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NINTH UNITED NATIONS REGIONAL CARTOGRAPHIC CONFERENCE FOR ASIA AND THE PACIFIC

Wellington, 11-22 February 1980

Volume II. Technical Papers

NEUVIÈME CONFÉRENCE CARTOGRAPHIQUE RÉGIONALE DES NATIONS UNIES POUR L'ASIE ET LE PACIFIQUE

Wellington, 11-22 février 1980

Volume II. Communications techniques

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Department of Technical Co-operation for Development

Département de la coopération technique pour le développement

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FOREWORD

The official records of the Ninth United Nations Regional Cartographic Conference for Asia and the Pacific held at Wellington, New Zealand, from 11 to 22 February 1980, 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 style and practice. The views expressed in these papers are those of the authors and do not imply the expression of any opinion on the part of the United Nations Secretariat.

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; E/CONF.62/3 (Sales No. E.74.I.7) and E/CONF.62/4 (Sales No. E.74.I.25) for the Seventh Conference; E/CONF.68/3 (Sales No. E.77.I.12) and E/CONF.68/3/Add.1 (Sales No. E.78.I.8) for the Eighth Conference.

[1] *Ninth United Nations Regional Cartographic Conference for Asia and the Pacific*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.81.I.2).

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Explanatory Notes

The following symbols have been used in the tables throughout the report:

Three dots (...) indicate that data are not available or are not separately reported;

A dash (—) indicates that the amount is nil or negligible;

A blank in a table indicates that the item is not applicable;

A minus sign (-) indicates a deficit or decrease, except as indicated;

A full stop is used to indicate decimals

Use of a hyphen between dates representing years, e.g., 1971-1973, signifies the full period involved, including the beginning and end years

A slash between dates representing years, e.g., 1980/81, indicates a crop year, a financial year or an academic year.

Reference to "dollars" indicates United States dollars, unless otherwise stated.

TECHNICAL PAPERS
PRESENTED TO THE CONFERENCE

AGENDA ITEM 6

Country reports and progress made since the Eighth Conference

REPORT ON ACTIVITIES DURING 1977-1979*

Paper presented by Australia

RÉSUMÉ

La plupart des nouvelles cartes établies en Australie au cours de la période 1977-1979 étaient à une échelle supérieure à 1/100 000. Parmi celles d'une échelle supérieure à 1/25 000, un bon nombre étaient des orthophotocartes. En ce qui concerne la cartographie à petite échelle, on met maintenant l'accent sur la révision des cartes existantes.

Les progrès réalisés dans toutes les séries de cartes topographiques, thématiques et marines sont rapportés en détail et de nombreuses techniques nouvelles sont examinées.

Le document comporte des rapports séparés sur les progrès réalisés dans le domaine des levés géodésiques, de la photographie aérienne, de la cartographie informatisée et de la compilation des nomenclatures toponymiques. Il contient également un résumé sur l'assistance récemment fournie par l'Australie pour l'exécution des cartes de pays voisins.

Les adresses où l'on peut se procurer des informations supplémentaires sur les activités sont données en annexe.

This report presents a brief review of the progress of mapping in Australia during 1977-1979, and is a summary of the work carried out by federal and state mapping authorities, the chief contributors being:

Federal authorities

Division of National Mapping, Department of National Development
Royal Australian Survey Corps, Department of Defence
Hydrographic Office, RAN, Department of Defence
Australian Survey Office, Department of Administrative Services

State authorities

Department of Mapping and Surveying, Queensland
Central Mapping Authority of New South Wales
Department of Crown Lands and Survey, Victoria
Department of Lands, Tasmania
Department of Lands, South Australia
Department of Lands and Survey, Western Australia
Department of Lands and Housing, Northern Territory

Authorities from whom additional information may be obtained are listed in the annex.

*The original text of this paper, prepared by the Division of National Mapping on behalf of the National Mapping Council, appeared as document E/CONF.72/L.39.

NATIONAL MAPPING COUNCIL

Mapping Australia is a co-operative enterprise shared between the 11 major map-making organizations listed above, whose work is co-ordinated by the National Mapping Council. The Council was created by agreement between the Prime Minister and the Premiers in 1945. Its formal function is to "plan and co-ordinate Commonwealth and State Government geodetic and topographic survey and mapping activities".

Members of the National Mapping Council see themselves as a team united on a common task. Their resolutions have no legal backing: everything is achieved through a sense of common responsibility, goodwill and good communication.

GEODETIC SURVEY

During the period 1977-1979 the major achievements were:

Doppler satellite observations were completed at 106 major junction points of the Australian Geodetic Survey by mid-1977. The results of the survey were reported by the Division of National Mapping in Technical Report 21—"The Australian Doppler Satellite Survey 1975-1977";

The previous Doppler reduction software has been replaced by more flexible and more efficient programs written in-house. The Doppler Software Package, DOPACK, designed to run on an HP 1000 series minicomputer under RTE-4 or compatible system in a multi-

user environment, is reported in National Mapping Technical Report 25. The paper at agenda item 7(*a*), "Geodesy in the Division of National Mapping", covers this more fully;

A dense model 8 geodimeter trilateration network of over 1,000 lines was observed in south-east Queensland;

An extensive net of over 200 model 8 geodimeter lines was observed in south-west Western Australia;

All observations used to form the Australian Geodetic Datum in 1966 (AGD66) and all geodetic observations since made have been adjusted by Dr. J. S. Allman of the University of New South Wales, using program CHAOS. A paper on this adjustment was presented to the International Association of Geodesy in Canberra in December 1979. The paper at agenda item 7(*a*), "Geodesy in the Division of National Mapping", covers this more fully;

The levelling of Tasmania was completed and adjusted to produce the Australian Height Datum (Tasmania);

Intensification of urban control in the Adelaide area was completed and the re-establishment of the primary horizontal network along the River Murray in South Australia is under way;

The Lunar Laser Ranger at Orroral near Canberra, operated by the Division of National Mapping, successfully obtained ranges to the moon on 30 nights. The paper at agenda item 7(*a*), "Geodesy in the Division of National Mapping", covers this more fully;

The Photographic Zenith Telescope at Mount Stromlo near Canberra resumed operation in July 1977 and has obtained over 900 plates since then;

A National Geodetic Data Base of horizontal and vertical geodetic control stations is being established by the Division of National Mapping on its HP 1000 minicomputer for the National Mapping Council. The paper at agenda item 7(*a*), "Geodesy in the Division of National Mapping", covers this more fully;

Monumentation parties in New South Wales established 482 new concrete pillars.

