0	51	3036	33 46 14.18	78 23 3.65	2345.
2930	70	065	000505	0	39.0	2	0.6	0.6	11.4	51.6	0	51	0	33 46 8.36	78 23 3.67	2346.
2930	70	065	000535	0	39.3	2	0.6	0.6	11.4	51.9	0	52	0	33 46 2.58	78 23 3.70	2347.
2930	70	065	000605	0	40.2	2	0.6	0.6	11.4	52.8	1	53	0	33 45 56.72	78 23 3.35	2348.
2930	70	065	000635	0	38.5	2	0.6	0.6	11.4	51.1	0	51	0	33 45 50.89	78 23 2.98	2349.
2930	70	065	000705	0	37.6	2	0.6	0.6	11.4	50.2	1	50	0	33 45 45.08	78 23 2.97	2350.
2930	70	065	000735	0	38.1	2	0.6	0.6	11.4	50.7	0	50	3037	33 45 39.14	78 23 3.05	2351.
2930	70	065	000805	0	38.2	2	0.6	0.6	11.4	50.8	0	51	0	33 45 33.31	78 23 3.19	2352.
2930	70	065	000835	0	38.9	2	0.6	0.6	11.4	51.5	0	51	0	33 45 27.39	78 23 3.16	2353.
2930	70	065	000905	0	38.2	2	0.6	0.6	11.4	50.8	0	51	0	33 45 21.43	78 23 3.16	2354.

2843.186 X

Figure 186. United States of America: automated data listing available to cartographer during verification of smooth sheet sounding overlay

VES ID	YR	DAY	TIME	IND	DEPTH	VTAB	VEL	TIDE	TRA	POS NUM	TYP	P1CR	P1C	P2CR	P2C	COORDINATES LAT	COORDINATES LONG	RECORD NUMBER
			RED. DEPTH		EXCESS													
2930	70	064	232806	0	38.0	2	6	6	114	3028	11	76.11	-0.45	279.28	-0.13	33 43 49.05	78 23 18.52	2305.
			50.6		0													
2930	70	064	232836	0	38.8	2	6	6	114	0	11	75.25	-0.45	279.32	-0.13	33 43 54.62	78 23 18.64	2306.
			51.4		0													
2930	70	064	232906	0	39.1	2	6	6	114	0	11	74.43	-0.45	279.35	-0.13	33 43 59.94	78 23 18.80	2307.
			51.7		0													
2930	70	064	232936	0	38.7	2	6	6	114	0	11	73.57	-0.45	279.47	-0.13	33 44 5.56	78 23 18.66	2308.
			51.3		0													
2930	70	064	233006	0	38.5	2	6	6	114	0	11	72.72	-0.45	279.63	-0.13	33 44 11.14	78 23 18.38	2309.
			51.1		0													
2930	70	064	233036	0	39.8	2	6	6	114	0	11	71.90	-0.45	279.91	-0.13	33 44 16.56	78 23 17.67	2310.
			52.4		0													
2930	70	064	233106	0	39.0	2	6	6	114	3029	11	71.06	-0.45	279.98	-0.13	33 44 22.12	78 23 17.73	2311.
			51.6		0													
2930	70	064	233136	0	38.0	2	6	6	114	0	11	70.24	-0.45	279.92	-0.13	33 44 27.56	78 23 18.24	2312.
			50.6		0													
2930	70	064	233206	0	37.5	2	6	6	114	0	11	69.40	-0.45	279.91	-0.13	33 44 33.16	78 23 18.60	2313.
			50.1		0													
2930	70	064	233236	0	37.5	2	6	6	114	0	11	68.56	-0.45	279.92	-0.13	33 44 38.79	78 23 18.89	2314.
			50.1		0													
2930	70	064	233306	0	37.0	2	6	6	114	0	11	67.75	-0.45	280.16	-0.13	33 44 44.28	78 23 18.37	2315.
			49.6		1													
2930	70	064	233336	0	37.2	2	6	6	114	0	11	66.93	-0.45	280.35	-0.13	33 44 49.86	78 23 18.04	2316.
			49.8		0													
2930	70	064	233406	0	38.0	2	6	6	114	3030	11	66.14	-0.45	280.37	-0.13	33 44 55.23	78 23 18.30	2317.
			50.6		0													
2930	70	064	233436	0	38.2	2	6	6	114	0	11	65.35	-0.45	280.36	-0.13	33 45 0.62	78 23 18.68	2318.
			50.8		0													
2930	70	064	233506	0	38.5	2	6	6	114	0	11	64.51	-0.45	280.44	-0.13	33 45 6.40	78 23 18.77	2319.
			51.1		0													
2930	70	064	233536	0	38.5	2	6	6	114	0	11	63.72	-0.45	280.65	-0.13	33 45 11.90	78 23 18.40	2320.
			51.1		0													
2930	70	064	233606	0	38.1	2	6	6	114	0	11	62.91	-0.45	280.77	-0.13	33 45 17.54	78 23 18.36	2321.
			50.7		0													

2843.187 X

Figure 187. United States of America: composite listing of all hydrographic survey data contained on disc during automated processing

THE INTERNATIONAL CHART, DWARF OR GIANT?*

Paper presented by the United Kingdom of Great Britain and Northern Ireland

International co-operation in hydrography is now a mature and well-established principle which has flourished with increasing vigour since the formation, in 1921, of the International Hydrographic Bureau, now known as the International Hydrographic Organization (IHO). The history of this co-operation has been admirably treated by Ritchie, Moitoret and Newson,[1] among others; their papers demonstrate clearly that IHO is a forward-looking community of surveying and charting countries which render one another invaluable assistance in many ways, whose transactions are conducted in an atmosphere of friendly co-operation and whose conferences form a splendid example for all international gatherings.

Taking stock at one of their regular conferences in 1967, the hydrographers representing the members of IHO observed that whereas there is little duplication of hydrographic surveying, as between one member and another, there is considerable duplication of charting effort, with various members producing similar charts of the same areas. At the same time, the hydrographic offices were finding it increasingly difficult to cope with the ever-rising flood of new material from various sources; perhaps they no longer had the productive resources to justify the duplication of charting effort. These thoughts led to the concept of the International Chart—a concept which, in the ensuing six years, has turned into a reality. The achievements to date have been striking; but, at the same time, disappointing to those who discern a need for more rapid progress.

This paper makes no attempt to relate the history of the International Chart, which has been fully chronicled by Pascoe, Moitoret and Ritchie;[2] but it is necessary to summarize the principal developments so far, in order properly to prepare the arguments which follow. The members of IHO have agreed upon two world series of small-scale charts on the scales 1:10,000,000 and 1:3,500,000. Specifications and procedures for publication and correction have been formulated, and the production of the 80 charts has been apportioned among 16 members. All members have the right to request reproduction material and to print their own version of any of these charts, making such modifications as they require to conform to national needs, an interesting device enabling members to retain full independence within a project involving interdependence. It is important to note that the 80 small-scale charts can, in due course, replace as many as 291 charts currently published on comparable scales by the members of IHO—a striking indication of the amount of duplication.

It is clear that the achievement of this first objective is now virtually assured, not, perhaps, as rapidly as those engaged in the formative discussions might have wished, but patience was ever an essential quality for cartographers. The April 1972 issue of the *International Hydrographic Bulletin* lists the progress to date, and it may be seen that 33 of those 80 charts will have been published by 1974. Evidently, the designated producer countries have difficulty in allocating scarce resources to the production of some of these charts. Moreover, the first objective, the establishment of the series of small-scale charts, was a very limited one, worthy, but rather unambitious in terms of the whole problem of duplication. But the time taken to achieve this limited goal throws into sharp relief the massive nature of the whole problem and makes even the more hopeful and optimistic of the cartographers concerned flinch at the task involved in pursuing the concept to its logical conclusion.

One may ask why there is a need to develop the concept further. The answer to this question lies deep in the complex of charting by numerous national agencies as it has evolved over the years. Despite the growth of international co-operation, most charting authorities have had to meet a demand from their mariners for charts in their language. Language differences and differing national approaches have resulted in differences in representation, so that despite 50 years of effort by IHO, standardization has not gone far enough. The formation of more and more independent hydrographic offices, an inevitable and necessary development, has aggravated the problem. Bear in mind, also, that not all have opted to join IHO. Additional effort throughout the world, accompanied by striking advances in techniques for data acquisition, has produced a vast increase in survey information. Growing local requirements have shown shifts of emphasis away from, or additional to, overseas interests; and the demand grows for more charts to satisfy these local requirements. Little wonder, then, that it has become increasingly difficult for those countries which have traditionally charted the world, or large parts of it, to keep pace in keeping their series up to date.

Then, one may ask, why they must continue to try. They must because, apart from the language and representational differences already mentioned, it is not practicable to select, from the numerous charts published by the various national agencies, a folio of charts suited to the needs of the world's mariners at large. Too many charts would be required; only by careful selection, change of scale and pruning of numbers can a satisfactory world series be maintained. Furthermore, it is not simply a question of selecting charts and printing them. They have to be distributed throughout the world, as do the notices to mariners which keep the charts safe for navigation.

There have been various attempts by pairs or groups of charting countries partially to solve the problem by agreements enabling participants to reproduce one

*The original text of this paper, prepared by D. Russom, Hydrographic Department, United Kingdom, appeared as document E/CONF.62/L.64.

[1] G. F. Ritchie, "International co-operation in hydrography", *Journal of Navigation*, vol. 25, No. 1 (1972); Victor A. Moitoret, "The International Hydrographic Bureau: 50 years of progress", *International Hydrographic Review*, vol. XLVIII, No. 2 (1971); D. W. Newson, "The General Bathymetric Chart of the Oceans", *Cartographic Journal*, June 1971.

[2] L. N. Pascoe, "The International Chart", *Journal of the Institute of Navigation*, vol. 22, No. 4 (1969); Pascoe, "International charts", *Journal of Navigation*, vol. 25, No. 2 (1972); Victor A. Moitoret, "Progress in achieving an international set of charts", *International Hydrographic Review*, vol. XLVI, No. 2 (1969); Ritchie, *op. cit.*

another's charts in facsimile. The advantages of this practice and the possibility of using it in the move towards the International Chart were discussed in a paper by Langeraar,[3] but there has been no widespread move to eliminate duplication at the larger scales. The indications are that the major offices attempting to chart the world and to provide the essential world-wide after-sales correctional service must make more use of solutions involving translated and otherwise modified facsimile reproduction of charts produced by other countries, if the needs of the world's mariners for up-to-date charts are to be properly met. If this cannot be done, if their hitherto essential service cannot be continued, it will be not only the maritime interests of the major charting countries which will suffer; the harmful effects will be much more widespread, to the extent that efficient world charting acts as a lubricant to maritime trading operations. The risk of marine casualties would be increased, with greater risk to environmental pollution from certain cargoes. It will be a sad day for all if the world-charting countries are forced by lack of resources to cut their commitments before satisfactory alternative charting is available.

What is required, therefore, is an agreed world coverage of charts designed primarily to meet the needs of overseas shipping, preferably to a uniform specification, and capable of adaptation to alternative languages. Such a folio would include large-scale charts of selected ports of international importance and large-scale charts of the immediate approaches to these ports, supplemented by coastal charts on suitable scales dependent upon the nature of these waters. The present agreed series of international small-scale charts would complete the scale series, the total number of charts required being approximately 1,500–2,000. Bearing in mind the relatively small number of charts already agreed, the sheer size of the task becomes apparent, although it is to be hoped that many existing national charts might be incorporated in the series. The initial production of such a world series should be shared by as many active producer countries as possible—all those which recognize the need and have the capacity to participate enthusiastically. Ideally, once the compilation and preparation of a chart of this series are completed, reproduction material should be readily available to all members of IHO. Even those which may not be able to participate in the work of compilation and preparation will be supplying quantities of original data—the most costly part of the charting operation. Such a scheme provides benefits for all, maintains independence of choice and action, and allows for the production of supplementary charts to meet local requirements.

If the benefits of such a series are seen to be enjoyed not only by the major charting countries, but by all countries with maritime trading interests, it is possible that some apparent suspicion of the International Chart may be dispelled. It may be that it can be shown that the development of the concept could lead to more economical charting possibilities for smaller countries with limited cartographic resources. For while there is a clear-cut need, in general, for each country to maximize its hydrographic surveying potential and to be a member of IHO, a decision to set up a chart compilation and printing establishment may not be so obvious, political considerations apart. Those countries which have recently decided to establish chart-producing offices, but have not yet had time to build up national chart series, should have no difficulty in conforming to International Chart specifications and agreed sheet limits. The major difficulty of the next phase lies in persuading long-established hydrographic offices publishing many existing charts that there is much to be gained by participation in such a scheme. The question is whether such countries can be persuaded that long-term benefits which are difficult to quantify would justify the short-term disadvantages of change and interference with current maintenance plans.

It may be that only a very few charting countries would recognize sufficient mutual benefit in such a scheme that they could fully participate. Even if only a very few join together to avoid duplication, the concept could be justified; but the desired end could be achieved more quickly by general participation. This move could call for a change of approach by some established hydrographic offices which are satisfied that they individually have a good working solution to current problems and see no need for change. The question is whether they can be persuaded that a complete reappraisal might point to International Charting as a better answer to some of their problems and a better approach to the needs of the last quarter of this century. A major objective of this paper is to appeal to hydrographers everywhere to examine their basic philosophy of charting to see if, over the next few years, it may be possible for all, or most, or some, gradually to shape their efforts towards the International Chart. It would be naïve to expect wholesale early changes, but gradual movement towards the International Chart framework is a different matter and could be looked on more favourably.

One imagines that a certain amount of central guidance would be necessary, probably through a committee established by IHO, consisting largely of members that would be prepared to play a major part in production. In consultation with other members, such a committee would recommend chart limits and specifications. The agreed specifications should be concerned with what should be shown, as well as how it should be depicted, so that a degree of standardization of selection and generalization could be achieved. It is necessary also to consider the establishment of agreed criteria for selection of items for notices to mariners, in order to keep the correction problem down to manageable proportions. Such a committee would probably need to be supported by regional committees, and the recent activities of the North Sea Hydrographic Commission demonstrate the valuable part that such regional commissions can play in development. The members of that commission have already moved a little further along the road towards the final goal by agreeing upon four additional International Charts of the North Sea to supplement the small-scale series. As this paper is being written, they are considering the problems of extending the International Chart series into the large-scale charts of the North Sea area. Much could depend upon the success of these efforts. The question is whether the inertia of existing publications, standards and national outlooks will inhibit further progress towards the ideal of the International Chart and cause the concept to remain stunted; or whether hydrographers and their financial advisers will be able to take the long view, to re-examine their philosophy of charting and to make the International

[3] W. Langeraar, "Towards an International Chart", *International Hydrographic Review*, vol. XLVI, No. 2 (1969) (reprint of a paper presented to the Twelfth International Congress of Surveyors, 1968)

Chart a giant of the future. It is to be hoped that a concept so manifestly in keeping with the ideals of the United Nations will continue to expand and will, before long, provide the brotherhood of ocean-going mariners with a suitable modern set of International Charts which can be easily kept up to date.

THE PAST AND CONTINUING ROLE OF THE SURVEYING SERVICE OF THE ROYAL NAVY IN FAR EASTERN AND ASIAN WATERS SINCE 1946*

Paper presented by the United Kingdom of Great Britain and Northern Ireland

With the end of hostilities in 1945, the need for recharting and resurveying of the waters of Asia and the Far East was imperative. After six years of war, most charts were in the same state that they had been in 1939; and since the echo-sounder had only come into general use for surveying in 1935, the greater part of the charts covering this part of the world were based on lead-line surveys. The navies of India and Pakistan were forming their own surveying service, and the Royal Navy was happy to leave the charting of the shores of the subcontinent to them. Work was therefore concentrated at first on two main areas, namely, the Persian Gulf and the southern shores of the South China Sea.

Prior to the Second World War, most of the oil from the Middle East came from Iran and Iraq; and if shipped by sea, tankers used the well-worn and comparatively deep-water routes near the north shore of the Gulf to the mouth of the Shatt-el-Arab. Oil was discovered in 1932 in Bahrain; and in 1938 and 1939 in Kuwait, Qatar and Saudi Arabia. However, although Bahrain was a thriving oil port by 1936, development of the other three countries was delayed by the war until 1945-1946, although HMS *Challenger* had run test lines in 1939 for the channel into Ras at Tannura.

At the end of the war, the great bight between the Musandam Peninsula and the coast of Qatar were virtually unsurveyed. The oilfields in Qatar being on the west coast at Dukhan where the water is too shallow, an oil terminal needed to be located on the east coast. HMS *Challenger,* returning to the Gulf after an absence of seven years, located and surveyed a comparatively deep-water channel through the reefs to Umm Said where the terminal was built. Once that was done, oil could begin to flow and carried to the rest of the world. For the next 20 years, the Royal Navy surveying ships worked in the Gulf, charting dangers and opening up new channels, as more and more oil was discovered off shore and in the Trucial States. Despite this steady work, there are still areas of unsurveyed waters there, and it is intended to return to survey these areas in the near future.

Farther east, around the coasts of what are now Malaysia and Sabah, the charts had also become sadly out of date. Before the war, there had always been two surveying ships on this station; but due to the pressure to get the United Kingdom coastal charts up to date, this could no longer be managed. It was possible, however, to keep one ship there continuously, working the coasts to take advantage of the monsoons. In 1948, HMS *Dampier,* the first of the converted Bay Class frigates, appeared on station, where it remained for the next 19 years, continuously updating the charts of the east and west coasts of Malaya and Borneo. There are few charts of that area now that are not based on its work. Almost worn out, HMS *Dampier* returned to the United Kingdom in time for Christmas 1967, where it was scrapped.

While the Dampier was being fully occupied around these coasts, it was felt that more effort must be made towards updating the charts of the Pacific Islands, particularly those of the Solomons and Fiji. There, many of the charts were still based on work done in the eighteenth and nineteenth centuries. HMS *Cook* was detached from its United Kingdom surveys and sailed to the Pacific, where it worked in and around the islands from 1957 until 1963, when it was so badly damaged on hitting an uncharted reef in Bligh Water that it had to be sailed home after repair and be scrapped.

The rapid increase in ship draughts in the 1960s increased the concern felt over the charting of the shallow routes, in particular, the Malacca Straits. Surveyed before the war, it was no longer adequate for deep-draught, very large crude carriers, and there were increasing numbers of newly reported shoals. Before its return to the United Kingdom in 1967, HMS *Dampier* surveyed two areas off One Fathom Bank and Cape Rachado; these surveys brought to light a disturbing number of pinnacles which had not been found in the days of lead-line sounding.

This survey and an exploratory survey carried out by the Japanese also showed numerous areas of sandwaves. Because of this finding and the increasing importance of this Strait, the Royal Navy proposed to survey a 10-mile-wide strip down the centre of the Strait; and after consultation with Indonesia and Malaysia, HMS *Hydra* was sent out there in 1969, commencing work at the north-western end of the Strait. This survey was completed in March 1971 and disclosed a great number of potential dangers to deep-draught shipping.

Since the end of 1971, HMS *Hydra* has been working in the Solomon Islands, charting Bougainville Strait in order to locate a deep-draught route through this Strait. On completion of its work in these islands, it will move to Fiji, following a request to assist this newly independent country to chart its waters.

This rapid and sketchy account of a quarter of a century of surveying shows the steady and unspectacular work needed to keep charts up to date and to open up new areas to trade. Over this time, surveying methods have improved vastly. At the beginning of the period, visual methods of control only were possible, which meant that work was confined to daylight hours and as much time was entailed in establishing control as was used in sounding. Now, with the almost exclusive use of radio fixing systems, the time taken to survey an area may well have been cut by two thirds. Satellite navigation and inertial navigation systems mean that off-shore dangers can be fixed accurately and that off-shore

*The original text of this paper, prepared by Captain M J. Baker, Royal Navy, United Kingdom Hydrographic Department, appeared as document E/CONF.62/L.73

surveys do not necessarily have to be tied in to the nearest coastal geodetic net.

The ships of the Royal Navy will continue to work in these waters; and while they have ample work programmed, the Hydrographer of the Navy is always ready to consider requests from other countries for assistance in surveying their waters. This arrangement is in accordance with the report of the *Ad Hoc* Group of Experts on Hydrographic Surveying and Bathymetric Charting,[1] which met at United Nations Headquarters from 31 March to 10 April 1970, and with resolutions 23 and 25 of the Sixth Conference;[2] and it can take a number of forms. In some cases, it will take the form of actual surveys, e.g., Fiji and Maldives. In other cases, it can be training of personnel, technical advice or assistance in setting up or improving Hydrographic Offices. Asian and Far Eastern waters cover a great area; and it is to everyone's interest, not least the littoral States, that they should be adequately charted.

[1] "Report of the *Ad Hoc* Group of Experts on Hydrographic Surveying and Bathymetric Charting", *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.72.I.20), pp. 347-359.

[2] *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.71.I.15), p. 20.

AUTOCARTA—ONE CONSEQUENCE OF RADIO NAVIGATION*

Paper presented by the United Kingdom of Great Britain and Northern Ireland

This paper recounts how the advent of radio positioning systems has increased the capability of the hydrographic surveyor—and also his workload. It then describes an automated system which has been developed to assist the surveyor in his tasks.

Background information

Electronic systems for marine navigation were developed just before and during the Second World War. They were made available for general navigation in the late 1940s, and their potential was very soon recognized as an aid to hydrographic survey. Since, on the frequencies used, the range of the systems was not limited by line of sight, their introduction meant that surveys could be conducted a hundred or more miles from the coastline with an accuracy that was considerably greater than could have been achieved by earlier methods. At the time, these methods were limited to sextant fixes on floating marks, taut wire, astronomical fixes and dead reckoning, alone or in combination.

The surveyor, however, was still not satisfied. The navigational chains were reliable, they made it possible to survey areas he could not have adequately surveyed before and they allowed him to work in any visibility conditions. Their accuracy was, however, less than could be obtained by visual fixes on terrestial objects and was not generally sufficient for the average coastal survey, except in certain limited areas. One early method of improving accuracy was to use a modified navigational system in the two-range mode, thereby considerably improving the geometry of the fix, while, at the same time, providing greater pattern stability by eliminating the overland propagation path necessary in most hyperbolic navigation chains. In a parallel development in several countries, special survey systems were developed which employed a higher propagation frequency; and which had, therefore, a higher inherent relative accuracy. One can today make a general distinction between navigation systems and the positioning systems used by the surveyor. Navigation systems are invariably hyperbolic, permanent, of sufficient accuracy for general navigation; and, above all, foolproof. Positioning systems, on the other hand, may be either hyperbolic or two-range; they are generally transportable and they provide considerably greater accuracy. The price that must be paid for these features is that they require a greater degree of knowledge on the part of the user if accurate positions are to be obtained.

It would not be exaggerating to say that the introduction of electronic positioning systems has transformed hydrography almost to as large an extent as had the introduction of the echo-sounder two decades previously. Field-work may be progressed 24 hours a day and regardless of the visibility, so that much greater quantities of data may be collected. Collecting the data, however, is only part of the story; the work still has to be committed to paper. Soundings must be selected from the echo-sounder trace and drawn on a transparent overlay of the vessel's work. Then, the soundings must be checked by an experienced eye, correlated with adjacent sounding lines and the depth contours inserted. Frequently, one or more fair copies must be drawn to compile the work of the ship and its boats on to a single chart.

In the days of visual positioning, this paperwork was rarely a problem, since it could be done after dark or on the days when poor visibility prevented work. These opportunities, however, are no longer available; and there is now an imbalance between the task of collecting data and that of processing it. Greater output could be obtained from the majority of survey vessels if the surveyors could be relieved of the tedium of reducing their data by hand. The use of a computer ashore is scarcely relevant in this connexion since the majority of major survey ships are entirely self-contained and work far from their base port. The surveyor in charge needs to be able to look at the soundings obtained at least by the following day so that he may plan his next day's work. Where shoals are indicated, additional sounding lines must be run, in order to ensure that the least depth shall be found.

Autocarta—outline of operation

It was against this background that the Autocarta family of systems was developed. Autocarta X (see figure 188) is a self-contained computer-based system, the primary function of which is to collect and edit depth

*The original text of this paper, prepared by C.G. McQ. Weeks, appeared as document E/CONF.62/L.74.

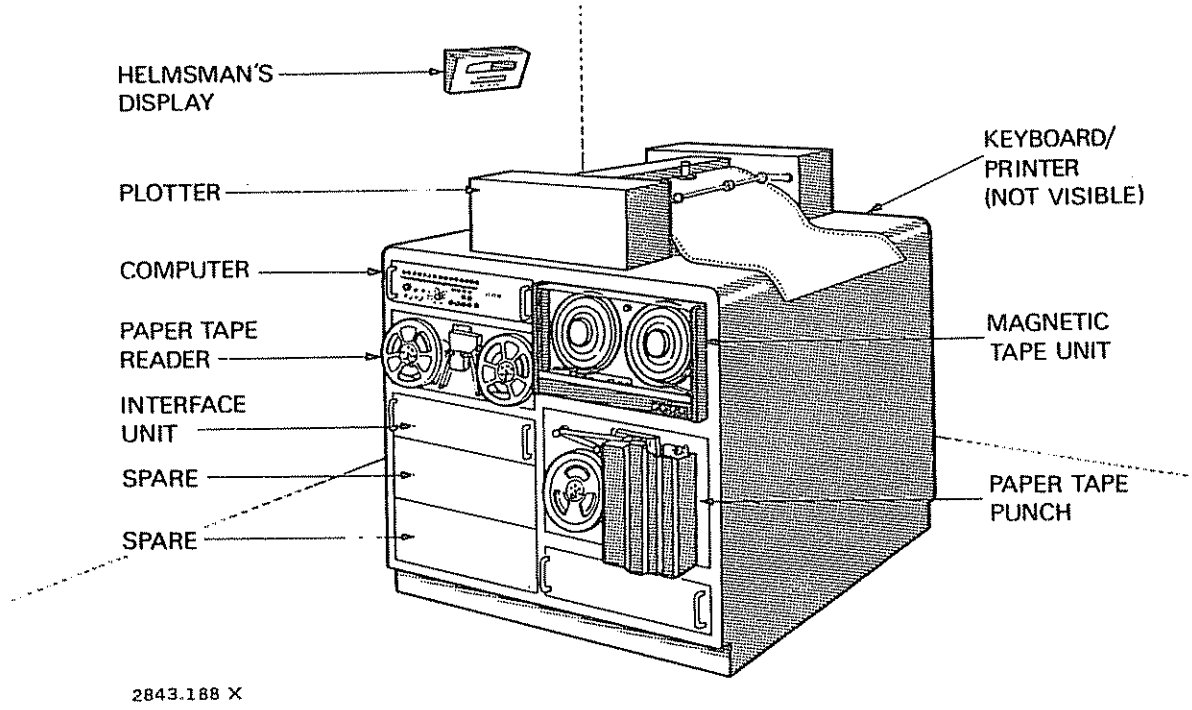


Figure 188. United Kingdom: Autocarta X

and position data, and then to draw the resulting hydrographic chart.

The system is used in two phases, very much as the surveyor works by conventional means. During the day, while the ship is steaming up and down, collecting data, the system is used in the on-line mode (see figure 189). Once a second, the two position values are converted into an *x-y* position and fed to the plotter to give a track plot. From the *x-y* position, the computer calculates the distance of the ship from whatever line the surveyor desires to run and displays this distance on the left/right indicator.

Simultaneously with performing the position computation, the computer is processing depths. Every sounding obtained by the echo-sounder is read in, checked for validity and edited. The depths are then combined with the positions, and the resulting soundings are selected to the scale of the survey. Lastly, they are output on to an intermediate tape, which may be either paper or magnetic. The programme that does this is called "Programme A".

At the end of the day—or at some other convenient time when the tide readings are available—Programme B is put in the computer; the observed tide readings are typed in through the keyboard/printer and the intermediate tape is run back through (see figure 190). The reduced soundings will then be drawn on the plotter, and a paper tape will be punched containing the value of each sounding. This paper tape may be used both to prepare a clean copy of the final chart and for transmittal to a shore-based data centre for permanent record.

The three systems

The system described above is Autocarta X, which is entirely self-contained. One of the possible applications for these systems is aboard the major survey ships of a government hydrographic agency. These ships normally carry three or four sounding boats, and it is desirable that the advantages of automation should also be extended to these boats. There are usually size and weight restrictions in these boats, so for them there is a system which is half the size and well under half the cost, and which does half the job. It is called Autocarta B—for boat. The system is used on line in a similar manner to an X system, but at the end of the day, when the boat returns to the ship, the tape is taken to the mother ship's X system and the chart is drawn there. Therefore, a B system may only be used in conjunction with an X.

The third system of the family is Autocarta P—for port authority. It is designed for applications where the sounding vessel returns to the same port every night, where there is access to a shore-based computer. The system is very similar to Autocarta X in appearance, except that it does not include a plotter, and the magnetic tape unit uses standard IBM-compatible tape. Again, the on-line use is the same as for the X; but at the end of the day, the tape is taken to the shore-based computer. This feature makes the system rather similar to a data-logging system; the major difference is that instead of the shore-based computer being required to process 360,000 soundings, the number taken in 10 hours of work, it is given only the 500–5,000 soundings which will actually appear on the chart. Instead of a large number of relatively complex mathematical conversions from hyperbolic to *x-y*, it is given soundings ready to plot, with only the tidal reductions to be made. In all, this signifies a very substantial reduction in computer load, enough in some cases to pay the additional cost of Autocarta within the first year.

Position conversion

It is appropriate at this point to return to the on-line mode and look in greater detail at the way in which

Programme A works. A sounding is made up of two elements, position and depth; and they should be considered separately. The problem of converting positions from hyperbolic or circular values to x-y is not a difficult one for a computer, but the user should satisfy himself that the method is sound. In Autocarta, all computations are done on the survey grid; and each time a position is calculated, the scale corrections to be applied to the next two position values are recomputed. The algorithm has been checked against a spheroidal solution, in which positions are calculated on the spheroid, in latitude and longitude, and thence converted to grid. Some 20 positions agreed to 0.2 of a metre, using a hyperbolic chain with base lines of 50 and 60 miles, towards the edge of a grid zone.

Depth selection

The depth problem is more complex. Figure 191 shows a hypothetical echo trace, where the saw-toothed effect is caused by the rolling and vertical motion of the sounding vessel. In addition to the sea-bed, echoes can also be caused by fish, wrecks, seaweed and even air bubbles. It is, of course, very important that the chart should be based on the sea-bed and not on all these false echoes; but it should be noted that since these false echoes are almost invariably shoal ones, they will inevitably appear on the chart unless steps are taken to eliminate them at the outset.

For the surveyor, this is a simple task, since he sees the echo trace as a whole, after the event. For the computer, however, it is more difficult. It makes no difference whether it is a large IBM computer ashore or a small mini-computer in a boat, the technique is basically the same; each sounding as it comes in must be compared with past history, and a decision made whether to accept or reject it. In Autocarta, the comparison is a simple one: each sounding is compared with its immediate predecessor; and if the difference exceeds a given value, then that latest sounding is discarded. Obviously, the maximum possible range between consecutive valid soundings will vary with the nature of the bottom, the speed of the boat and the sounding rate of the echo-sounder, so the surveyor has the means of changing the test value. The important thing, however, is that the comparison is made between two soundings 1/10 second apart so that the computer is working on exactly the same information as the human eye—as it must if it is to do as good a job.

Let it be assumed, then, that all of the false soundings have been discarded, and let it be noted in passing that the wreck has also been eliminated. This means that the surveyor must still visually inspect the echo trace to find the wrecks. The next step is to mean the soundings over a period of time—again, selectable by the surveyor between 1 and 5 seconds, depending upon scale, speed and sea conditions. A mean position and a mean time also are calculated for the group of depths. The purpose of meaning depths is to provide some measure of compensation for the effects of rolling and short-period waves, since the mean depth will always be the one to appear on the chart, except over the top of shoal, where the least depth is used.

Let it be assumed that the first group shown in figure 192 was a selected sounding. The programme then goes on, looking at the following groups; and each time the distance is computed, on the chart scale, from the previous selected sounding. As soon as this distance

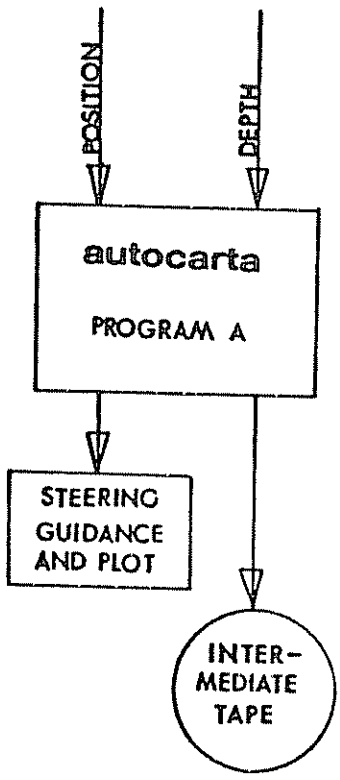


Figure 189. United Kingdom: on-line mode

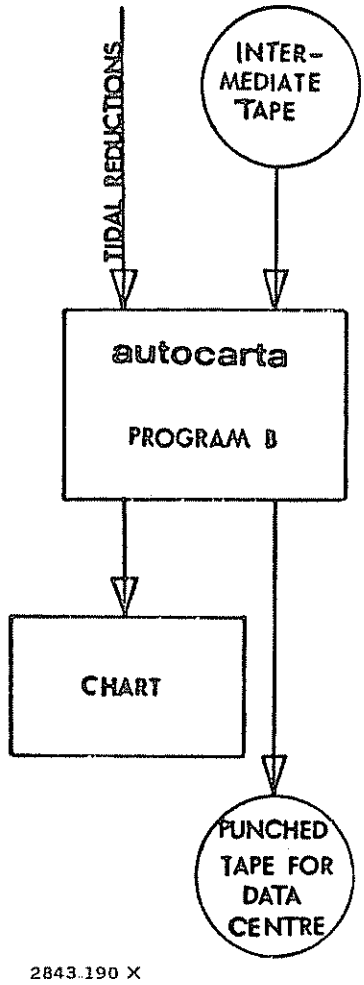


Figure 190. United Kingdom: off-line mode

becomes large enough to write in another sounding, that sounding is selected. However, the programme is always on the look-out for shoals. When one occurs, the preceding and succeeding selected soundings are dropped to avoid overwriting, the shoal is recorded in its correct place and the process continues. Thus, there will normally be a wider gap than usual on one side of a shoal sounding, but this is inevitable if the shoal is to be shown in the correct place without being overwritten. Apart from shoals, where the least depth is used, the mean depth is always the one selected for insertion.

One way in which Autocarta is currently unique among automated systems is that the computer looks at every sounding that is taken; earlier automated systems all had to reduce the amount of data by an arbitrary sampling technique, so that soundings were read once a second, once every 5 seconds or once every 10 seconds. Figure 193 shows the effect of a sampling technique on sounding selection. First, the peak of a shoal has been missed, which could be vital if it happens to lie in a main shipping channel. Secondly, each sounding may be half a metre or so different—either plus or minus—from that which would have been selected by the surveyor, since there can be no compensation for short-period rolling and swell. Lastly, the point marked by an arrow shows that the value in the digitizer at the moment of sampling was a false one. When it reaches the computer, however, the difference from its predecessor looks reasonable and so it is accepted. There is now a false shoal sounding on the chart, with possibly costly consequences. Had the computer been able to compare the false echo with the sounding immediately preceding it, the programme would almost certainly have discarded it.

Checking

One area that is of vital interest to the surveyor is the manner in which the results of the system can be checked. A computer-assisted survey is no less prone to error than any other, since human beings are involved at every stage of the process. The means provided in Autocarta are very much what the surveyor is used to. First of all, a fix mark is drawn on the echo-sounder trace very minute, or every 2 minutes, as selected by the surveyor. At each fix, a print-out gives Time, Pattern I, Pattern II, Easting, Northing and Depth. Lastly, the plotter, which all the time is plotting the current position of the ship in order to give a track plot, draws a cross in the position of each fix. Thus, if the surveyor wishes to check the source of any sounding, he may lay the sounding sheet over the track plot to identify the fix number and go from there to the echo trace to check the depth, or to the print-out to check position.