Most states have densified the AGD66 network established in 1966 to provide control for large-scale mapping, particularly in populated areas.

Most states are also extending their vertical control on the Australian Height Datum (AHD). About 190,000 km of levelling now makes up the AHD compared to the original 161,000 km in 1971.

The *Electronic Survey Computing Bulletin* continued to be published in July each year, listing computer programs on surveying and mapping written by government departments, universities and industry in Australia. The accent is swinging from geodesy to digital cartography.

AIR PHOTOGRAPHY

The use of colour photography for photo interpretation is increasing and South Australia uses all colour for this purpose, but for photogrammetric purposes black-and-white is still universally used.

Cyclic programmes of photography are undertaken in most states. For example, in New South Wales and South Australia for:

Metropolitan areas—1:16,000 scale—two- to five-year intervals;

Developed areas—1:40,000-1:50,000 scale—five- to eight-year intervals;

Remote and arid areas—1:60,000-1:85,000 scale—ten- to twelve-year intervals.

Avgas shortages in 1978-1979 interrupted many programmes.

In South Australia, to preserve and protect the aerial films which are a valuable record of the state's development and which should consequently be maintained for future generations, most films are being duplicated to black-and-white film negative copies with a LogEtronic SP10/70C strip duplicator. This is particularly important with colour films which are more easily damaged and mapping films which must be unmarked for preparation of photomaps. All black-and-white photo products are prepared from the duplicate copy.

Aerial films are now also being copied to continuous-tone 35-mm roll film. Departments in South Australia that are major users of aerial photography are using copies of these films to establish their own aerial photography files at relatively low cost. This avoids the time-consuming requirement to continually visit the Department of Lands to refer to its aerial photo library. The films are viewed on microfilm readers.

Queensland has adopted a system of competitive tenders per square kilometre for a number of zones throughout the state. Zone boundaries were determined, in consultation with the contracting companies, according to the difficulty of obtaining photography.

Work is available in 1:100,000 map areas according to prices tendered, with follow-up areas awarded on the submission of satisfactorily completed area. Present indications are that the new system is succeeding in improving productivity while keeping costs to an acceptable level.

TOPOGRAPHIC MAPPING

The small-scale mapping programme continued with emphasis changing from production of new maps to revision of existing maps. (See papers at agenda item 7(*a*) presented by Division of National Mapping, entitled "Revision cycle forecast model" and "Revision of the National Topographic map series".)

Enquiries into mapping activities

Several states have had formal enquiries into their mapping activities. For example, in South Australia, government mapping activities are being reviewed to establish future requirements so that the objectives for mapping organizations can be set for the next 10 to 15 years. The mapping enquiry reviewed the mapping and survey drafting functions throughout South Australia. The review team reported its findings at the end of 1979.

Developments in map styles and printing methods

Many authorities have experimented with different formats and colours. For example, in New South Wales, four-colour printing is now used exclusively for topographic maps and about 80 per cent of printed maps are marketed in folded form.

See also the Division of National Mapping papers at agenda item 7(*b*), entitled "Topographic maps—layout and folding" and "Four-colour reproduction".

Division of National Mapping (Natmap)

The old 1:250,000 R502 series completed in 1967 is being replaced by the 1:250,000 National Topographic

map series with 50-metre contours. Thirty-one have been published.

Production of maps in the peripheral areas of Australia will be at 1:100,000 scale. Five hundred and eight of the 1,646 have been published. Line maps of the central area of Australia will be published at 1:250,000 scale to show clearly the man-made detail. These will be backed up by 1:100,000 orthophotomaps which show more clearly the natural features. Production of orthophotomaps has a low priority. (The paper at agenda item 7(*a*) presented by the Division of National Mapping, entitled "Topographic mapping", covers this further.)

The 1:1,000,000 series was revised and used by the *Reader's Digest* in its *Atlas of Australia*.

Royal Australian Survey Corps (RASC)

Most activity in Australia was directed to the 1:100,000 and 1:50,000 mapping programmes. One hundred and six 1:100,000 maps were published in the period, bringing the total to 521.

Other mapping included:

1:250,000 joint operations graphics in areas of military interest. Seventeen were published in the period.

1:1,000,000 aeronautical charts for the defence forces. These are reviewed annually and revised as necessary.

Large-scale maps and orthophotomaps.

Queensland

The two types of topographic mapping being produced are orthophotomaps and the traditional topographic line maps.

The air photography and associated geodetic control for the 1:25,000 series has been designed so that a range of map products can be produced from a set of photographs and control. The photogrammetric output provides both 1:10,000 orthophotomaps and 1:25,000 topographic line maps.

In addition to these map forms, cadastral plots at 1:25,000 are derived from photogrammetric plots and 1:10,000 cadastral plots are based on the orthophotos. Thus, from one set of information four map types are derived, ensuring harmony of scale and registration between topographic and cadastral maps.

To accelerate map production a series of orthophotomaps at a scale of 1:25,000 covering two 1:100,000 areas will be tried out. For an orthophoto to take the place of a topographic map, the reproduction of detail needs to be clear. The Department of Mapping and Surveying considers that the definition of halftone orthophotomaps is adequate up to the scale of 1:10,000, but at 1:25,000, screening reduces definition below an acceptable level. To overcome this, 1:25,000 orthophotomaps produced from black-and-white photography will be published in colour.

The black-and-white photos will be photographically interpreted into negatives of varying densities which will be printed in colours chosen to highlight detail and will therefore not necessarily be true to nature.

Ten-metre contours will depict relief, and roads, railways and creeks will be highlighted to aid interpretation.

The photographic content of the enhanced orthophotomap is great. However, savings in time and labour in other areas of production of the maps offer a means of faster and cheaper 1:25,000 topographic map coverage.

Under a cost-sharing arrangement with local authorities and with the participation of the private sector, the Queensland Department of Mapping and Surveying is involved in the preparation of 1:2,500 orthophotomaps over urban areas of a number of cities and towns in the state. This form of mapping has been well accepted by local governments, and the Department of Mapping and Surveying expects a continued commitment to these projects in the future.

The 1:2,500 orthophotomaps are published in black and white and reproduced as dyelines. They show grid, graticule, title, selected nomenclature and 1-metre contours. Cadastral maps follow orthophotomaps where development warrants.

New South Wales

Mapping is done at four basic scales: 1:4,000 for urban areas, 1:25,000 for eastern areas, 1:50,000 for the middle west, and 1:100,000 for the far west. A 1:10,000 series for the rapidly developing coastal seaboard may be introduced.

Maps at 1:10,000 and larger are produced on a grid format with an orthophoto background; those at 1:25,000 and 1:50,000 as line maps on a graticule format. The sparsely vegetated areas of the far west are on a graticule format at 1:100,000 with an orthophoto background to depict vegetation. In other respects these 1:100,000 maps are line maps.

It is expected that the state will be covered by maps at these basic scales by 1983. The current status of the topographic mapping programme is shown in the following table:

Scale	*Base*	*Format*	*Contour interval (m)*	*Maps in series*	*Compilation 1976-1979*	*Total completed*	*Balance in series*	*Expected completion*	*Revision cycle (years)*
1:4,000	Ortho	3kmx2½ km	2	1 600	599	1 199	403	1981	5
1:25,000	Line	15' long x7½' lat	10	702	155	649	53	1982	10
1:50,000	Line	30' long x15' lat	20	213	45	87	126	1983	10
1:100,000	Line/ ortho	30' long x30' lat	20	132	47	50	82	1983	15

Victoria

The emphasis is now on very large-scale mapping, 1:2,500 and larger, for local authorities. Work is done on standard sheet lines and will eventually cover the metropolitan and other urban areas.

Tasmania

On 22 August 1978, from a reorganization in mapping, the Mapping Division was formed within the Lands Department, the function of which is to produce and revise base maps, plans and aerial photographs of

the State of Tasmania to satisfy the requirements of the various departments of the public service and other approved organizations. The Mapping Division is now actively engaged in its major task of revising the existing map series and preparing new large-scale maps of the state. A State Mapping Advisory Council has also been established to advise the Director-General of Lands on the programme of mapping and to review mapping equipment and staff.

A number of map user seminars have been held to determine the precise needs of map users within Tasmania for large- and medium-scale maps. These seminars have indicated a need for a 1:25,000 map series with a 10-metre contour interval covering the whole of the state and the detailed specifications for this new series are being finalized. Production is planned at the rate of approximately 40 maps per year so that the state will be completely covered in 11 years. The information collected from the seminars has also indicated that there is a need for a series of maps at a scale of 1:5,000 covering the more closely settled areas of the state. This series will be based on orthophotomaps with a contour interval of 5 metres.

The 50 maps in the 1:100,000 series of Tasmania were completed in 1979 and will now be used to revise the 1:250,000 and the 1:500,000 map series.

A Wild OR1 orthoprojector system was installed in 1977 to provide orthophotographs at large scales. Plans have been prepared for the introduction of digital techniques in map preparation, and the formation of a land information system is being investigated.

South Australia

Topographic mapping is carried out by the Surveyor General's Office, a division of the Department of Lands. The Mapping Branch was established in 1967 with the objective of producing and revising maps, plans and aerial photographs to satisfy the requirements of the various departments of the public service and other organizations interested in the development of the state.

The programme of maps produced in South Australia includes:

1:2,500	Topographic/cadastral maps
1:10,000	Topographic/cadastral maps
1:50,000	Topographic maps

Work began in 1978 on the preparation of topographic base maps at 1:100,000 scale with 20-metre contours. These maps are in areas of interest for mineral exploration and are outside the area programmed for coverage in the 1:50,000 topographic series. The base maps are being prepared for compilation of geological maps by the Department of Mines and Energy and it is not intended to publish the maps as a topographic series.

A feature of the work on the 1:100,000 maps has been the co-operative effort with Commonwealth mapping authorities. Vertical height control by airborne laser profiling was provided by the Division of National Mapping and horizontal and further vertical ground control by the Royal Australian Survey Corps. Aerial photography, aerotriangulation and photogrammetric compilation is done by the Mapping Branch.

A special series of six sheets covering the Adelaide metropolitan area and surrounding districts was prepared from the 1:50,000 topographic bases. Further cartographic enhancement, in particular the addition of all streets and names, was carried out and the series printed in six colours. The aim of the series was to provide a general-purpose base map, particularly for the State Disaster Committee.

During 1977-1978 a firm was retained to research the marketing of maps in South Australia. The Department of Lands has since improved the marketing of its aerial photographs and maps by the establishment of a Marketing Branch with a new map store and a new centrally located shop. Promotion of the available products and the uses to which they can be put has been emphasized. The demand for maps and income from their sale are increasing.

In view of the high cost of mapping today, it is essential for mapping authorities to ensure that the greatest possible use is made of maps and to maximize sales in order to reduce the net cost to the taxpayer.

Western Australia

Orthophotomapping is contributing to the total topographic map cover at scales of 1:5,000 and 1:25,000. The orthophotomap is seen as an information system, in many cases attracting the professional user. Therefore, although enhancement techniques are practised they are intended to improve the photographic image rather than superimpose a line map.

Northern Territory

The Department of Lands and Housing operates two Wild A8 and one Wild B8 stereoplotters plus associated data-acquisition equipment for project mapping. Aerial triangulation is performed by the independent model method.

Map scales range between 1:200 and 1:10,000. Sheets are reproduced as either photographic stable base transparencies or as diazo prints.

Antarctic mapping

Photomaps at 1:250,000 and 1:500,000 scales were produced by the Division of National Mapping from unrectified LANDSAT imagery over areas of topographic interest.

New editions of the 1:10,000,000 and 1:20,000,000 maps of Antarctica were published by the Division of National Mapping in late 1979.

Future series mapping coverage in the Australian Antarctic Territory will be produced from controlled LANDSAT imagery.

HYDROGRAPHIC CHARTING

The period 1977-1979 was productive for the Hydrographic Service of the Royal Australian Navy. Surveys were carried out by HMAS Moresby in waters off Western Australia and by HMAS Flinders in waters off North Queensland and Papua New Guinea. A new offshore positioning system has been installed in both ships, development of a laser airborne depth sounder is well advanced and an automated cartographic system has been installed in the hydrographic office (see paper at agenda item 7(*d*) by the Royal Australian Navy, entitled "Autochart").