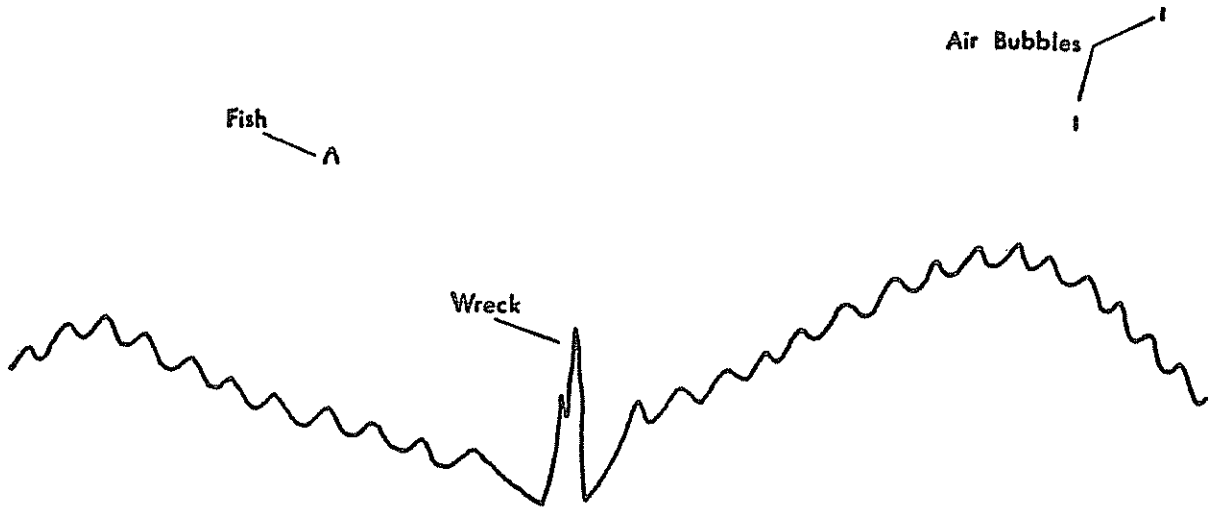


Figure 191. United Kingdom: a typical echo-sounder trace

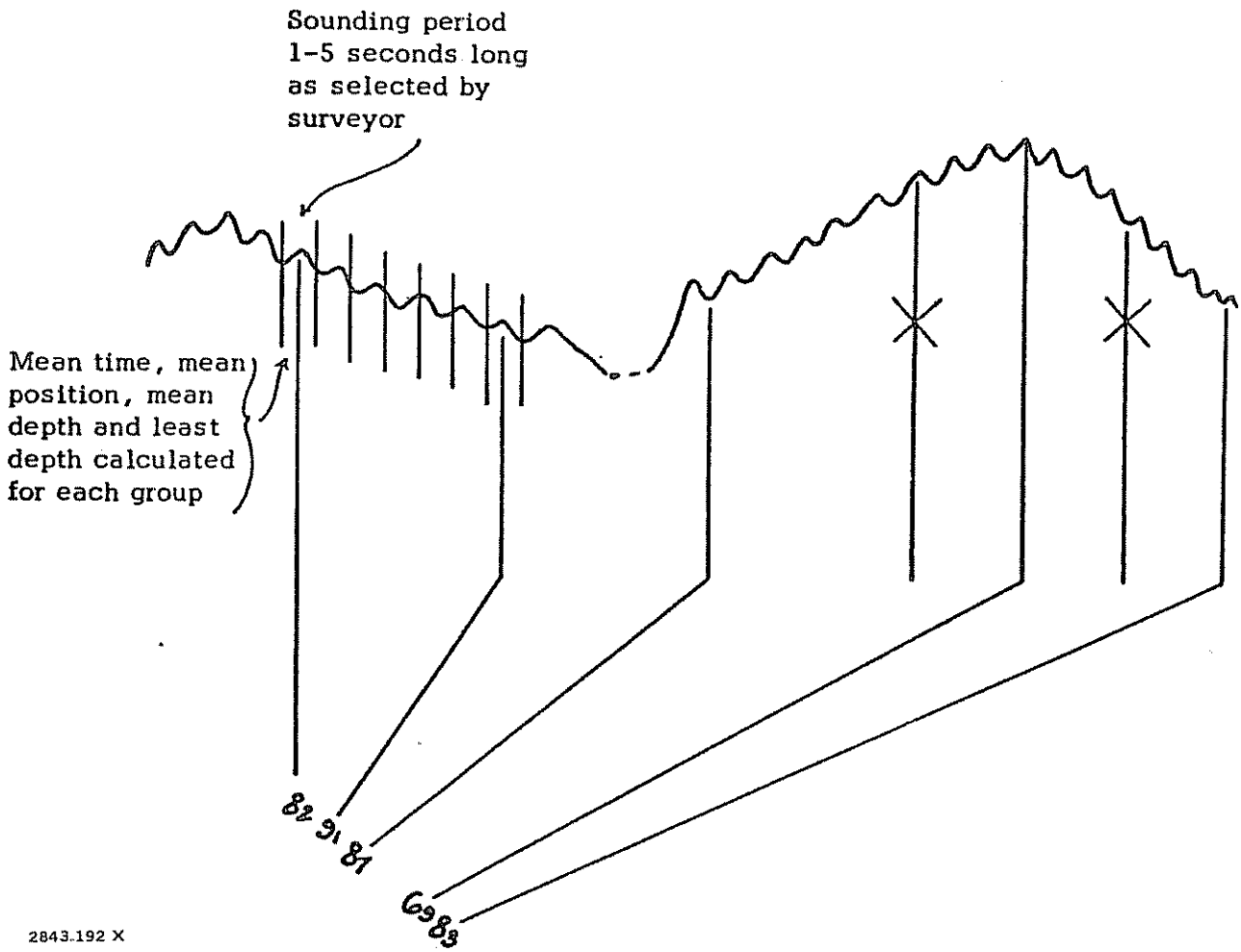


Figure 192. United Kingdom: Autocarta depth selection

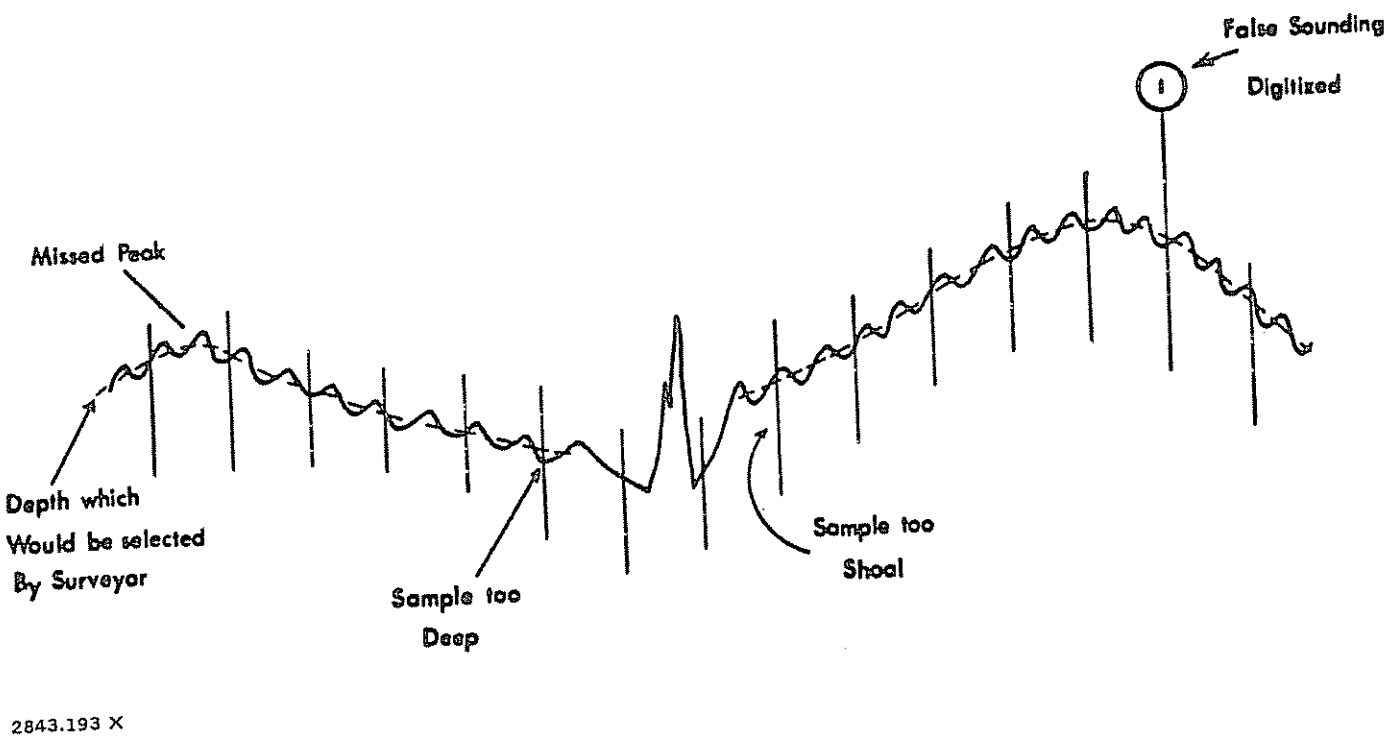


Figure 193. United Kingdom: effect of sampling on depth selection

Ease of operation

Another area of particular interest to the surveyor is ease of operation, since an automated system should be capable of operation by his existing grades of personnel. At the same time, it must be flexible, since the same ship may one month be carrying out a very large-scale harbour approach survey in north-western Europe, and the next be working on, say, the scale 1:200,000 in the south Atlantic. These two factors, ease of operation and flexibility, must, to an extent, work in opposition to each other; and a compromise is necessary.

The approach in Autocarta is to allocate a sequence of 1,000 registers, numbered 0-999; of these, 0-9 are called the "flag registers" and allow the surveyor to exercise options or issue commands, while 10-999 may contain data. Currently, less than half of these registers are being used; the remainder are available for special options. The registers are normally addressed through the keyboard/display, which contains a 12-Nixie display and a 16-key keyboard. The system is so set up that the left-hand three digits show the register number; the next tube, plus or minus; and the remaining eight digits show the content of that register. Where the data are changing—as, for instance, the distance to the end of the line—the display will be updated once a second. Alternatively, the 16 keys may be used to enter new data to that register.

Figure 194 gives an example of how the register is used. The co-ordinates of the line *AB* are entered into registers 50-53 at the start of the day's work. Then, to run any line parallel to *AB*, it is only necessary to enter the offset into register 54. Register 55—and the left/right indicator—will then show distance from that line; and registers 56 and 57 will give distance from either end. Other registers contain the various values involved in the selection of soundings, and still others hold the basic chain data for up to eight different positioning networks.

Benefits

Autocarta and its method of operation have been described briefly. In conclusion, it is proper to consider some of the benefits which can be gained by using it. First of all, there is increased output. Ever since the advent of electronic positioning, there has been an imbalance between the rate at which data can be collected and the rate at which it can be processed. The chart-drawing stages form a bottle-neck which prevents full utilization of the very expensive resources necessary to conduct a survey, the survey ships themselves. With an automated system, the balance is restored; and fieldwork may be progressed through every hour available without fear of creating an unacceptable backlog of paper work.

Another way in which output is increased is less obvious. A survey ship requires guidance if it is to cover the ground rapidly and economically; and, in the past, this has been obtained by following the position lines of the fixing system. However, with a hyperbolic system, these lines converge and the inner ends will necessarily be oversurveyed if the correct spacing is not to be exceeded at the outer end. With a computer aboard the vessel, the sounding lines can be straight, parallel and in any direction. The United States Coast and Geodetic Survey, as it was then called, has proved a 30 per cent increase in output from this cause alone.

With Autocarta, the soundings can be looked at on the day they are taken; and the final chart could, if required, be drawn within hours of completing the fieldwork. This time spent is in contrast to the weeks or months that such work customarily takes.

The arguments, thus far have applied mainly in comparison with the hand-processing of data. Some organizations already have a measure of automation by means of a data-logging system, and the comparison there also should be discussed.

The principal advantage of Autocarta lies in the considerable reduction, for a P- of elimination, for an X- of shore-based computer costs. The expense of processing hydrographic data on a shore-based computer, if the job is to be done properly, is considerable; the savings can be shown to pay the cost of an Autocarta within the first one or two years.

A principle disadvantage of the data-logging technique, which hitherto has prevented its more general introduction, is that the vessel must return each night to the same port. With Autocarta X, this return is not necessary; yet, the less costly P version is also available where such a restriction is acceptable.

There is also a psychological advantage to Autocarta which should not be overlooked. The surveyor remains in charge of the whole process from beginning to end. The final product is a chart for which he is responsible and to which he may sign his name. He is not a mere pawn, collecting what are to him meaningless rolls of paper or magnetic tape. The effect on job satisfaction is obvious.

The final advantage of Autocarta is increased accuracy, which may sound a daring claim, but it is one which can be substantiated, as is shown in figure 195. The soundings were taken in Tor Bay, England; and there are several features here that deserve attention. First of all, there are the figures themselves. Although this is a Xerox copy of a Xerox copy, the digits are still recognizable, because they were specially designed for Autocarta. The normal computer-drawn figure uses the same shape for the 3, the 6, the 8 and the 9, all of which tend to become indistinguishable blobs when they are photo-copied, and particularly if they are photo-reduced.

Next, look at the depth contours, which are at 1-dm interval, about 4 inches apart, which shows how flat the bottom was in Tor Bay. Every surveyor knows how difficult it is to draw straight-depth contours over a flat muddy bottom, although logic tells him that they should be straight. The author is of the opinion that there will be agreement that these contours are straight, consistent and believable, although they are at such a fine separation. To have obtained the same result by hand would have required a degree of diligence that is not commonly given to the task.

Lastly, to offset the claim of increased accuracy, there are two obviously false soundings at the north-western end, a 2-4 and a 2-5 in the middle of the 12s and 13s. When this was seen, the sounding sheet was laid over the track plot to identify the fixes at which the soundings were taken. This indicates that one was taken at 55 fix and the other just after 57, and the actual echo trace may be seen in figure 196.

The digitizer response—the lower mark—shows that the sea-bed was being correctly digitized except at 55 fix and at 57 fix, where there are gaps. At these points on the

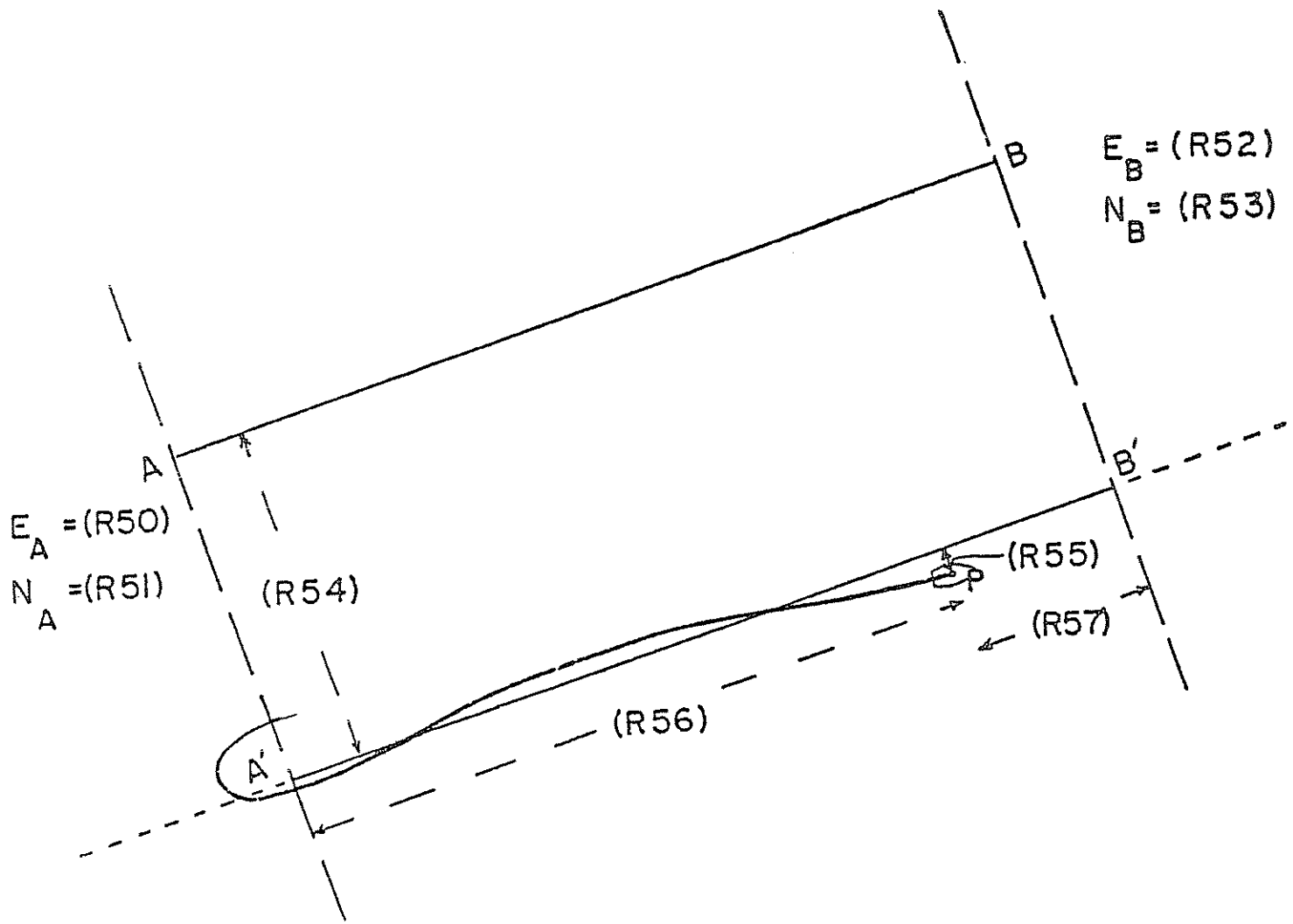


Figure 194. United Kingdom: illustration of use of registers

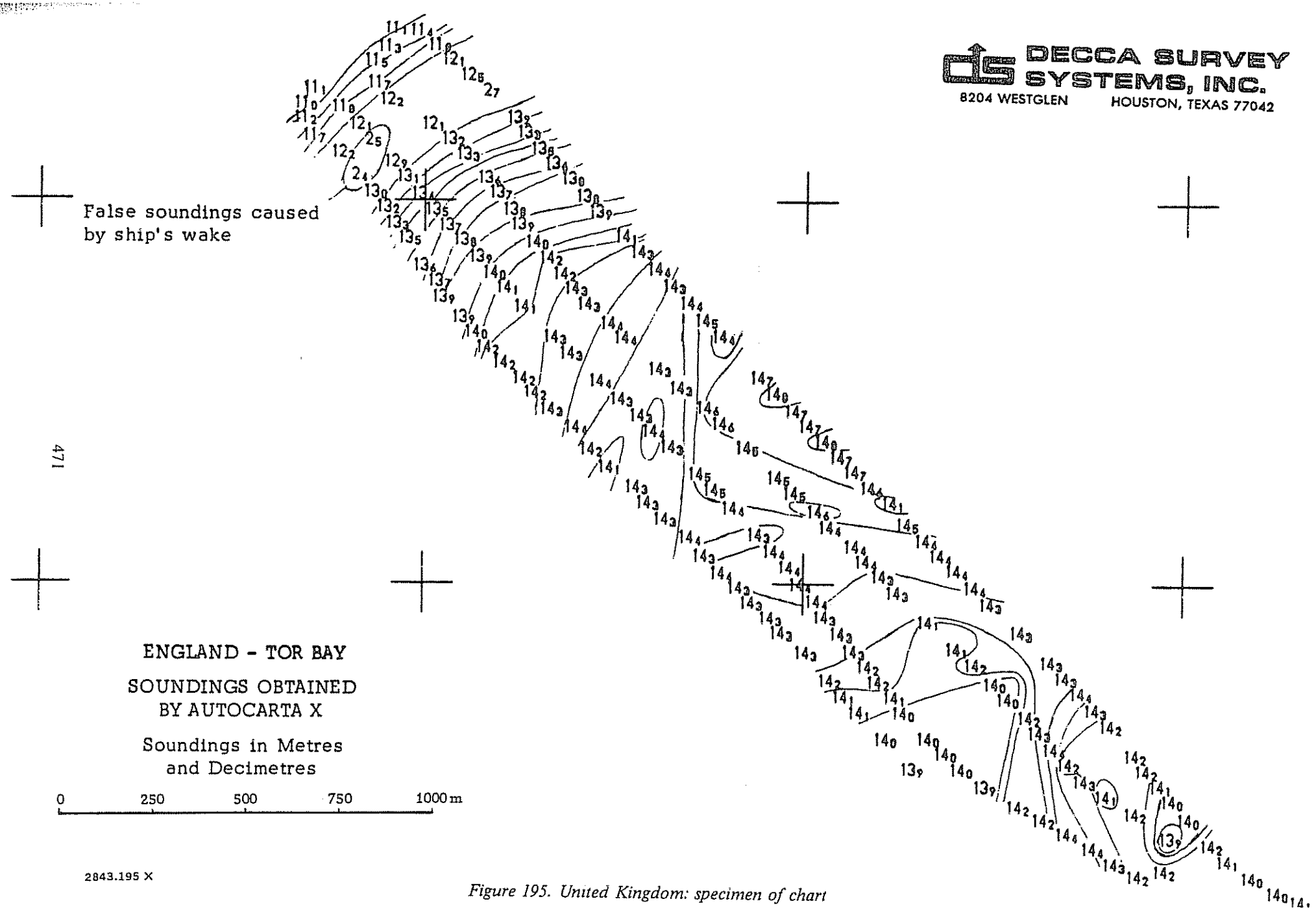


Figure 195. United Kingdom: specimen of chart

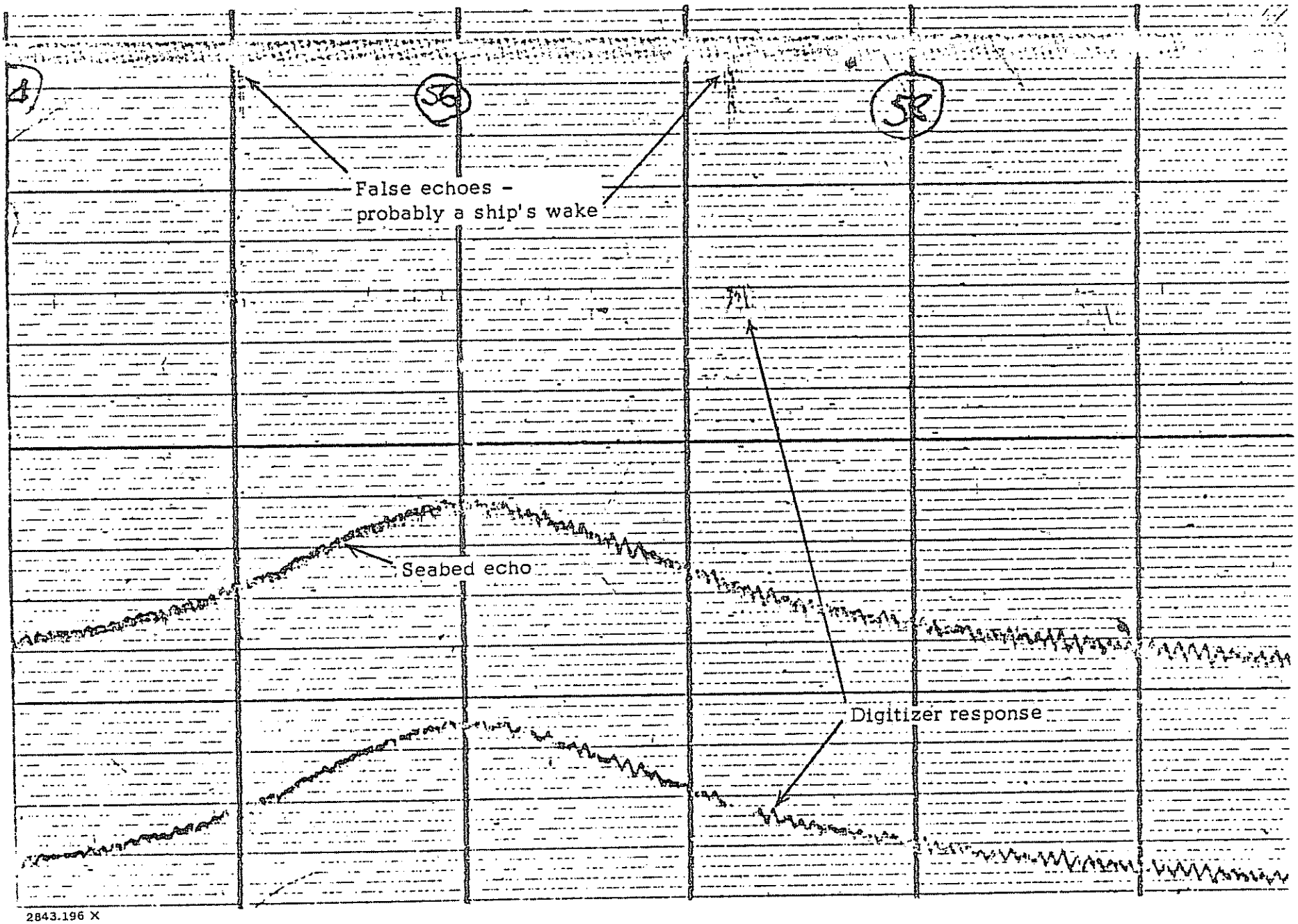


Figure 196. United Kingdom: section of echoes showing false echoes

trace, a much shoaler a digitizer response can be seen, caused by a near-surface echo, which could have been fish, but which was more probably the wake of another ship, and which has obviously given rise to the false soundings. It might well be asked why the software check did not eliminate the erroneous values. The reason was that this was the first time that the system had been used in Tor Bay; and the allowable distance between consecutive soundings had been set at 1 m, which successfully discarded the first eight or nine depths. However, every time a sounding is missed, the allowable distance must be increased, so that after 10 soundings had been discarded, the allowable distance was, in fact, 10 m; and shortly after that one of the false soundings would have got through. Once it was accepted, of course, it would inevitably appear on the chart.

Had the allowable difference been set to 2–3 dm, those false depths would all have been discarded. However, the surveyor would have been no better off; he would still have had to go back to the original raw data to find out why there was a gap in the soundings and to take the correct value off the trace.

The moral of this is that surveyor is just as essential as he has been in the past. He must still go through the echo trace to scan for wrecks; when the chart is drawn, he must look at every sounding, draw the depth contours, and check the source of any sounding he mistrusts. The major difference is that 98 per cent of the tedious "donkey" work has been done for him, and he can save his energies for the tasks that require his judgement and discrimination.

TIDE AND CURRENT PREDICTIONS BY ELECTRONIC COMPUTER IBM S/360 E-30*

Paper presented by the Philippines

In the Philippines, the Bureau of Coast and Geodetic Survey (BCGS) has been, since 1952, the sole government agency responsible for tide and current predictions and the publication of the Tide and Current Tables. The Bureau has six primary tide stations and five reference stations in various parts of the Philippines.

Calculating machines were used in the computation of harmonic constituents, astronomical argument factors, time of moonrise and moonset at the six tide stations and the times of sunset and sunrise at local civil time. The actual prediction of tide and currents at six tide and five current stations were calculated by the use of a 32-component Doodson-Lege tide-predicting machine.

Inasmuch as the machine used in the tide and tidal current predictions has limited capabilities, as it could not hold on to more than 32 harmonic constituents, the office replaced it with electronic IBM computer S/360 E-30 in 1967, after personnel had completed training in IBM programming.

General description of the prediction programmes

The maximum and minimum daily measurements in the prediction of both tides and currents are determined by the zeros of a function of sinusoidal character.

All computer programmes were designed to conform with the specification of a Fortran IV language. Eventually, due to the limitation of core memories of the level-E model, the prediction programme was segmented into the following three programmes with their respective programme identifications:

(*a*) Tide: a programme to predict the height and time of high and low tide;

(*b*) Flow: a programme to predict the time and maximum magnitude of current velocity in phases of ebb and flood;

(*c*) Slack: a programme to predict the time of zero velocity (slack water).

The calculation of tide and tidal current involves a function of sine and cosine, and will require the use of these functions a number of times, necessitating the use of the computer for prolonged periods. In order to shorten the use of the machine, a cosine table was stored in memory and generated by the programme itself. Moreover, it was calibrated on an allowed tolerance which will not affect the accuracy of the predicted value.

Mathematical development of the programme

Prediction of times and heights of high and low waters

The problem of prediction is to find the values of time, t, which will satisfy:

$$dy/dt = \sum_{n=1}^{N} o_n f_n H_n \cos\left(v_n + u_n - g_n + o_n t + \frac{\pi}{2}\right) = 0$$

where:

o_n = speed of the nth constituent;
f_n, v_n, u_n, = astronomical arguments for the nth constituent;
H_n = means amplitude of the nth constituent;
g_n = phase lag of the nth constituent;
N = number of harmonic constants.

This is done by an iteration process which was proved to converge to value t.

To obtain the height, the value t is then substituted in:

$$Yt = Z_o + \sum_{n=1}^{N} f_n H_n \cos\,(v_n + u_n - g_n + o_n t)$$

where: Y_t = height of tide at time t;
Z_o = elevation of mean sea level above datum plane of prediction, which in this case is mean lower low water.

Prediction of times and velocities of ebb and flood follows the procedure for tide prediction. An additional problem is the determination of time when velocity is zero, which is done by solving for time, t, which will satisfy the following equation:

$$V_t = V_o + \sum_{n=1}^{N} f_n H_n \cos\,(v_n + u_n - g_n + o_n t) = 0$$

*The original text of this paper, prepared by Claudio S. Ramos, Acting Geophysicist, Bureau of Coast and Geodetic Survey, the Philippines, appeared as document E/CONF.62/L.95.

where: V_o = velocity of any permanent current along the axis in which the prediction is to be made.

The amplitude, H_n and g_n, of each constituent are constant on every specified locality for which the prediction is required and have been determined by means of harmonic analysis from a long series of tidal observations.

The angular speed, o_n, is constant on each constituent.

The nodal factor, f_n, used to determine the true amplitude of each component; and the equilibrium argument, $(v + u)_n$, of each component depend upon the year of prediction which are computed following the mechanics presented in A. T. Doodson's article on tidal analysis.

Numerical solution

The method for the numerical solution of transcendental equation falls into two categories.

(1) Methods that make use of the behaviour of the derivatives;

(2) Methods that find zero only according to the function's sign.

The second method, although converging slowly, is very applicable in the solution of the function which is sinusoidal in nature.

It is so applicable by the inversion of sign method considerably finding all zeros of the transcendental equation in the interval upon the condition that the minimum intervals in which a single solution exists be known. Its accuracy, however, can be enhanced to the maximum number of significant digits, depending upon the capabilities of the computer in use.

Inversion of sign method

The finding of the zeros of a function is obtained by beginning from an initial point of desired prediction of a selected field definition and increasing the value of the time variable. At each increment, the value of the function is calculated. When the sign of the value calculated is equal to that of the preceding point, the independent variable is further augmented. However, in the case where the signs are not equal, it is necessary to return using one half the increment of the time variable.

The augmentation is continued until the desired accuracy for the time variable is obtained, calculating that the transcendental function being examined is zero.

When the times of high and low water are found, the time variable is increased by a constant amount. The above-described procedure is repeated up to the completion of the desired prediction.

Fortran programme

Block diagram

The block diagram refers to the tide and current calculation. However, because of the limited memory of the computer used, separate programmes for tides and current predictions have been prepared.

In the prediction of the speed of tidal current, it is also important to calculate the instant when the velocity is zero (slack-water time). Although it can be integrated in the current prediction programme, another programme has been prepared, also due to the memory limitation of the computer.

Figure 197 depicts the logical flow of instructions used in calculating high and low tides.

The following symbolic names were used:

MONTH:	name of the month of the year;
NTHDAY:	number of days of the month;
JOBS:	number of ports to make prediction;
IMONTH:	first month of prediction;
LMONTH:	last month of prediction;
DHDT:	value of the derivatives at any instant;
T:	any instant within the scope of prediction;
HTS:	computed height at any given time;
STEP:	that value augmented to time;
OVRN:	value is 1 when an overrun of prediction of one month is desired.

Coding

The Fortran programme makes use of the symbols in the diagram. For those who know Fortran language, it is easier to comprehend the logics of the programme.

The programme is designed to read 30 cards of cosine values, accurate to the allowed tolerance, and generates its cosine table to be used in the computation.

After complete access to the parameters required, two control cards are read for use at different times in finding the zeros of the function by the inversion of sign method.

Predictions for the required years are made, one port at a time. However, prediction can be begun any time of the year depending upon the prediction requirements. It also avails of an overrun, i.e., the prediction of the value of January which immediately follows the end of the year of prediction, to check the validity of the following year constants.

When the times of high and low have been found with the applied method, the value of HTS is calculated by means of equation 2. As the time is incremented successively, the result should not be equal to or more than 24 hours. If either case occurs, then the stored computed times and heights are punched in cards and printed on the line-printer.

The process for every port considered will continue until the value of the LMONTH is satisfied.

The work ends when the prediction of the stations under consideration (which is controlled by the values of JOBS) have been calculated.

Conclusion

The calculation of tide and tidal current values using the above-mentioned method is a complete simulation of the calculation by the use of the standard tidal-predicting machine.

Before this system was approved for use, a thorough examination of the predicted values of both systems was made. Some differences were found in predicted values. Upon further verifications from the machine prediction rolls, differences were found to be due to human error.

Currently, statistical examination of the predicted and observed values are carried out, and differences of

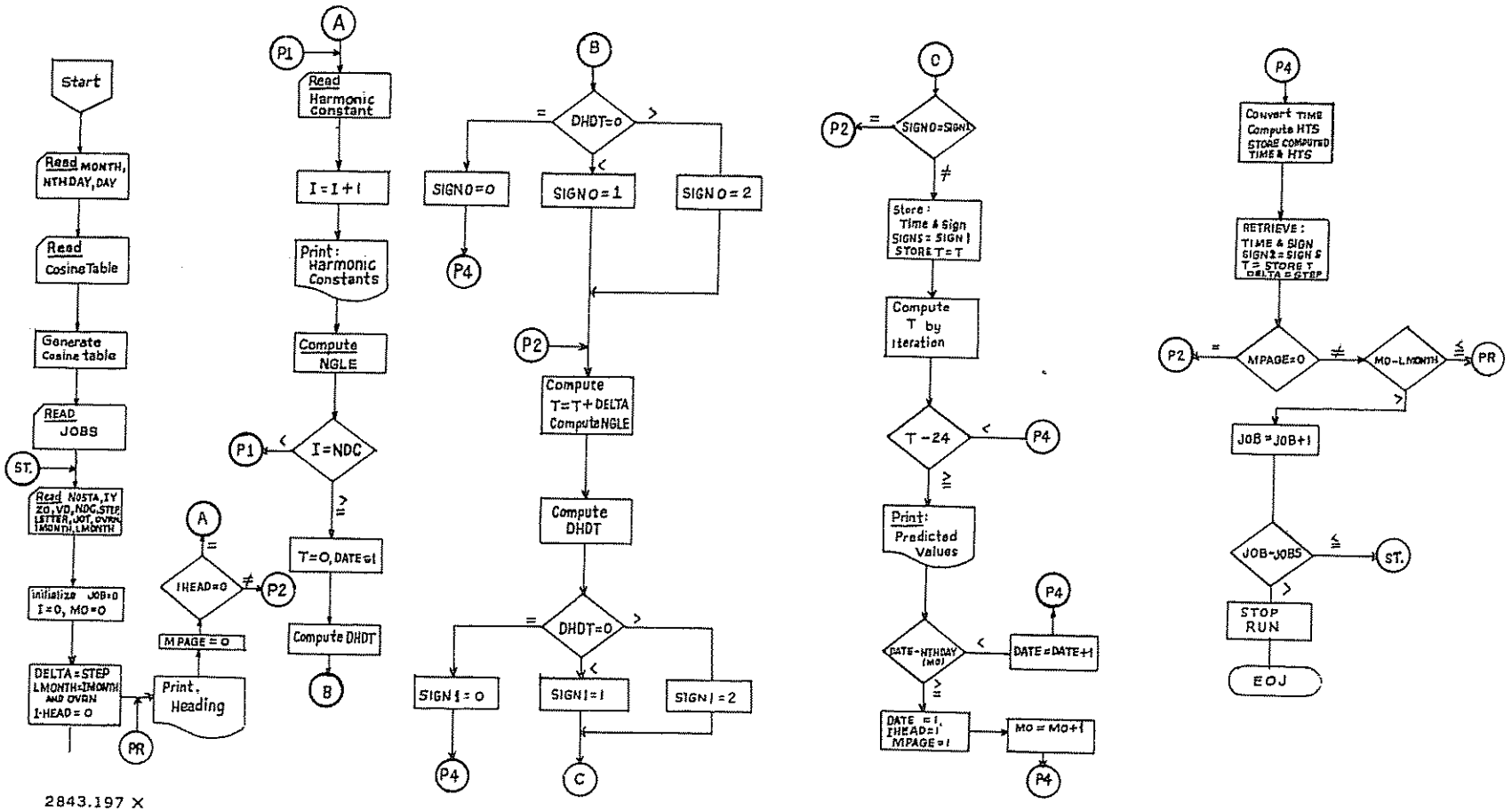


Figure 197. Philippines: block diagram of tide and current calculation

appreciable values are noted. These differences may be the effect of meteorological interferences. However, a harmonic analysis is being prepared for the updating of the harmonic constant.

Final outputs of the three programmes of specific formats are presented in the annex.

ANNEX

Table 1. San Fernando Harbor, Philippines: times and heights of high and low waters, February 1975

	Day	Time	Ht. ft.	Time	Ht. ft.	Time	Ht. ft.	Time	Ht. ft.
1	Saturday	06.50	0.1	13.31	0.9	19.00	0.5		
2	Sunday	00.02	0.8	6.32	0.2	14.07	1.2		
3	Monday	05.49	0.1	14.52	1.5				
4	Tuesday	03.44	−0.1	15.43	1.8				
5	Wednesday	03.06	−0.4	16.36	1.9				
6	Thursday	03.34	−0.6	17.30	2.1				
7	Friday	04.10	−0.6	18.20	2.1				
8	Saturday	04.42	−0.6	19.07	2.1				
9	Sunday	05.11	−0.6	19.48	2.0				
10	Monday	05.33	−0.5	20.24	1.9				
11	Tuesday	05.47	−0.4	20.56	1.8				
12	Wednesday	05.55	−0.2	21.27	1.6				
13	Thursday	05.56	−0.1	11.58	0.3	13.17	0.3	21.57	1.5
14	Friday	05.56	0.1	11.45	0.5	15.06	0.4	22.29	1.3
15	Saturday	05.55	0.2	11.59	0.7	16.42	0.5	23.03	1.0
16	Sunday	05.51	0.2	12.26	0.9	18.32	0.5	23.40	0.7
17	Monday	05.40	0.3	13.03	1.1	21.04	0.4		
18	Tuesday	00.20	0.4	05.13	0.3	13.49	1.4		
19	Wednesday	00.30	0.1	14.42	1.6				
20	Thursday	01.32	−0.3	15.43	1.8				
21	Friday	02.16	−0.5	16.43	2.0				
22	Saturday	02.58	−0.7	17.42	2.2				
23	Sunday	03.36	−0.7	18.39	2.3				
24	Monday	04.11	−0.7	19.32	2.2				
25	Tuesday	04.39	−0.6	20.24	2.1				
26	Wednesday	05.00	−0.4	10.59	0.2	12.37	0.2	21.15	1.8
27	Thursday	05.10	−0.1	10.38	0.5	14.47	0.2	22.05	1.4
28	Friday	05.10	0.2	10.52	0.8	16.32	0.2	22.56	1.0

Table 2. San Bernardino Strait: times of slack water, February 1975

	Day	Time	Time	Time	Time
1	Saturday	01.32	07.08	14.42	19.19
2	Sunday	02.34	07.25	15.23	20.30
3	Monday	04.10	07.29	16.12	21.57
4	Tuesday	17.14	23.55		
5	Wednesday	18.21			
6	Thursday	01.30	19.27		
7	Friday	02.34	20.23		
8	Saturday	03.19	21.12		
9	Sunday	03.57	21.53		
10	Monday	04.29	12.21	14.21	22.30
11	Tuesday	04.55	12.32	15.17	23.06
12	Wednesday	05.19	12.45	16.04	23.40
13	Thursday	05.42	13.00	16.47	
14	Friday	00.15	06.02	13.17	17.30
15	Saturday	00.51	06.21	13.40	18.15
16	Sunday	01.32	06.40	14.06	19.02
17	Monday	02.25	06.57	14.38	19.57
18	Tuesday	03.49	06.49	15.19	21.02
19	Wednesday	16.15	22.29		
20	Thursday	17.25			
21	Friday	00.25	18.38		
22	Saturday	01.49	19.42		
23	Sunday	02.45	20.40		
24	Monday	03.30	11.57	13.27	21.32
25	Tuesday	04.10	11.57	14.42	22.21
26	Wednesday	04.44	12.04	15.42	23.10
27	Thursday	05.12	12.19	16.38	23.57
28	Friday	05.36	12.38	17.32	

Table 3. San Bernardino Strait: tides, February 1975
(*Flood*(+), *dir. 225 deg. true; ebb*(−), *dir. 45 deg. true*)

	Day	Time	Vel. knots	Time	Vel. knots	Time	Vel. knots	Time	Vel. knots
1	Saturday	04.37	−3.8	10.37	5.7	17.18	−2.4	22.48	4.5
2	Sunday	05.20	−2.3	11.12	5.3	18.14	−2.6	23.46	3.4
3	Monday	06.08	−0.8	11.50	4.8	19.16	−2.7		
4	Tuesday	01.01	2.4	07.10	0.6	12.37	4.3	20.25	−2.9
5	Wednesday	04.31	2.4	08.29	1.5	13.40	3.9	21.37	−3.2
6	Thursday	05.46	3.2	09.52	1.8	14.57	3.8	22.44	−3.8
7	Friday	06.35	3.8	11.05	1.5	16.10	4.1	23.40	−4.5
8	Saturday	07.12	4.4	12.01	0.8	17.12	4.5		
9	Sunday	00.25	−5.1	07.44	4.8	12.42	0.1	18.01	5.0
10	Monday	01.05	−5.5	08.12	5.0	13.20	−0.7	18.44	5.4
11	Tuesday	01.40	−5.6	08.31	5.2	13.55	−1.3	19.23	5.7
12	Wednesday	02.14	−5.5	08.42	5.3	14.31	−1.7	20.01	5.9
13	Thursday	02.48	−5.1	08.59	5.5	15.05	−2.0	20.38	5.8
14	Friday	03.20	−4.5	09.22	5.5	15.38	−2.2	21.18	5.6
15	Saturday	03.50	−3.7	09.50	5.4	16.10	−2.3	21.55	5.1
16	Sunday	04.16	−2.7	10.20	5.2	16.46	−2.3	22.37	4.4
17	Monday	04.42	−1.6	10.48	4.8	17.29	−2.2	23.25	3.7
18	Tuesday	05.12	−0.5	11.18	4.3	18.31	−2.2		
19	Wednesday	00.31	2.9	05.57	0.7	11.50	3.8	19.50	−2.3
20	Thursday	02.08	2.5	08.20	1.6	13.03	3.4	21.10	−2.8
21	Friday	05.22	3.2	09.55	1.8	14.37	3.3	22.22	−3.6
22	Saturday	06.10	4.2	11.07	1.3	15.53	3.8	23.22	−4.7
23	Sunday	06.48	4.9	11.59	0.6	16.55	4.5		
24	Monday	00.12	−5.6	07.20	5.5	12.42	−0.4	17.52	5.3
25	Tuesday	00.55	−6.2	07.46	5.9	13.22	−1.4	18.44	6.0
26	Wednesday	01.37	−6.3	08.07	6.1	13.59	−2.3	19.33	6.4
27	Thursday	02.16	−5.9	08.29	6.2	14.37	−3.1	20.20	6.5
28	Friday	02.55	−5.1	08.55	6.2	15.16	−3.6	21.05	6.3

THE BATHYMETRIC MAPPING OF THE AUSTRALIAN CONTINENTAL SHELF*

Paper presented by Australia

The Australian Continental Shelf, to a depth of 200 m, covers an area of approximately 2.1 million km². Of this, some 20 per cent has already been surveyed by the Hydrographic Service of the Royal Australian Navy, in dispersed blocks of varying size, to acceptable modern standards.