A period of expansion is at hand with the commissioning of HMAS Cook, the construction of four 10-metre survey motor boats, and the proposed construction of four 27-metre survey motor launches.

BATHYMETRIC MAPPING

The bathymetric survey of the Australian continental shelf by the Division of National Mapping continued, more slowly than was originally intended, but 80 of the 247 map sheets have been surveyed. A Decca Hi-Fix 6 long-range radio-positioning system was purchased in 1977.

Since 1977 the Division of National Mapping and the Bureau of Mineral Resources have been engaged in a co-operative effort to record bathymetric and marine geomagnetic data in digital form. Programs are being developed for the computer drawing of bathymetric plots and contour overlays. (See paper at agenda item 7(*d*) by the Division of National Mapping, entitled "Bathymetric mapping by the Division of National Mapping, Australia, 1977-1979".)

The Australian Survey Office is providing data on the gradients and approaches to reefs for the Great Barrier Reef Marine Park Authority. In 1977-1978 a pilot study was undertaken on reefs in the Heron/Wistari area. Work is currently being carried out in the Cairns/Cape Flattery area. Output is in the form of a rectified photo image at 1:5,000 with overlays showing spot heights at a nominal grid spacing of 50 metres.

GEOLOGICAL AND GEOPHYSICAL MAPPING

The Bureau of Mineral Resources (BMR) is the main producer of geological and geophysical maps in Australia (see paper at agenda item 7(*b*) by the Division of National Mapping, entitled "Thematic mapping in Australia", for further details), although most states are also active in this mapping. For example, most of New South Wales is covered at 1:250,000 and 1:500,000 with explanatory notes for approximately one third of coverage at the larger scale. 1:50,000 and 1:100,000 maps are available of areas of intense mining activity together with maps at 1:1,000,000 and 1:3,000,000.

A series of metallogenic maps is available for the south-eastern part at 1:250,000 and 1:500,000, with explanatory notes and data sheets.

LANDSAT imagery is used for the investigation of geological structures, conventional colour photography for coastal studies and sediment dynamics.

THEMATIC MAPPING

There is a wide range of thematic maps produced in Australia by a variety of authorities. These are reported in the *Thematic Mapping Bulletin* published in May each year. Some of these include:

Aeronautical charts produced by the Royal Australian Survey Corps with the Royal Australian Air Force to military specifications at scales from 1:250,000 to 1:3,000,000 for defence force use;

Energy resource maps produced by the Division of National Mapping and maps of statistical areas produced in co-operation with the Bureau of Statistics;

National and regional atlases produced by many authorities, for example, the "Western Australia Atlas of Human Endeavour";

1:5,000,000 single-sheet maps of Australia are prepared by Natmap as projects or for other authorities. Because of their general interest, they are being published as a series, as unfolded maps, and from the early part of 1980 as folded maps in distinctive covers;

Land-use maps by some authorities, for example in Queensland, maps for erosion investigation;

Tourist maps in Western Australia are printed in book form and sales are being monitored to test their appeal in relation to the original sheet form.

In New South Wales a series of regional tourist maps has been produced at scales ranging from 1:250,000 to 1:1,000,000. Larger-scale maps of specific tourist interest have been produced of coastal areas and national parks. Three historical maps dating from the earliest days of the settlement of New South Wales in the early nineteenth century have been reproduced and marketed with a high degree of success.

In Queensland a series of 20 A3-size route maps were printed to assist in the conduct of the Pacific 1,000 offshore power boat race from Cairns to the Gold Coast. It is intended that this series be developed as a small-craft chart series along the Queensland coast for sale to the boating public.

Road maps, where in Western Australia a new approach has been taken. The *Traveller's Atlas of Western Australia* is compiled from the 1:1,000,000 series and apart from its value to the travelling public affords a graphical basis for data collection generally.

A more complete picture is found in the paper at agenda item 7(*b*) by the Division of National Mapping, entitled "Thematic mapping in Australia".

COMPUTER-ASSISTED MAPPING

Most contributing authorities have introduced computer techniques at various stages in the mapping process. For example:

The Royal Australian Survey Corps (RASC) has introduced Automap, a detailed account of which is at agenda item 7(*a*) by the RASC, entitled "Automation in computer-assisted cartography";

The Royal Australian Navy (RAN) introduced a semi-automatic chart production system in 1979. A detailed account is at agenda item 7(*a*) by the RAN, entitled "Autochart";

In New South Wales a programme of digitizing contours is being actively pursued at 1:4,000 partly through on-line digitizing during photogrammetric compilation. The remaining data will be captured with X-Y digitizers applied to existing mapping;

In South Australia digital techniques have been introduced to map compilation procedures during the past two years with further research and development continuing;

Stereoplotters have been interfaced to dedicated Data General NOVA 1220 minicomputers to enable map data to be photogrammetrically acquired in a digital mode and stored on magnetic disc storage units;

Interactive editing can take place by means of an on-line Tektronix 4014 graphics display screen on which the captured data can be graphically portrayed and amended where required. This has removed the necessity for the preparation of a simultaneous hard copy graphical edit plot;

Cartographic processing of the digital photogrammetric data takes place on a cartographic editing unit comprising a Data General NOVA 1220 minicomputer with fixed and removable magnetic disc storage units,

two magnetic tape units, a Tektronix 4014 graphics display screen and a digitizing tablet;

Computer programs have been developed to allow the data to be edited by deletion, amendment and addition of map data. Edit plots are prepared on an in-house fast edit plotter and final plots at this stage are carried out through a service bureau. However, a Gerber 4432 Cartographic Plotter is due to be installed in the Branch in early 1980;

In Western Australia analytical equipment and computer-assisted systems recently installed have initiated advances in photogrammetric techniques of topographic mapping. A main digital system computer, the PDP 11/70, is now processing aerotriangulation adjustments and software is being developed for the first stages of a digital mapping system which is at present confined experimentally to three instruments, i.e., one A8, one A7 and one B8;

The PAT.M.43 adjustment program of professor Fritz Ackermann has been implemented and is in regular successful use in conjunction with the Zeiss C112 Analytical Stereo Plotter.

The increase in the acquisition of data in digital form has prompted the National Mapping Council to set a standard for the exchange of this data. A report on the standard is presented at agenda item 7(*b*) by the Division of National Mapping, entitled "Australian standard format and codes for the exchange of digital mapping and charting data on magnetic tape".

GAZETTEERS

Most authorities maintain at least one gazetteer but some have several. For example:

In Queensland there is a gazetteer of official place names, i.e., those names shown on maps published by the Surveyor General; another showing details of their origins; and another of unofficial place names, i.e., those names shown only on maps not published by the Surveyor General and names of all man-made features;

In South Australia a gazetteer is prepared from the 1:50,000 topographic map series for eventual inclusion in the National Gazetteer. Most of the time-consuming manual aspects of this work have been eliminated by the use of a digitizing tablet interfaced to a minicomputer. This enables the point locations to be digitized in relation to the map grid with the appropriate name keyed in on the terminal; and

In Western Australia the manual selection, listing and typesetting of feature names appearing on atlases and small-scale maps has been partly automated by the development and establishment of a gazetteer entitled "The Western Australian Cartographic Names File". It was compiled from 1:500,000 topographic sheets and contains approximately 13,000 of the most significant named features in the state. They are filed on disc storage in a Cyber 4 computer in the Main Roads Department accessed by a terminal in the Department of Lands and Survey;

A second gazetteer listing all townsites and localities has now been completed for general administrative purposes and is also filed in the Cyber 4 computer. The listing includes distances in kilometres from Perth and the nearest major centre together with relevant 1:250,000 and 1:100,000 map-sheet references and the local government area;

A third gazetteer consisting of a total capture of rural road names and feature names has commenced, with anticipated completion in 1982. It will be suitable for all mapping scales and will also be the principal basis of a geographical names information system in Western Australia;

The Division of National Mapping has a gazetteer of all feature names appearing on the 1:250,000 R502 map series;

A second gazetteer entitled "The Master Names File" has been established as the basis for automated selection and typesetting of feature names for 1:250,000 and smaller-scale maps produced by Natmap. This gazetteer is updated with the feature names appearing on the 1:100,000 National Topographic map series.

ASSISTANCE TO OTHER NATIONS

The Department of Defence has provided mapping, charting and geodesy support through defence co-operation programmes to:

Papua New Guinea. The Royal Australian Survey Corps continued to provide support for:

Field surveys;

Topographic mapping at scales 1:50,000, 1:100,000 and 1:250,000;

Aeronautical charting;

Indonesia. The Army and the Royal Australian Air Force provided assistance for the acquisition of air photography and mapping control in the Irian Jaya and Maluku provinces. Technical support was given for aerotriangulation and adjustment of earlier as well as current programmes;

Fiji. Equipment and technical support was provided to assist in fixation of control for determination of the Exclusive Economic Zone;

Solomon Islands. Control was established on an outer island group as a co-operative effort between the Solomon Islands, Papua New Guinea and Australia;

Training was arranged for 65 personnel from Papua New Guinea, Indonesia, Fiji and Thailand.

Formal courses were conducted under the control of the School of Military Survey, and/or on job training held at appropriate Royal Australian Survey Corps units.

Training covered a wide range, and included: control survey and astronomy; orthophoto equipment; air camera operation; cartography, lithography, photogrammetry, production management, general drafting, engineering survey.

The Australian Survey Office has supplied personnel for oversea aid projects in Fiji, Indonesia and the Gilbert Islands. The largest of these projects is the Fiji Land Survey Project, involving the survey of the sugar estates previously owned by the Colonial Sugar Refining Company. In addition, the Survey Office has given in-house training to surveyors and draftsmen from Fiji, Tonga, Ghana and Hong Kong.

National Mapping provided a photogrammetrist to Papua New Guinea to assist in establishing a photogrammetric office for the Public Works Department.

Annex

ADDRESSES FROM WHICH ADDITIONAL INFORMATION MAY BE OBTAINED

NATIONAL MAPPING COUNCIL MEMBERS

Geodetic survey, aerial photography, topographic and bathymetric mapping, national and regional atlases and thematic mapping:

The Director
Division of National Mapping
Department of National Development
PO Box 548
Queanbeyan NSW 2620

Director of Survey—Army
Department of Defence
Army Office
Campbell Park Offices ACT 2600

Commonwealth Surveyor General
Australian Survey Office
Department of Administrative Services
PO Box 2
Belconnen ACT 2616

Surveyor General & Director of Mapping
Department of Mapping and Surveying
PO Box 234
North Quay Brisbane QLD 4000

Director
Central Mapping Authority of NSW
Panorama Avenue
Bathurst NSW 2795

Surveyor General
Department of Crown Lands and Survey
2 Treasury Place
Melbourne VIC 3002

Director of Mapping
Department of Lands
Box 44A GPO
Hobart TAS 7001

Surveyor General
Department of Lands
Box 1047 GPO
Adelaide SA 5001

Surveyor General
Department of Lands and Surveys
Cathedral Avenue
Perth WA 6000

Surveyor General
Survey and Mapping Division
Department of Lands and Housing
PO Box 1680
Darwin NT 5794

Hydrographic surveys and nautical charting:

Hydrographer, RAN
161 Walker Street
North Sydney NSW 2060

OTHER AUTHORITIES

Geological and geophysical surveys and mapping:

The Director
Bureau of Mineral Resources, Geology and Geophysics
PO Box 378
Canberra City ACT 2601

REPORT ON THE PROGRESS OF SURVEYING AND MAPPING IN CHINA*

Paper presented by China

RÉSUMÉ

Parallèlement au renforcement de la défense nationale, à l'édification de l'économie et au développement de la recherche scientifique, la nouvelle Chine a réalisé, depuis sa fondation en 1949, de rapides progrès dans le domaine des levés et des cartes. En ce qui concerne les levés, des travaux de triangulation primaire, secondaire et tertiaire ainsi que de nivellement de précision ont été effectués sur tout le territoire, ce qui a permis l'établissement de cartes de l'ensemble du pays (pour la plupart à l'échelle de base du 1/50 000) au moyen de la photogrammétrie. On a également poursuivi la préparation et la publication de cartes et d'atlas à petite échelle de la Chine et du monde.

A partir des années 70, outre la refonte d'une partie du réseau astrogéodésique, la densification du canevas de nivellement de précision et la révision des cartes à l'échelle du 1/50 000, on a entrepris des travaux photogrammétriques, principalement à l'échelle de base du 1/10 000, en vue de l'exécution des plans topométriques nécessaires au génie civil.