In order to depict the shelf in sufficient detail for bathymetric mapping at 1:250,000 scale, lines of soundings are usually surveyed at a basic spacing of 1,500 or 3,000 m, usually between the 20-m contour at the inshore boundary and the 300-m contour at the outer edge of the shelf. This spacing of sounding lines is varied, depending upon the relief of the sea-bed; and it is expected that two thirds of the continental shelf area can be adequately portrayed by sounding lines spaced at 3,000 m. On the other hand, areas of complex sea-bed topography will require special sounding patterns.

The Bathymetric Mapping Branch of the Division of National Mapping commenced the programme in 1971, with a small staff and contract assistance. Staff and equipment are currently being augmented with the objective of making the Branch more self-sufficient and increasing the rate of production.

Three contracts have been completed covering the area of the shelf between Sandy Cape on Frazer Island, Queensland and New South Wales/Victoria border; and an area off Port Hedland, Western Australia. It was a requirement of the first contract that dual positioning systems be used, one of which was to be a radio or radar system; and the other, a system combining Doppler satellite, sonar Doppler and gyro-compass observations in order to permit an assessment of the accuracy and reliability of the latter system for bathymetric survey.

It did prove suitable, and divisional operations in the Timor Sea area commenced during May 1973, with a computer-integrated form of this equipment aboard the Department of Transport Navaids vessel MV *Cape Pillar*.

The impetus on acquisition of data will be accelerated during 1974, and the entire programme is currently planned for completion in 1980.

In the case of subsequent contract operations, the contractor has been required to provide an acceptable radio or radar positioning system and to instal one of the Division's satellite positioning systems. The observations from the latter equipment are used by the Divisional Inspecting Surveyor to confirm the positioning accuracy of the contractor's equipment.

During the survey, the positioning and uncorrected depth data are plotted continuously, as well as being recorded in a sounding log-book. In this way, predetermined lines of sounding can be maintained, positioning data are checked and areas of sea-bed relief requiring further sounding are brought to notice while in the area. The plot sheet is then used to provide a base from which the manuscript map is drawn on the scale 1:150,000. This map shows each position fix, usually at approximately 1,000-m spacings along the sounding lines, and the depth data corrected to mean sea level from which contours are interpolated.

The bathymetric maps derived from the manuscripts are produced in two colours and follow basically the same sheet lines and format as the 1:250,000 topographic map series of Australia. An index to the bathymetric map series, showing also the approximate 200-m isobath around Australia, is shown in figure 198. This index also shows the progress to date of the bathymetric mapping and should be viewed in conjunction with figure 13 in the report on cartographic activities in Australia,[1] which shows the state of hydrographic surveying around Australia, as hydrographic survey information is being utilized in the preparation of bathymetric map compilations.[1]

Some planimetric detail is shown on land areas, while at sea isobaths are drawn at 20-m intervals up to the 300-m isobath. Spot depths are shown to indicate significant changes from an even gradient between contours. No information is shown at depths greater than 300 m due to the generally less accurate and often sparse information available.

The map carries a caution note to the effect that it is not produced for navigation purposes, as, unlike hydrographic charting, no effort is made to indicate possible hazards to shipping or to depict navigational information; nor are the depths related to the type of datum used for charts.

Apart from the close liaison maintained with the Hydrographer of the Royal Australian Navy, to avoid duplication of effort and to ensure that bathymetric surveys should assist the hydrographic charting programme, other requirements have emerged for which data can be usefully collected during the course of bathymetric survey operations.

Inclusion of other scientific data collection activities in conjunction with survey operations is restricted to those which do not interfere with the basic purpose of providing bathymetric information at the required production rate. Thus, seismic, gravity and bottom-sampling are not undertaken, as these tasks would slow down the progress of the survey by at least 50 per cent. However, the operations already include the following secondary observations for other agencies.

Sea-surface temperature is continuously recorded at the request of the Division of Fisheries of the Commonwealth Scientific and Industrial Research Organization. Equipment of the Bureau of Meteorology is carried, from which six-hourly weather reports are telegraphed to the Bureau while the vessel is at sea. Magnetometer observations are recorded using equipment provided by the Bureau of Mineral Resources, in order to provide detailed magnetic anomaly data. The Bureau of Mineral Resources has also requested that subbottom profile data be acquired, and this matter is currently being investigated with a view to providing suitable data for their purposes. The Bureau has already made use of the bottom profiles, from which the bathymetric data are extracted, to study the micro-geomorphology of the sea-bed.

*The original text of this paper, prepared by Division of National Mapping, Department of Minerals and Energy, Canberra, appeared as document E/CONF.62/L.114.

[1] "Cartographic activities in Australia 1970–1973" (E/CONF.62/L.35), pp. 3–21.

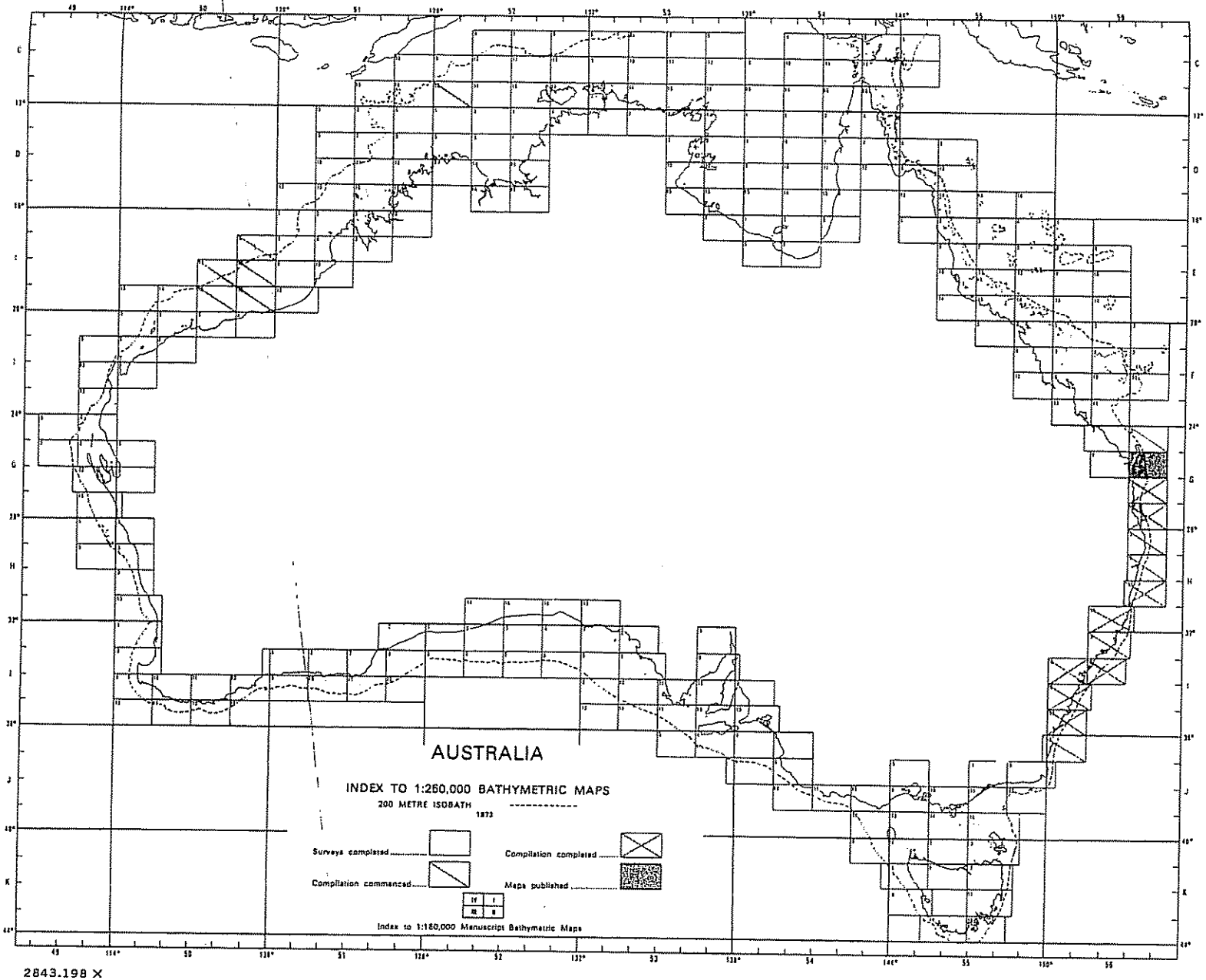


Figure 198. Australia: index to 1:250,000 bathymetric maps

Recently, the Division of Fisheries of the Department of Primary Industry has studied the echo-sounder charts obtained in previous surveys and has found that a great deal of information can be extracted on the nature of the sea-bed and fish distribution to assist in trawling operations. Further co-operation is currently under way to provide more adequate information in this respect.

There seems little doubt that further co-operation will develop during the course of the programme; and that, even though the surveys remain basically bathymetric, much additional scientific data of value to various disciplines can be collected without detriment to the programme.

Lastly, the following are some production figures from the MV *Cape Pillar* survey, using satellite/sonar Doppler positioning equipment:

(*a*) Period of survey, 12 weeks;
(*b*) Days on which soundings were made, 38;
(*c*) Days lost due to equipment malfunction, 29;
(*d*) Line-miles sounded, 5,420.

These figures include the commencement period when considerable time was lost due to equipment malfunction. Production during the last five weeks of the period was 3,875 line-miles. Substantial reliance on electronic maintenance support has been found necessary during the survey.

THE ROLE OF THE INTERNATIONAL HYDROGRAPHIC ORGANIZATION IN FOSTERING INTERNATIONAL CO-OPERATION IN HYDROGRAPHY*

Paper presented by the International Hydrographic Organization

Of all the branches of cartography and surveying, hydrography is one which has had major international significance over a considerable period of time, primarily for reasons of practical necessity. It is only in comparatively recent years that an international demand has been generated for land maps, as a result of increased communication facilities; but the mariner, by his very profession, has always needed to know the water routes of countries with which he has traded.

For many centuries, mariners have been required to use charts of foreign ports and to interpret these in foreign languages. Thus, in the interests of peaceful trade, as well as for strategic reasons, there was a pressing need for standardization of charts at an international level.

Hydrographers, charged with providing charts for the merchant fleets of their countries, recognized this requirement and therefore felt the urgent need for co-ordination effort with the objective of standardization. Delayed by the hostilities of 1914–1918, they finally united, largely due to the energetic activities of Ingénieur Hydrographe Renaud, the French Hydrographer of the time; and the first Hydrographic Conference took place at London in 1919.

This Conference laid the foundations of the present International Hydrographic Organization (IHO), and it is remarkable that today, over 50 years later, the activities of the Organization follow so closely the aims then laid down.

The headquarters of IHO, the International Hydrographic Bureau in Monaco, pursues the objectives of international co-ordination in this field, the scope of which is being continuously broadened as a result of ever-increasing activity in hydrographic surveying and nautical cartography.

During the past 50 years, due to the forum provided by IHO with its regular conferences, which are held every five years, and continuous communication by correspondence, a remarkable similarity in production of charts and ancillary publications has been achieved. National practices have wisely been sacrificed to the goal of making these publications intelligible to navigators from any part of the world. Language problems have been overcome, symbols and abbreviations have been standardized and a great deal has been achieved towards standardization of light lists (lists of lighthouses and their characteristics), sailing directions (written descriptions of coasts, ports and dangers, and directions for safe sailing) and tidal information.

Over the period of half a century, through the co-ordination of IHO, many countries of the world have contributed knowledge of bathymetry outside their national boundaries towards a data centre, so that a data bank could be built up for the benefit not only of seamen, but of scientists who are now so active in the seas. The General Bathymetric Chart of the Oceans (GEBCO) has been one product of this continued effort.

With its objectives of co-ordination and standardization close to realization, IHO has moved to broader plans. Following the Conference of Hydrographers in 1967, a series of small-scale International Charts has been designed. Realizing that national efforts were, in many cases, leading to duplication of efforts, the idea was promoted of allocating responsibility to a number of volunteering countries for the production of charts for a world coverage of navigable waters. These "producer" countries make charts to a common set of specifications, which are then made available to other countries in a reproducible format so that the latter may, in turn, reprint the original charts rather than each having to compile its own.

The problems associated with such a scheme should not be underestimated, but they have been largely overcome and the members of the International Hydrographic Organization are now looking hard at the possibility of extending the scheme to medium- and large-scale charts.

Meanwhile, the collection and interchange of ocean bathymetric data steadily increases with improved equipment and technology. The requirements of the GEBCO charts have changed in the light of modern oceanography; and IHO, in co-operation with other international scientific organizations, is in the process of modernizing this valuable series of charts.

*The original text of this paper, prepared by Commodore D. C. Kapoor, Director, International Hydrographic Organization, appeared as document E/CONF.62/L.120

The Bureau, as instructed by its member States, continues to produce special publications on a variety of technical subjects of hydrographic interest and regularly publishes the *International Hydrographic Review* and the *International Hydrographic Bulletin*. The *Review* comprises practical, learned and technical articles on every subject connected with hydrography, while the *Bulletin* deals mainly with matters of topical interest.

Charts, more so than maps, have to be kept continuously up to date. The mariner operates over a terrain that is visually obscured, and, therefore, he depends upon charts to a far greater extent than the map user. To keep charts of the world continuously updated for an endless stream of new discoveries, alterations and changes of undersea features, man-made aids and land features is by no means an easy task. It is achieved by regularly published correctional circulars called "Notices to Mariners"; and, for urgent matters, radio navigational warnings. One of the great achievements of IHO has been the standardization and, following from that, the quick dissemination of this vital information to navigators of all nationalities wherever they may be in the world.

The navigator has on hand light lists, sailing directions and tide tables to augment the information on his chart. It is through international co-operation that the mariner can, today, rely on any of these publications published by different hydrographic offices.

A number of developing countries have large areas of poorly surveyed waters and overtaxed resources with which to undertake the work required. One of the concerns of the International Hydrographic Organization is to study the state and progress of hydrography in various parts of the world and the Organization has co-operated with the United Nations in work in this field.

In pursuance of resolution 1313(XLIV) of the Economic and Social Council, a meeting of the *Ad Hoc* Group of Experts was convened at New York in April 1970 to study the question of hydrographic surveying and bathymetric charting, with particular reference to developing countries. The report of this Group was tabled at the Sixth Conference at Tehran in 1970.[1]

The report deals in a comprehensive manner with the status of charting throughout the world and contains a diagram presenting an evaluation of bathymetric knowledge of the oceans[2] as well as a list showing the capabilities of various countries for hydrographic surveying.[3] It will, however, be noticed that in a large number of developing countries, this capability has been listed as either non-existent or inadequate.

Among the salient factors that have an important bearing on the desirability for developing countries to establish their national hydrographic services can be listed the following:

(*a*) Detailed hydrographic knowledge provides essential information for safe navigation—for ships, coastal traffic and fishing-boats;

(*b*) Bathymetric data collected during surveys form the basis for more detailed geophysical and geological investigations undertaken for the purpose of exploration and exploitation of off-shore mineral deposits and hydrocarbons;

(*c*) Even in marine biological research operations undertaken for the exploitation of living resources, the nautical chart is an essential tool;

(*d*) Studies of tidal and current patterns, which normally form a part of all hydrographic surveys, are essential for such operations as the planning of port schemes, dredging operations and studies of coastal erosion and pollution;

(*e*) A modern chart minimizes the risks of groundings at sea, which, in the case of giant tankers, can lead to dangerous coastal and off-shore pollution;

(*f*) A modern chart, based on a good survey, is an essential prerequisite of the delineation of territorial waters and the continental margin of other areas of national jurisdiction.

For the reasons outlined above, it would seem highly desirable that developing countries should give very serious consideration to establishing their own national hydrographic services as a matter of priority.

At first, much could be achieved by establishing a simple and unsophisticated service. The first essential would be an authority to be responsible for hydrography who could assess the needs and establish an office with a small cartographic and clerical staff. This group could immediately initiate notices to mariners, and collect and disseminate other information essential for navigation so as to maintain and improve such charts as exist of national waters.

It then follows that hydrographic survey capabilities should be progressively built up. As an interim measure, surveys could be undertaken by contract with a number of commercial hydrographic organizations in existence in many countries of the world. At first, a small survey team could be established with quite simple equipment. Essentially this equipment consists of a launch, an echo-sounder and a few simple instruments.

Most developing countries have fairly advanced land surveying and mapping services, and a small nucleus of personnel drawn from them could form the technical staff for the initial unit. The basic training could be given in the country of origin by obtaining the services of a hydrographic expert; here, the International Hydrographic Bureau might be able to assist in providing technical advice and recommending a suitable expert.

It is not essential, in order to undertake surveys of harbour approaches, in-shore areas, bays or roadsteads, to acquire a great deal of sophisticated equipment. Such equipment certainly extends the off-shore range of surveys and speeds up the work, but is costly both in money and in maintenance. However, the problem of its acquisition should not be a deterrent to establishing a hydrographic service.

The International Hydrographic Organization is well aware that the core of hydrographic surveying is, of course, trained personnel. Certain basic and advanced courses in hydrography are conducted by member States of the Organization, and full details of these courses can be obtained from the Bureau in Monaco on request. However, there are still not many universities or schools that teach hydrography, and the standards and curricula are so varied that IHO has taken the initiative of establishing a working group for the study and preparation of training curricula in hydrography. These studies are being made with the object of developing acceptable

[1] "Report of the *Ad Hoc* Group of Experts on Hydrographic Surveying and Bathymetric Charting", *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.72.I.20), pp. 347-359.
[2] *Ibid.*, p. 348.
[3] *Ibid.*, p. 350, table 1.

curricula reflecting the basic standards of excellence which should be common to all hydrographic surveys.

It is considered relevant to draw attention to a resolution[4] adopted at the Third United Nations Regional Cartographic Conference for Africa:

"The Conference,

"*Having examined* the United Nations Report of the Meeting of the *Ad Hoc* Group of Experts on Hydrographic Surveying and Bathymetric Charting (E/CONF.57/L.1) submitted to the Conference, and

"*Considering* that modern hydrographic surveys and charts are of great importance to all coastal states for, *inter alia,* improvement and safety of navigation, exploitation of natural resources, and control of pollution,

"*Recommends* that African maritime nations make every endeavour to establish their own hydrographic services;

"*Further recommends* that those countries seek the help that the International Hydrographic Bureau can give in the form of technical advice, and in the meantime, where possible, enter into multilateral and/or bilateral arrangements with one another and with those countries in a position to render assistance in hydrographic surveys".[4]

The International Hydrographic Organization has always encouraged co-operation on a regional basis and as a result of resolutions adopted by the International Hydrographic Conferences in 1957 and 1967, certain regional hydrographic commissions have been established. Two of these commissions which are currently functioning are the North Sea Hydrographic Commission and the East Asia Hydrographic Commission. Another regional commission with which contact is maintained and which has been in existence for a number of years is the Northern Hydrographic Group, consisting of the Hydrographers of the Scandinavian countries. The regional commissions have been responsible for a number of co-ordinated projects, both in surveying and in chart production. The North Sea Hydrographic Commission, in particular, has achieved a great deal through regional co-operation.

It is relevant at this Conference to draw special attention to the East Asia Hydrographic Commission, which is chaired by the Hydrographer of Thailand and has a membership of seven countries from the region of Asia and the Far East.

[4] "Report of the Third United Nations Regional Cartographic Conference for Africa", Addis Ababa, 1–30 November 1972 (E/CN.14/580), p. 13.

AGENDA ITEM 13

Remote sensing, mapping methods for environmental research and control

REMOTE-SENSING METHODS FOR ENVIRONMENTAL CONTROL*

Paper presented by the Federal Republic of Germany

Recent events, such as increasing water pollution, oil pest on the high seas, air pollution through industry and motor-car emissions, poisoning of grain and meats, and the geometrical increase in wastes are now matters of concern for the average man. One great difficulty in environmental control is that most of the pollution factors are not immediately visible to the naked eye on the surface of the earth; many effects are so widespread that they cannot be easily appreciated from a local point of view.

The current demand is for methods to define and represent pollution, to determine the interaction and stress limits of environmental factors. In order to carry out these researches, it is necessary to have both small-scale overviews of regions and large-scale measurements of localized emission sources. The "remote sensors" are particularly suited to application from space and airborne vehicles: environmental research includes the possibility of environmental control.

AERIAL PHOTOGRAPHY

The photographic camera and the television camera, which operate in the visible range between ultra-violet and infra-red, are still the most important instruments for "remote sensing". This is due in part to the fact that technical developments have led to better lenses and finer grained and more sensitive films, as against the materials available 30 years ago.

For many decades, the vertical aerial photograph has been an invaluable aid in the fields of cartography, geosciences, planning and economics; it provides a rapid, objective overview of large areas and the basis of interpretation for many uses. Today, the information base from airborne or space vehicles is no longer solely photography with a conventional aerial camera in the visible light range; this information base now includes the reception of all possible signals along the electromagnetic spectrum. Among these are photographic processes for multispectral aerial photographs, density-slicing processes, such as Agfacontour film, reproduction of sharp, high-contrast colour positives with Cibachrome and Agfachrome, and the reproduction of thermal infra-red imagery.

With remote sensors, the signals are directly recorded on magnetic tape, where they are stored and/or subsequently may be reproduced as picture imagery; however, information from pictorial images still provides the best possible regional overview of an area. The aerial photograph or photographic image provides a higher information content for a given area than the corresponding computer print-out. An aerial photograph of 9" × 9" presents information consisting of several million bits. The aerial photograph also provides an exactly timed documentation as a basis for comparative studies of changes and developments within the environment.

The observation that objects photographed in the visible region do not have the same degree of reflection led to experiments with various film-filter combinations. It was possible to obtain maximum information for the colour ranges blue, green, red and infra-red; either a synchronized battery of aerial cameras or multilensed cameras which take simultaneous exposures in different regions may be used. Interpretation of multiband photography may be made with projectors having various colour filters, which allow simulation of colour and/or infra-red colour imagery.

In environmental research, the use of infra-red colour film, which is similar to the "Spectrozonal" film used in the Union of Soviet Socialist Republics, seems preferred as a basic remote sensor. The contrast of vegetation on this film is very high; and as vegetation has proved to be a precise indicator of environmental quality, the film contrast for shades of green is a welcome advantage in photo-interpretation. The high reflectivity of the mesophyll of leaves is as readily apparent on infra-red colour as are areas of moisture and bodies of water; the film also penetrates shadowed areas and "high-light" sources.

Special aids are available to increase contrast of important features on films and to provide a base for field work. The evaluation of areas of equal density on photographs can now be quickly and easily made with density-slicing Agfacontour film.

Field work often entails the finding of objects that are only marginally visible on aerial photographs. Since film transparencies are not well suited to transport and rough handling in the field, high-contrast colour copies offer an ideal solution to the problem. High-contrast, fine-grained non-fading colour prints, with a resolution of 50 lines to the millimetre and a contrast of 1,000 to 1, can now be made in direct positive reproduction (silver bleach). An example of the contrast on such prints is the

*The original text of this page, prepared by S. Schneider, Bundesforschungsanstalt für Landeskunde und Raumordnung, Bonn, appeared as document E/CONF.62/L.10.

mapping of aquatic plants growing in strips only 50 ft wide from aerial photographs at a scale of 1:5,000.

Other remote sensors

Infra-red scanner

Together with camera systems and film-filter combinations in both visible and near infra-red regions, of thermal scanners to examine thermal radiation in water or air, particularly for the atmospheric infra-red windows, 3–5 and 8–14 microns are extensively used. Radiation, which every object emits, is gathered and then reflected from the rotating prismatic scan-mirror onto a parabolic collector, then through a detector and amplifier, through a light source (which reacts to the radiation intensity); and the radiation is transformed into tones and recorded on film. The various differences in thermal radiation of the ground are recorded by the scan at right angles to the flight line of the aircraft, and the differences in tone on the film are identical with variations in warmth of the scanned objects. Infra-red scanners operate at night and through haze and smoke, so that they can be effectively used for detection of forest fires. The imagery ground resolution from an altitude of 1,000 m is approximately 3 m.

Infra-red radiometer/thermometer

For exact thermal observations, the simple qualitative reference of objects, "cool is dark and warm is light", does not suffice. Exact absolute temperature measurements are required, and modern IR line-scanners have so-called "black bodies" as calibration elements. Thermal imagery taken without such black-body calibration requires additional infra-red radiometer/thermometer measurements and the co-ordination of the curves with the thermal image. The infra-red radiometer/thermometer measures surface temperatures during flight and registers the variations as graphic curves. The radiometer is set for a vertical strip along the line of light, and from an altitude of 1,000 m views a ground patch of 50 × 50 m.

Correlation spectrometer

Since environmental monitoring is particularly concerned with the invisible gaseous pollutants in the atmosphere, a special device for detecting particular gases and determining their concentrations in the atmosphere has been developed. With the correlation spectrometer, the reflected light from the earth is registered in the part of the spectrum in which the gas has used energy.

This instrument is used to determine the concentration of such gaseous pollutants as sulphur dioxide (SO_2) and nitric dioxide (NO_2), and is currently used in European cities to control and check air pollution.

Side-looking radar

Side-looking radar has been effectively used in geomorphological and topographic studies and other geosciences; but specific criteria for applications in the field of environmental control are very few, except the detection of oil pest in the open seas. Currently, there seems no justification for systematic use of this relatively expensive system in the field of environmental control.

The advantages of the modern remote sensors lie not only in the synchronous and synoptic observation of phenomena for regional studies, but in the combination of interpretation results from the various sources: aerial photography; imagery; combined computer data; and field work. There will, no doubt, be cases where the use of any one method will satisfy the demands made on individual research projects. However, the multi-informational remote-sensing system, whereby interpretation of data from the various sources is undertaken by interdisciplinary working groups, will provide the best overview of the environment.

Examples of systematic application of remote-sensing methods

Air pollution

Densely populated industrial areas suffer under steadily increasing air pollution, which inevitably affects the population. The quality of the air is growing worse; and the construction of new industrial plants, the rising number of private motor-cars and the emission from chimneys all add their part to polluting the air. In the populated industrial agglomeration on the Lower Main River, located by Frankfurt am Main, all of the above-mentioned factors have led to rapidly decreasing air quality in the river basin between hilly ranges. Some 40 per cent of the days in any year are wind-still, which leads to smog conditions. The only constant fresh circulation of regenerated air comes from the slopes of the Taunus Mountains, to the north of the river basin. In order to determine local climatic conditions for the area, the Regional Planning Board for the Lower Main has carried out a pilot study of air quality and meteorological measurements. Flights with remote sensors, infra-red line-scanner and infra-red radiometer, were made at various seasons of the year; and correlations were made for climate, emission and amount of fresh-air circulation for the area. On the basis of these results, the remaining fresh-air corridors were mapped and definitive plans made for the preservation of these important oxygen-rich "veins" for the city. The objective of the Planning Board is not only to prevent indiscriminate building across the remaining corridors, but to improve the clean-air circulation by "greening" the hill slopes. Efficient regional planning measures of this type provide good environmental conditions in densely populated areas.

For various industrial areas, so-called "emission cadastral maps" have been devised, which are charted from information on aerial photographs and remote-sensor imagery. For the Frankfurt area, four types of emittants were distinguished:

(1) Emission from large industrial plants with an exhaust of 20 pounds and more of SO_2 per hour (point sources);

(2) Emission from other manufacturing plants with an exhaust of between 2 and 18 pounds per hour (point sources);

(3) Emission from private heating (areal sources);

(4) Emission from traffic vehicles (linear sources).

Stereoscopic interpretation of vertical photography provides position and height measurements for the emission sources, and a correlations spectrometer may provide the basis for determining the type of emission.

The problem of refuse dumps as sources of air pollution is very serious in small, densely populated countries, such as the Federal Republic of Germany. Burning trash in the open air is an unsatisfactory solution, as recent

studies with aerial photography and thermal imagery have shown. Infra-red colour aerial photos were interpreted to distinguish the location of refuse dumps in the Saarland. Smouldering fires on the dumps, which produce a great deal of air pollution, could be more easily determined on colour aerial photos and thermal imagery.

Water pollution

The first systematic study of the effects of water pollution in the Federal Republic of Germany, using a combination of remote-sensing methods, was conducted in 1971–1972 for the Saar River, which flows through an industrial agglomeration near the city of Saarbrücken.

At first, a stretch of the central Saar valley was photographed with panchromatic black-and-white, colour negative and false-colour films on the scale 1:5,000. The project study area has vertical coverage consisting of some 350 aerial photographs in stereo-overlap. At the time the photography was flown, measurements were made at the sewage outlets into the river. Other indications of water pollution, such as discolouration of the river water and eutrophy of plants, were mapped in the field. Two flights with an infra-red line-scanner were made at a height of 1,000 m above the river surface. One flight was made at 5:30 a.m., before sunrise, and the second flight on the same day at 6 p.m., shortly before sunset in June. Test measurements were made with an infra-red radiometer/thermometer built into a helicopter, which flew a height of 100 m above the river surface. The measurement curves give the absolute surface temperature of the river-water at the time of flight. Comparison aerial photography in colour and false-colour was made in the autumn of 1971.

The available material was interpreted with mirror stereoscopes, reflecting projector and light table; and the shades or colour tones were, where necessary, density sliced with Agfacontour film and Densitometer curves. All changes in the water, such as eddies, plumes, striping, stippling and frothing, were exactly positioned and mapped on the base map at 1:5,000 scale in colour codes. The result is a thematic map of the central river course, showing the various sources of pollution. A comparative study conducted by the State Health Institute, Saarbrücken, arrived at the independent result that of 60 known sources of effluents in the project area, 58 were located and correctly defined through interpretation of aerial photographs and/or remote-sensor imagery. The remaining sources were not discharging at the time of flight. Of the 17 outlets for cooling waters, 15 were exactly determined in the thermal imagery of the infra-red line-scanner. It was necessary to compare the imagery taken before sunrise and before sunset; and this comparison showed that six thermal sources did not show up on imagery taken before sunrise, but were identified on imagery made in the evening. Vice versa, only two thermal sources did not show up on the evening imagery, which were identified on the early-morning pictures. These differences are probably due to work processes in the plants.

The study showed that for interpretation purposes, the combined use of multispectral film materials and flying at different times of day for thermal imagery gives the best results. Infra-red colour photography allows identification of 84 per cent of all sources localized on aerial photographs; 72 per cent of all sources were identified on colour photography and 55 per cent on panchromatic black-and-white film. At this stage of study it is considered possible to identify all sources of emissions, using a combination of multispectral photography and thermal imagery on the scale 1:5,000.

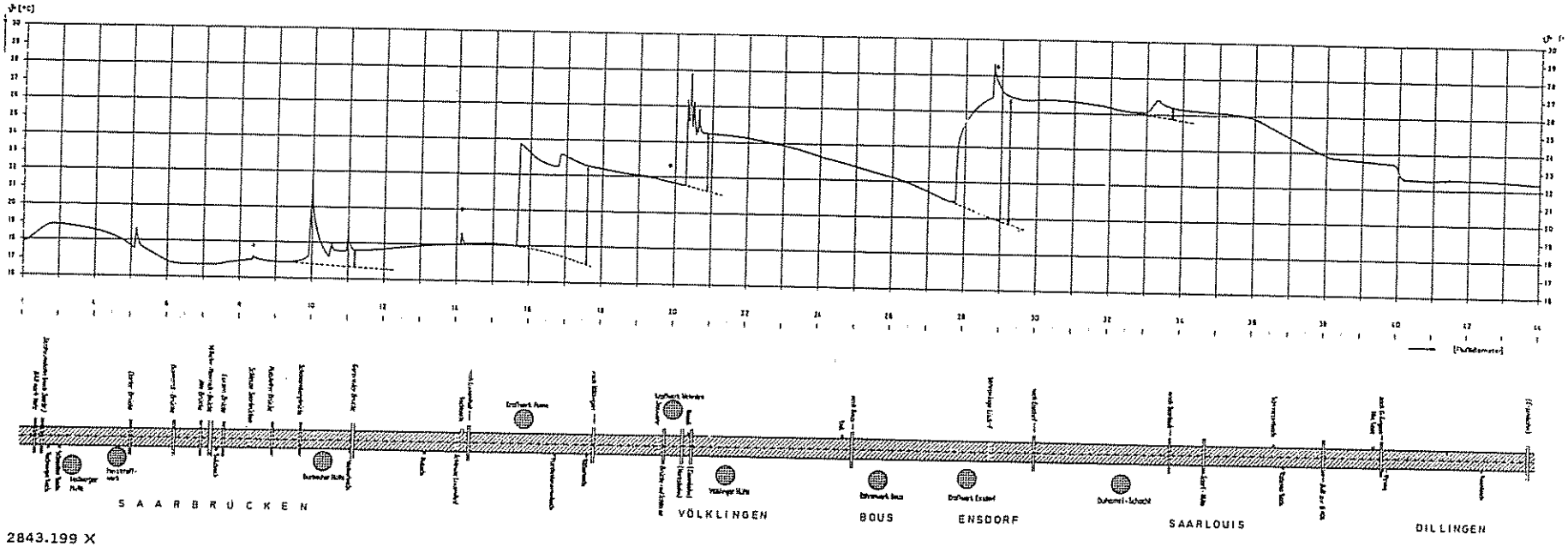
Identification of outlet sources on the available materials was made on the basis of visibly noticeable changes in the water structure; hereby, only qualitative identifications were possible. Since simple qualitative identifications are not sufficient for the important questions of temperature increase of river-water and the progressive increment of warmth for the lower reaches of the river, additional flights with the infra-red radiometer/thermometer provided measurement curves of the water-surface temperature. A simple arithmetical mean was not made of the various measurements, which consisted, in some cases, of two runs, and in others, of four runs for the various points; but an extrapolation was constructed of the probable curve of the water temperatures. At the same time, an attempt was made to determine roughly the effective increase in warmth of the river-water. The temperature curve of the water before an effluent source was extrapolated, and the difference was taken between the extrapolated value and the actual temperature reached after the effects of a thermal source had peaked (see figure 199).

The actual temperature curve of the water surface proves that cooling-water outlets of power-plants contribute most of the thermal increase of the waters of the Saar River, as against the minimal increases in temperature caused by effluents from industrial plants. Hydraulic engineering measures, such as shipping canals, have shortened various river sections as well as the stretches in which the river-water can cool off naturally. Any additional cuts will have adverse effects on the thermal household in the lower river-course.

Vegetation studies

Water quality can probably be adequately determined on the basis of spectrometric measurements; but aquatic plants on the shores of lakes and rivers are even more sensitive indicators of water pollution. A project sponsored by the International Water Control Commission for Lake Constance included checking and mapping the plant associations on the shores of the lake. The State Institute for Biological Research at Karlsruhe (G. Lang), carried out the interpretation of aquatic plant types and associations on the basis of colour aerial photographs. Available panchromatic black-and-white photography did not permit the fine distinctions necessary for preliminary mapping. On the basis of the colour-positive photographs, all plant types and associations were mapped for the entire shore-line of Lake Constance. As a correlation, water quality could be defined and sources and extent of pollution located.

Similar results were obtained during a study of water quality for the heavily polluted Saar River. Aquatic weed associations, such as *potamogeton pectinatus,* indicate eutropic conditions; and these weeds bordered the shore-line in strips ranging from 50 cm up to 2 m in width. In cases where industrial effluents contained poisonous wastes, even these hardy weeds died out. In false-colour aerial photographs, the sources of four outlets with waste residues were indicated by bare stretches 25–145 m in length, where no plants could survive. In one case, where a highly polluted tributary flowed into the Saar, no aquatic plants grew for more than 10 km down stream.