Dans le domaine de la cartographie, la préparation et la rédaction de cartes topographiques à l'échelle du 1/250 000 ou du 1/1 000 000 ont été effectuées à l'échelon tant régional que national; les travaux de rédaction de cartes thématiques ont été intensifiés.

Along with the development of national defence, economic construction and scientific research, rapid progress has been made in the surveying and mapping of New China since its founding in 1949. In the first instance, primary, secondary and tertiary triangulation and precise levelling were conducted over all the country, followed by the nation-wide mapping mainly at the basic 1:50,000 scale by means of the photogrammetric method. In the mean time, we also proceeded with the preparation and publication of maps and atlases of our country and the world at small scales.

* The original text of this paper appeared as document E/CONF. 72/L 79

Since the 1970s, besides the reformation of a part of the astro-geodetic net, the densification of the precise levelling line and the revision of maps at 1:50,000 scale, photogrammetric work, mainly at the basic 1:10,000 scale, was carried out for the purpose of meeting the needs of engineering planning.

In the field of cartography, preparation and compilation of topographic maps on the scale 1:250,000 or 1:1,000,000 were made at both the regional and national levels, while the work on compiling thematic maps became more and more intensive. China's activities and progress in surveying and mapping may be summarized as follows.

System and Organization of Surveying and Mapping

In China, the tasks of surveying and mapping are undertaken by technical personnel in four different fields, namely, in the system of the National Bureau of Surveying and Mapping, in the military system, in the sectors of industry, geology, petroleum, metallurgy, coal, railways, water conservancy with their own surveying and mapping personnel, and in the counties, communes and production teams with mass participation in surveying and mapping work. In addition, the National Bureau of Civil Aviation is responsible for the nation-wide aerial photography for civil use.

The surveying and mapping personnel in the National Bureau are working in all the 29 provinces, autonomous regions and municipalities directly under the Central Government (exclusive of Taiwan Province for the time being). They carry out the rural geodetic surveying work including various types of basic surveying such as astronomical, gravity, triangulation, traverse, levelling and aerial surveying, as well as map preparation, production and publication for the provision of maps in connexion with national economic construction.

As one of the governmental organizations, the National Bureau is responsible for the management of the nation-wide surveying and mapping and for training senior and intermediate technicians for surveying. It is also in charge of the work in aid of foreign countries and of international co-operation in surveying and mapping. Besides the direct management and direction of the work of the bureaux or departments of the 29 provinces, autonomous regions and municipalities directly under the Central Government, it has the following subordinate units:

The Research Institute of Surveying and Mapping —the organization for the study of surveying and mapping techniques, consisting of sections on geodetic surveying, photogrammetry, cartography, geographical names, information, and of an electronic computer station and a workshop for the trial production of instruments;

The Wuhan College of Geodesy, Photogrammetry and Cartography—one of the key national institutes of higher learning for training senior surveying and mapping technicians. In the college there are six departments, offering eight specialties, i.e., the Departments of Geodesy, Photogrammetry, Cartography, Engineering Surveying, Optical Surveying and Mapping Instrument-making, Electronic Surveying and Mapping Instrument-making (including computing techniques). The duration of training is four years;

The Map Publishing House—an enterprise consisting of two parts, one for plotting and compiling maps and the other for publishing maps. It consists of the Office for Plotting and Compiling Chinese Maps, the Office for Plotting and Compiling World Maps, the Office for Plotting and Compiling Historical Maps, the Office of Information and a map-printing house. Among the maps which have been plotted and compiled are those for the use of teaching in primary schools and middle schools, atlases of China and the world, maps in the Chinese phonetic alphabet, thematic maps, tourist maps and so on;

The Publishing House for Surveying and Mapping —an institution especially for publishing surveying and mapping books and periodicals, consisting of an editorial department for periodicals and a publishing department;

The Office of the Committee on Geographical Names —the working body of the China Committee on Geographical Names, responsible for routine work. The Committee is responsible for establishing the rules for Chinese place names and for changing them and standardizing transference of geographical names abroad into Chinese or Chinese names into foreign languages;

The Chinese Society of Surveying and Mapping—a nation-wide academic organization for surveying and mapping, consisting of five special committees, i.e., special committees of geodesy, photogrammetry, cartography, engineering surveying and instrument-making. Its function is to organize symposia.

A Brief Account of Surveying and Mapping Activities in China

Since 1949 our surveying and mapping work has been greatly developed. Now we would like to present a brief account of our activities and progress in respect of geodesy, aerial photogrammetry, cartography, geographical names and instrument-making.

Geodetic work

With regard to geodetic work, a total of some 50,000 stations of primary and secondary triangulation and traverse were established all over the country according to the unified geodetic specifications and instructions (figure 1). The national triangulation net consists of four orders. The primary triangulation chains have been established along meridians and parallels, thereby forming loops in the form of squares (the interval between adjacent chains being about 200 km). At the junctions of the chains, initial sides and Laplace azimuths have been established. The mean side length of the triangle in the chain is 25 km. The standard error in angle measurement is less than $\pm 0.''7$. The constant term of reciprocal Laplace azimuths amounts to $\pm 1.''0$ on the average. The standard errors in latitude and longitude measurements are $\pm 0.''20$ and $\pm 0.^s01 \sim \pm 0.^s02$, respectively. The relative standard error of initial side is less than 1:35,000. The nation-wide secondary triangulation net was established in two stages. Prior to 1958, each primary loop was divided into four equal parts by laying within it two secondary chains intersecting at right angles; then these parts were filled with a supplementary network of second order observed with an accuracy of $\pm 1''.8$ (standard error of angle measurement). After 1958, the secondary chain and supplementary network

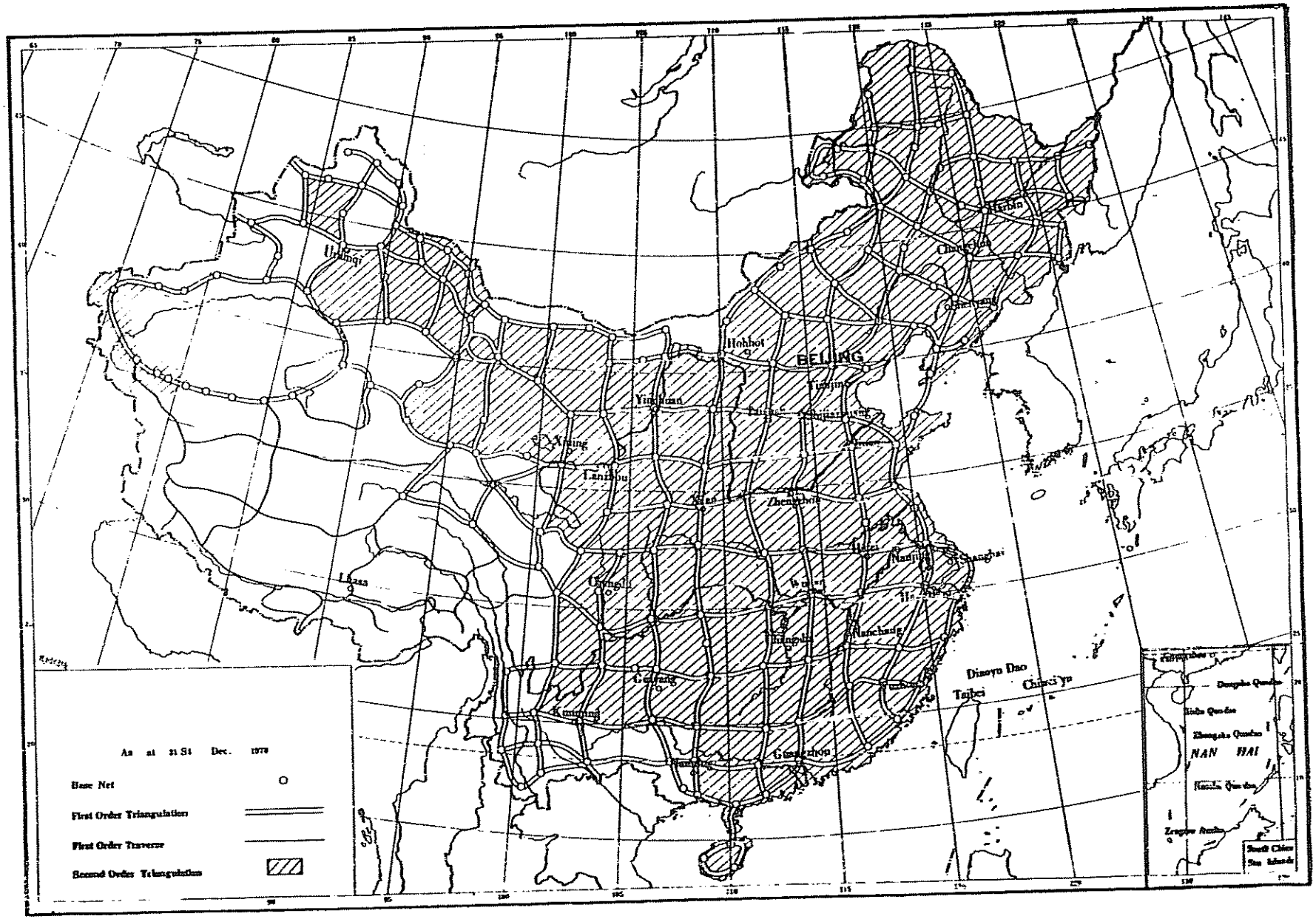

Figure 1. China: national geodetic survey network

within each primary loop were superseded by continued secondary net with a mean side length of 13 km and standard error in angle measurement less than $\pm 1''.0$. Moreover, the latter was strengthened by additional initial side and Laplace azimuth. These measures strongly improved the accuracy of our astro-geodetic net. In accordance with the needs of engineering construction and topographic survey, the first and second triangulation nets were densified locally by tertiary and fourth triangulation points. The tertiary and fourth triangulations, having mean side lengths of 8 and 4 km, respectively, were observed correspondingly with accuracies of angle measurements of $\pm 1''.8$ and $\pm 2''.5$.

Four orders are also adopted in the national levelling with the mean sea level of the Yellow Sea as datum surface. Prior to 1973, the first-order levelling consisted of several major lines in north-south and east-west directions, which were later densified into loops. The perimeters of the first-order loops in plains, hills and mountains (including deserts) are about 1,000, 1,500 and 2,000 km, respectively. Bench-marks are established along levelling lines every 2-6 km. The standard error M_Δ in the average height difference of 1 km estimated from discrepancies of fore and back levellings is generally less than ± 0.5 mm (figure 2). The length for the second levelling line is 500-750 km with M_Δ less than ± 1.0 mm. The first- and second-order levelling bench-marks are resurveyed about every 15 years. The third- and fourth-order levelling are carried out according to the needs of engineering construction and topographic survey. The length of the annexed line of the third-order levelling is less than 200 km with $M_\Delta < 3.0$ mm, while that of the annexed line of the fourth-order levelling is less than 80 km with $M_\Delta < 5.0$ mm.

In order to provide working co-ordinates to meet the stringent needs of the various departments concerned, from the mid-1950s, we successively took some segments as a block and carried out adjustment separately. In the planning stage of the astro-geodetic net, we scheduled to adjust the entire net as a whole. At an early stage in the 1970s, an adjustment programme was made for a simultaneous adjustment of primary chain loops and the continued secondary nets within them. In the adjustment of the astro-geodetic net, the projection method has been adopted by reducing all geodetic observations and initial sides on to the reference ellipsoid. For this reduction, we began to undertake the work of nation-wide gravimetry in the mid-1950s.

A system of three classes is adopted in our gravimetric control stations, i.e., basic stations, first-class stations and second-class stations, the first two classes belonging to the national gravimetric control stations. As a rule, the basic stations form a loop, while the first-class stations are determined radially from the basic stations. The standard error in connecting measurements between basic stations appears no more than ± 0.15 mgal and that between the first-class stations is no more than ± 0.25 mgal.

The astro-gravimetric levelling which is requisite for the determination of geoidal height is classified into two classes: high-precision and low-precision. In the high-precision levelling, gravity stations are set up within a limit of 4 l (l being half the distance between two adjacent astronomical stations), while in the low-precision levelling, this limit is reduced to 3 l. Densified gravity stations take their centre at an astronomical station and are set up densely around it, but become sparse as they go further from the latter. In districts inaccessible to astro-gravimetric levelling, astro-geodetic levelling is utilized as an alternative. Both astro-gravimetric and astro-geodetic levelling should yield geoidal heights with such an accuracy that the accumulated error from the geodetic datum to remote border must not exceed ± 3 m.