Note: Measurements were taken with an infra-red radiometer, which was installed in a helicopter; flight altitude was 100 m above the surface. The curve is a combined average temperature from two or four readings taken between 9.30 a.m. and 12 noon. The dot indicates the water temperature at 1 p.m., as measured to a depth of 50 cm. An extrapolated dash curve indicates the normal cooling-off process, if additional effluents were not run off into the river. The letter A indicates warm effluents from iron and steel workings and other manufacturing plants; B indicates warm cooling-water from power-plants. Emissions are so closely spaced along this stretch of the river that the water cannot cool off to its "normal" temperature before a new effluent rewarms the water. Air temperature at the time of the test flight was between 10° and 13° C, and the extreme difference between water-surface and air temperatures caused intense evaporation and surficial cooling of the water surface, as shown by the water-temperature measurements made in 50-cm depth. The sudden increase in warmth at the mark 27.6 km is due to a back-up of warm water from a power-plant.

Figure 199. Federal Republic of Germany: Saar River, water-surface temperatures as measured on 5 October 1971

Forestry

The earth's vegetation not only provides basic food for man; even more important is the function of vegetation in providing a livable environment. The concern of environmental control systems is to protect earth's green cover. Today, for example, the function of stands of trees and of forests has the same importance as the production of wood-products. Basically, forests provide regeneration of air and water in densely built-up areas, help to maintain ground-water levels, protect soil from water and wind erosion, shield roads and streets, and engender a comfortable micro-climatic atmosphere. Stands of trees in industrial areas act as noise and dust filters, in addition to their important function of hiding the eyesores of manufacturing plants from the public view. A series of studies on the emission intensity of industry and the effects on adjacent forests have been carried by Messrs. Hildebrandt and Kenneweg of the Institute of Forestry at the University of Freiburg. Colour and false-colour aerial photography has been flown in various areas, and comparisons made for different types of emissions and the extent of spread into neighbouring settled areas and damage to forests—both for immediate and for long-range results. Aerial photographs are used for planning commissions to project the areas necessary as "green lungs" in built-up regions. Large-scale research is also being done on the problem of trees dying out along main traffic arteries, which is directly related to the degree of air pollution caused by motor-car exhaust fumes.

If one summarizes the current activities in environmental control by remote sensing one finds only a few systematic integrated studies. At London in 1971, A.E.S. Mayer stated that although aerial sensors had a number of potential applications, the tendency in the past had been to evaluate the techniques in isolation from one another and with only a single objective. A co-ordinated approach would have a number of advantages and would make it possible to study most of the variables affecting imagery and to use the information obtained in the interpretation of the results for various objectives of environmental research.

Because there is a sophisticated instrumentation of remote sensors and because the development and tendencies in remote sensing are known, there should be increased and better contact with those organizations of regional and international environmental control which should be the users of the results of these remote studies.

Those concerned with environmental control should: (*a*) give models for environmental control by remote-sensing instrumentation; (*b*) promote systematic regional studies on the same subject and offer them to the authorities of environmental control; (*c*) intensify interregional and international contact on remote sensing of the environment in order to establish a global environmental monitoring system.

ESTIMATION OF THE PROBABILITY OF SLOPE DISASTERS ALONG NATIONAL HIGHWAYS*

Paper presented by Japan

Each year, a large number of landslides, such as slumps, rock-falls, debris avalanches and debris flows, are caused by torrential rainfalls in Japan. These landslides cause heavy damage to lives and property, and often interrupt social and economic activities. Most heavy rainfalls occur during the summer, due to "*baiu*-front" activities or typhoons, some of which are extremely local and intensive. On occasion, the area covers only 50–100 km² and hourly rainfall exceeds 100 mm. While it is a certainty that every year extremely intensive rainfalls will occur somewhere in the country, it is not possible to say exactly where for the year, except for a few places in the southern districts.

The likelihood of an intensive rainfall at a given place in a given year is, in general, so small that many of the people living within a potentially dangerous area have not yet suffered such a bitter experience nor have any idea that they are living in danger. Once such a rainfall occurs there, the damage will be greater than in an area that has already undergone this experience.

Rainfall, as well as an earthquake, is an immediate factor initiating a landslide; but it is quite difficult to predict a heavy rainfall exactly, because it occurs accidentally and does not last long. On the other hand, there are some other factors, such as topography, geology and vegetation, which define the potential ground condition against a landslide peculiar to each slope. In this paper, they are called "potential factors". It is not impossible to assess them by various methods if they last long enough to be studied precisely, such study would be worth while for estimating the probability of a landslide.

While there are many qualitative case studies of disaster likelihood, there are few quantitative studies. There is, however, a great demand for quantitative methods from the administrative side today, because this type of study is expected to be more effective for an objective and synthetic estimation of the probability and to provide a standard of estimation for a wider area in the country.

In 1971, the Geographical Survey Institute (GSI) began the project of estimating, using the quantitative technique, the probability of slope disasters along national highways. The method used is described below.

Method of estimating probability of slope disasters

The fundamental principle in the estimation of future landslides is to apply to them the knowledge obtained from past landslides. The first step in the process is to investigate where landslides occurred and where they did not occur. The next question concerns what potential factors were effective for the occurrence of these landslides. Then, a search is made for other places that have not yet been affected by landslides, but that are considered potentially dangerous areas on the basis of such significant factors. These places are concluded to be dangerous areas during coming heavy rainfalls. In order to evaluate the potential factor and detect the dangerous areas, it is preferable to have quantitative data obtained by statistical techniques.

*The original text of this paper, prepared by Eisaku Tsurumi, Geographical Division, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.62/L.12.

GSI has had some experience on slope disaster research mainly from the geomorphological and geological points of view. Most of these researches have been done by the qualitative method. The project along the national highways began as a quantitative estimation of potential danger of natural slopes with respect to debris avalanche and debris flow along the highways, using the statistical technique, i.e., discriminant analysis. A landslide originating in bed-rock is not considered at this time. Highways 19, 29, 33, 41 and 42, and two planned routes of expressways have been studied.

Slope chronology by photo-interpretation

In order to use the statistical technique effectively, one must have an outlook on the relation between the landslides and the geomorphological, geological and meterological aspects of the area, using all kinds of source materials. Aerial photographs are one of the most useful tools, especially for studying geomorphological aspects.

As a rule, a mountain in Japan is dissected by an association of the fluvial process and mass wasting. A stream undercuts the foot of a mountain side by the fluvial process and makes the slope unstable. Then a landslide occurs there and moves detritus down to the channel below. The stream, thereafter, removes these materials, undercuts the foot of the mountain further and makes the mountain side unstable again. Then another landslide occurs there. In this way, the mountain is gradually dissected. Thus, it may be said that a large proportion of slopes of a mountain are formed by repeating landslides. These slopes are of various ages. Some are very old, so-called "dead slopes" or "dormant slopes", which are now stable; while some are of recent age, so-called "active slopes", which have distinct forms resulting from recent landslides and will probably undergo frequent slides in the future.

A chronological study of land surfaces is done mainly by the morphological method and/or stratigraphic method. This is a very common task for terraces and plains, while for mountain slopes it has not yet become common because stratigraphic evidences are usually very poor on the mountain sides due to erosion. However, if a morphological analysis of mountain sides is very carefully made by stereoscopic observation of aerial photos, it is still possible to develop a slope chronology. The key for chronological classification of a mountain side is the "knick-line" on which the gradient changes discontinuously. There are two kinds of knick-lines with respect to the vertical profile, convex and concave. The convex knick-line is discussed here because it shows a boundary between the order slope on the upper and the younger slope on the lower. Mr. Hatano and others of GSI have mapped such knick-lines as "erosional front" in the geomorphological land-classification survey at 1:50,000 scale, quadrangle Hofu, Yamaguchi prefecture (1968); and in the landslide investigation of Kitamatsuura districts, Nagasaki prefecture (1970).

Figure 200 shows such knick-lines in a small area, Gifu prefecture, which are classified into two grades according to the distinctness of the line. The distinctness may be an index of the slope age. There seems to exist a close relationship between the distribution of the classified slopes and that of the existing landslides.

Quantitative estimation

Many estimations or predictions are practically given today by quantitative methods in broad fields, such as the natural, biological and social sciences, and various applied sciences, while very few attempts have been made in the field of landslides in Japan. Mr. Maruyasu reported a discriminant analysis of landslides along the Dosan Rail Line, Shikoku Island, in 1965. The Japanese

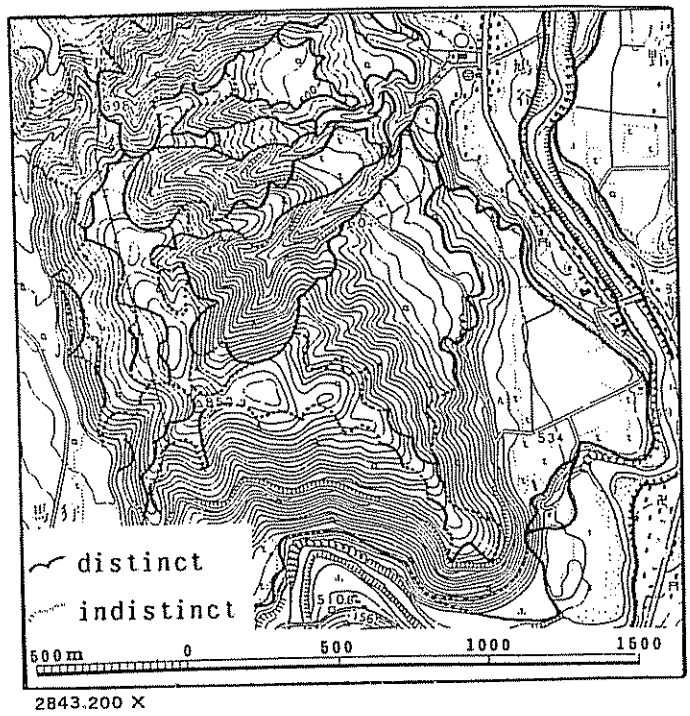


Figure 200. Japan: nick-lines read in a stereo-photograph

National Railway has been trying to develop it for landslide prediction widely along the rail lines. The Tokyo Metropolitan government also applied it to landslide prediction at Tokyo. Several organizations have been using this technique for prediction of snow avalanches, which are quite analogous to landslides.

The process of analysis is generally as follows.

(1) *Unit slope classification* (or unit square setting);

(2) *Survey of the former landslides.* Each unit slope is examined to determine whether any scar, which is evidence of a recent landslide, is present;

(3) *Potential factor selection.* Potential factors, which are supposed to be significant, are selected as the prediction parameters. Several categories are set in each factor;

(4) *Potential factor survey.* The category to which each unit slope belongs is judged for each factor by photo-interpretation, map measurement and field survey;

(5) *Discriminant analysis.* This process includes the following steps:

(*a*) From these unit slopes, several hundred sample slopes are taken at random. Scarred unit slopes must also be included;

(*b*) A discriminant equation that gives good discrimination between two different events, presence and absence of scars in each sample unit slope, is given as:

$$Y = a_1 x_1 + a_2 x_2 + \text{---} + a_n x_n$$

where $_n$ is the number of selected factors;

a is the weight of a factor;

x is the value that each category of a factor obtains. These values are determined based on the frequency of scarred unit slopes;

(*c*) Y is calculated for each sample unit slope;

(*d*) The discriminant boundary is determined so that it gives the most effective discrimination;

(*e*) If the effectiveness, which is expressed by the rate of correct discrimination to the total, is high enough, the equation will be useful for estimating the probability of disasters on other unit slopes. If not, some alterations or modifications may be needed in unit slope setting, potential factor selection, category setting, factor surveys and so on.

The process of analysis was applied to the estimation of the highways as described below.

Unit slope classification

Mountain sides having an influence upon a highway may be divided into two groups according to their situations. One is "slope" in an ordinary sense, which meets a highway on a line and may cause rock-fall and debris avalanche disasters. Another is "valley", which meets the highway at a point and may bring debris flow disasters. The former type was classified into unit slopes, while the latter type was classified into unit valleys. The units of each group were numbered differently (see figure 201).

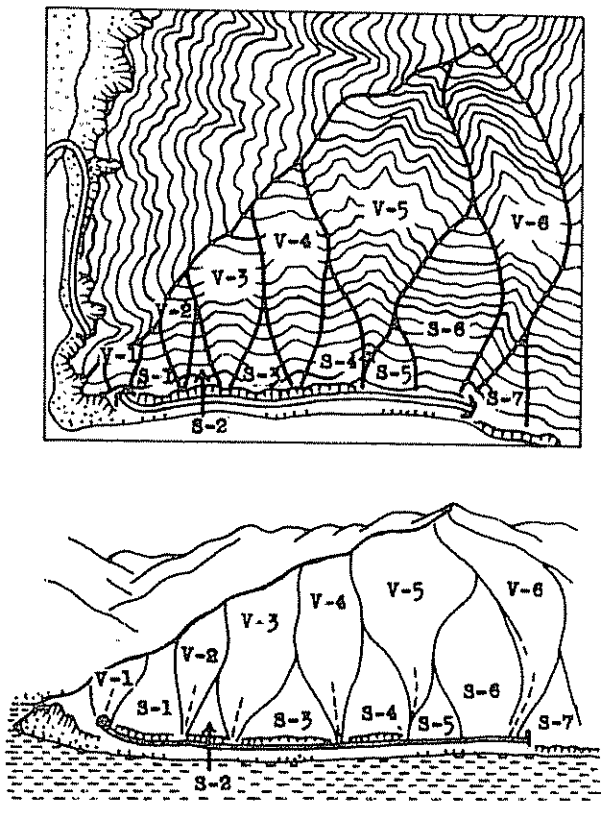


Figure 201. Japan: unit slopes and valleys

Survey of former landslides

For the unit slopes, scars, which are seen as white in aerial photos, were interpreted as former landslides that recently occurred; while for the unit valleys, evidences of recent debris flows which reached the highway or the planned route were examined instead of scars (see table 1).

Table 1. Unit slopes and valleys

	Scarred unit slopes (S)	*Total unit slopes (T)*	*S/T (percentage)*	*Flowed unit valleys (F)*	*Total unit valleys (T)*	*F/T (percentage)*
Highway 19	68	214	32	43	148	29
Highway 29	40	226	18	27	128	21
Highway 33	39	180	22	32	130	25
Highway 41	39	224	17	47	154	31
Planned routes:						
A	153	654	23	33	235	14
B	28	146	19			

Potential factor selection

Potential factors are selected as the prediction parameters for the slopes and for the valleys of each highway, respectively. For each factor, from three to six categories were set. In the case of Highway 19, for example, 10 factors and 45 categories were set for slope, and 12 factors and 47 categories for valley.

Potential factor survey

Photo-interpretation was extensively applied to the survey, especially for topographic factors, vegetation and surface geology. Topographic maps on the scale 1:5,000 were used for measuring the gradient and area. Bed-rock geology and some other geological properties were surveyed in the field. The results were summed up with respect to the frequency of scarred unit slopes and flowed unit valleys, as shown in part in tables 2 and 3. In order to eliminate such factors as are not actually significant as the prediction parameters, X^2 -tests were tried at the significant level of 0.05.

Discriminant analysis

All surveyed unit slopes and valleys, excluding Highway 42, were adopted as samples to construct a discriminant equation. After determination of a and x for each

Table 2. Highway 19, frequency of scarred unit slopes for each category

Factor	*Category*	*Scarred unit slopes (S)*	*Total unit slopes (T)*	*S/T*
Horizontal section	Plane	12	59	0.20
	Plane and with distinct streams	8	20	0.40
	Convergent	15	47	0.32
	Divergent	7	22	0.32
	Compound	26	66	0.36
Longitudinal profile	Straight	16	78	0.21
	Convex	17	45	0.38
	Concave	8	36	0.22
	Compound	27	55	0.49

Table 3. Highway 19, frequency of flowed unit valleys for each category

Factor	*Category*	*Flowed unit valleys (F)*	*Total unit valleys (T)*	*F/T*
Longitudinal profile	Straight	17	51	0.33
	Concave	16	45	0.36
	Compound	10	52	0.19
Average gradient	~ 30°	3	21	0.14
	30° ~ 35°	8	38	0.21
	35° ~ 40°	16	49	0.33
	40° ~ 45°	11	27	0.41
	45° ~	5	13	0.38

Highway, y was calculated for each sample unit slope and valley. Then, a discriminant boundary, which might bring the highest rate of correct discrimination, was determined. For each highway, the rate was obtained, ranging from 67 to 82 per cent, as shown in table 4.

Table 4. Correct discrimination rate

	Slope	*Valley*
Highway 19	79.0	77.0
Highway 29	71.3	82.1
Highway 33	67.3	72.0
Highway 41	73.5	76.7
Planned routes:		
A	70.7	77.7
B	75.1	

The range of y is considered to indicate the significance of each factor for the occurrence of landslides. For example, in the case of Highway 19, the three most significant factors for slopes were: (1) amount of detritus; (2) minor features of the slope; and (3) shape of the longitudinal profile, in decreasing order. For valleys, the factors were: (1) scar density; (2) thickness of detritus; and (3) minor features in the basin.

Application of the equation

The equations given here have not been applied to the estimation of other slopes and valleys or other areas, bu

they will probably be used in the future after being improved on the basis of a few more experiments on factor investigation.

According to the principle of estimation, it would be a misapplication to use an equation for the slopes (or valleys) which have been sampled for constructing the equation. For example, it cannot be concluded that a unit slope is dangerous because it gains a large value of y, if it was adopted as a sample. But if a unit slope that has been adopted as a sample for an unaffected slope gains a large value of y, this slope may be concluded to be a dangerous slope. In principle, the equation should be used for unaffected slopes (or valleys), while affected slopes (or valleys) should be examined by some other method.

Final judgement

The discrimination resulting from the calculation mentioned above does not necessarily work as the direct index of the probability of disaster for a highway itself, because sometimes a factor that has been omitted may actually play a significant role for the highway. For example, a small and flat area, small woods or some structures for slope control, between the upper dangerous slope and the highway, may reduce the amount of danger. Therefore, a final judgement for each unit segment of the highways had be to given synthetically by taking such factors into consideration.

It is stressed that the quantitative method should be used for the first step of the estimation, which is followed by several types of additional precise surveys at the individual sites.

Basic materials for a better prediction

The following materials are desirable in order to be prepared for a better prediction:

(*a*) Aerial photos on the scale 1:10,000 or more, taken every 5–10 years, and especially just after intensive slope disasters. Colour photos would be more appropriate;

(*b*) Records of every disaster with a map showing the details of location;

(*c*) Records of rainfalls, such as the daily and hourly rainfall;

(*d*) Terrestrial photos of the entire slope and valley.

(*e*) Topographic maps on the scale 1:10,000 or more, the contours of which faithfully express the details of the land surface;

(*f*) Surface geological maps on the scale 1:10,000, which give much information concerning detritus deposited on steep slopes and valley floors.

BASIC SURVEY OF THE COASTAL AREA—TOPOGRAPHIC MAP AND LAND-CONDITION MAP OF COASTAL AREA*

Paper presented by Japan

Despite the advantageous geographical situation of Japan, being surrounded by sea and thus being a marine country, it is distinctly backward with respect to the marine scientific technology on which marine development is based, when compared with other developed countries. Recently, there has been a nation-wide request for the promotion of active marine development, demanding that the Government take some concrete countermeasures.

Marine development involves many dimensions, such as the efficient utilization of space, procurement of marine resources and preservation of marine environment. Systematic and comprehensive marine development requires, above all, the prompt, exact and systematic grasp of the various marine topographic conditions.

The Ministry of Construction, being cognizant of these situations, placed the first emphasis on the coastal areas, directing the Geographical Survey Institute (GSI) and other research institutes to collect and check all basic survey data on the main coastal areas throughout the country as soon as possible. On the other hand, to support the above-mentioned work, "the basic survey of the coastal area" commenced in the fiscal year 1972. The methods adopted and the problems involved in this survey to make the topographic map and the land-condition map of the sea-bottom are discussed below.

*The original text of this paper, prepared by Toshitomo Kanakubo, Geographical Division, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.62/L.47.

Outline of the basic survey of the coastal area

The development of the coastal area has to be closely linked with the regional development plan for the hinterland. Therefore, the survey on the coastal area is to be conducted in full compliance with the related land survey.

As the objects of the basic survey of the coastal area, the main gulf and inland sea, totalling 42,500 km^2, which await the scheduled development plan of the various resources along the coastal area and necessitate the urgent survey, have been selected. The current five-year plan, which began in the fiscal year 1972, has as its objective chiefly the depiction of the topographic map and land-condition map of the coastal areas on the scale 1:25,000, as well as the execution of the survey of sea and atmospheric phenomena (tide, long-shore current, water nature, water temperature, etc.). In the fiscal year 1972, 905 km^2 of the coastal area along the Ise Bay were surveyed with a budget of 70 million yen, and the printing of this result on three sheets of four-six block is completed. The year 1973 will cover, with a budget of 88 million yen, the survey of portions of Ise Bay and Yatsushiro Bay, as well as the printing of its results.

Methods of the survey

The procedure of the basic survey of the coastal area is shown in figure 202.

The outline of each of the main procedures is given below.

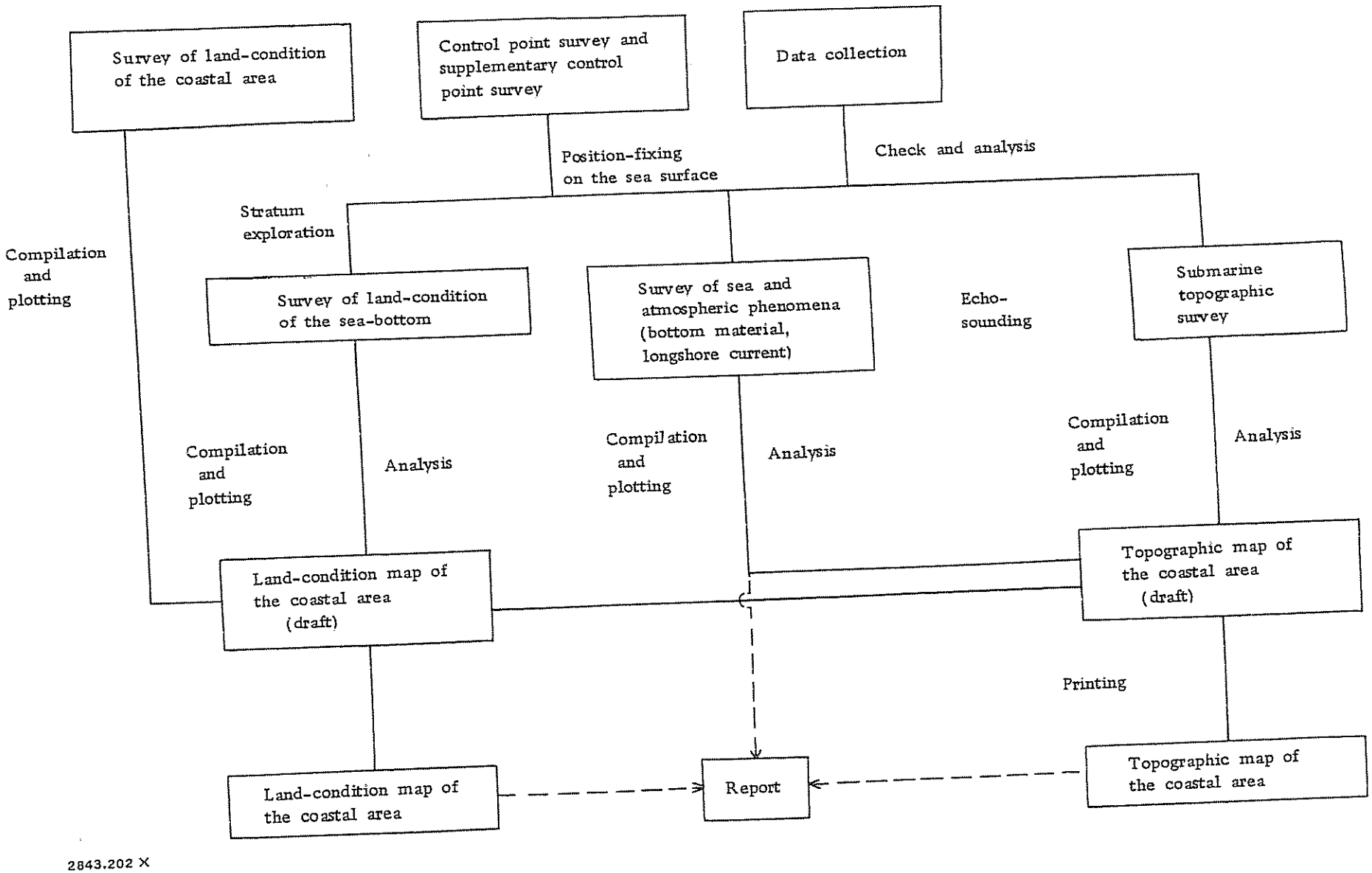


Figure 202. Japan: procedure of the basic survey of the coastal area

Position-fixing on the sea surface

Even though highly accurate data and information are obtained by means of using various types of equipment for marine survey, the uncertain fixing of the position devaluates such information. Therefore, position-fixing on the sea surface plays a very important role. One of the following methods, or the combination of them is used for this task in the current survey:

(*a*) Three-point resection using a sextant;

(*b*) Method of intersection length by use of electronic distance-measuring equipment;

(*c*) Straight course leading method by the transit.

Currently, electronic distance-measuring equipment is widely used for the purpose except for surveys of relatively narrow areas. This method uses the microwave. The master station is set on the survey ship and the slave station on the control point of the land. The distance between the master station and the slave station is measured to fix the position of the ship, and the distance is shown as a digital on the master station.

Echo-sounding and submarine topographic survey

A submarine topographic survey, as well as the stratum exploration mentioned below, is the main item of the basic survey of the coastal area. The echo-sounder is chiefly used for this survey. The echo-sounder transmits the supersonic wave pulse directed to the sea-bottom from the surface and measures the time lag between the transmission and the reception of the reflected wave pulse, thus permitting computation of the water depth. As the velocity of the supersonic wave in sea-water varies, depending upon the water temperature and salinity density, the actual water depth is computed by adjusting the values obtained by the echo-sounder.

Stratum exploration and survey of bottom material

Stratum exploration, in which the methods of geophysical exploration and seismic profiling on the land are applied to the sea area, is now not generally adopted because it damages the fisheries and causes seawater pollution.

What is currently used as a substitute is sonic prospecting. The sonic prospector includes the sparker, sonoprobe, sono-strator, etc., which are used in the current survey.

The sonic prospector is designed to make a constant and automatic exploration of the geological structure of the sea-bottom. It transmits the supersonic wave to the sea-bottom and depicts the reflected wave from the border stratum below the sea-bottom on the recording paper as a profile of sea-bottom stratum. The composition material and geological structure below the sea-bottom are analysed from the record.

In addition, the material on the sea-bottom is collected as a part of the bottom survey by dredgers and T-type sampler.

Expression of topographic map and land-condition map of the coastal area at 1:25,000 scale

The topographic map and land-condition map of the coastal area on the scale 1:25,000 are meant to be fully utilized as basic data for the development plan of the coastal area, the site selection for various structures on the coastal area, the prevention plan against various disasters along the coastal area, and the culture and maintenance plan of marine creatures and undersea landscape. The outlines of these two maps are described below.

Topographic map of the coastal area

The topographic map of the coastal area uses the existing topographic map for the land area and is composed of the following three items for the sea area: topographic conditions; various facilities; administration. The contents of these three compositions are shown in three colours. The compositions are briefly described below.

Topographic conditions

The depth contour is important both for showing the framework of the sea-bottom and for comparing it with land topography. As the slope of the sea-bottom is generally less steep than that of the land, the contour interval is desirably dense. Therefore, the intermediate contour of 1-m depth intervals and the index contour of 5-m intervals are used. To make a clear comparison of the linkage between the land area and the sea area, the datum level is set as the mean sea level of Tokyo Bay (TP).

Other topographic conditions include auxiliary topographic symbols, depth points, cliffs, steep slopes, protrusions, dents, reefs and aquatic plants. The bottom material is expressed, in general, according to the grain size classification by Wentworth. About 20 per cent of the total sampling points are chosen for the grain size analysis, and the median diameter values (M dØ) at each point are shown on the map. Moreover, the transparency of the sea-water at the points where bottom-material sampling is made is measured to be expressed on the map.

Various facilities

The following facilities, which are supposedly connected with the development and maintenance plan of the coastal area, were selected to be depicted on the map with their locations and shapes:

(*a*) Coastal structures (revetment, rubble mound);

(*b*) Port facilities (quay, dolphin);

(*c*) Observation facilities (tide station);

(*d*) Marine safety facilities (lighthouse, radio relay station);

(*e*) Fisheries facilities (settled fishing implements, fishing reef);

(*f*) Sight-seeing facilities (undersea observation tower);

(*g*) Supply facilities (submarine pipeline).

Administration

The border lines designated by following various laws and regulations are to be shown:

(*a*) The boundary of harbour and the harbour district set by law of harbours and port regulations, as well as other designated border by port regulations (mooring buoy area, anchoring berth, anchor-prohibited area, quarantine anchorage);

(*b*) The limit of fishing zone within which the right of fishery (settled fishery right, sectional fishery right, common fishery right) is set forth by law of fishery;

(*c*) Other boundaries, such as closed zone for fishery, boundary of gravel picking, boundary of mining, preservational water surface and water storage boundary;

(*d*) National park and the designated national park zone set forth by natural park law, prefectural park zone set forth by prefectural regulations and the undersea park to be designated in the important sea area along the coast from the environmental preservation point of view;

(*e*) Reclamation of the dredging zone in the seaside land or in the sea.

Land-condition map of the coastal area

Whereas the topographic map of the coastal area is of a general nature, the land-condition map of the coastal area is the thematic map of the land condition of the sea-bottom, namely, of submarine geomorphological classification, water depth classification of bottom material, classification of alluvium and bed layers in the sea-bottom and various facilities.

Submarine geomorphological classification

The topography of the sea-bottom is divided into the flat portion, the undulating landform and the other slopes. The flat portion is further divided into the depositional flat surface formed by the sedimentation of sand and mud brought by rivers, currents and long-shore currents, and the erosional flat surface formed by erosion, such as by broken waves.

The depositional flat surface is classified into the following details: (*a*) foreshore, tidal flat; (*b*) sedimentary platform; (*c*) other depositional flat surfaces.

The erosional flat surface is subdivided into the following details: (*a*) wave-cut bench; (*b*) abrasion platform; (*c*) other erosional flat surfaces.

The undulating landform is classified as follows: (*a*) ridge line and valley line; (*b*) reef exposed at low water, and reef; (*c*) bar and trough; (*d*) waterway; (*e*) deep-sea channel; (*f*) submarine canyon and cauldron.

Each topographic category (flat surface, undulating landform and other slopes) is shown in the colours specified for that category, based on consideration of the origin, configuration and distribution.

Consideration is also given to artificially formed topography, such as dredged surfaces and banked-up surfaces, which are also expressed on the map.

Classification of bottom material, alluvium and bed-layers in the sea-bottom

From the analysis of sonic prospecting, the composition materials of the sea-bottom alluvium are divided into gravel, sand and mud. And from the ratios of these composition materials to the thickness of the stratum, the densities A and B are derived. The distribution of these symbols A and B in the alluvium will make it possible to read roughly the composition ratios in the alluvium.

As for the bed-layer, both the depth contour from the mean sea level to the surface of the bed-layer which is just below, the alluvium, being known from the sonic prospecting analysis, and the composition material of the surface portion of bed-layer are expressed on the map. To facilitate the quick reading of the thickness of alluvium, the figures in metres are given at appropriate intervals.

UTILIZATION OF THE SURVEY RESULTS

As the result of the basic survey of the coastal area, the topographic map of the coastal area and the land-condition map of the coastal area are to be obtained, the uses of which are expected to be wide-ranging, from sociology, education and research, industry and economics to various other fields. The basic uses are cited below:

(*a*) Information on site selection for coastal development and for development control area, distribution of the weak sea-bottom and its thickness, distribution of steep slopes; site selection for reclamation, for dredging and for harbour construction. Such information for structures as ground resistivity, thickness and distribution of steep slope land is also expected;

(*b*) Information for the benefit of environmental preservation, such as pollution of sea-water, pollution of sea-bottom and undersea landscape. This information will be used as basic data for the purpose of preserving nature in the coastal area;

(*c*) Information on the distribution and deposit of the sea-bottom resources (such as gravel);

(*d*) Information for fishery resource preservation, such as data conducive to the marine-creature culture plan and to the submarine pasture plan.

PROBLEMS RELATING TO DRAWING OF THE SEA MAP

Problems relating to the execution of the basic survey of coastal area, namely, the drawing of the maps of the sea, are summarized as follows: (*a*) problems of natural conditions; (*b*) problems accruing to survey technology and survey equipment; (*c*) problems of cartographic expression.

Problems of natural conditions

The geomorphological landform in the sea differs greatly from that on the land. Generally speaking, the land is always subject to the flowing water and efflorescence, and is of erosion landform, whereas the sea is the final place where materials carried from the land are deposited. It can safely be said that there has been almost no knowledge on the process of geomorphological landform in submarine land compared with that of the land.

Under this condition, the knowledge of basic oceanography (submarine landform, geology, oceanophysics) has to be enriched in order to make sea maps.

Problems accruing to survey technology and survey equipment

The following requirements are imposed on the submarine survey which is beyond the scope of visual observation:

(*a*) The echo-sounder development has raised the accuracy of measured water depth, but the equipment and technology for the submarine three-dimensional survey (such as the application of side-scanning sonar and photographing by submarine camera) have to be improved;

(*b*) The stratum exploration has to be improved with respect to the choice of equipment, depending upon the

stratum structure, namely, to use the appropriate equipment in consideration of the property, such as its measurable depth and analysis ability, which vary with the change of frequency. The analysis method of the record by these types of equipment (adjustment of the velocity change of sonic propagation between that in sea-water and that in sedimentation materials, and distinction of sedimentation materials) has also to be established;

(*c*) The construction of the survey ship exclusively used for the survey of the coastal area is needed immediately, and the survey equipment for the breaker zone (such as a remote-controlled boat) is to be explored.

Problems of cartographic expression

Many problems remain unsolved, such as whether the unified and harmonized geomorphological classification criteria can be used for the various land conditions (geomorphological landform, geological structure) between land and submarine land where land formation forces differ from each other; and, on the other hand, whether the method and criteria for the geomorphological classification on land can be appropriately used for development, prevention of disasters and environmental preservation, all of which are original objectives of the marine survey. The names in the sea area, compilation, cartography and printing method are also included in the problems under this category.

NATURAL ENVIRONMENTAL MAPS IN SOUTH AND SOUTH-EAST ASIA*

Paper presented by Japan

Purpose of the map

The Japanese Government is often asked to assist those developing countries located in tropical regions which wish to modernize their agriculture and industry as Japan has done. However, there are difficulties involved in such technical assistance because of major regional differences in the natural environment—climate, topography, soil and flora—of Japan, which is located in the temperate zone, from that of the developing countries located in the tropical zone.

Therefore, in order to assist the countries technically, one needs a great deal of basic knowledge about the environment in the tropical regions. For this purpose, topographic maps, geological maps, soil maps, vegetation maps, land-use maps, etc. are basic requirements.

Studies on the above-mentioned items in the tropical regions have been done fragmentarily by institutes, universities, firms, etc. In spite of their high quality, many of these materials have remained known to a few people only.

Thus, there is a need to catalogue the materials and make the list, especially of maps, known. This list would be useful for engineers, economists and other scientists wanting to assist developing countries in tropical regions.

In addition to cataloguing existing maps, it is very important to make new maps showing regional divisions based on the natural environment.

Method

The first step will be the collection of the materials and maps, existing in Japan, concerning tropical environments.

The second step will be to collect maps of tropical regions in south and South-East Asia.

The third step will be the classification of the above-mentioned maps according to scale, country, region and topic. A card catalogue will be produced according to these classifications. The card catalogue will be very useful to those wishing to assist south and South-East Asia technically or economically.

Lastly, new maps will be made showing the regional divisions of south and South-East Asia with respect to climate, soil, flora, etc., based on the existing maps and materials.

New maps are going to be made, for example, for Sri Lanka, West Malaysia and Thailand, in turn.

*The original text of this paper, presented by the National Institute of Resources, Science and Technology Agency, Japan, appeared as document E/CONF.62/L.48.

SIDE-LOOKING AIRBORNE RADAR SURVEY*

Paper presented by Australia

In June 1972, the Division of National Mapping and the Bureau of Mineral Resources let a contract for the side-looking airborne radar (SLAR) survey of approximately 17,000 km² between Mount Isa and Cloncurry in Queensland, Australia. This area was chosen because it had been mapped both geologically and topographically, and thus provided a good test area.

The radar system used was the Goodyear synthetic aperture GEMS, which was mounted in a Caravelle aircraft operated by Aero Service of Philadelphia, Pennsylvania (United States of America).

Four mosaics were produced at 1:100,000 scale. The contractor had been supplied with 1:100,000 topographic maps of the area, and those maps were used to control the mosaic. The mosaic was made from the near-range strips of imagery, while the far-range imagery was supplied in individual strips at 1:100,000 scale, thus allowing stereoscopic examination of the mosaics.

The mosaics were compared with aerial photographs

*The original text of this paper, prepared by the Division of National Mapping, Department of Minerals and Energy, Australia, appeared as document E/CONF.62/L.68.

and with topographic and geological maps. It was found that some topographic features were well defined, while others were barely visible. Microwave towers, transmission-line pylons and some fences were visible; but some roads and railways were barely visible. Hills, water and drainage patterns were shown clearly except for one section of rugged small hills. This area tended to look like an alluvial flat as there was no shadow, but the drainage pattern indicated that this appearance was incorrect. It is suspected that the system may have become confused by the greater number of signals received from these reflecting surfaces.

The planimetric accuracy of the mosaics was tested by comparing it with the topographic maps. This method had to be used because survey stations could not be identified on the mosaics. Co-ordinates of 28 identifiable points were derived from the mosaic, and those co-ordinates were compared with the scaled map co-ordinates. The results of these comparisons are set out below:

	E	*N*
	(millimetres)	
Largest difference	3.2	1.6
Least difference	0.4	0.2
Mean difference	1.3	0.9

The geological investigations have shown that the lithological interpretation is best carried out on enlarged radar strips under stereoscopic vision. Rock types that have a strong morphological expression were readily identified. For other rock types, identification was difficult. However, by relying on subtle differences in relief, drainage pattern and fracture pattern, different "radar units" could generally be distinguished and then related to lithological units by means of existing geological information. Many structural features, such as faults, lineaments, fracture patterns and bedding trends, were easily identified both on the strips and on the mosaic. Structural features having regional size (larger than 50 km) are well displayed on the mosaic.

It is concluded that SLAR mapping is very good for regional mapping on the scale 1:250,000 or smaller. It will never replace aerial photography, but it is a useful tool to use in conjunction with photography. In areas that are often clouded or that lack maps, SLAR will provide a good base for planning and exploration.

RADAR SURVEY*

Paper presented by the Union of Soviet Socialist Republics

In addition to conventional photogrammetric methods, there are currently available different types of surveys at various zones of spectrum.

Radar survey is one of such surveys. The specific features inherent in it make the application of radar survey very promising; moreover, the properties of radar imagery taken at small scale are very close to those of photography.

The phenomenon of reflection of signals from distant objects is the basic idea of all radar systems. Measurements of the delay of echo-signals in respect of the time of transmitter signal permits determination of the distance to the object. The density of the image obtained on the screen of the cathode-ray tube of the radar system receiver depends upon the shape, as well as upon the physical and mechanical properties, of the object.

Radar systems can be installed either on immovable objects (stationary installations) or aboard mobile carriers, depending upon their purpose. One of the types of airborne systems (mobile carriers) is the so-called "side-looking radar system". These systems feature a continuous image of a locality; such a continous image is conventionally obtained with slot aerial cameras while making an aerial photography survey. The mode of operation of the side-looking radar system is as follows.

The transmitter, by means of directed aerial, sends short-duration pulses at a right angle to the flight trajectory.

The received echo-signal is amplified and passed to the registration box. The recording of the radar image is done by an indicator cathode-ray tube with weak after-luminescence. The brightness of a point on the screen depends upon the reflective properties of the surface, and the value of vertical divergence (scanning) corresponds to the distance between the aircraft and the object. The scanning is projected with an optical system to a film. A tracking gear pulls the film along with a speed corresponding to that of the aircraft. The direction in which the film is pulled is perpendicular to the direction of distance scanning. As a result, radar imagery of a locality is obtained on the film.

In the Union of Soviet Socialist Republics, side-looking radar systems with high resolving power were worked out. These systems have a small coefficient of signal energy absorption in the medium of propagation even under the most unfavourable meteorological conditions.

These advantages were provided with the proper selection of wave lengths of the signals in an ultra-short band, with aerials of narrow-beam emanation and with use of pulses of short duration.

One of such systems is an all-weather survey system, "Toros", which works under the most unfavourable meteorological conditions—fog, overcast, snowfall and so on. There are two narrow beaming parabolic aerials, pulsing cm-band radio-waves. The aerials are installed along the aircraft fuselage. They are set in the direction perpendicular to the line of flight. The scanned imagery of a locality is registered on a 19-cm wide photofilm. The

*The original text of this paper appeared as document E/CONF 62/L 78

Toros system is widely used for ice-condition study and forecast, geological explorations and so on.

The application of this system in Arctic regions of the USSR under unfavourable meteorological conditions has proved that by radar imagery, one can obtain the following characteristics of the sea ice-cap: its age (using enlarged gradation); degree of packing with detailed picture of ice spacing; size of ice-fields; their shape, hummockness, distribution of channels and free-water areas. One can also trace the regularity of ice-cap formation and its dynamics. All this makes possible the quick compilation of sea-ice condition maps and enables one to produce the necessary information.

By comparison of the radar survey results with those of aerial survey, it is determined that discrepancies do not exceed 3–4 per cent and that the radar image of ice-cover has all the merits of that of aerial photographs.

In the field of geological explorations, the Toros radar system has provided the means for quick receipt of aerial images enveloping territories up to hundreds of kilometres with unique representation of topography, surface texture, hydrography, moisture and salinity of soils, vegetation and so on. All this is possible due to specific peculiarities of radar beam absorption by the earth's surface. That feature gave rise to the new kind of geological interpretation and permitted the compilation of structural schemes and maps of faults, and even the determination of types of rocks in some cases.

The peculiar mode of radar imagery construction accentuates the features of topography and imparts to it a sculptured quality, which makes possible successful geomorphological interpretation and enables one to sutdy the forms of topography. In some cases, one can trace buried structures using the existing dependencies between contemporary forms and ancient topography.

The Toros and other radar systems are becoming more and more applicable for the solution of scientific, technical and practical problems. The wide use of radar survey is based upon such factors, which make possible determination of geometrical forms of objects, texture of surface, moisture, electric and magnetic properties of rocks.

The above-described properties make it possible to use the radar systems for environmental studies and mineral resources inventory; and, in particular, for mapping of vegetation cover, soils and rural arable lands, for land reclamation and other purposes.

The auspicious outlook for application of the side-looking radar system for compilation of topographic maps of remote areas is clear.

The possibility of conducting an aerial radar survey under practically any meteorological conditions, the high efficiency due to envelopment of wide strips of an area and the possibility of building a three-dimensional model of a locality by means of radar survey data—all permit a considerable reduction of time and amount of aerial surveying, as well as of the amount of work for horizontal and vertical control of surveys.

Ultimately, the application of radar systems for mapping will bring about a considerable reduction of mapping production cost.

APPLICATIONS OF REMOTE SENSING TO POLLUTION PROBLEMS*

Paper presented by France

Water pollution is, perhaps, one of the most disturbing problems of the modern world. The sources of pollution are many and varied; sewage, industrial wastes and petroleum products all contribute to the constantly accelerating degradation of both the marine environment and the fresh waters of rivers. There are, of course, many processes currently in existence for locating and treating such pollution; but very often they provide only a partial solution to these problems. Observations are still too limited both in time and in space.

The Institut géographique national (IGN), an agency of the Ministry of Physical Planning and Capital Development, which is responsible for preparing and keeping up to date the French base maps, has long been using aerial photographs for topographic purposes. During the past few years, however, it has begun experimenting with a variety of emulsions, with new non-photographic methods and even with other airborne platforms (in particular, satellites). This experimentation has made it possible to record phenomena by means of electromagnetic waves of frequencies very different from those of the visible spectrum. All these techniques, both conventional photo-interpretation and new processes, have been grouped under the general term "remote sensing".

Remote sensing solves the problem of locating sources of pollution and studying the surface of polluted waters, which, in turn, will facilitate the "treatment" phase (which is outside the scope of this paper) by promoting a concentration of resources on particular areas.

Remote sensing

The purpose of remote sensing is to record: first, the solar radiation reflected by terrestrial objects, such as water, vegetation and rocks, for which purpose aerial photography is used; secondly, the emission from such objects themselves, which is the field of thermography.

The electromagnetic spectrum is notable for its range and its continuity. However, it is considerably affected by the atmosphere, which absorbs part of the radiation and scatters another part. Only a few "windows" which are little affected by atmospheric absorption can be used. The main ones are: the visible and near infra-red region, 0.4–1 micron; two bands in the medium infra-red region, 3.5–5 microns and 8–14 microns, in both of which there are a few narrow absorption bands characteristic of certain molecules—for instance, CO at 4.6 microns, 0_3 at 9.5 microns; the millimetre and centimetre waves used in radar (although these are not relevant in the present context).

Atmospheric scattering, which is inversely proportional to the fourth power of the wave length, is signifi-

*The original text of this paper, prepared by the Institut géographique national, France, submitted in French, appeared as document E/CONF.62/L.124.

cant in the case of short wave lengths, but becomes negligible in the infra-red region.

In the case of a black body obeying Planck's law, the energy emitted (spectral emittance) is a function of the temperature of the body and of the wave length. Spectral emittance curves show that the energy radiated is maximum for a wave length in the neighbourhood of 10 microns, for the temperature usually encountered at ground level (about 300° K), and that it remains substantial above 2 microns.

In practice, actual bodies can be equated to black bodies only approximately. It is necessary to introduce the concept of emissivity, which is the ratio of the actual emissive power of the body under consideration to the emissive power of the corresponding black body at the same temperature. Its maximum value is 1 (black body); for water, it varies from 0.9 to 0.7, depending upon the amount of sedimentary matter, i.e., the pollution.

Physical means of remote sensing

The main components of a remote-sensing system are the recording devices (sensors) carried by vehicles. The vehicle may be an aircraft, a balloon or a satellite. IGN has a specialized unit (Service des activités aériennes) based at Creil, which has, in 1973, about 15 aircrafts (twin-engine Hurel-Dubois and Aero-Commander aircraft, four-engine B-17s, one twin-jet Mystère 20). However, the Service de la télédétection is able to use data collected on board other vehicles, including the balloons of the Centre national d'études spatiales (CNES) for small-scale photographs; and, in particular, such satellites as the Earth Resources Technology Satellite (ERTS-A) of the National Aeronautic and Space Administration (NASA) of the United States of America.

The first sensors used by IGN were cameras; they are still, of course, used a great deal, particularly where conventional photo-interpretation is called for. The main models currently in use are film cameras with various focal lengths (88, 152, 210 or even 610 mm) which allow a wide range of photographic scales, depending upon the flying height.

Panchromatic emulsion is the one most commonly used; it covers the entire visible spectrum and has a well-balanced response with a mean in the vicinity of 620 nanometres. While this emulsion is very well suited to the needs of the topographer, it is less useful to the photo-interpreter, especially in studies of vegetation and hydrographic systems. During the past few years, other emulsions have come into use, in addition to panchromatic.

The first was black-and-white infra-red, sensitive up to about 950 nanometres, used with a red filter in order to screen out the shorter wave lengths. The facts that open water absorbs infra-red radiation is helpful to the interpretation of lakes, ponds, marshes and the like.

"Natural-colour" emulsion makes it possible to record the visible spectrum on three layers (yellow-magenta-cyan) corresponding to three different emulsions on the same film base, which break the subject down into the three basic colours: blue, green and red. This emulsion, used without any coloured filter (except anti-ultra-violet), is very useful for pollution studies, since the way in which radiation of shorter wave lengths penetrates water differs according to the presence of sedimentary matter, pollutants and the like.

"False-colour" emulsion also comprises three layers on one base; two of them (yellow and magenta) record the visible spectrum, and the third (cyan) is used for the infra-red part of the spectrum (up to about 900 nanometres). Radiation below 500 nanometres is screened out by orange-yellow filter. This emulsion is used mainly for studying vegetation problems and, in particular, the chlorophyll function.

In the case of thermal infra-red, the most important sensor that IGN currently has is the Cyclope infra-red scanner. This instrument makes it possible to distinguish between terrestrial objects differing in temperature by a few tenths of a degree. As the aircraft moves, the Cyclope, using a mirror rotating at the rate of 70 revolutions per second, successively scans narrow strips of ground and receives the radiation from the ground. The radiation is focused so that the image received is concentrated on a detector cell, sensitive within the 3–5 micron band, which emits an electrical signal that varies with the ground temperature. This signal is then amplified and recorded on magnetic tape. Processing of the data is carried out on the ground, currently by electrophotographic means; the magnetic tape is read by a transcriber bay, which produces a black-and-white image on 70-mm film. This film constitutes the master thermogram, and enlarged copies can be made on paper; for a composite study, the different strips are assembled (semi-controlled mosaics on the IGN base map).

Lastly, the importance of observation from space for the study of phenomena relating to water, vegetation and morphology should not be overlooked. NASA has established a programme of earth resources studies involving the launching of a number of specialized ERTS satellites; foreign countries were invited to propose experiments. Accordingly, IGN is participating, as co-researcher, in a programme of remote-sensing studies of the French coastline (French Atlantic Littoral-Fralit—carried out by the ERTS-A satellite, whose orbit is circular and is planned so as to ensure that both the scale of the imagery and the light conditions shall be as constant as possible.

The ERTS-A satellite carries two sensor systems: (*a*) a set of three RBV television cameras; (*b*) a multispectral scanner (MSS). Only the second system has provided usable data.

The data are stored on board the satellite and are subsequently transmitted for processing to Goddard Space Flight Center at Greenbelt, Maryland, which distributes them in the form of magnetic tapes, films and prints.

Applications of remote sensing to water-pollution problems

After the foregoing brief survey of the means of remote sensing currently in use, a few cases of their application to the detection of pollution should be considered.

It is generally possible with this method to detect, in a heterogeneous medium, masses of water with different characteristics. The method is useless for studying a homogeneous mass, such as a uniformly polluted watercourse.

Conventional photo-interpretation is of value in studying mechanical pollution, mainly with the use of "natural-colour" emulsion. The ability to differentiate

sediment-laden waters is due to their particular reflectivity, and especially to the great penetrating power of this emulsion (diapositives). Significant results have been achieved in detecting chemical pollution through the different reflectivity of the subjects in relation to the surrounding medium.

However, the most effective tool is, no doubt, thermography, which allows a better quantitative approach to problems. Qualitatively, it makes it possible: to locate point sources of pollution; to detect the form and extent of polluted water surfaces and classify them by temperature; to observe phenomena over a period through the selective timing of exposures (working hours of a plant, business hours of a city, effect of weather conditions and the like).

Thermography allows quite a number of indirect studies, such as studies of tidal currents or of the diffusion of fresh water in the ocean, thus making it possible to observe (and predict) the drift of industrial pollutants and agricultural pollutants (pesticides). It is also the best method for studying thermal pollution (coolant water from power-plants, factory wastes).

Various projects have been carried out by IGN in France on these applications of thermography.

Recording by satellite makes it possible to study a new category of problems. From the very small-scale documentation produced, one can detect large areas of pollution and observe them over a period of time, because of the repetitiveness of the recordings.

Methodology—data processing

Once the remote-sensing process suited to the phenomenon to be studied has been selected, it is necessary to decide on the photographic parameters, such as boundaries of the area to be covered, scale and flying height. Simultaneously with the airborne mission, there often has to be a ground mission for the purpose of seeking data to facilitate interpretation and reporting, or, in the case of thermography, making physical and meteorological measurements designed to calibrate the recordings.

The interpretation part is carried out mainly by means of conventional photo-interpretation processes, namely, detailed study of the recordings in photographic form and preparation of data-based overlays. However, a number of methods can be used to improve this process at both the data-processing and the reporting stages. One such method which has proved to be of interest is the "coloured equidensities" process. It consists of dividing the scale of densities of the black-and-white photographs into a number of segments which are then transposed in a variety of colours ranging from violet to red. Where density is itself a function of the phenomenon to be recorded (as in the case of thermography), this produces, directly by photographic means, documentation that is easily readable and usable.

Future research and prospects

Thus, remote sensing has already become a suitable means for the qualitative study of pollution phenomena, primarily by locating polluted surfaces and describing them geometrically. However, there is reason to hope for further improvements in recording techniques so as to advance to the quantitative stage, involving such matters as the absolute temperature of observed masses of water and a better knowledge of emissivity, which would make it possible to study variations in concentration of industrial wastes. The recording of data in numerical form, which is possible with some sensors, should also considerably improve reporting methods, at least in the case of large-scale operations. Another problem that remains to be solved is the effect of weather conditions. Even thermal infra-red is distinctly more penetrating than the visible spectrum; haze and light fog are relatively transparent. The use of centimetre-wave devices capable of piercing thick cloud cover will make it easier to deal with these problems (including, in particular, surveillance of the oceans).

Remote sensing, a new and rapidly developing technique, can and should play a large part in combating pollution, which will be a prerequisite of life in the world of tomorrow.

AGENDA ITEM 14

Earth resources satellites for surveying, mapping and earth resources studies

AUTOGRAPHIC THEME EXTRACTION SYSTEM*

Paper presented by the United States of America

HISTORY AND BACKGROUND

The mushrooming space technology of the latter 1960s demonstrated that monitoring and cataloguing the earth's resources from space would soon be feasible, as well as highly desirable. Consequently, the United States Department of Interior assigned the Geological Survey (USGS) the task of developing and directing the Earth Resources Observation Systems (EROS) programme. It soon became clear that EROS must include some means of isolating and extracting the various resources data in order to be a viable and complete remote sensing programme. After preliminary research, a team of USGS scientists and engineers began planning and designing the EROS Autographic Theme Extraction System (ATES) in 1970. Examination of state-of-the-art image-processing hardware and techniques soon convinced the team that the most efficient and cost-effective storage and processing of the expected vast amounts of image data would necessarily use photochemical and photomechanical techniques as much as possible. Therefore, it was specified that theme extraction should use a maximum of photolab methodology, with only limited digital image-processing utilized as an aid where necessary. In the near term, EROS expects to draw heavily upon earth imagery obtained from the ERTS and Skylab space flights, which feature multiple-sensor imagery, meaning that the spectral return of each earth scene is subdivided into three or more separate bands by means of filters, gratings or other devices. Each spectral band portrays a selected theme as a slightly different hue or density in relation to other components of the scene. By use of current advanced hardware, together with colour-filtering and density-slicing techniques, a particular hue or density band in a single photo-image can be isolated or enhanced without difficulty. However, if the enhancing spectral or transmittance band is made wide enough to pass 100 per cent of the selected theme signal, varying amounts of spurious information or noise, also get through and complicate quantitative measurement of theme data. The real problem, then, lies in suppressing noise while extracting thematic data of high reliability.

The reliability of theme isolations based on hue or density ratios can be most efficiently increased by combining two or more properly processed spectral images into a photographic composite or sandwich in which each band tends to obscure or cancel out the spurious data in the others. The techniques required to produce composites are well known in photo-lab methodology. However, the experimental effort needed to establish the best processing procedure for each spectral image and thereby to produce the optimum composite is frequently time-consuming and expensive. Obviously, then, the photo-lab techniques must be supplemented by some rapid and convenient method of determining the optimum processing parameters for effectively enhancing and isolating any given theme in a multispectral earth scene. Consequently, ATES is an instrumental collection of electronic and photo-mechanical hardware of widely varying capability and applications.

DEFINITION AND DESCRIPTION

The ATES is currently made up of three parts: a digital image-processing section, the Density Manipulation System (DMS); an analogue electronic multichannel image analysis section, the Multichannel Image Analysis System (MIAS); and a high-quality graphic-arts photographic laboratory. The digital processing hardware consists of image digitizer, interactive display, tape recorder and film recorder, all interfaced with a mini-computer. It is used to produce unsharp, windowing and other filters and masks needed for density normalization and image enhancement, and to perform digital-to-photographic and photographic-to-digital image conversions.

The MIAS is an analogue electronic photo-lab. With it, as many as four spectral bands or images or a scene can be relatively registered, scaled and selectively processed to obtain a desired composite picture viewed in black-and-white or colour on television displays. Graduated scales on the controls provide data an analyst needs to write processing instructions for production of the desired photographic composite in the photo-lab.

The photographic laboratory houses the varied films and chemicals needed for specialized photo-mechanical hue and density isolation techniques, as well as all the photo-mechanical hardware normally found in a well-equipped graphic-arts lab.

USAGE

The ATES is used to obtain thematic data of cartographic utility from imagery obtained with spacecraft and conventional aircraft as well. Each theme must

*The original text of this paper, prepared by Doyle G. Smith, United States Geological Survey, Washington, D.C., appeared as document E/CONF.62/L.60

possess, in addition to cartographic utility, a unique and distinct spectral signature or autograph by which it can be readily identified. Four gross themes under active study are open water, vegetation, ice-snow cover and concentrated works of man.

The isolated theme data are customarily stored in the form of easily reproducible two-level or binary graphic extractions, usually as a photographic transparency or colour-foil overlay. Figures 203–217 illustrate examples of binary extraction. Figure 203 is an Earth Resources Technology Satellite (ERTS) multispectral scanner picture of a section of southern Maryland and northern Virginia near the eastern coast of the United States. Figure 204 is the open-water theme graphic; and figure 205 is the infra-red-reflective vegetation graphic derived from this scene. Vegetation has been subdivided into two categories; forest (figure 206) and field or grass (figure 207).

Figure 208 delineates two types of features: highly urbanized city areas; and low-lying damp or swampy areas subject to frequent inundation. Figure 209 is a theme graphic of the high-density urban and suburban areas in the Washington-Baltimore corridor. This type of graphic is valuable for land-use planners interested in monitoring and controlling urban and suburban sprawl around large cities. Figure 210 shows large areas of interest to scientists studying soil erosion and water pollution caused by rainfall run-off.

Figure 211 is a photograph of an area in the south-western United States, obtained during an earth orbit of one of the Apollo space flights. Figures 212 and 213 are open-water and snow-cover theme graphics derived from figure 211. This type of theme data can prove valuable in assessing potential future water-supplies of arid or semi-desert regions.

Figure 214 is another ERTS image, this time a California-Nevada scene; and figures 215 and 216 are breakdowns of the open-water theme into two distinct classifications. Figure 217 shows sandy areas susceptible to wind erosion.

Conclusion

Theme graphics of appropriate scale and fitted with an appropriate reference grid are cartographic products usable in many applications. They can be used to assess snow packs in otherwise arid regions. They can be used to track and document some types of pollution, generally in open water. They can monitor the seemingly relentless creep of urban sprawl. Many other distinct themes which can be isolated are of direct economic benefit in analysing land use. Bulk data from flying remote-sensing systems pose problems of interpreting and correlating specific data which can be solved most efficiently by close and knowledgeable analysis of spectral signatures.

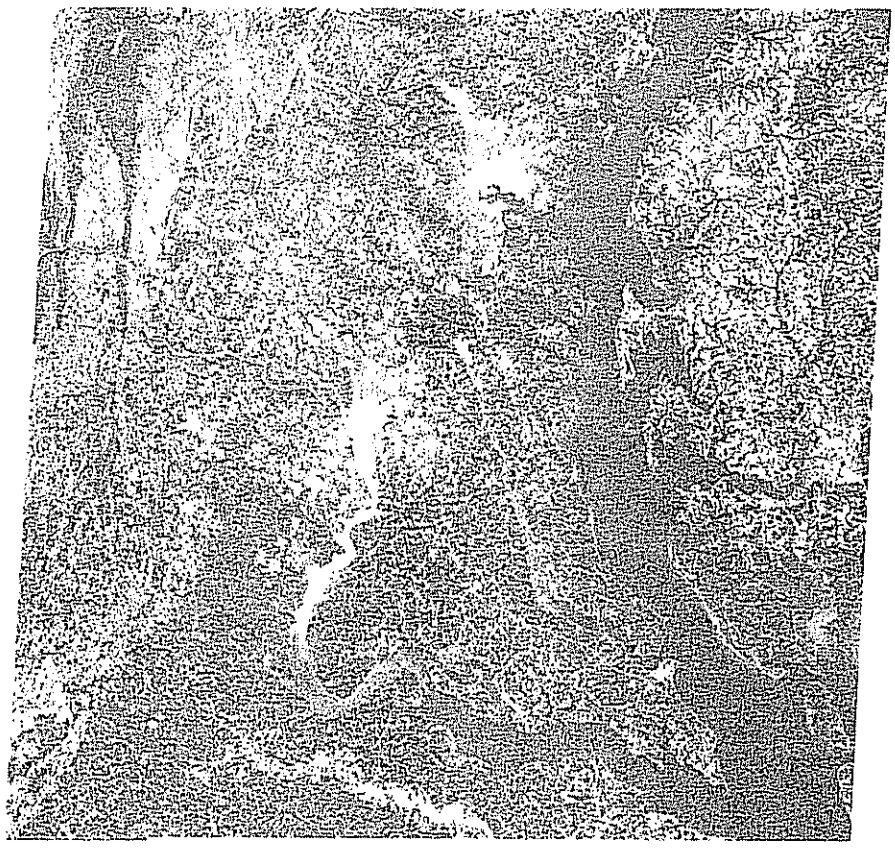


Figure 203. United States of America: ERTS multispectral scanner scene, Maryland-Virginia

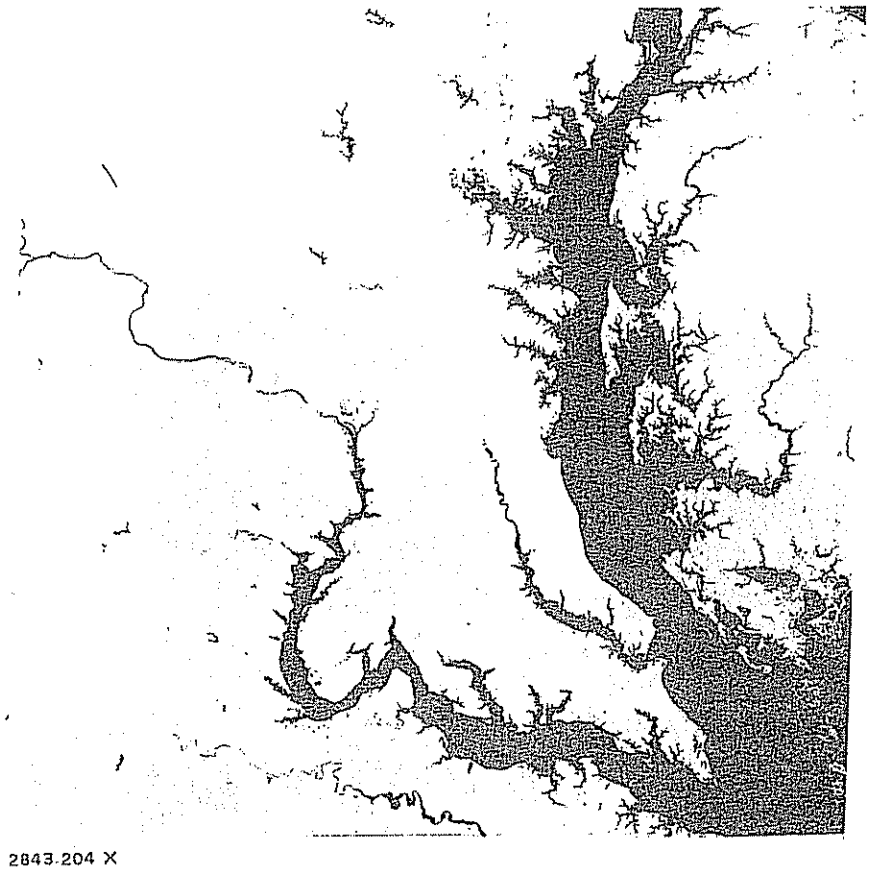


Figure 204. United States of America: open-water theme (black)

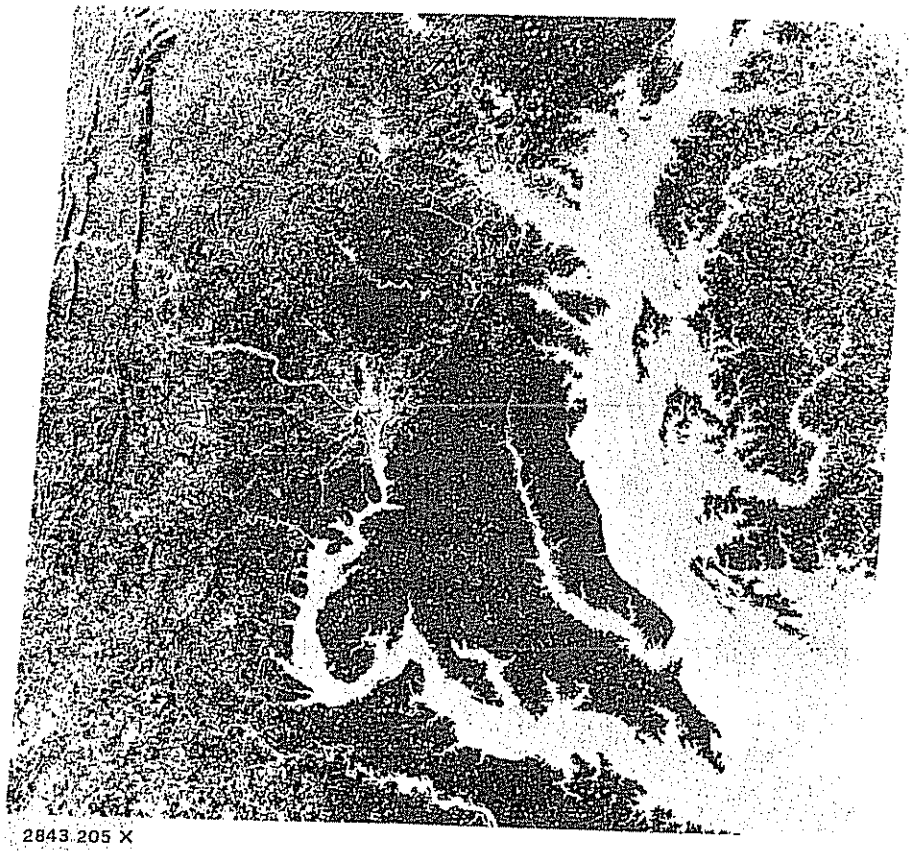


Figure 205. United States of America: infra-red reflective vegetation

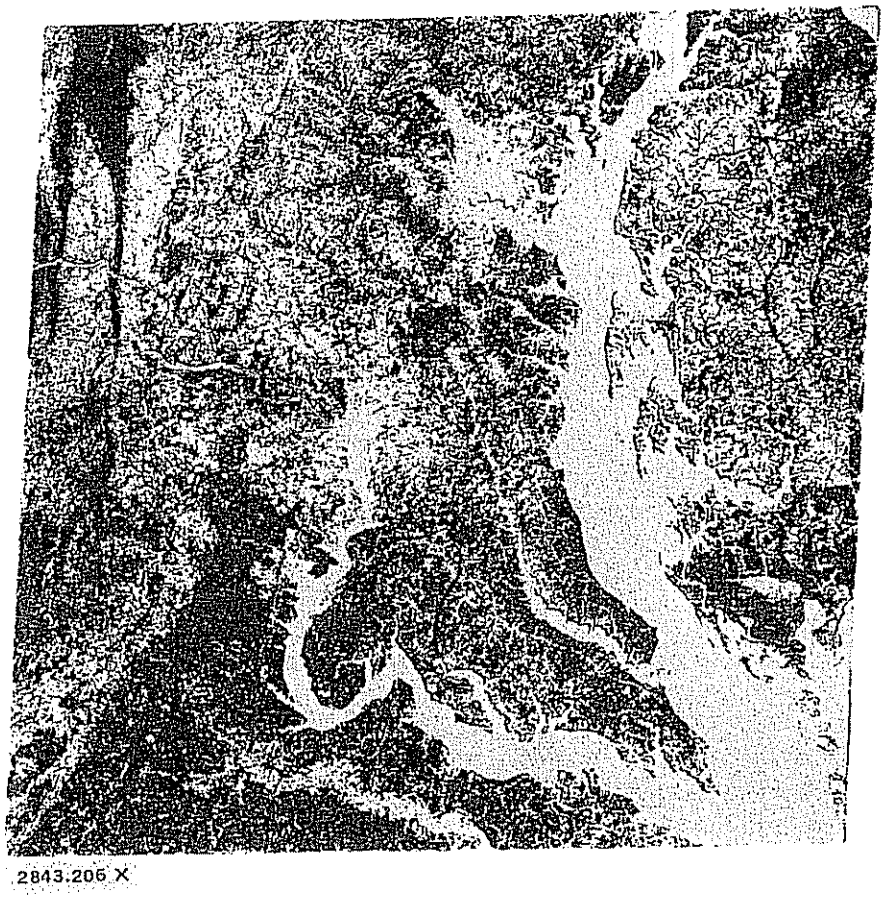


Figure 206. United States of America: forested areas (black)



Figure 207. United States of America: field and grassland (black)

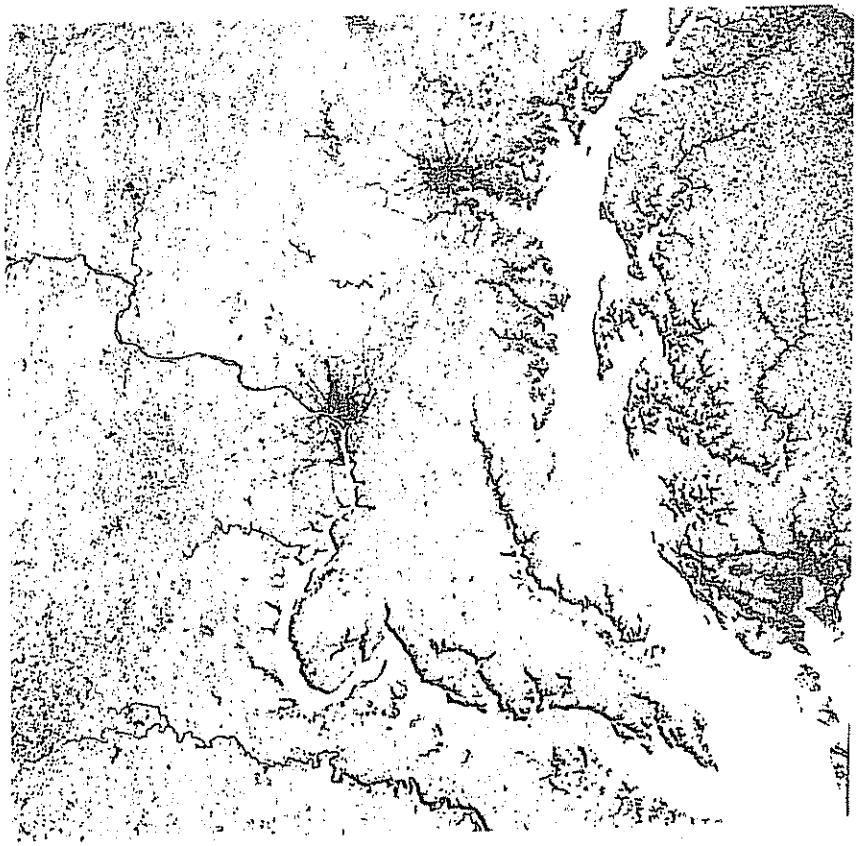


Figure 208. United States of America: urban areas and swamps



Figure 209. United States of America: high-density urban and suburban areas

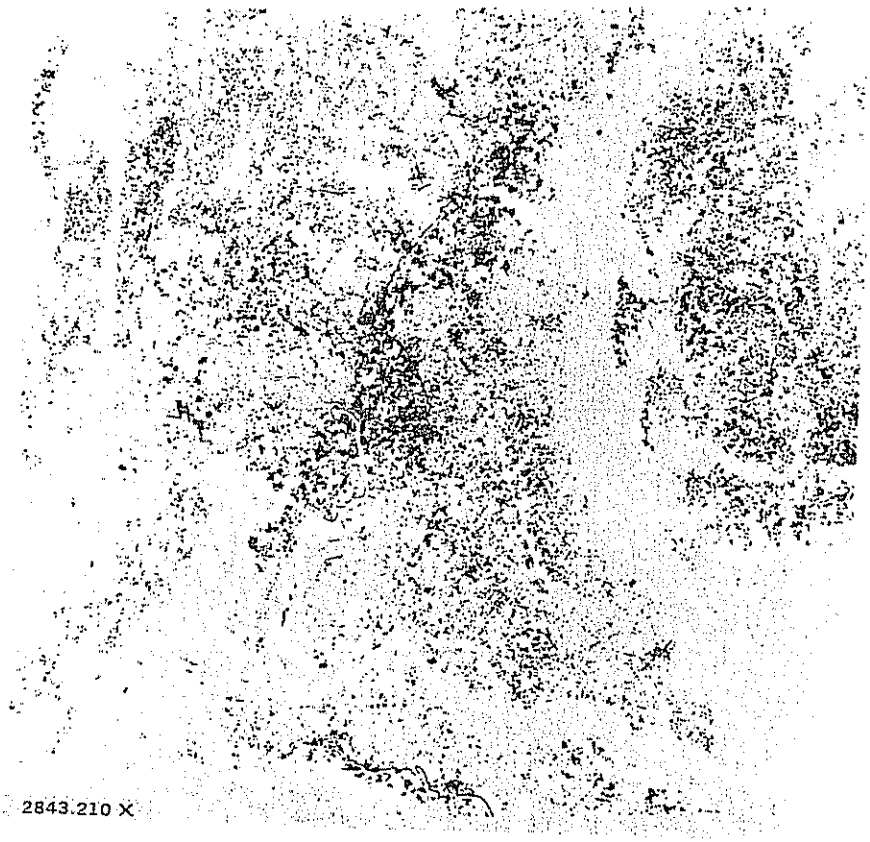


Figure 210. United States of America: concrete surfaces and bare ground

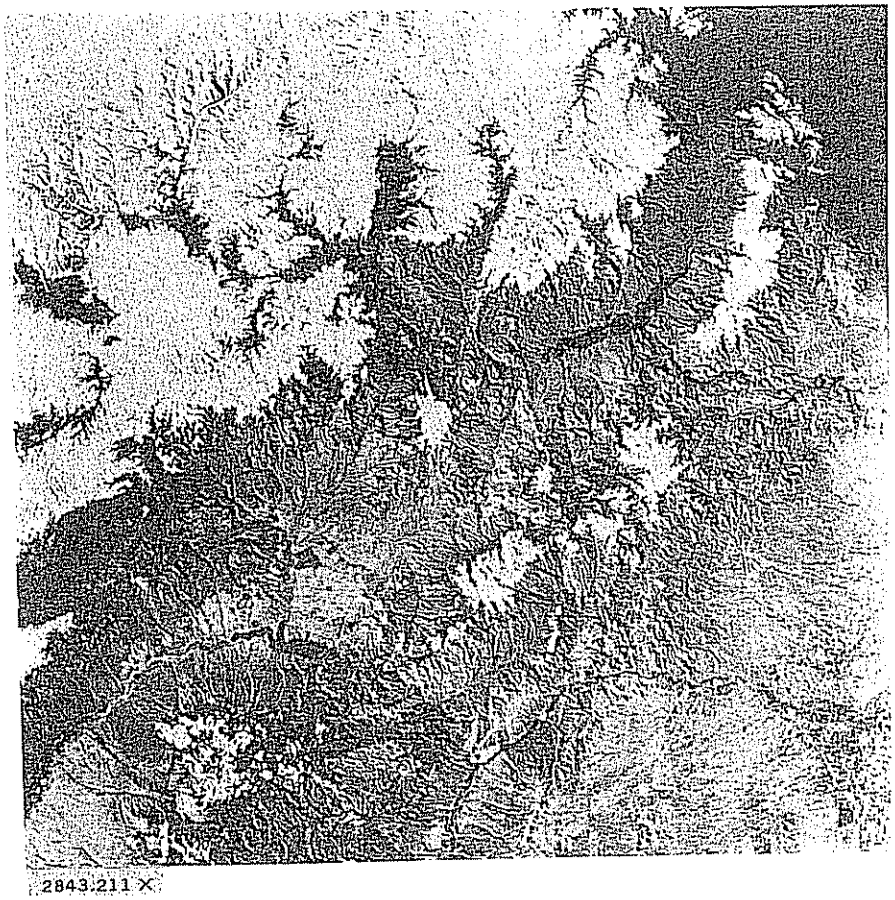


Figure 211. United States of America: Apollo 9 photograph

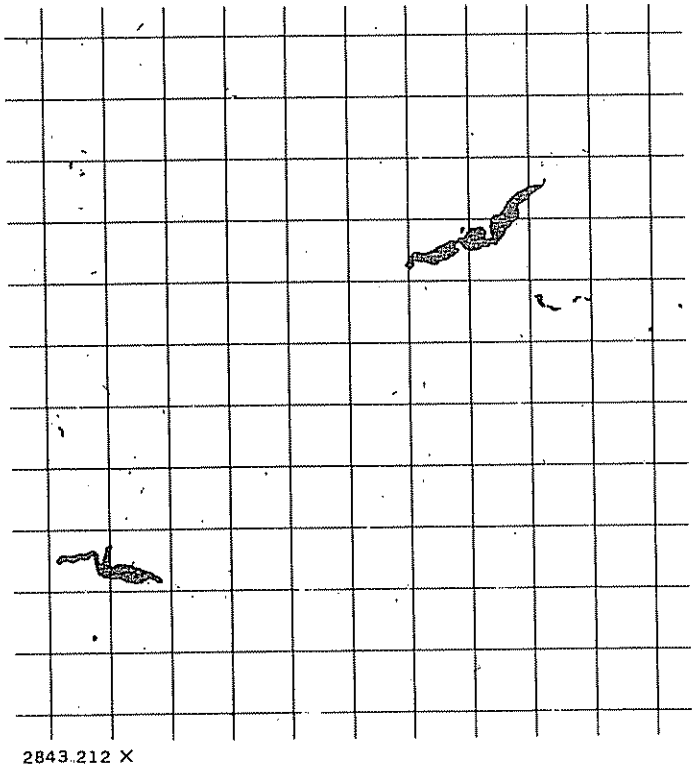


Figure 212. United States of America: open-water theme (black) derived from Apollo 9 photograph

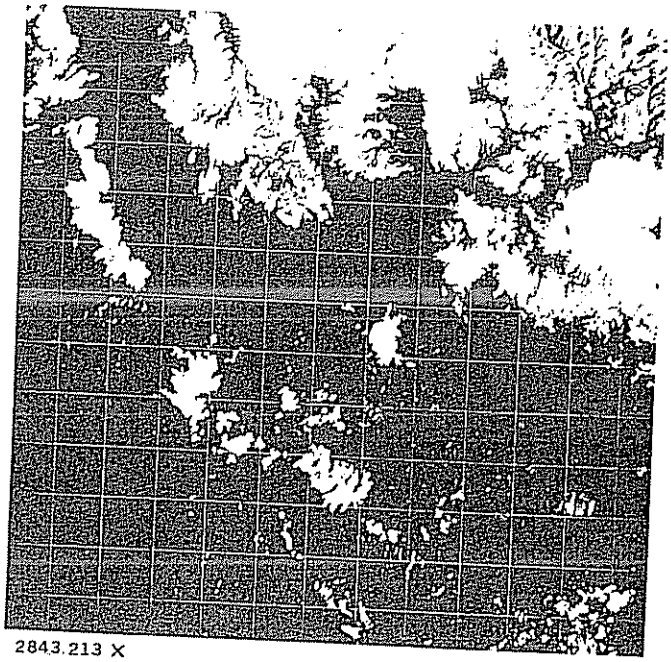


Figure 213. United States of America: snow cover (white) derived from Apollo 9 photograph

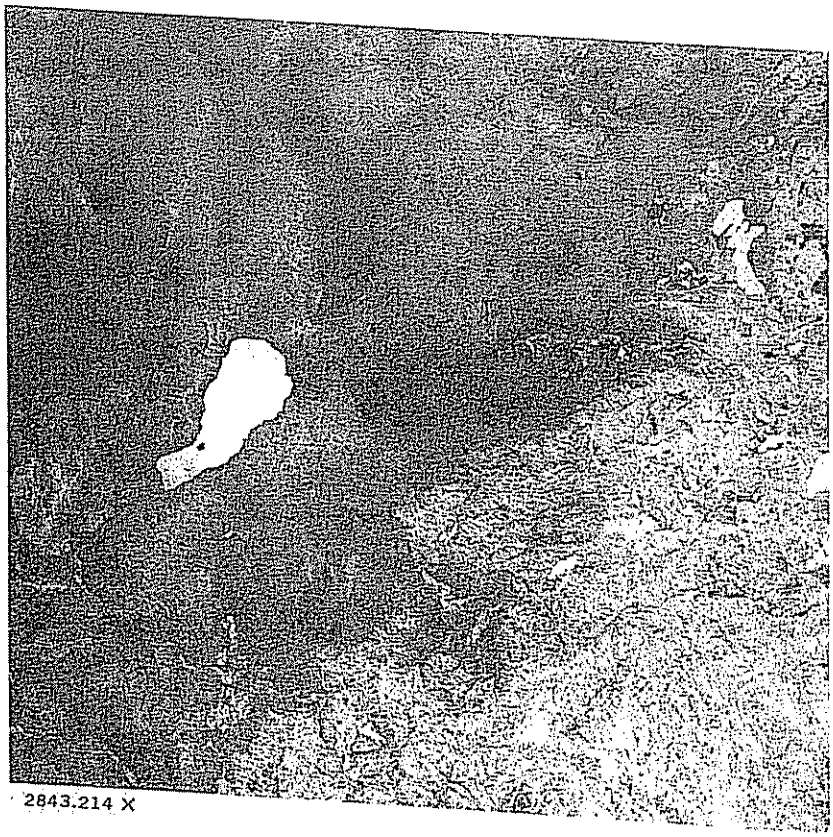


Figure 214. United States of America: ERTS multispectral scanner scene, California-Nevada

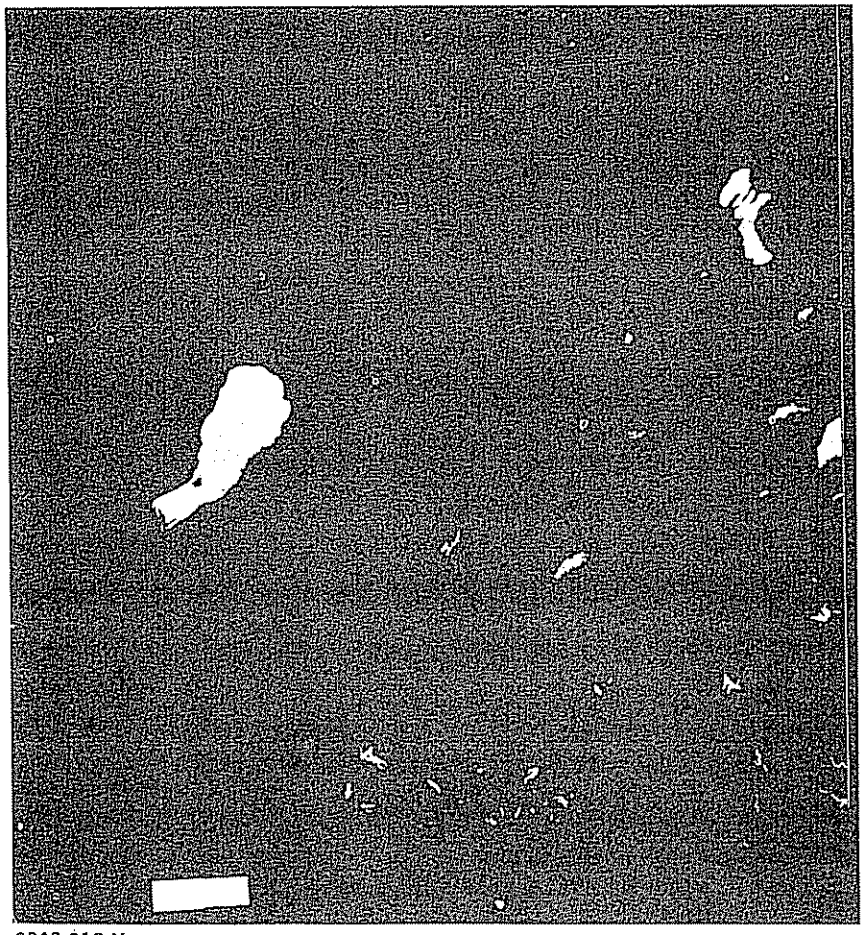


Figure 215. United States of America: clear, deep open-water (white)

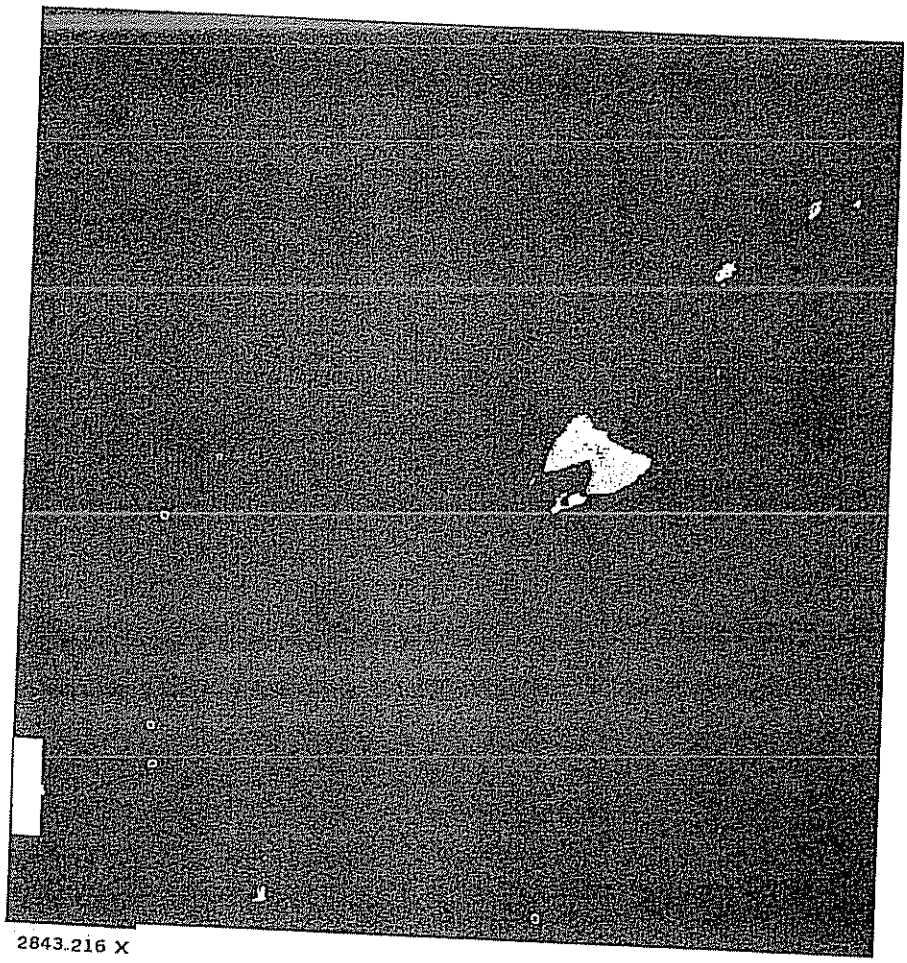


Figure 216. United States of America: shallow, turbid water (white)

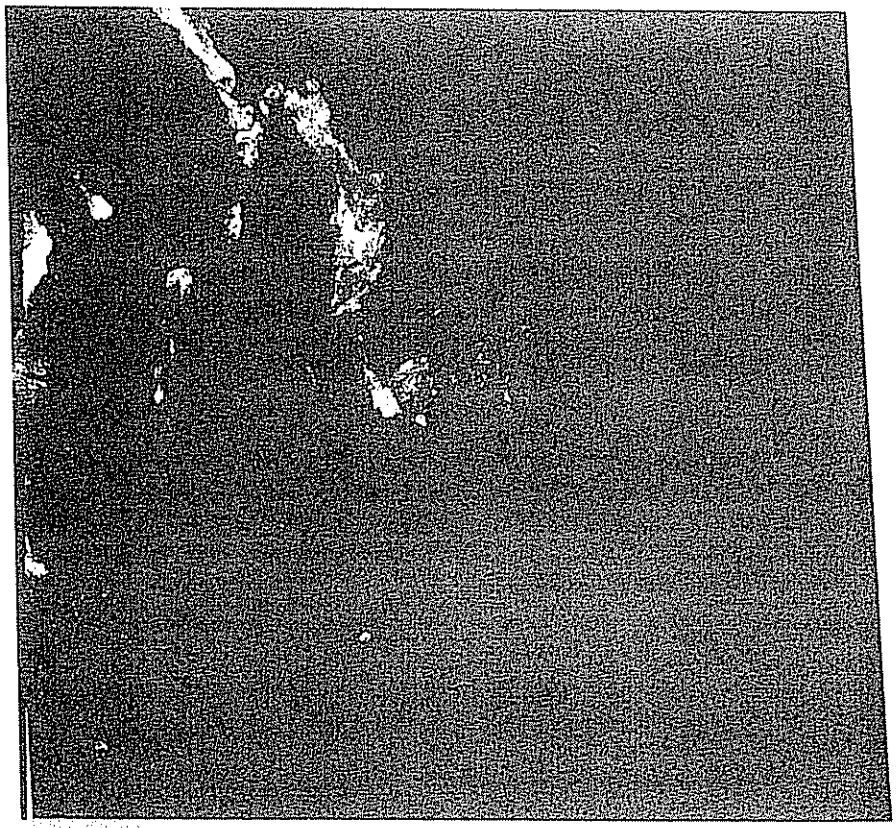


Figure 217. United States of America: desert/sand (white)

PHILIPPINE EARTH RESOURCES SURVEY PROGRAMME*

Paper presented by the Philippines

The Philippines has no consolidated programme on remote sensing. Activities along this field are being undertaken independently by user-agencies. To remedy this, the National Committee for Mineral Exploration and Survey Operations (NACOMESO) was given the task of co-ordinating the scattered efforts on natural resources surveys by utilizing remote sensing.

Preliminary discussions and exchange of communications concerning Philippine participation in the Earth Resources Technology Satellite (ERTS) programme of the United States of America were held with the United States Embassy at Manila and the State Department at Washington, D.C. These discussions resulted in the visit of a four-man natural resources survey team to the Philippines in October 1971. The team evaluated the capabilities and requirements for remote sensing of the different user agencies and prepared its recommendation to the United States Agency for International Development (USAID).

On 17 April 1972, the National Committee for Mineral Exploration and Survey Operations activated a study group to draft a complete and detailed study for a Philippine natural resources survey programme. The bases for the programme proposal were the reports and recommendations of the Philippine seven-man earth resources survey team and the United States advisory team, which visited the country.

This programme proposal is an initial attempt of the Philippine Government to co-ordinate government agencies in drafting an integrated programme that will be responsive to the actual total requirement of the natural resources development field and the national economy. The proposed programme is envisioned as a work plan to link the different resources survey projects and activities of the various agencies involved in its preparation.

Due to the multidisciplinary nature of the activities covered by this programme proposal, the major areas of investigative interest nave been phased according to the degree of development of local capability to absorb advanced survey techniques. These areas are treated separately by means of related subprojects. Various methodologies used and supporting figures are presented in each subproject.

The preliminary objective of the programme is to improve the information system of the country, capitalizing on technical innovations available, so that ade-

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quate, timely and accurate basic data could be made available for the formation and monitoring of sound and realistic agriculture and natural resources inventory and development plans.

Consistent with the goal of the Government's Four-Year Development Plan (FY 1972-1975) to attain sustained economic prosperity through sound management of the natural resources of the country, this programme envisions the development of an institutional framework through which interagency co-ordination, data collection, processing, analysis, storage and uses of earth resources survey data can be mobilized to support the requirements of multiagency earth resources survey projects.

The acquisition and application of operational remote-sensor techniques to accelerate the exploration and development of the various natural resources of the Philippines will redound to a systematic and efficient utilization of these potentials. Corollary to the acquisition of this capability is the establishment of a data-monitoring system, using advanced multisensor survey techniques to provide a continuing source of surveillance data.

The estimated total investment cost of the five-year programme will come from the USAID loan package, and the Philippine Government contribution to the programme will be provided mainly by the annual appropriations of the Department of Agriculture and Natural Resources, which will represent the Government as borrower. Part of the local contribution will also be generated by the various participating agencies and the operational income of the proposed data centre.

Scope of the programme

The Philippine proposed earth resources survey programme envisions the utilization of operational and promising remote-sensing technologies to improve the information system of the country with respect to its environment and natural resources. The first objective is to consolidate and improve in-country capability and enrich existing resources survey projects, before embarking on a massive programme involving more sophisticated systems, whose technical and economic feasibilities have yet to be demonstrated.

The Philippine Government proposes to develop an institutional framework through which interagency co-ordination, data collection, processing, analysis, storage and uses of earth resources survey data can be effectively mobilized, consistent with the interdisciplinary and multiagency nature of earth resources survey technology. Emphasis is given to the development of an indigenous capability which will enable the Philippines to conduct modest resources surveys using operational remote-sensing techniques, at the same time keeping pace with the state-of-the-art by way of the advanced techniques demonstration portion of the programme. To accomplish these objectives, a three-part programme, consisting of the following phases, is proposed:

(1) Development of an interagency institutional capability;

(2) Acquisition and application of operational aircraft sensors and techniques on specific natural resources development projects;

(3) Application of multisensor techniques and establishment of a monitoring system.

Description of the programme

The following outline gives the different phases and details of the Philippine earth resources survey Programme:

Phase I. Development of an interagency institutional capability:

(1) Establishment of a central facility;

(2) Utilization of existing imagery to provide:

- (*a*) Land-classification maps;
- (*b*) Tax and cadastral maps;
- (*c*) Forest inventory and soil maps;
- (*d*) Crop inventory and crop zonification scheme;

(3) Development of a minimal remote-sensing capability.

Phase II. Geophysical exploration:

(1) Marine seismic and magnetic surveys;

(2) Airborne magnetic surveys;

(3) Shipborne magnetic surveys;

(4) Expansion of geophysical laboratory facilities.

Phase III. Multisensor demonstration surveys:

(1) Establishment of ground truth sites;

(2) Introduction of aircraft sensing techniques:

- (*a*) Thermal infra-red scanning—Volcanology Commission;
- (*b*) Colour and multispectral photography:
  - (i) Epidemiological survey of coconut cadang-cadang disease;
  - (ii) Epidemiological survey of citrus greening;
  - (iii) Assessment of crop damage due to typhoons and floods;

(3) Adoption of applicable multisensor systems for utilization in resources inventory monitoring projects:

- (*a*) Interpretation of available multispectral imagery from high-altitude aircraft and spacecraft;
- (*b*) Establishment of interpretation and storage system utilizing electronic data computers;

(4) Data-gathering flights to continue and expand according to success and project emphasis;

(5) Data and technology exchange with the National Aeronautics and Space Administration (NASA) of the United States of America.

Progress to date

Shortly after the visit by the team from the United States, a seven-man team, composed of representatives from Philippine user and support agencies, was organized and sent to the United States on a three-week observation tour of centres actively engaged in operational and experimental remote-sensing applications. The Philippine earth resources survey team visited the offices and field demonstration sites of the United States Geological Survey, NASA, United States Topographic Command, United States Department of Agriculture, Research and Extension Service, Bureau of Reclamation, Engineer Agency for Resources Inventory, and the University of California at Berkeley. A preliminary report was prepared by the Philippine team after arrival, embodying its observations concerning the applicability

of the remote-sensing method and equipment to Philippine resource survey requirements.

It has recommended the following procedures: (*a*) utilize to the fullest extent all available remote-sensing data (black-and-white aerial photography) now with different government agencies; (*b*) adopt colour, colour infra-red photography and thermal scanners for crop, soil, forest, geology, hydrology, volcanology and mineral surveys; (*c*) upgrade and expand local capabilities and facilities for remote sensing.

The team is currently engaged in preparing a preliminary feasibility study to support its project proposals and to spell out the benefits that may be expected out of the five-year remote-sensing survey of Philippine natural resources. A United States consultant is scheduled to arrive in the Philippines very soon to assist the team in preparing its proposals.

AN ACCOUNT OF THE THAILAND NATIONAL PROGRAMME OF THE EARTH RESOURCES TECHNOLOGY SATELLITE*

Paper presented by Thailand

Background information

The Thailand National Programme of the Earth Resources Technology Satellite (ERTS) originated from the General Assembly of the United Nations in September 1970, at which the representative of the United States of America declared to other countries the importance of utilizing space technology. He also informed the General Assembly that the United States would be happy to disseminate information obtained by the Earth Resources Technology Satellite, the first of which was to be launched by the United States at an approximate cost of $100 million and would travel around the world on a polar orbit. In April 1971, F. Z. Kutena, an expert on land development and water resources of the Food and Agriculture Organization of the United Nations (FAO), informed the National Research Council (NRC) of Thailand that should Thailand wish to survey its natural resources by means of the satellite when it travels over Thailand, the United States could make arrangement for the satellite to photograph its resources without charge and would also be ready to provide assistance in interpreting the photographs taken by the satellite.

After NRC and other related Thai government agencies had considered Mr. Kutena's proposal, they unanimously agreed that Thailand still needs a considerable amount of data on natural resources; and application of the satellite technology would yield immediate, accurate information to meet this urgent need. The NRC therefore sought the approval of the Cabinet to collaborate with the National Aeronautics and Space Administration (NASA) on the United States ERTS programme. On 14 September, 1971, the Cabinet appointed a co-ordinating committee on the Thailand National Programme of ERTS, consisting of 20 concerned government agencies and having Mr. Pradisth Cheosakul, Secretary-General of NRC, as chairman.

The co-ordinating committee therefore appointed a working subcommittee with Boon Indrambarya, Director of the Environmental and Ecological Research Institute, the Applied Scientific Research Corporation of Thailand, as its leader, and Joseph Morgan from the United States Agency for International Development (USAID) as its adviser. The working subcommittee prepared the Thailand National Programme of ERTS for submission to NASA, which subsequently approved the participation of Thailand in its resources survey.

*The original text of this paper, prepared by Kaew Nualchawee, National Research Council, Thailand, appeared as document E/CONF.62/L.97.

Objectives

The Government of Thailand submitted a request to NASA to participate in the ERTS programme based on the following statement of objectives:

(*a*) To promote satellite data evaluation programmes by existing government institutions in order to evaluate the extent to which ERTS data could be beneficially applied in various sectors of economy to assist in the difficult task of acquiring data needed for resources inventory, planning and management at the national level;

(*b*) To introduce to Thailand space technology for resources survey and management;

(*c*) To improve and add to information on resources needed for specific development projects of national planning;

(*d*) To develop training facilities and offer courses to other countries and in the long projection;

(*e*) To develop a modern national resources survey and data bank centre.

Expected benefits from ERTS

Participating government departments have defined objectives specific to their areas of responsibility which will contribute to evaluation of applicability in the various disciplines of importance. The various disciplines and their expected benefits are described below.

Agriculture

As an agricultural country, Thailand urgently needs quantitative information on planting areas and production of major crops of the country. This is mainly to assure adequate production for the ever-increasing population, as well as for export purpose. The conventional method of obtaining information and collecting statistics is time-consuming and unreliable, which may, on many occasions, lead to a wrong interpretation of the economic situation of the country.

Because of the unique property of ERTS in that it covers a synoptic view of an area of 185 × 185 km and has a repetitive fashion of coverage, it gives an impression that it has more coverage accuracy and records timely changes of terrain information. The agriculture discipline could expect to make use of ERTS in the following ways:

(*a*) To set up crop calendars, showing cycles of major crops of the country;

(*b*) To estimate the area of planting of some major economic crops;

(*c*) To estimate the area damaged by natural phenomena and the production of the major economic crops;

(*d*) To identify the changes in land area used for production of some major economic crops;

(*e*) To estimate the probable yields of major economic crops (with support from ground truth data).

Forestry

Thailand has an area of approximately 514,000 km^2. According to the national economic development plan, it is required to reserve about half of the total area for national forest reserves. Currently, the forest condition has changed throughout the country for many reasons, such as damage by natural phenomena, shifting cultivation, and illegal cutting and illegal possession of forest land. These occurrences usually take place in remote areas where access by authorities is very difficult, if at all possible. In addition to the aforementioned importance, the need to set up boundaries for the national forest reserves is also very urgent. This work has always been in conflict with other departments whose responsibilities are to make use of land for other development purposes.

The Royal Forestry Department and the Faculty of Forestry of Kasetsart University realize the potential importance of the ERTS programme and have confidence that ERTS should provide a basis for them to achieve the following objectives within a reasonable period of time:

(*a*) To detect forest and non-forest areas of the entire country;

(*b*) To estimate the current and future forest production;

(*c*) To identify the changes in forest land use.

Oceanography

Remote sensing is an advanced science and technology which could benefit fisheries and oceanography. Benefits from ERTS output for fisheries would be direct, as concerns benefit to the aquaculture programme and the economy, and would provide data towards some of the objectives of the Department of Fisheries:

(*a*) Thermal readings for water surfaces for various water bodies, including the Gulf of Thailand, as well as the coastal areas off the western shore of peninsular Thailand;

(*b*) Water-body movements, so that the circulation patterns of such areas as the Gulf of Thailand may be known;

(*c*) Appearance of pollutants of varying concentrations and types in run-off, effluents and on the surface, i.e., oil slicks or seeps;

(*d*) Presence of planktonic blooms and extent of such blooms, since they are primary producers upon which all economic considerations of aquatic resources are reliant.

This type of data could be collected with existing methods; but it would be years before the interpretations could be given; it would be financially impossible; and, above all, it would be out of date by the time the interpretation was completed.

Geography, demography and cartography

Thailand, being an agricultural country, urgently needs information concerning current land use and area harvested. This information, together with information relating to land capability, soil suitability, crop yields and management requirements is needed for planning of the total agricultural programme of the country.

With this information, agricultural planning could be based on areas of land available for crop production and the location of each crop on soils and in areas best suited for most efficient production. More accurate estimates of production for each crop could be made, and modification and adjustments to meet changing needs and market conditions could be made more efficiently. The land-use mapping programme in Thailand intends to map out various types of current land use throughout the country on the scale 1:1,000,000, emphasizing principal land uses and forest areas. With more experience in interpretation of ERTS type data, it is expected that the land-use mapping programme will achieve the following goals:

(*a*) Accelerate the programme to get land-use maps in a reasonable period of time;

(*b*) Permit updating of existing maps;

(*c*) As ERTS acquires information at regular intervals, it is possible to repeat the observations as needed for identification of changes in tonal signature, which, together with a crop calendar, will permit identification of various crops.

Geology

It has been accepted as a fact that minerals of any origin play an important role in the national economy. Both government and private organizations have been surveying and exploring mineral resources. The Department of Mineral Resources is a government organization that deals directly with mineral resources survey. The Department of Mineral Resources is responsible, in addition to its major activities in geological mapping, for mining exploration and ground-water investigation. The Department expects to benefit from the ERTS data more accurately and faster than from conventional aerial photography. Additionally, the multispectral data obtained from ERTS could be made into colour composite data to enhance different geological features, which will make interpretation easier and more accurate. The projects expected to be undertaken are:

(*a*) Photo map of Thailand on the scale 1:1,000,000, which will be made available to all agencies concerned;

(*b*) Basic geological mapping on the scale 1:250,000, with the following information:

(i) Lithological mapping, discrimination of major rock units;

(ii) Structural lineation of Thailand, mineralization zones, major faults, major structures and structure of petroleum reservoirs;

(iii) Underground-water mapping;

(iv) Morphology.

Hydrology and meteorology

Water resources development projects were initiated in Thailand more than 50 years ago. The projects were designed mainly for irrigation, flood control, water conservation, power generation, waterway transportation, and other areas of development that have to do

with the population's well-being. Hydrological and meteorological information is an important parameter from which the development project accomplishes its goal. If data collection and analysis are accurate and up to date, the development plan would be improved.

Efficient operation of these projects, which demand timely information on various phases of the hydrological cycle within the watershed area, can be improved using ERTS data. For example, the soil moisture condition of the basin floor and the upper watershed may be assessed more accurately. Correct correlation between basin rainfall and river run-off may be determined using such information, on which flood forecasting procedures may be developed, and flood warning and flood damage minimization can be properly managed.

The National Energy Administration (NEA), the Royal Irrigation Department (RID) and the Meteorological Department realize that hydrological and meteorological information contributes a great deal to success of a development project. They set up data collection stations throughout the country for that reason. The collected data will be supplemental to that obtained from ERTS. It is expected that the information from ERTS would furnish a source of improved data for operational purposes:

(*a*) Determination of flood areas within the major river valleys and in the central plain areas. Such determination would include the boundaries, as well as the flooding depths. Results would be applied to the estimation of flood damage;

(*b*) Identification of changes of hydrological parameters within the river basins that may be useful in forecasting the river run-off at various river reaches.

Scope and procedure

Upon acceptance from NASA to participate in its ERTS programme, the Thailand National Co-ordinating Programme of the Earth Resources Technology Satellite was set up and chaired by the Secretary-General of the National Research Council, for policy and guidance. The National Research Council co-ordinates the participation of all interested Thai departments, assisted by the Applied Scientific Research Corporation of Thailand. An interdepartmental task force of Thai scientists was organized for programme development and implementation. ERTS data have been regularly transmitted to Thailand from NASA for analysis and interpretation in the fields of interest of the participating agencies. Research, development and findings are reported and compiled. The scope of work of the programme is described below.

Accomplishments

The ERTS programme utilizing remote-sensing technology is relatively new to Thailand. The Government recognized the need for trained manpower to interpret and utilize the satellite output in its various departmental programmes and requested USOM for assistance in providing necessary training. The remote-sensing training courses for improving Thai or third-country national resources management and development were arranged.

Training abroad

Sathit Wacharakitti of the Faculty of Forestry of Kasetsart University, was the first Thai scientist who received training from the University of Michigan in the field of remote sensing.

A group of Thai scientists/administrators received a grant from the United Nations Development Programme (UNDP) and USAIU to participate in the NASA ERTS programme during 24 January-12 February 1972, in the United States.

The group comprised:

(*a*) Boon Indrambarya, Applied Scientific Research Corporation of Thailand;

(*b*) Chamni Boonyopas, Royal Forestry Department;

(*c*) Smarn Panichapongse, Land Development Department.

With the assistance of UNDP, the National Research Council sent a group of six Thai scientists to the United States of America for training. They are from the participating departments: Royal Forestry Department; Department of Land Development; National Energy Administration; Agricultural Technical Department; National Statistical Office; and Applied Scientific Research Corporation of Thailand. They received their training at Purdue University in the survey of natural resources by means of satellite and interpretation techniques using automatic data-processing.

Training in Thailand

With additional support from USAID, it was possible for NRC and USOM to organize a remote-sensing training course in Thailand. The training course was conducted in two phases:

(a) *First-phase training.* The six-week training course in remote sensing was held during 4 January–14 February, 1973. There were 57 Thai participants from participating Thai government agencies, four participants from the Committee for Co-ordination of Investigations of the Lower Mekong Basin and 10 participants from member countries of the United Nations Economic Commission for Asia and the Far East (ECAFE). Instructors were experts from the United States Geological Survey (USGS) and some universities in the United States. The six Thai scientists who were trained in the United States served as assistant instructors.

(b) *Second-phase training.* Under the same arrangement, a four-week training period was held 20 May-20 June 1973. The purpose was to follow up progress or results of phase-one training with respect to understanding and approaching remote-sensing problems, especially interpretation techniques of ERTS data. It was also intended for Thai scientists to exchange ideas and problems with the team of remote-sensing experts from the United States. During the training period, many lectures concerning potential applications of ERTS data to the natural resources of Thailand were delivered to many groups of people in various government departments by the United States team of experts. The lectures drew many enthusiastic responses from many people, including high-ranking officials as well as students.

Public lectures

The USGS team of experts, after departure from Thailand in June 1973, stirred up interest in many sectors of the community, including students at Bangkok, concerning the application of the ERTS-1 images of Thailand. Through the management of the Children's Hall (Sala Wan Dek) of the Ministry of Education, some

20 lectures on the topic were delivered by members of the Working Sub-committee. One lecture had an audience of about 200 high-school students. The Sala Wan Dek authorities also had 2,500 copies of a black-and-white photo map of Thailand reproduced on the scale 1:4,500,000 from the original multispectral scanner photo-mosaic of Thailand on the scale 1:1,000,000, to hand out to students and schools concerned for educational materials.

Research, development and service project

The Applied Scientific Research Corporation of Thailand, being a focal point for a co-operating programme, such as the Thailand National Programme of the Earth Resources Technology Satellite, and an action agent for the National Research Council on the same programme, has to provide service for users, in addition to its own research and development programme. Many research, development and service projects have been initiated, some of which are:

(*a*) Basic calculations of relationships between Thailand parameters and those of ERTS-1;

(*b*) Modification of chip mounting frame for 70-mm positive transparencies to fit the four-channel projector/viewer;

(*c*) Production of additional data products, including diazochrome colour transparencies, 35-mm black-and-white and colour slides, printing and enlarging service, Vugraph transparencies;

(*d*) Line-of-sight limit, Bangkok to ERTS-1 orbit, and a consideration for setting-up of a receiving station at Bangkok.

The last-named project was considered because of the usefulness of a data receiving station capable of receiving transmitted data directly from the satellite, when it is within the line of sight. A data receiving station, similar to those in Canada and Brazil, could be erected at Bangkok and could supply data to Thailand and surrounding countries. The station would be capable of receiving image data in real time when the satellite passes over areas within a circle with a radius of approximately 3,000 km centred on Bangkok. Processing facilities would be required for production of magnetic tapes, conversion of tapes to photographic images, and reproduction and dissemination of the images.

It is clearly evident, with the growing experience of the Thai Government and the geographical location of Bangkok, that a data receiving station serving all south-east Asia and the surrounding countries could effectively be operated at Bangkok (see figure 218).

FUTURE PLAN

The Thailand National Programme of the Earth Resources Technology Satellite does not yet have a separate operating base (office), but shares in part with ASRCT and in part with NRC. The Working Sub-committee meeting agreed that the programme should set up a separate office to serve as a centre for information in remote-sensing research at the national level. The Working Sub-committee advised the Co-ordinating Committee for further action, and the request for approval has been submitted to the Office of the Prime Minister by NRC. The condition and procedures include:

(a) *Office of the Thailand National Programme of ERTS.* The name of the office was proposed to be "ERTS Co-ordination/Research Centre", and its functions would be:

(i) To deal with NASA concerning receiving, maintaining, cataloguing, and reproducing ERTS data;

(ii) To procure and maintain specialized equipment as might be acquired from various sources as the project progresses;

(iii) To act for NRC in dealing with both NASA and participating agencies concerning all aspects of remote sensing that have to do with the ERTS programme;

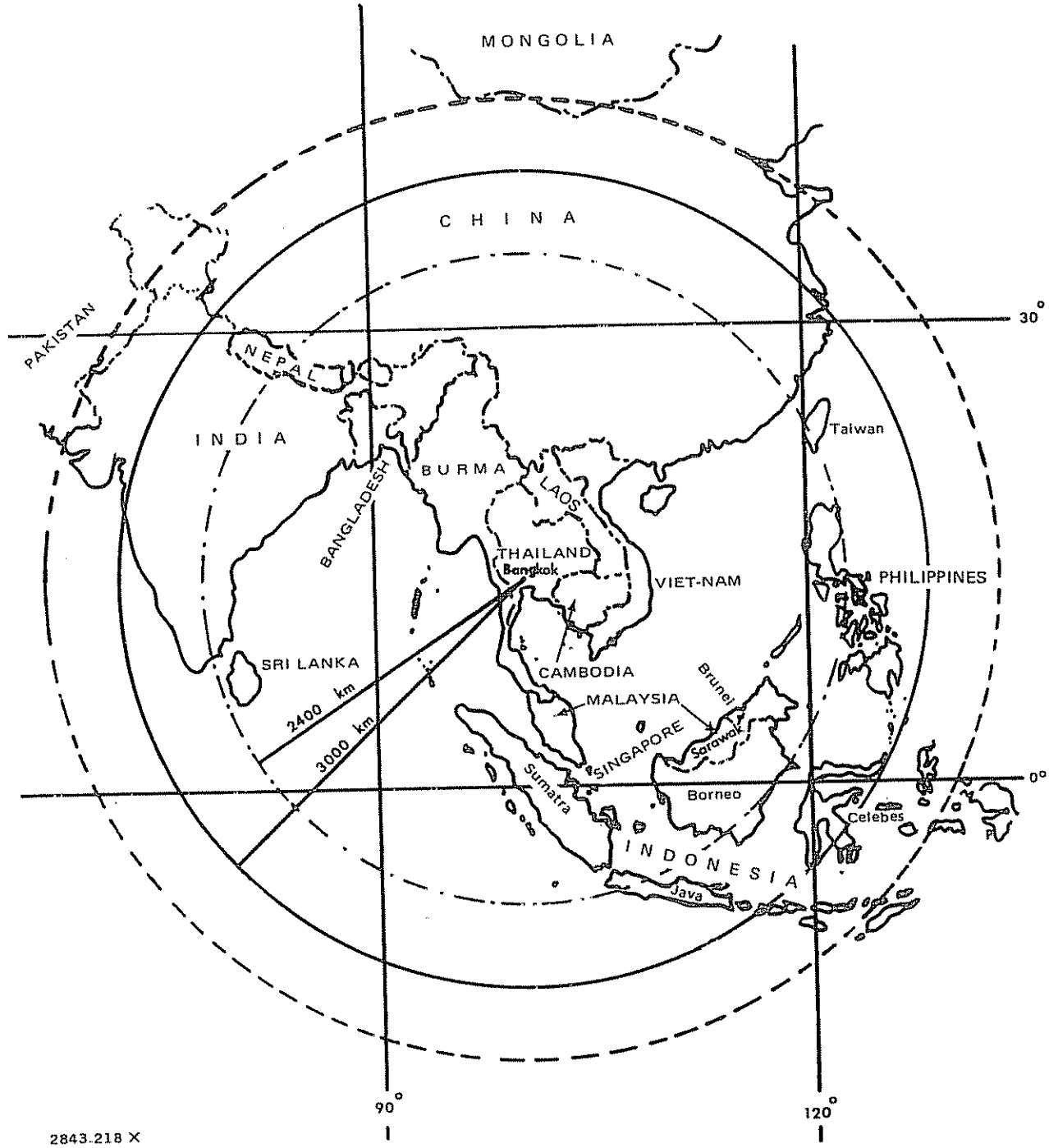
(iv) To present proposals, reports of results and findings to NASA and other concerned organizations;

(v) To co-ordinate closely with all participating agencies so that the National Programme of ERTS might be implemented and the goal achieved;

(b) *Personnel.* The minimum number of personnel for the centre as requested consists of the following staff: one programme co-ordinator; one assistant programme co-ordinator; two technical officers; two technician/specialists; two secretary/typists. It is hoped that if the proposal for setting-up of the ERTS Co-ordination Research Centre is approved by the Cabinet, the number of personnel will increase as needed through the growth of the programme in future;

(c) *Budget.* The National Research Council, by the advice of the National Programme of ERTS, submitted a request for budget to the Office of the Prime Minister on 17 July 1973. The annual budget requested is 2,425,220 Baht for the fiscal year 1974, and 2,094,670 Baht each year thereafter.

Because of expected benefits from ERTS in the planning and management of the natural resources of the country and the experience gained during the course of investigation by participating agencies, it is hoped that Thailand will benefit from ERTS as a whole and that the request should be approved.



Note: Inner circle indicates a conservative 3,000-km radius, within which reception would be reliable. The outer circle (broken line) represents the distance to the horizon, approximately 3,500 km, from the ERTS-1 satellite.

Figure 218. Thailand: service area for an ERTS data receiving station located at Bangkok

ON THE USE OF SPACE PHOTOGRAPHY FOR EARTH RESOURCES EXPLORATION*

Paper presented by the Union of Soviet Socialist Republics

The current period of earth sciences development is defined by the use of new technical means for exploration of the earth's surface—space techniques and, above all, space photography. The new stage in such exploration was begun by the development of space photography interpretation methods; thereby, spatial correlations between natural phenomena occuring in vast areas, which formerly were beyond observation, were ascertained.

Scientists in geology, geography and cartography were given space photographs—documentary data containing information on large regions and the whole planet, thereby making it possible to solve many problems of earth study.

The first earth observations and surveys were from space vehicles carried out in 1961, from the spacecraft "Vostok", with the astronaut Gagarin; and from the Vostok-2 with the astronaut Titov. Subsequent earth explorations from space were done from a series of spacecraft "Soyuz." For example, a number of experiments was carried out from Soyuz-7, including photographing the Caspian sea region. Through a joint action programme of the spacecraft Soyuz-9 and the research vessel *Academik Shirshov*, as well as by "Meteor" sputnik, experiments were carried out which were of certain value for national economy. Subsequently, the surveys from the space station "Salut" were performed.

Using optical instruments, crews of spacecraft observed the earth, photographed geological and geographical features for mapping, and observed and photographed atmospheric formations.

For exploration of the earth's surface from space, different remote-sensing techniques, utilizing various bands of electromagnetic waves, are used. The bulk of research information is provided by methods of space photography and by television survey, which work in the light band and nearest to the light band, the infra-red band of electromagnetic radiation (λ=0.3–1.1μ).

The scales of original negatives for survey heights of 200–400 km are 1:1,000,000–1:8,000,000; the scales of most optimum prints used to solve different geological problems can be established as 1:1,000,000–1:2,500,000 for which a 60–80 per cent overlap is recommended.

In a number of cases, infra-red survey is highly efficient. It not only supplements and specifies data of photographic and television surveys, but makes it possible to obtain different qualitative characteristics of the geosphere, for example, with respect to exploration of regions of contemporary volcanic and hydrothermal activities.

Remote sensing of the earth calls for consideration of the atmospheric stratum, which distorts the surface radiation. Therefore, the problem of reduction of spectral observation data to the underlying surface is opportune. The transmissive function of the atmosphere is that the underlying surface system permits determination from the spectral brightness of natural objects and from their contrasts, measured from space, of the conformable characteristics on the ground level. The investigations of spectrophotometrical data obtained from the manned spacecraft Soyuz-7 and Soyuz-9, undertaken by K. J. Kondratiev and others, made it possible to work out methods for the reduction of satellite data to the earth's surface by means of transmissive functions P and R. The first problem to solve is to obtain the general values of the transmissive function for practical processing of data of space spectrophotometrology.

The most promising methods of exploring the earth's surface from space are based on obtaining imagery in various parts of the spectrum. In this connexion, determination of the optimum of aggregates of spectral intervals bearing a maximum of information with a minimum number of intervals is most important. The investigations K. J. Kondratiev, O. B. Vasiliev and G. A. Ivanian proved that in the spectral band 0.4–1.0μ, the maximum informative capacity for the survey of the earth's surface from satellites is obtained with spectral intervals of 0.54–0.56; 0.66–0.69; 0.78–0.82 μ.

Different trends in the practical utilization of space survey data performed during the recent years are examined below.

In the Union of Soviet Socialist Republics, space photographs are most widely applied in the field of geology, where both black-and-white and multicoloured photographs are used. By matching them and changing the brightness of images in different bands of the visible and the nearest infra-red parts of the spectrum, one can achieve the maximum exposure of interesting geological features.

The basic principles of geological interpretation of space photographs are still being worked out, taking into consideration the experience obtained from geological investigations of separate regions and areas. In their work Soviet scientists have interesting examples of geological interpretation of space photographs of Kazakhstan, the Caucasus and the Pamirs.

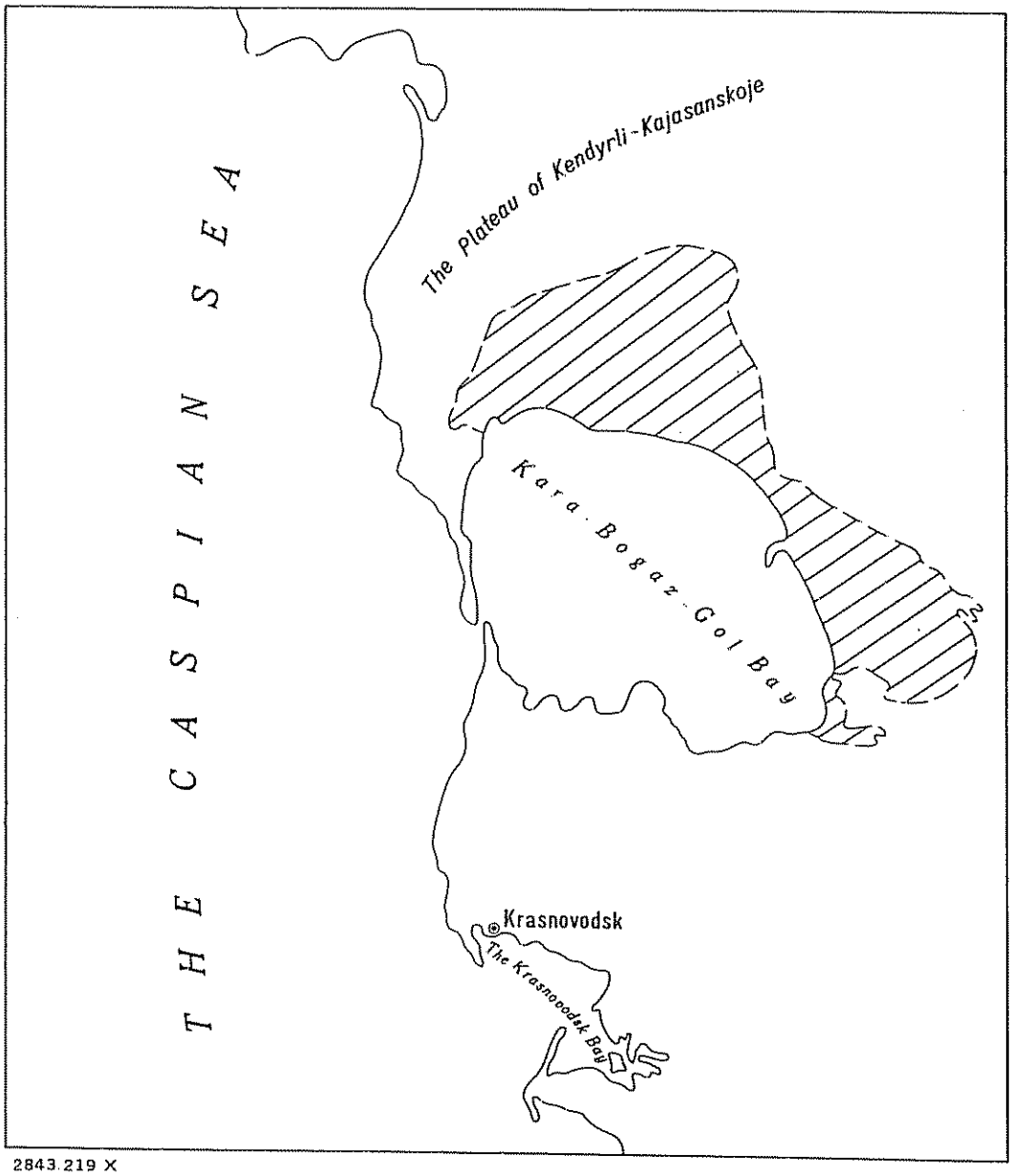
Researches by B. V. Vinogradov (1970, 1971) and A. A. Grigoriev (1970, 1971) initiated the utilization of space photographs in the field of geomorphology. They selected a number of interpretational signs of geomorphological formations—fluvial forms, coastal plains, banks and so on—which facilitate interpretation of space imagery. The complex analysis of the television-image of Balkhash Lake, carried out by B. V. Vinogradov and K. J. Kondratiev, made it possible to expose the main features of the geomorphological structure and the soil vegetation cover of this region, and to single out types of accumulative plains of the southern Balkhash. As another example, the alteration of the coastline of the Caspian Sea was revealed by a survey from the spacecraft Soyuz-9, as shown in figure 219.

Space photography opens new ways for geological research in the field of tectonics, geomorphology and lithogenesis, the study of geological processes in their development.

A system of standard regions in various parts of the USSR is being set up to work out complex geological methods of interpreting space photography.

Geological study of these areas was carried out; interpretational signs of stratigraphy, topography and

*The original text of this paper appeared as document E/CONF.62/L.108.



Scale 1:2500 000

LEGEND

Shore-line, obtained for long-term observation period (1940-1955)

Shore-line, obtained by spase-ship "Sojuz-9" surveying data

Drained part of bay bottom due to fall of sea-level (7031 km^2)

Figure 219. Union of Soviet Socialist Republics' shore-line dynamics map of Kara-Bogaz-Gol Bay of the Caspian Sea, 1940-1970

structural formations were studied; and aerial and space photographs of different scales were interpreted.

Features of the most recent (Neocene-Quaternary) structure and the principles of its representation were studied in space photographs of Tien Shan, the Caucasus. The most recent structure, due to clear representation of structural forms in topography and to the absence of later overlaid deformations, proved to be the very model of nature, which makes it possible to work out in the best way the modes of operation for interpretation of the imagery of various geological objects. It showed the feasibility of using space photographs for revealing spatial correlations and interrelations of structural elements over vast areas.

A large heterogeneity of geological structure, which probably reflects base-rock surface structure, and a number of other peculiarities were revealed by space photographs of the Usturt platform.

The preliminary results of study of interpretational signs of various geological formations (lithological-stratigraphic, geomorphological, structural-tectonic) by photographic and television images made it possible to draw a number of practical conclusions on the basic peculiarities of interpretation of these images, and on the differences from aerial photo-interpretation. The work in this direction is continuing.

One of remote-sensing methods used to study the earth's surface from satellites is that of super-high-frequency radiometry. Super-high-frequency measurements of the earth's radiation permit the solving problems relating to determination of the temperatu and conditions of the earth's surface under difficu weather conditions. For instance, one can measure tl temperature of soil under snow or ice cover, determi the humidity of the surface, locate zones of forest an peat-bog fires, determine the thickness of ice cover an so on.

Data for solving the above-mentioned problems ar contrast, spectral, and polarizable characteristics of th super-high-frequency of the earth's radiation in centime tres and decimentre bands. It is possible to determin average monthly temperature of the ground by data o radio-bright measurements in one channel of centimetr band. For example, by use of radiometers installec aboard the satellites "Cosmos-234" (1968) and "Cosmos 384" (1970), latitudal variations of temperature in some regions were fixed. Those variations were concordant with the average monthly air temperature. Measurements of radio-bright characteristics of moist covers in the USSR in centimetre band proved that there was correlational dependence between radio-bright temperature and soil humidity. The accuracy of estimation of soil humidity by super-high-frequency radiometrical data for soils devoid of vegetation is 3-5 per cent.

These examples prove a considerable feasibility of usage of satellites for study of natural resources. But these explorations will be even more efficient with a combination of satellites and aircraft and with utilization of spectrozonal, infra-red and radar surveys.

AGENDA ITEM 15

Geographical names

A GAZETTEER FOR THE AUSTRALIAN 1:250,000 MAP SERIES*

Paper presented by Australia

At its twenty-fourth meeting in April 1966, the National Mapping Council of Australia adopted standard recommended procedures for recording of geographical nomenclature on a national basis.

The several states and the Commonwealth, which are responsible for geographical 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.

The Division of National Mapping has prepared a gazetteer of all names on the 1:250,000 map series of Australia. This gazetteer is an interim publication to fill the gap before the publication of regional and national gazetteers. (At the time of publication of this map series, it was not practicable to obtain prior approval by appropriate authorities of all names.)

The format of the gazetteer, which is shown in annex I, is described below:

(*a*) Names are in alphabetical order for easy reference and both approved and unapproved names have been included;

(*b*) The first column shows the place or feature name (Variant names are included with a cross reference to the standard name.);

(*c*) The designation of the type of feature to which the name refers has been abbreviated to a code of four letters or less for convenience of processing and listing and appears in column 2 (see annex II for explanation);

(*d*) The third and fourth columns show the latitude and longitude of the name feature to the nearest minute;

(*e*) The fifth column identifies the map upon which the name appears, by a distinguishing number, and may be located by reference to a master index;

(*f*) The final column shows the state in which the name is located.

The listing of names on Gazetteer Lists (see figure 22 in annex III) was carried out by contractors, and the Division arranges sample checks to ensure accuracy of listing.

The Australian Government Publishing Service, Canberra, has arranged punching of cards, transfer to magnetic tape, alphabetical sorting, automatic type setting, printing, collation and binding.

The Gazetteer contains about 125,000 names, and a valuable by-product of the operation will be a name bank which will provide a basis for automatic type setting for the next edition of the 1:250,000 map series.

*The original text of this paper, prepared by the Division of National Mapping, Department of Minerals and Energy, Australia, appeared as document E/CONF 62/L 45.

ANNEX I
Format of the Gazetteer

Name	*Code*	*Latitude*	*Longitude*	*Map*	*State*
ABBIEGLASSIE	HMSD	27 15	147 35	SG 56- 2	QLD
ABBOT BAY	BAY	19 50	148 00	SF 49-16	QLD
ABBOT, MOUNT	MT	20 05	147 45	SF 49-16	QLD
ABERCORN	POPL	25 10	151 10	SF 49-16	QLD
ABERCROMBIE RIVER	STRM	33 55	149 05	SF 49-16	NSW
ABERDEEN	POPL	32 10	150 50	SF 49-16	NSW
ABERFOYLE	HMSD	21 40	145 15	SF 49-16	QLD
ABINGDON DOWNS	HMSD	27 35	143 10	SF 49-16	QLD
ABINGTON REEFS	REEF	18 00	149 35	SF 49-16	QLD
ABMINGA	POPL	26 05	134 50	SF 49-16	SA
ABYDOS	HMSD	21 25	118 55	SF 49-16	WA
ACLAND	POPL	27 20	151 40	SF 49-16	QLD
ACRAMAN, LAKE	LAKE	32 05	135 20	SF 49-16	SA
ADAMINABY	POPL	36 00	148 45	SF 49-16	NSW
ADAVALE	POPL	25 55	144 35	SF 49-16	QLD
ADCOCK RIVER	STRM	17 20	125 50	SF 49-16	WA
ADELAIDE	POPL	34 55	138 35	SF 49-16	SA

ANNEX I (*continued*)

Name	*Code*	*Latitude*	*Longitude*	*Map*	*State*
ADELAIDE RIVER	POPL	13 15	131 05	SF 49-16	NT
ADELAIDE RIVER	STRM	12 40	131 20	SF 49-16	NT
ADELE ISLAND	IS	15 30	123 10	SF 49-16	WA
ADIEU, CAPE	CAPE	32 00	132 10	SF 49-16	SA
ADMIRALTY GULF	GULF	14 20	125 50	SF 49-16	WA
ADOLPHUS ISLAND	IS	15 10	128 10	SF 49-16	WA
AGNES, MOUNT	MT	16 00	125 40	SF 49-16	WA
AILERON	HMSD	22 40	133 20	SF 49-16	NT
AJANA	POPL	27 55	114 40	SF 49-16	WA
ALAWOONA	POPL	34 45	140 30	SF 49-16	SA
ALBACUTYA, LAKE	LAKE	35 45	141 55	SF 49-16	VIC
ALBANY	POPL	35 00	117 50	SF 49-16	WA
ALBANY DOWNS	HMSD	27 05	148 00	SF 49-16	QLD
ALBANY HIGHWAY	HWY	33 10	117 00	SF 49-16	WA
ALBATROSS BAY	BAY	12 40	143 45	SF 49-16	QLD
ALBATROSS ISLAND	IS	40 25	144 40	SF 49-16	TAS
ALBEMARLE	HMSD	32 30	143 20	SF 49-16	NSW
ALBERGA	POPL	27 10	135 30	SF 49-16	SA
ALBERGA RIVER	STRM	27 00	134 25	SF 49-16	SA
ALBERRIE CREEK	POPL	29 40	137 30	SF 49-16	SA
ALBERT, LAKE	LAKE	35 35	139 20	SF 49-16	SA
ALBERT, MOUNT	MT	28 10	114 20	SF 49-16	WA
ALBERT RIVER	STRM	17 45	139 35	SF 49-16	QLD
ALBURY	POPL	36 05	146 55	SF 49-16	NSW
ALCOOTA	HMSD	22 50	134 25	SF 49-16	NT
ALDERSYDE	POPL	32 25	117 15	SF 49-16	WA
ALECTOWN	POPL	32 55	148 15	SF 49-16	NSW
ALEXANDER, MOUNT	MT	22 40	115 30	SF 49-16	WA
ALEXANDER, MOUNT	MT	27 05	135 40	SF 49-16	SA
ALEXANDER, POINT	PT	12 50	136 35	SF 49-16	NT
ALEXANDRA	POPL	37 10	145 45	SF 49-16	VIC
ALEXANDRA BAY	BAY	16 10	145 30	SF 49-16	QLD
ALEXANDRA RIVER	STRM	18 20	140 00	SF 49-16	QLD

ANNEX II

Code for designations for topographic features

Complete code list

Code	*Designation*
ABAT	Abattoirs
AF	Airfield
	Airport
ANCH	Anchorage
AQDT	Aqueduct
ARCH	Archipelago
BANK	Bank
	Bar
	Sandbank
BAPL	Baths
	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

ANNEX II (*continued*)

Code	*Designation*
	Bell tower
	Chapel
	Church
	Convent
CHSM	Chasm
CLAY	Clayhold
	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
	Wetdock
DRN	Drain
DSRT	Desert
DUNE	Dunes
ENTR	Entrance
ESTY	Estuary
FARM	Farm
	Dairyfarm
FLD	Enclosure
	Field
	Meadow
	Pasture
	Uncultivated land
FORD	Ford
FORT	Fort
	Redoubt
FRST	Forest
	Woods
FTRY	Brewery
	Factory
	Plant
	Steel works
	Tannery
	Works
FY	Ferry
GAS	Gas field (well)
GATE	Gate (city exit)
GL	Grassland
GLCR	Glacier
GLLY	Gully
GRDN	Garden
	Vineyards
GULF	Gulf
HBR	Harbour
	Haven
	Roadstead
HDG	Hedge
HILL	Butte
	Knoll
	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
	Tarn
LBED	Lake bed
LDGE	Ledge
LGRD	Landing ground
LH	Lighthouse
LNDG	Landing place
LOCK	Lock
LSTA	Lifeguard station
LT	Light
MET	Meteorological station
	Weather station
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
OIL	Oil well
OS	Out station
PARK	Park
PASS	Pass
	Passage
	Gap
PEAK	Mountain peak
PEN	Peninsula
PGDA	Pagoda
PIER	Pier
PIT	Pit
	Sandpit
PL	Plateau
	Tableland
PLAN	Plantation

ANNEX II (*continued*)

Code	*Designation*
PLN	Downs
	Tableland
	Plain
	Prairie
PLNA	Place name
PO	Post office
POND	Pond
	Stagnant pool
POOL	Pool
POPL	City
	Town
	Village
PORT	Port
PRO	Province
PROM	Promontory
PRSH	Parish
PRSN	Prison
PT	Head
	Headland
	Ness
	Point
	Spit
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	Patch
	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 where appropriate.

DIVISION OF NATIONAL MAPPING

GAZETTEER LIST

Page No. 3 of 17 Sheets

Map Name CAPE FICTITIOUS Series No. R502 Map No. SH56-8 Square No. 9 Contract No. CN1234 Listed by J. BLON

A	B	C	NAME	FEATURE CODE	LATITUDE		LONGITUDE		SHEET No.				STATE	
			1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33	35 36 37 38	41 42	44 45	48 49 50	52 53	56 57	59 60	62 63		76 77 78	79
1			LOWDOWN	POPL	38	14	154	37	5W	56	08		NSW	1
2			THE ENTRANCE	POPL	38	23	154	41						1
3			MOUNT ISA	POPL	38	26	154	43						1
4			MORTCHUP OR MORTJUP	POPL	38	31	154	48					NSW	2
5			MORTJUP (SEE MORTCHUP)											1
6	?		DINGO DEN	PLNA	38	32	154	50						1
7			COTTER PICNIC GROUNDS, THE	PLNA	38	35	154	53					NSW	1
8			FOREST RIVER MISSION TELEGRAPH –	TO	98	37	154	54					NSW	3
9			FOREST – OFFICE	HMSD	38	39	154	55						1
10			MIRANDA DOWNS	HMSD	38	42	155	00						1
11			OTIS RANCH	STRM	38	10	154	51						1
12			FLY RIVER	STRM	38	16	154	54						1
13			MOLE RIVERS, THE	GLLY	38	19	154	57						1
14			NUMBER THREE GULLY	STRM	38	24	154	40						1
15			NILLOM (SHADY) CREEK										NSW	2
16			SHADY CREEK (SEE NILLOW CREEK)											1
17	?		ANTHONY LAGOON	LAGN	38	30	154	43						1
18			BYRONS, CAPE	CAPE	38	17	154	46						1
19			BRUNSWICK HEADS	HEAD	38	36	154	50						1
20			CARPENTARIA, GULF OF	GULF	38	44	154	58						1
21			TREASURE ISLAND	IS	38	46	155	00						1
22			GREAT DIVIDING RANGE	MTS	38	21	154	38						1
23			KOSCIUSKO, MOUNT	MT	38	26	154	42						1
24			BARKLY TABLELAND	PL	38	31	154	46						1
25			NULLARBOR PLAINS	PLN	38	37	154	52						1
26														
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Figure 220. Australia: gazetteer list

THE PREPARATION OF GAZETTEERS OF PROVINCIAL GEOGRAPHICAL NAMES IN THE REPUBLIC OF VIET-NAM*

Paper presented by the Republic of Viet-Nam

At the beginning of 1971, a long-term programme was adopted for the preparation of a dictionary of geographical names covering the entire territory of the Republic of Viet-Nam.

The objective of this programme is not to compile a list of names taken from existing maps. The programme involves, on the one hand, a comprehensive compilation, in the field, of all geographical names based on reliable information; and, on the other, a thorough study of the method of transcribing and describing the names collected and catalogued.

As the preparation of such a dictionary requires a great deal of time, the National Geographical Directorate begins by preparing a provincial gazetteer for each province. The Republic of Viet-Nam comprises 44 provinces (excluding the capital and other towns); there will thus be 44 gazetteers numbered from 01 to 44 in the alphabetical order of the provinces. These gazetteers will provide a basis for the preparation of the definitive dictionary.

The preparation of the gazetteers comprises two stages: collection of the geographical names in the field; transcription and description of these names.

COLLECTION

Collection is carried out in the field using the 1:50,000 topographic base map.

Using the necessary documents and applying their personal experience, specialists from the National Geographical Directorate evaluate the information compiled and select an accurate toponym. Dubious toponyms must be verified on the spot with the local authorities: they cannot be accepted in final form until approved by these authorities and the indigenous population.

Compilation is governed by the following principles:

(*a*) Each name collected must be entered on an index card, on which the geographical features are classified, plotted and defined;

(*b*) Universal Transversal Mercator (UTM) co-ordinates from the 1:50,000 base map and, in certain cases, polar co-ordinates with respect to the centre of administrative units will be used to plot such features;

(*c*) The official documents relating to the status of the administrative units must be collected with a view to determining the origin of such units;

(*d*) In order to obtain information concerning bridges and roads, use must be made of the gazetteer of bridges and roads issued by the Ministry of Public Works; the most recent edition was issued in 1970. For bridges and roads that have not yet been given an official designation or numbering, the name most frequently used in the area must be determined;

(*e*) Geographical features are classified by type;

(*f*) The objective is to compile geographical names, rather than to verify names already appearing on the 1:50,000 base map. Using all means at their disposal, the specialists compile existing names and annotate them as far as possible, by consulting regional monographs and maps published by various governmental bodies (such as the former Indo-China Geographical Service, the Direction Générale du Cadastre and the Directorate of Shipping), and by making inquiries of the indigenous population, especially local scholars;

(*g*) The most recent documents relating to regional geography (population, ethnic groups, religion, the economy, etc.) should also be collected;

(*h*) Annotations should be made as to the origin of names. This delicate and difficult problem is usually beyond the capacity of the specialists—who, it must be added, are not linguists. The National Geographical Directorate is not too demanding in this respect.

The above-mentioned principles, which provide the groundwork for compilation operations, have greatly facilitated the work of the specialists and have enabled them to obtain excellent results over a considerable length of time.

For example, in the province of Chương Thiện, which covers an area of 2,369 km² and has 243,576 inhabitants, a team of two specialists worked for two months and produced 1,116 index cards of geographical names; of that number, 1,021 remained after careful screening, to be used for the gazetteer proper.

WORK ON TRANSCRIPTION AND DESCRIPTION

The index cards, once prepared, are checked and selected before being classified in alphabetical order. The rules for preparing them are given below.

Transcription

The rules for transcription are as follows:

(*a*) The orthography, including diacritical marks, is strictly respected. *Examples:* Suối Đá Hàn, Xóm Bánh Tét, Cù lao Cát;

(*b*) Initial letters are capitalized, with the exception of the initial letters of articles, prepositions and conjunctions. *Examples:* Vĩnh An, Giồng Dừa, Cù lao Xanh từ Vĩnh Thành đến Vĩnh An;

(*c*) Hyphens are deleted. *Examples:* Sài Gòn, Rạch Giá, Mỹ Tho;

(*d*) Pleonasms should be avoided. *Examples:*

Correct transcriptions	*Transcriptions to be avoided*
Nam Hải	Biển Nam Hải
Hoàng Liên Sơn	Núi Hoàng Liên Sơn

(*e*) The polysyllabic form of names that are not of Viet-Namese origin, but were introduced by the French, is adopted on a provisional basis. *Examples:* Kontum, Pleiku;

(*f*) Translation into Viet-Namese of names from minority languages is not permissible. *Examples:*

Meanings	*Translations to be avoided*	*Correct transcriptions*
River Na	Sông Na	Nậm Na
Ouac Mountain	Núi Ouac	Pia Ouac

(*g*) Names of non-Viet-Namese origin are transcribed phonetically into Viet-Namese on the basis of their

*The original text of this paper, prepared by the Ministry of National Defence, Republic of Viet-Nam, submitted in French, appeared as document E/CONF.62/L.67.

correct pronunciation. *Examples*: Ea Krong No, Ia Ta Miêng, Chu' Dron;

(*h*) The translation into Viet-Namese of names introduced by the French (or Europeans) is to be avoided. Their original form should be found. *Examples*:

Names introduced by the French	*Translations to be avoided*	*Original names (to be adopted)*
Rivière claire	Thanh Giang	Sông Lô
Cap de la Table	Mũi Cái Bàn	Mũi Hòn Chông

Description

Each toponym is described as follows:

(*a*) Name;

(*b*) Classification (depending upon the type of features);

(*c*) Administrative status (based on the hierarchy of administrative units: hamlet; commune; *arrondissement*; etc.);

(*d*) Plotting, by means of UTM co-ordinates, or polar co-ordinates with respect to the centre of the nearest administrative units;

(*e*) Characteristics: population; ethnic groups; religion; economic and cultural activities; in the case of inhabited places;

(*f*) Origin (if possible).

Despite the fact that rules have been laid down, many difficulties are encountered in the preparation of gazetteers, for the following reasons:

(*a*) Geographical features the names of which, as given by the indigenous population, are completely different from conventional geographical terminology;

(*b*) The use of the same names to indicate various features which differ in importance;

(*c*) Names whose composition complicates the task of classifying them alphabetically.

The procedure followed is given below:

1. Orographic and hydrographic names, such as *vàm* (mouth), *phá* (lagoon), *Hói* (linking channel) and *dông* (small hill), which are usually referred to as *cửa* (mouth), *đầm* (lagoon), *rạch* (linking channel) and *gò* (small hill), are purely regional names. In order to conserve their regional names, on the one hand, and, on the other, to clarify their geographical meanings, the National Geographical Directorate describes them as follows:

(*a*) In the south of the Republic of Viet-Nam (delta region):

Vàm Cỏ Đông	**Vàm (Cửa)*
Vam Cỏ Tây	**Vàm (Cửa)*
(*Vàm, Cửa* = mouths)	

(*b*) In the centre of the Republic of Viet-Nam (Thủa Thiên and Bình Thuận provinces):

Của Sắt	**Hói (rạch)*
Ô Khả	**Hói (rạch)*
(*Hói, rạch* = linking channels)	
Bà Lụa	**Động (gò)*

"Động", in the geographical sense of the word, means "cave". However, in Bình Thuận province, it refers to a small hill, as does the word *"gò"*.

Tam Giang	**Phá (đầm)*
(*Phá, đầm* = lagoon)	

2. In cases where two or more geographical features share one name, such as:

Suối Đại Hòa (Đại Hòa stream), Cầu Đại Hòa (Đại Hòa bridge);

Núi Ba Thê (Ba Thê mountain), Kinh Ba Thê (Ba Thê canal);

Đồng Tháp Muồi (Tháp Muồi plain), Kinh Tháp Muồi (Thàp Muồi canal);

the name is written only once, for the first feature. For subsequent features, the name is not repeated and is only marked by an asterisk (*). The names of administrative units, classified by size, are treated in the same manner:

Đại Hòa	**Suối* (stream)
	**Cầu* (*cäu* Q.L. 01-10-12) (bridge)
Ba Thê	**Núi* (mountain)
	**Kinh* (canal)
Tháp Muồi	**Đồng bằng* (plain)
	**Kinh* (canal)
Long Tri	**Ấp* (hamlet)
	**Xã* (commune)

3. For the purpose of alphabetical classification, the National Geographical Directorate proceeds as follows:

(*a*) If a toponym comprises only two terms, one of which is a common name and the other the feature's proper name which has no meaning by itself, it is classified in the alphabetical order of the common name. *Examples*:

Cầu Bắc, Cau Mỹ: classified under C (*cầu* = bridge);

Núi Đất, Núi Ông: classified under N (*núi* = mountain);

Sông Lũy, Sông Cát: classified under S (*sông* = river);

(*b*) If a toponym includes several terms, the first of which is a common name, followed by its proper name, it is classified in the alphabetical order of the proper name. *Examples*:

Cầu Hàm Luông: classified under H (*cầu* = mouth);

Hòn Thơ Châu: classified under T (*hòn* = island);

(*c*) Nevertheless, there are toponyms composed of several terms, the first of which is a common name. These toponyms are classified in the alphabetical order of the common name, since if they are classified in the alphabetical order of the second term, as are those in the preceding category, they lose all meaning. *Examples*:

Kinh Số Một (canal No. 1) and Kinh Số Mươi Lăm (canal No. 15) are classified under K and not under S;

Mùông Đào Cạn (small, shallow dug ditch) is classified under M and not under D.

(*d*) In cases where toponyms are composed of several terms, the first two or three of which are common names, they are classified in the alphabetical order which appears most logical. *Examples*:

Rạch Xẻo Cạn is classified under X, and not under C;

Rạch Xẻo Lùn is classified under X, and not under L;

Rach Xẻo Mây is classified under X, and not under M;

Ngọn Rạch Xẻo Mây is classified under X (or under R), and not under M;

Kinh Xẻo Gỗ is classified under X, and not under G;

(*e*) In order to make it easier to find toponyms in the gazetteer, they are repeated, but not described, under the initial letter of the first term. *Examples:*

Under K: Kinh Xẻo Gỗ	*Xem Xẻo Gỗ (*see* Xẻo Gỗ)
Under N: Ngọn Xẻo Mây	*Xem Xẻo Mây (*see* Xẻo Mây)
Ngọn Rạch Xẻo Mây	*Xem Xẻo Mây (*see* Xẻo Mây)
Under R: Rạch Xẻo Cạn	*Xem Xẻo Cạn (*see* Xẻo Cạn)

The above-mentioned rules and methods are applied by the National Geographical Directorate of the Republic of Viet-Nam only on a provisional basis for the pilot gazetteer being prepared for Chương Thiện province. Needless to say, each province will have its idiosyncracies, and an appropriate solution will have to be found in each case.

In an undertaking of such magnitude, some shortcomings are, of course, inevitable. The National Geographical Directorate, which has, thus far, been alone in dealing with the highly complex and difficult problem of the geographical names of the country, hopes to benefit from co-operation from other governmental bodies, including co-operation from linguists, in carrying out its task.

In the period 1971–1972, compilation work was carried out in four provinces: An Giang, Bình Thuận, Chương Thiện and Long An, where relatively safe conditions greatly facilitated the work of the specialists. The gazetteer for Chuong Thiện province has now been completed. Preparation of gazetteers for the three other provinces is under way.

ANNEX

Examples of the description of geographical names in a provincial gazetteer

I In Viet-Namese

LONG BÌNH *Ấp
Xã: long Phú, quận: Long Mỹ
Bản-đồ: tờ số 6128-III
Cạnh tỉnh-lộ 42-12—Cách quận-lỵ Long Mỹ 7 km về phía Đ-N
Dân số: 1.121 người
Công giáo: 10 per cent
Phật giáo: 90 per cent
Làm ruộng
Trường sơ-cấp Long Bình

*Xã
Quận: Long-Mỹ
Bản-đồ: tờ số 6128-III
Tọa-độ trụ-sở xã: WR 632.730
Gồm các ấp: Bình An—Bình Hiếu—Bình Thạnh A— Bình Thạnh B—Bình Thạnh C—Trung Nghĩa
Cạnh tỉnh-lộ 42—12—Cách quận-lỵ Long Mỹ 3 km về phía B
Dân số: 9.223 người
Việt: 99 per cent
Việt gốc Hoa: 01 per cent
Phật giáo: 60 per cent
Thờ Ông Bà: 30 per cent
Làm ruộng
1 trường tiểu-học cộng-đồng
2 nhà máy xay lúa—2 nhà máy nước đá
Đình thờ Ông Nguyễn trung Trực—Thánh-thất Long Mỹ
Thành-lập theo nghị-định: 244-NV ngày 24-12-1961

LONG MỸ *Quận
Bản-đồ: tờ số 6128-III
Gồm các xã: Long Bình—Long Phú—Long Trị—Phương Bình—Phương Phú—Thuận Hưng
Quận-lỵ đặt tại xã Long Trị—Cạnh hợp-lưu Kinh Trà Ban và sông Cái Lớn
Dân-số: 42.627 người
Việt 98 per cent
Việt gốc Hoa: 02 per cent
Công giáo: 08 per cent
Phật giáo: 30 per cent
Hòa-Hảo: 02 per cent
Thờ Ông Bà: 50 per cent
Trường trung-học bán công Long Mỹ
1 chợ—1 nhà thờ Tin-Lành—1 Thánh-thất Cao-Đài
Thành-lập theo nghị-định: 38-NV ngày 18-4-1963

LONG NIA *Rạch
Xã: Hòa Thuận, quận: Đức Long
Bản-đồ: tờ số 6028-I
Từ Kinh Ông Dèo (tọa-độ WR 464.843) đến Kinh Mười Lăm (tọa-độ WR 489 851)—Nằm theo hướng TN-DB
Dài: 2,500 km—Rộng: 5 m—Sâu: 2 m
Xuồng, ghe nhỏ lưu-thông được

LONG PHỤNG *Kinh
Xã: Phương Bình, quận: Long Mỹ
Bản-đồ: tờ số 6128-III
Từ Kinh Ông Phong (tọa-độ WR 762.757) đến tọa độ WR 795 758—Nằm theo hướng D-T
Dài: 3,500 km
Xuong nhỏ lưu-thông được

NUI ONG *Núi
Quận: Hàm Thuận
Bản-đồ: tờ số 6631-III
Tọa-độ: AN 733.254
Cách Phan Thiết 18 km về phía T-B
Cao: 906 m
Đỉnh núi: rừng già—Chân núi: rừng thưa

II English translation

LONG BÌNH *Hamlet
Commune: Long Phú; *arrondissement:* Long Mỹ
Map: Sheet No. 6128-III[a]
Close to highway No. 42-12; 7 km south-east of the capital of Long Mỹ *arrondissement*
Population: 1,121
Catholics: 10 per cent
Buddhists: 90 per cent
Agriculture
Commune school of Long Bình

*Commune
Arrondissement: Long My

[a] Topographic base map on the scale of 1:50,000

Map: Sheet No. 6128-III

Co-ordinates of the commune administration office: WR 632.730

Administratively subordinate hamlets: Bình An—Bình Hiếu—Bình Thạnh A—Bình Thạnh B—Bình Thạnh C—Trung Nghĩa

Close to highway No. 42-12: situated 3 km north of the capital of Long Mỹ *arrondissement*

Population: 9,233

Viet-Namese: 99 per cent

Viet-Namese of Chinese origin: 1 per cent

Buddhists: 60 per cent

Ancestor cult: 30 per cent

Agriculture

One commune school

Two rice-mills; two glass works

Temple of Nguyễn trung Trực; Cao đài Temple of Long Mỹ

Established by Ministerial Decree No. 244-NV of 24 December 1961

LONG MỸ **Arrondissement*

Map: Sheet No. 6128-III

Administratively subordinate communes: Long Bình—Long Phú—Long Trị—Phượng Bình—Phướng Phú—Thuận Hưng

Capital of the *arrondissement* situated in the commune of Long Trị; close to the junction of Trà Ban canal and the river Cái Lớn

Population: 42,627

Viet-Namese: 98 per cent

Viet-Namese of Chinese origin: 2 per cent

Catholics: 8 per cent

Buddhists: 30 per cent

Hòa Hảo (a Buddhist sect): 2 per cent

Ancestor cult: 50 per cent

Semi-public secondary school at Long Mỹ

One market; one Protestant church; one *cao đài* temple

Established by Ministerial Decree No. 38-NV of 18 April 1963

LONG NIA *Linking channel

Commune: Hòa Thuận; *arrondissement:* Đức Long

Map: Sheet No. 6028-I

Runs from Ông Dèo canal (co-ordinates WR 464.843) to canal No. 15 (co-ordinates: WR 489.851; runs SW-NE

Length: 2,500 km; breadth: 5 m; depth: 2 m

Navigable for small boats and motorized small boats.

LONG PHỤNG *Canal

Commune: Phượng Bình; *arrondissement:* Long Mỹ

Map: Sheet No. 6128-III

Runs from Ong Phong canal (co-ordinates: WR 762.757) to the co-ordinates WR 795.758; flows E-W

Length: 3,500 km

Navigable for very small boats

NÚI ÔNG *Mountain

Arrondissement: Hàm Thuận

Map: Sheet No. 6631-III

Co-ordinates: AN 733.254[b]

18 km north-west of Phan Thiết

Altitude: 906 m

At the summit: dense forest; at the foot: open forest.

[b] Co-ordinates of the summit.

ACTIVITIES ON STANDARDIZATION OF GEOGRAPHICAL NAMES IN ASIA AND THE FAR EAST*

Paper presented by Hungary

At the Sixth United Nations Regional Cartographic Conference for Asia and the Far East, a report was presented by Hungary on the standardization of usage of geographical names in Hungary.[1] In the present paper, activities in this respect relating to the area of Asia and the Far East are described.

At the Second United Nations Conference on the Standardization of Geographical Names held in London, 10-31 May 1972, Hungary presented three papers under the agenda item "Writing systems—transfer of names from one writing system into another". The paper entitled "Principles of romanization" (E/CONF.61/L.97) deals mainly with the so-called "donor" and "receiver" principles. These principles are intended to formulate the two possibilities of standardizing the transfer of geographical names from one writing system into another. According to the "donor" principle, the system of transfer (transcription or transliteration) is to be determined in the first place by the country using the geographical names in the original script, while the "receiver" principle takes the views of the users of the transferred names as a basis. The paper expresses the view that the "donor" principle could only serve as a basis for international standardization. The Hungarian Committee on Geographical Names is of the opinion that transcription systems to be approved for international standardization must be official in the "donor" country concerned, even if this is not reflected in published maps or gazetteers. At the same time, a possibility should be sought to establish such systems in countries lacking it.

Another paper (E/CONF.61/L.28 and Add.1) concerning the Hungarian proposition actually submitted by the joint conference (Prague, 1972) of the linguistic/geographical divisions—East Central and South-east Europe (which division also includes Hungary), and the Union of Soviet Socialist Republics—of the United Nations Group of Experts on Geographical Names—deals with the transcription of Chinese geographical names. In this paper, it is suggested that "the so-called Pinyin System (Hanyu Pinyin), the official Romanization in the People's Republic of China is to be adopted "as the international system for the Romanization of Chinese geographical names". Though China did not

* The original text of this paper, prepared by Ervin Földi, Secretary of the Hungarian Committee on Geographical Names, appeared as document E/CONF.62/L.122.

[1] "Report on the standardization of the use of geographical names in Hungary", *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.72.I.20), p. 408.

attend the Second United Nations Conference on the Standardization of Geographical Names, in a verbal communication to the Hungarian expert before the Fifth Session of the Group of Experts on Geographical Names (March 1973), full agreement with the Hungarian proposal was expressed by the Chinese Script Reform Committee and the Chinese Surveying and Cartographic Bureau, both of the State Council of China. The United Nations Conference delayed its decision on this matter until representatives of China would take part in the discussion, because of lack of information. The Hungarian Committee on Geographical Names looks forward to seeing the delegation of China at the Seventh United Nations Regional Cartographic Conference for Asia and the Far East, and at the next meeting of the United Nations Group of Experts on Geographical Names, to be held in 1974. At the same time, it would be most desirable to have a map and/or a gazetteer of Chinese geographical names, published in China, using the Pinyin system and containing Romanized forms of names as much as possible.

The third paper presented by Hungary at the Second United Nations Conference on the Standardization of Geographical Names merely gives information on the transcription system used for the transfer of Mongolian Cyrillic into Roman letters on the World Map at 1:2,500,000 scale. Correspondence following the Conference has shown that the Institute of Geography and Geocryology, of the Academy of Sciences of Mongolia, agrees to the above-mentioned system. It is possible, therefore, to suggest this system—with possible refinements—to the next Conference on the Standardization of Geographical Names (1977). Again, it would be useful to have a map or gazetteer published in Mongolia in an officially approved system. This could more readily lead to an international approval of that system.

Although no paper was presented at the Conference in this matter, Hungary is also responsible in the working group of the United Nations *Ad Hoc* Group of Experts for the Romanization of Korean. As a result of correspondence with the Linguistic Research Institute of the Academy of the Social Sciences of the Democratic People's Republic of Korea, information on an official Romanization system for Korean is now available. It is basically the same as the so-called "McCune-Reischauer system", but no diacritical marks or apostrophes (sign of aspirated sounds) are shown. If the above-mentioned publications (maps, gazetteers) would be available from this country for this system, this could also lead to the international approval in a shorter time.

The Hungarian Institute of Surveying and Mapping compiled and published, in German and in Russian, for the World Map at 1:2,500,000 scale, the rules of lettering of geographical names of 46 languages, among them rules for the languages of Asian and Far Eastern peoples. A copy of this work is displayed in the technical exhibition of this Conference.

As shown above, Hungary was and will be ready to support and help all countries of Asia and the Far East to have their official transcription systems approved by a United Nations Conference on the Standardization of Geographical Names. At the same time, these activities are in the interest of the countries concerned, as well as that of world cartography.

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Abb. 2

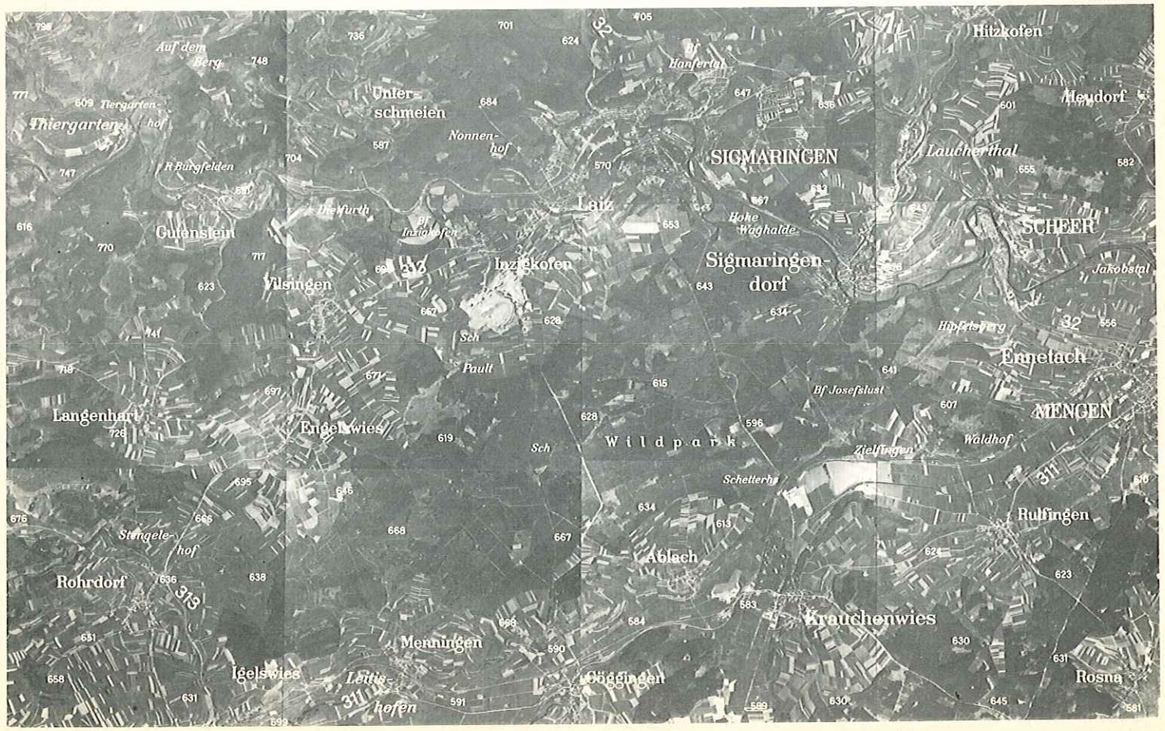
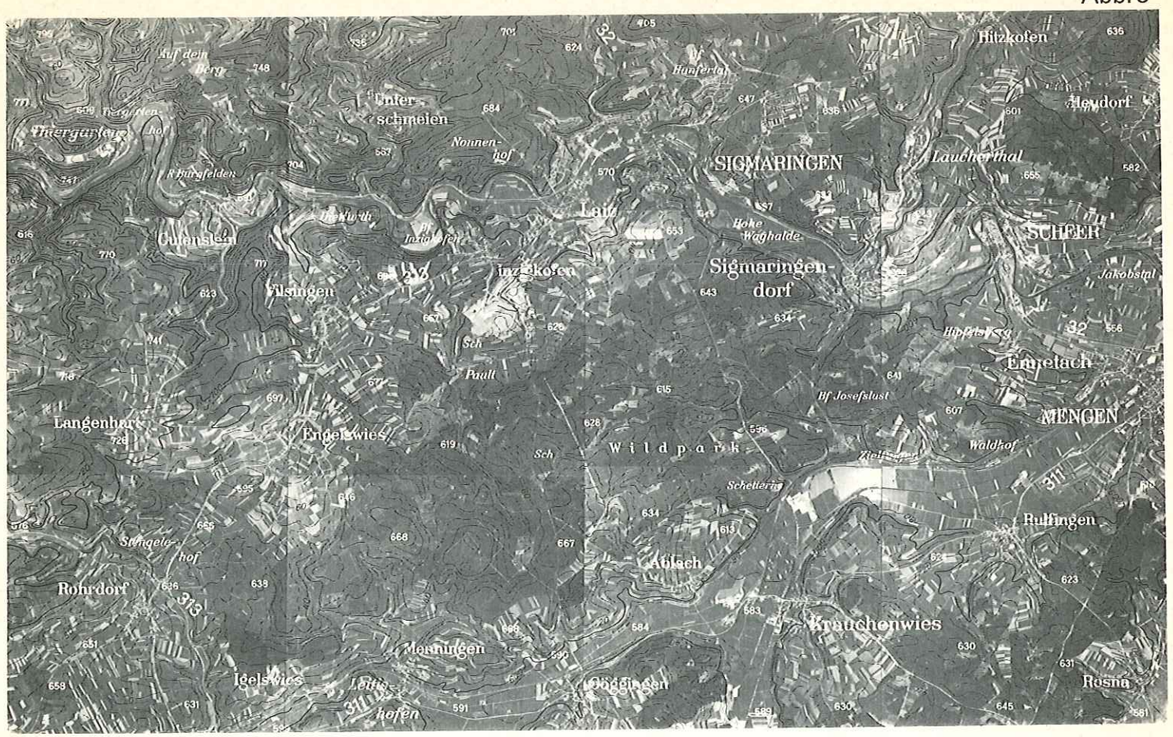


Abb. 3



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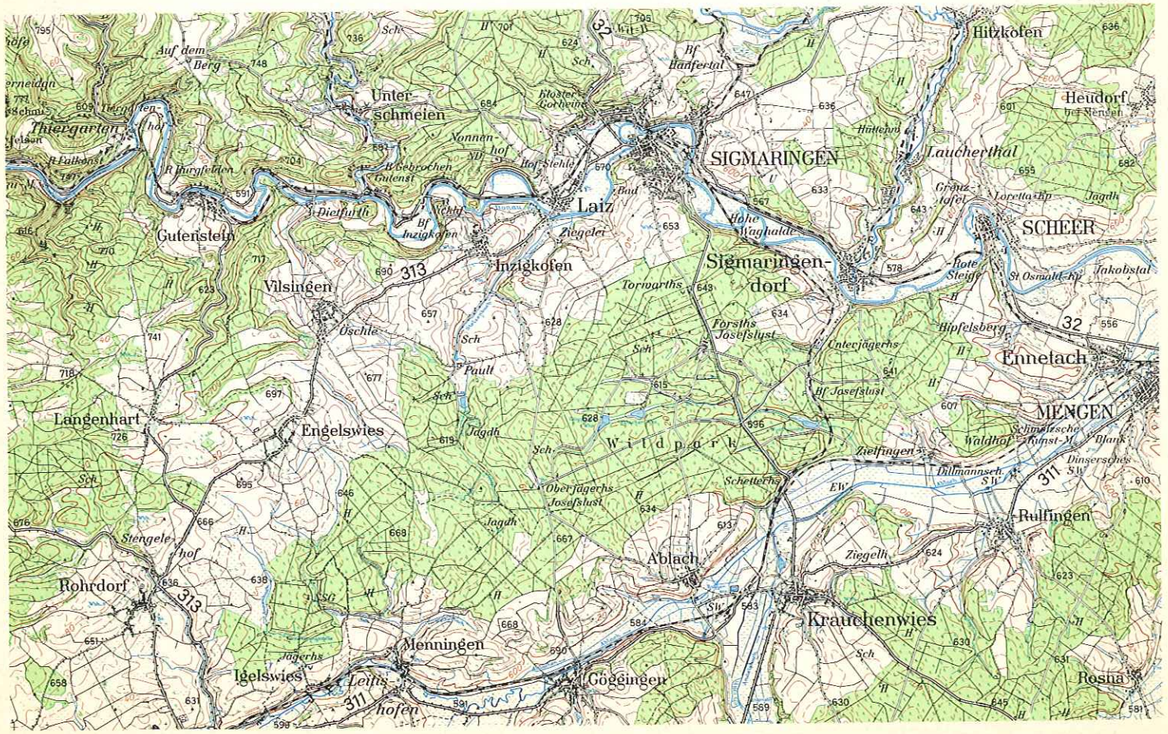

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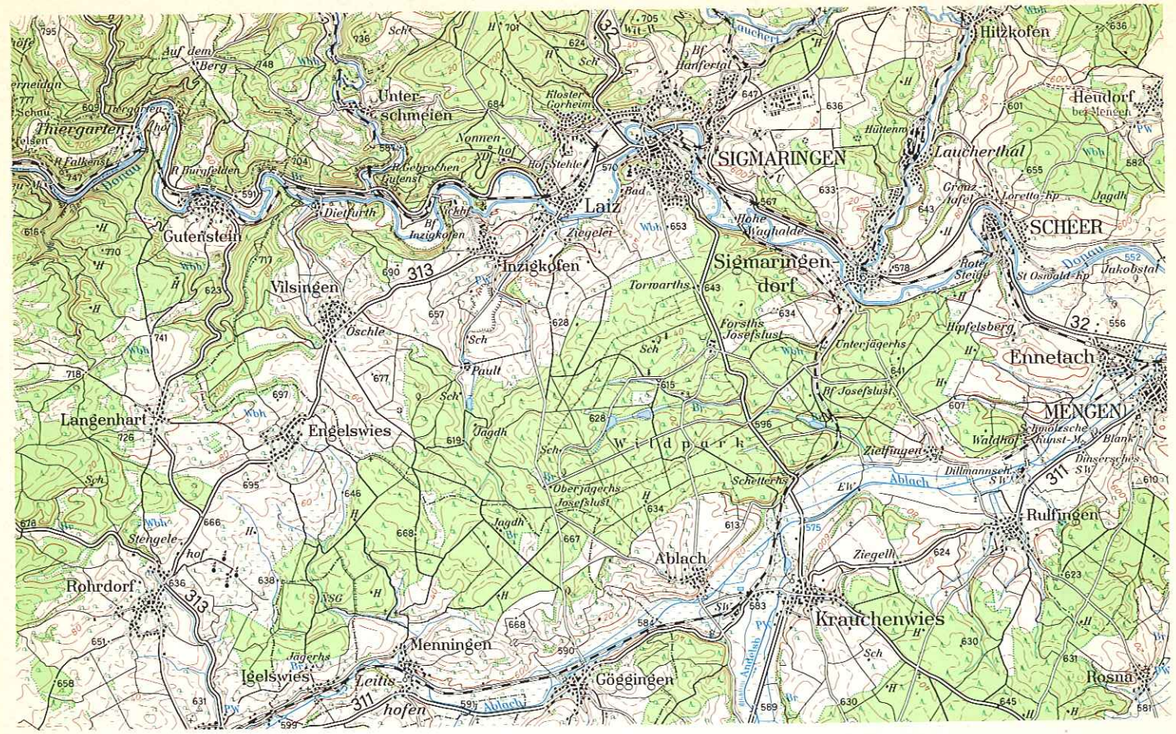
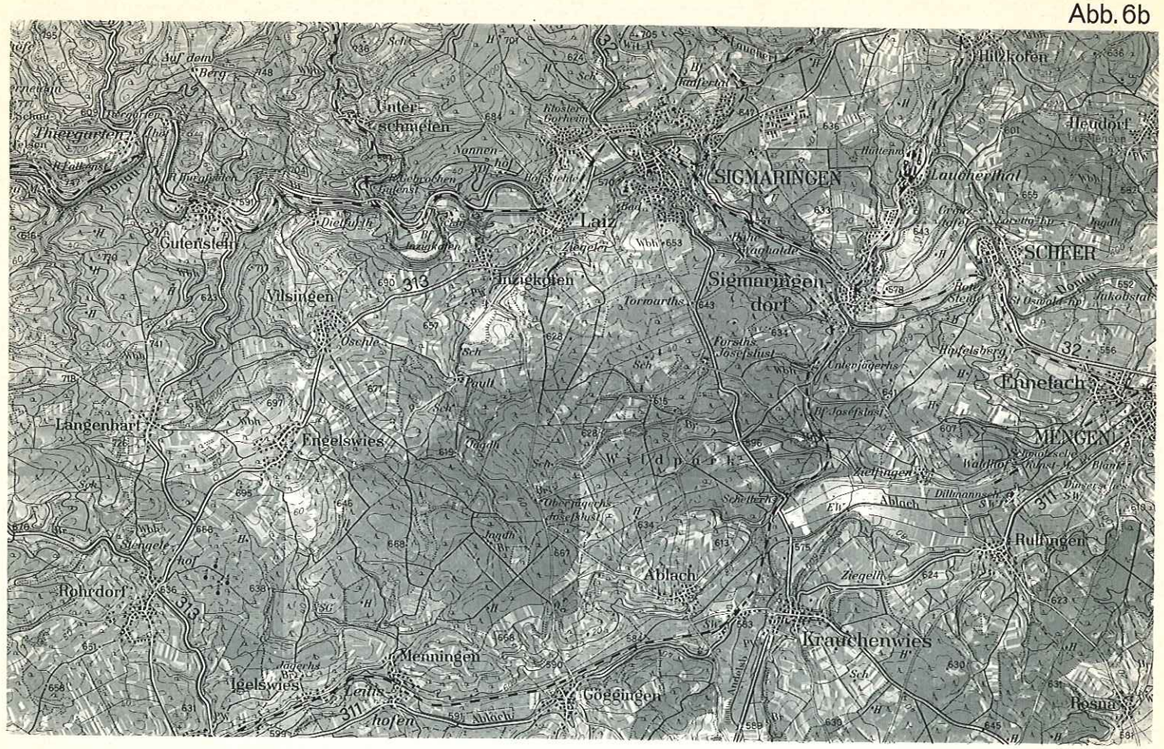


Abb. 6a



Abb. 6b



Eingereicht von der Bundesrepublik Deutschland durch W. Beck Landesvermessungsamt Baden-Württemberg
Submitted by the Federal Republic of Germany by W. Beck, Landesvermessungsamt Baden-Württemberg
Remis par la République Fédérale d'Allemagne par W. Beck, Landesvermessungsamt Baden-Württemberg

Dynamische Methoden bei der Herstellung topographischer Karten, erläutert am Beispiel der Topographischen Karte 1:100 000

Dynamic Methods in the Production of Topographic Maps, Illustrated on an Example of a Topographic Map of 1:100 000

Méthodes dynamiques pour l'établissement de cartes topographiques expliquées à l'aide de l'exemple de la carte topographique au 1/100 000 ème

Abb. 1



Abb. 1, 2, 3, 6a u. 6b Luftbild freigegeben durch Regierungspräsidium Oberbayern Nr. G 7/88116

Abb. 1 Luftbildkarte mit Schrift

Abb. 2 Orthophotokarte mit Schrift

Abb. 3 Orthophotokarte wie Abb. 2 und Höhenlinien

Abb. 4 Ausschnitt aus der Top. Karte 1:100 000 C 7918 Ebingen (Behelfsausgabe) mit Genehmigung

Abb. 5 Ausschnitt aus der Top. Karte 1:100 000 C 7918 Ebingen (Normalausgabe)

Abb. 6a Orthophotokarte und kombinierte Top. Karte 1:100 000 (Normalausgabe) - Negativ

Abb. 6b Orthophotokarte und kombinierte Top. Karte 1:100 000 (Normalausgabe) - Positiv

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B

RIVER GAMBIA

DANKUNKU ISLAND

Dankunku Bolon

Wharf

SAMBANG TENDA

Wharf

SAMBANG

Ker Nding Nding

Ker Yoro Sowe

Sambang Wollof

Ker Nding Nding

SABA KUNDA

SABA KUNDA

Ker Bamboi Lowe

Ker Bamboi Kunda

Sandwa Nding

NUMBIJAE

KOPPA KUNDA

N'Gonka

N'Yoro Kunda

Baloghel

Baloghel

Bolong Kolley

Bolong Kolley

Sabach

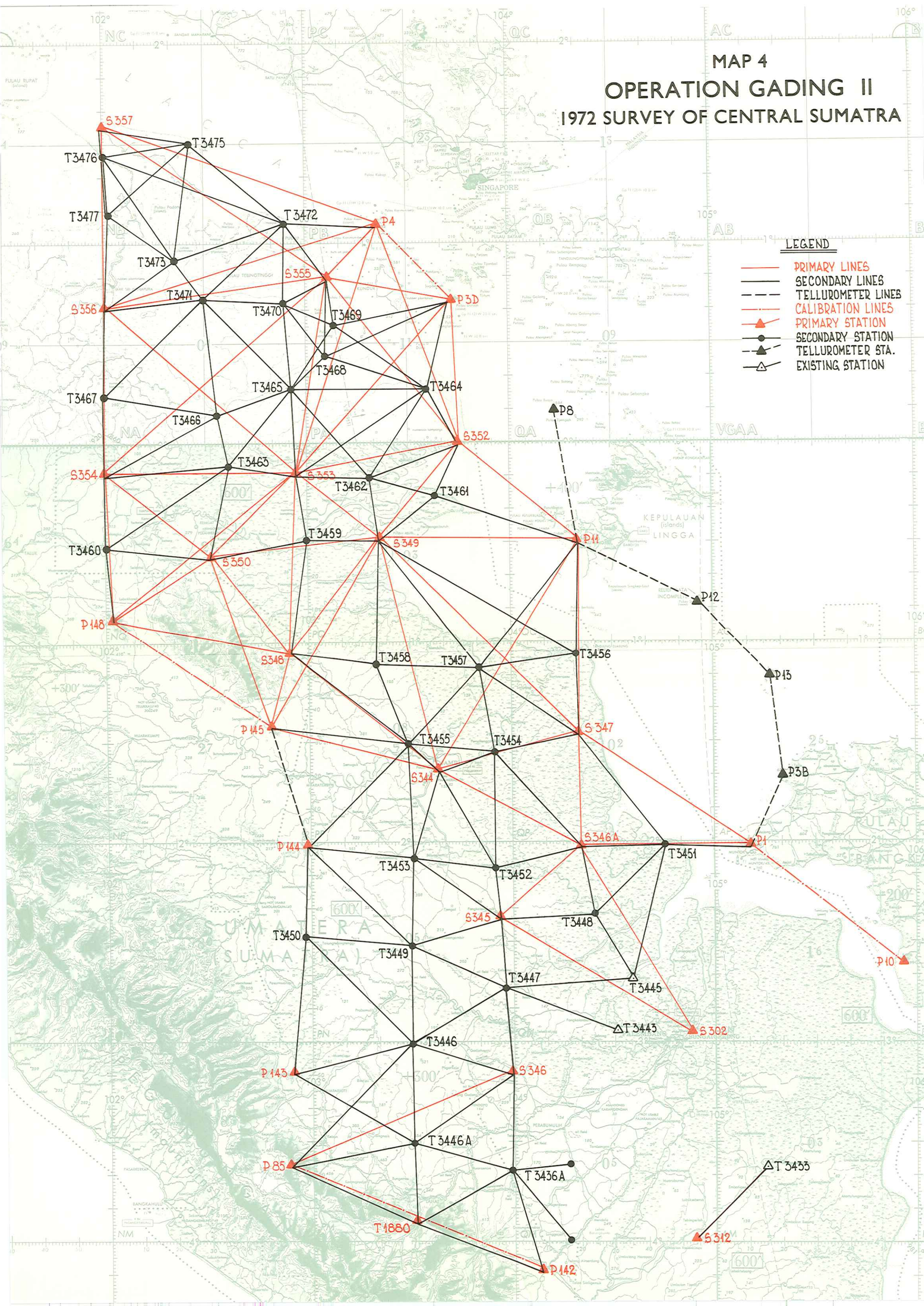
Sabach

Nding

Nding

Nding

MAP 4
OPERATION GADING II
1972 SURVEY OF CENTRAL SUMATRA



MAP 3
OPERATION GADING I
1971 SURVEY OF SOUTH SUMATRA

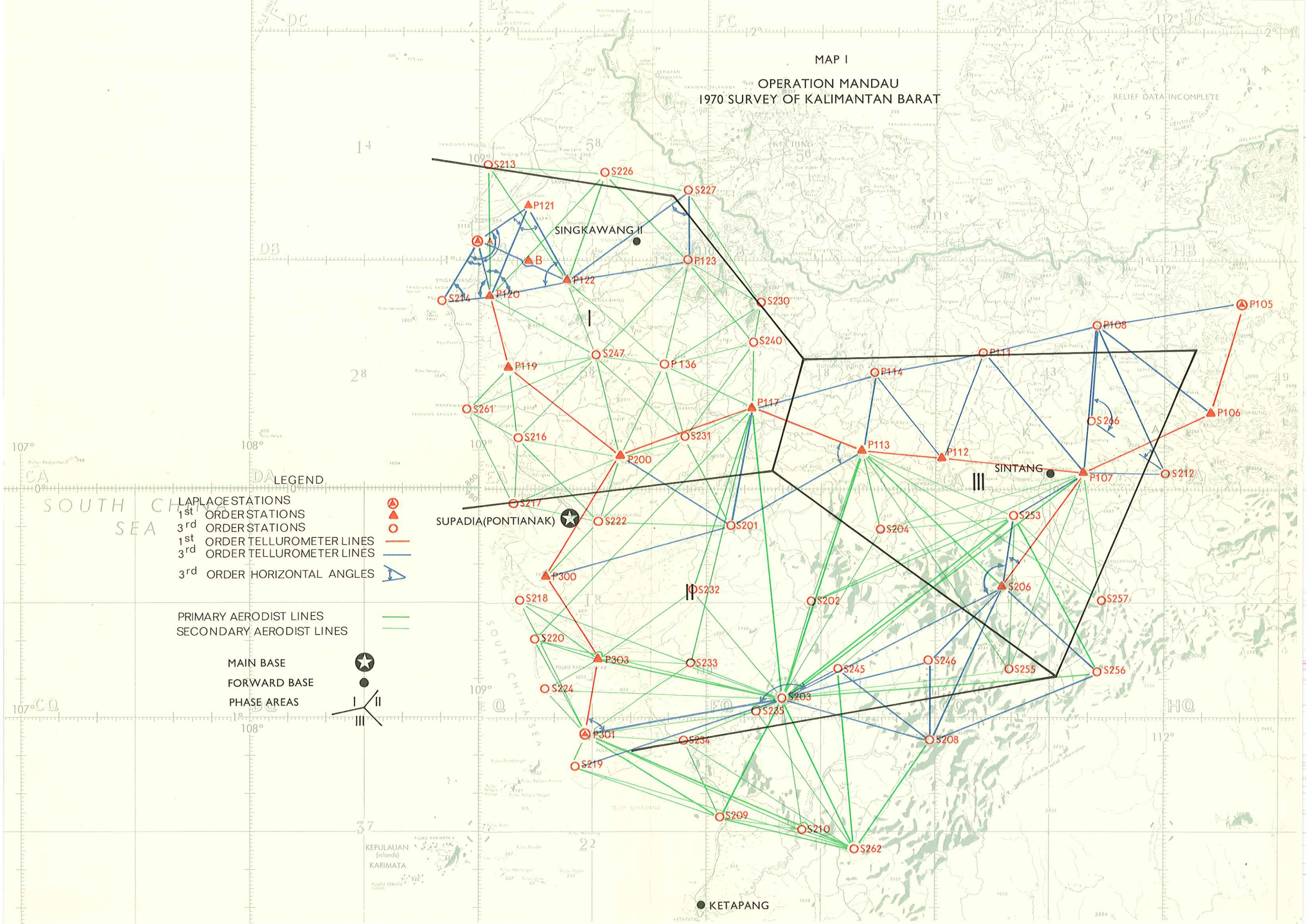
P144 S344 P1 P2
S345 S333 S334 S335 S336
IV
P10 S332 P11
T3445 T3444
III
PALEMBANG T3443 S302 S304 P13
T3442 S343
P143 S346 T3441 T3440 T3439 T3438 V S342
PENDOPO
P87 T3437
II
T3436 T3435 T3434 T3433 T3432
P85
T3431 T3430 S312 T3429 T3428 S315
P79 P142
T3427 T3426 T3425 T3424
P77 P141 I
ASTRA KSETRA T3422 T3421 T3420
P71 P140
S320
P70
P67

LEGEND

- 1st ORDER STATION
- 3rd ORDER STATION
- 1st ORDER TELLUROMETER LINE
- 3rd ORDER TELLUROMETER LINE
- 1st ORDER HORIZONTAL ANGLE
- PRIMARY AERODIST LINE
- SECONDARY AERODIST LINE
- AERODIST CALIBRATION LINE
- MAIN BASE
- FORWARD BASE
- PHASE AREAS I II III IV V

MAP 2


ATJEH
99°
5°N
MALAYSIA
IV
MEDAN
2°N
III
SINGAPORE
0°
V
II
BUKITTINGI
SUMATRA
VI
PALEMBANG
I
5°S
102°
DJAKARTA


MAP I
OPERATION MANDAU
1970 SURVEY OF KALIMANTAN BARAT
LEGEND
LAPLACE STATIONS
1st ORDER STATIONS
3rd ORDER STATIONS
1st ORDER TELLUROMETER LINES
3rd ORDER TELLUROMETER LINES
3rd ORDER HORIZONTAL ANGLES
PRIMARY AERODIST LINES
SECONDARY AERODIST LINES
MAIN BASE
FORWARD BASE
PHASE AREAS
SINGKAWANG II
SINTANG
SUPADIA(PONTIANAK)
KETAPANG
SOUTH CHINA SEA
KEPULAUAN (islands) KARIMATA
RELIEF DATA INCOMPLETE
S213
S226
S227
P121
A
B
P122
P123
S214
P120
S230
S240
S247
P136
P119
P117
S261
S216
S231
P200
S217
S222
S201
P300
S218
S232
S220
P303
S233
S224
S203
S235
P301
S234
S219
S209
S210
S262
S208
S245
S246
S255
S256
S202
S204
S206
S257
S253
P113
P112
P107
S212
S266
P106
P108
P105
P111
P114

MELBOURNE
VISUAL TERMINAL CHART

Scale 1:250,000

Aeronautical Information: 24 MAY 1973

LEGEND

AERODROMES — Land

Water

Helicopter

AERODROME LANDMARK
(Status and Serviceability unknown)

BASIC RADIO FACILITY

NON–DIRECTIONAL RADIO BEACON

NAVIGATION AID LIMITATION
(See back of VEC)

CONTROL AREA BOUNDARY
(Boundaries which are arcs of circles are centred on the Primary Airport)

CONTROL ZONE BOUNDARY
(CTR operative only when TWR manned)

COMPULSORY REPORTING POINT
(For aircraft proceeding to Primary Airport)

ENROUTE REPORTING POINT
(As required)

CHECK POINT
(When requested by ATC)

VFR APPROACH POINT
(Plan to fly over on VFR approach to Primary Airport)

MARINE LIGHT

AERODROME BEACON or
AERONAUTICAL GROUND LIGHT

HAZARD BEACON

OBSTRUCTIONS — Unlighted — Lighted

AIRSPACE WITH IDENTIFICATION NUMBER and VERTICAL LIMITS
P Prohibited Area
R Restricted Area
D Danger Area
D 209
0–5000

MILITARY CONTROL ZONE BOUNDARY

GLIDERS
LAUNCHING CABLES

MET BALLOON ASCENTS NEARBY

PARACHUTE JUMPING

AREA WHERE LESS THAN 500' CLEARANCE EXISTS BETWEEN TERRAIN and CTA LOWER LIMIT

DRIVE IN THEATRE

BEARINGS ARE MAGNETIC

HEIGHTS SHOWN IN FEET AMSL OR AS FLIGHT LEVELS

MAGNETIC VARIATION 10½° E (1970 VALUE)

LOCAL STANDARD TIME = GMT + 10

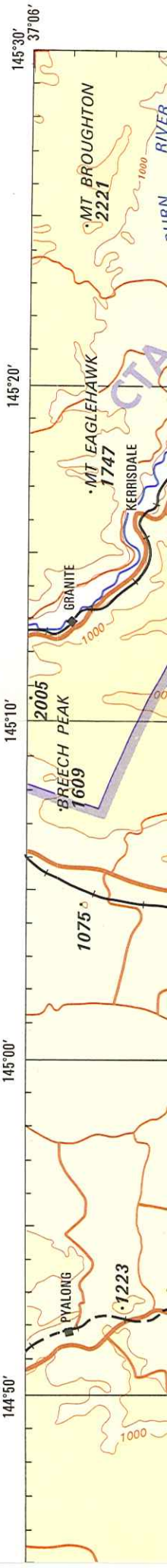
THIS CHART DOES NOT SHOW DETAILS OF AIRSPACE ORGANISATION ABOVE FL 200

COMMUNICATIONS

All Frequencies Allocated for Controlled Airspace Operation and Surface Movement Control are Mandatory (ANO 20.8)

STATION & SERVICE		CALLSIGN	FREQ	REMARKS
AVALON	TWR	AVALON TOWER	120.1 260 *	AVBL MON – FRI 2000 – 1000 AND BY ARRANGEMENT * VOICE AVBL ON AV L FOR EMERGENCY USE
LAVERTON (RAAF)	TWR	LAVERTON TOWER	133.1 344 *	AVBL MON – THU 2200 – 0700, FRI 2200 – 0500 OTHER TIMES BY ARRANGEMENT * VOICE AVBL ON NDB FOR EMERGENCY USE
MELBOURNE	FIS	MELBOURNE	124.9 * 122.1 # 122.4 ** 3008 5498 6575 8938	* FOR ALL WESTERN ROUTES INCLUDING BASS STRAIT AREA # FOR EASTERN, SOUTH EASTERN AND SOUTHERN ROUTES INCLUDING BASS STRAIT AREA ** FOR ALL NORTH EASTERN ROUTES
	ACC	MELBOURNE CONTROL	118.3	LAVERTON CTR AND LAVERTON/POINT COOK RESTRICTED AIRSPACE
	APP	MELBOURNE APPROACH	124.7	
	DEP	MELBOURNE DEPARTURES	118.9	
	TWR	MELBOURNE TOWER	120.5 121.7 * 121.2 #	* SURFACE MOVEMENT CONTROL # SURFACE MOVEMENT CONTROL (APRON)
	ATIS	MELBOURNE	113.9 377	BROADCAST ON ML VOR & EPP L
MELBOURNE/ ESSENDON	TWR	ESSENDON TOWER	125.1 121.9 *	* SURFACE MOVEMENT CONTROL
	ATIS	ESSENDON	356	BROADCAST ON EN NDB
MELBOURNE/ MOORABBIN	TWR	MOORABBIN TOWER	118.1 119.9 *	AVBL 2100 – 1100 EXTENDED BY ARRANGEMENT * SURFACE MOVEMENT CONTROL
	ATIS	MOORABBIN	120.9	
POINT COOK (RAAF)	TWR	POINT COOK TOWER	135.5 132.1 *	AVBL MON – THU 2200 – 0700, FRI 2200 – 0500 * SURFACE MOVEMENT CONTROL

Sealed — Unsealed or Natural Surface — Taxiway, Aprons




A
70
Pan
Pan
Gubudaga
Kudiha
Pan
Pans
70
Pan
118/BT/7
098
Pan
Pan
Pan
Pan
70
Gcanamukwe
Pan
118/BT/7
130


WALLAN
WALLAN EAST
RECOMMENDED VFR ROUTE
MT DISAPPOINTMENT
2610
TA LL 2000
BEVERIDGE
1400
BEVERIDGE
1359
Toorourong Reservoir
KINGLAKE WEST
BOL
L 362
EDEN PARK
HUMEVALE
1228
WHITTLESEA
1176
WHITTLESEA
1691
2170
FENTONS HILL
VOR 115.3
DONNYBROOK
WOODSTOCK
Reservoir
YAN YEAN
RESERVOIR
STRATHEWEN
MICKLEHAM
WOODY HILL
953
818
YAN YEAN
MELBOURNE CTR
1000
CRAIGIEBURN
OVERPASS
WOLLERT
MERNDA
ARTHURS
CREEK
874
R 349
0–1200
0-2000
896
725
ST ANDREWS
BULLA
EPPING
HURSTBRIDGE
CTA
ONE TREE HILL
1222
668
DAM
SOMERTON
MORANG
BROADMEADOWS
DIAMOND
CREEK
BROADMEADOWS
CITY–HALL
MELBOURNE
VOR 113.9
DME 7
PLE
L 218
KANGAROO GROUND
888
1005
RESERVOIR
LATROBE
UNIVERSITY
ELTHAM
YARRA
CTA LL 2000
R 337
0–1500
MELBOURNE/
ESSENDON
NDB 356
DME 5
WONGA PARK
WARRANDYTE
LILYDALE
IVANHOE
DEER
PARK
FLEMINGTON
RACECOURSE
GOLF LINKS
DONCASTER
SHOPPING
TOWN
CROYDON
LARGE SHED
SUNSHINE
(SAW TOOTH ROOF)
MELBOURNE
EASTLAND SHOPPING
CENTRE
GAS TANKS
BROOKLYN
BOX HILL
HOSPITAL
RINGWOOD
PETRO–CHEMICAL
WORKS
STATION PIER
ATV
TV TOWER
ALTONA
WILLIAMSTOWN
POINT ORMOND
RACECOURSE
MONASTERY
MONASH
UNIVERSITY
BRIGHTON
CARIBBEAN
GARDENS
POINT COOK
POINT COOK
RESERVOIR
JETTY
GASOMETER
CTR
0-2000
RACECOURSE
738
CERBERUS
BREAKWATER
GOLF COURSES
SPRINGVALE
ROAD
DANDENONG
RICKETTS POINT
SEWAGE
FARM
RESERVOIR
SEWAGE
TREATMENT
PLANT
GOLF COURSE
PATTERSON RIVER
MELBOURNE/
MOORABBIN
HAMPTON
PARK