The application of satellites for applied geodesy is at an initial stage. Two Marconi CMA-722B Doppler Geoceivers together with HP 21MX computers made in the United States were introduced from Canada, by means of which the geodetic positions and heights of Xisha Islands were accurately determined and the local co-ordinate system of the Islands is thus referred to the universal system of the country. In addition, we are scheduled to apply satellites for applied geodesy to improve the accuracy of the established primary, secondary and tertiary networks of chains.

Photogrammetry

Shortly after the founding of New China we started photogrammetric mapping in our vast territory in accordance with Gauss-Krügen projection and the international sheet division, for the purpose of preparing the maps chiefly at standard 1:50,000 scale in ordinary areas and 1:100,000 in the desert and mountain regions (figure 3). As for the map accuracy, the standard error in position of the ground objects relative to the nearby control points must not exceed 0.5 mm (on map) in plains and hills, and that in mountains, deserts and high mountains must not exceed 0.75 mm. In addition, the standard error in elevation point relative to the nearby elevation control points should not exceed ¼, ⅓ and ½ of the basic contour intervals in plains, hills and mountains, respectively. The basic contour interval for relief maps at various scales is generally $0.2 \times M$ m (M being the denomination of the map scale). The frame format of the camera used in the making of these maps is 18×18 cm^2 and all photogrammetric apparatus used in map-making is suitable for this format. From the 1970s, besides reviewing some maps at 1:50,000 scale, we have undertaken extensive photogrammetric work with the aim of compiling 1:10,000 maps (figure 4). Later we came to use the frame format of 23×23 cm instead of 18×18 cm. In making topographic maps, it takes three years from aerophotography to publication; this is a rather long time. Therefore we are making the following efforts to improve our techniques in photogrammetry and have achieved some success so that we are now able to do plotting in as short a period as possible: application of electronic computers in analytical aerial triangulation; trial of direct engraving of relief maps with all the elements on polyester sheets; study and application of orthographic projection in the compilation of image maps; study of the digitized plotting system and photogrammetic automation.

Cartography

National and world maps and atlases at 1:4,000,000 or smaller scale as well as a series of teaching maps have been compiled, the Map Publishing House being the major agency for this work. Since 1975, bureaux of the provinces, autonomous regions and municipalities directly under the Central Government have been engaged in compiling wall maps of their respective regions. A

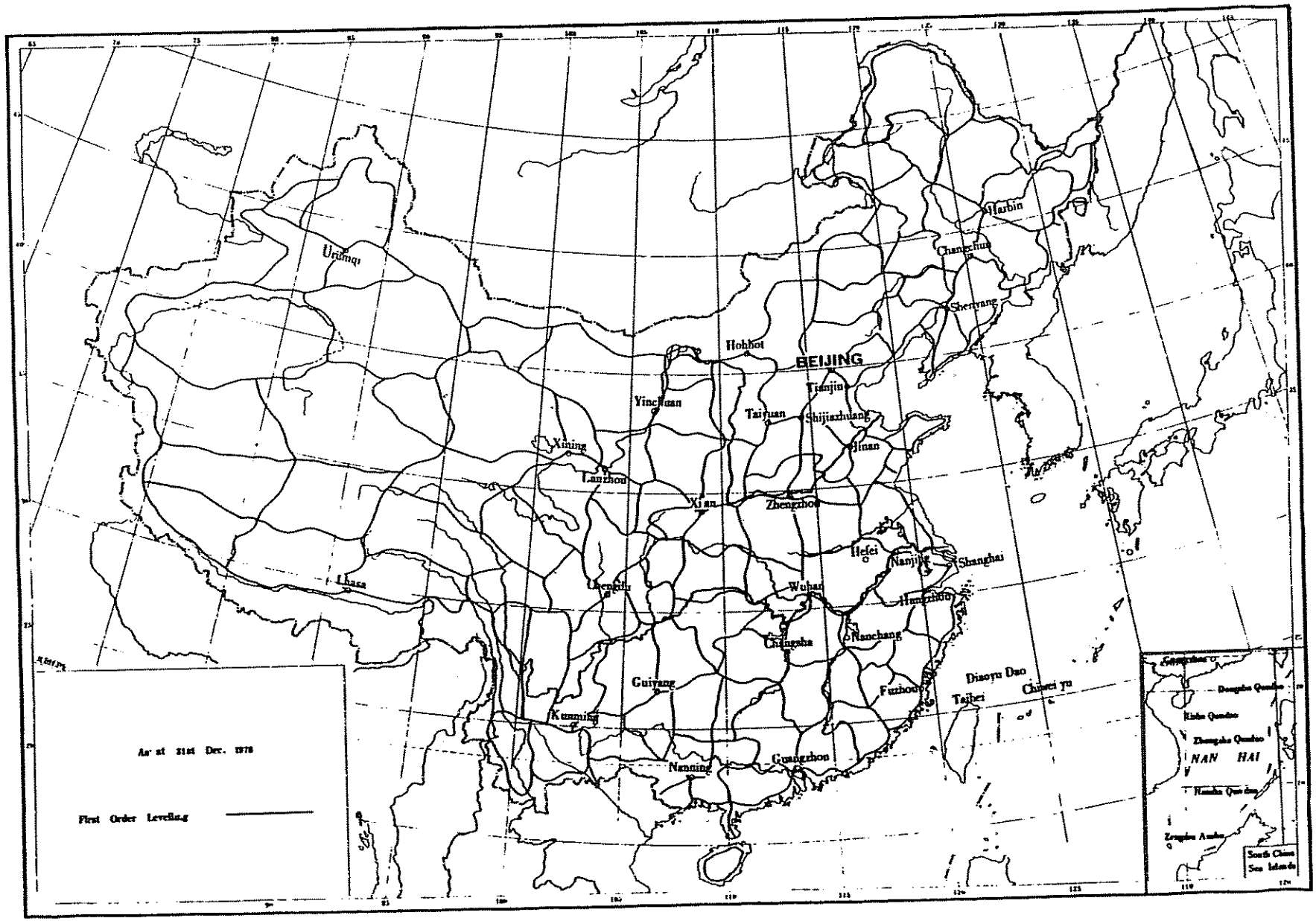

Figure 2. China: national levelling survey network

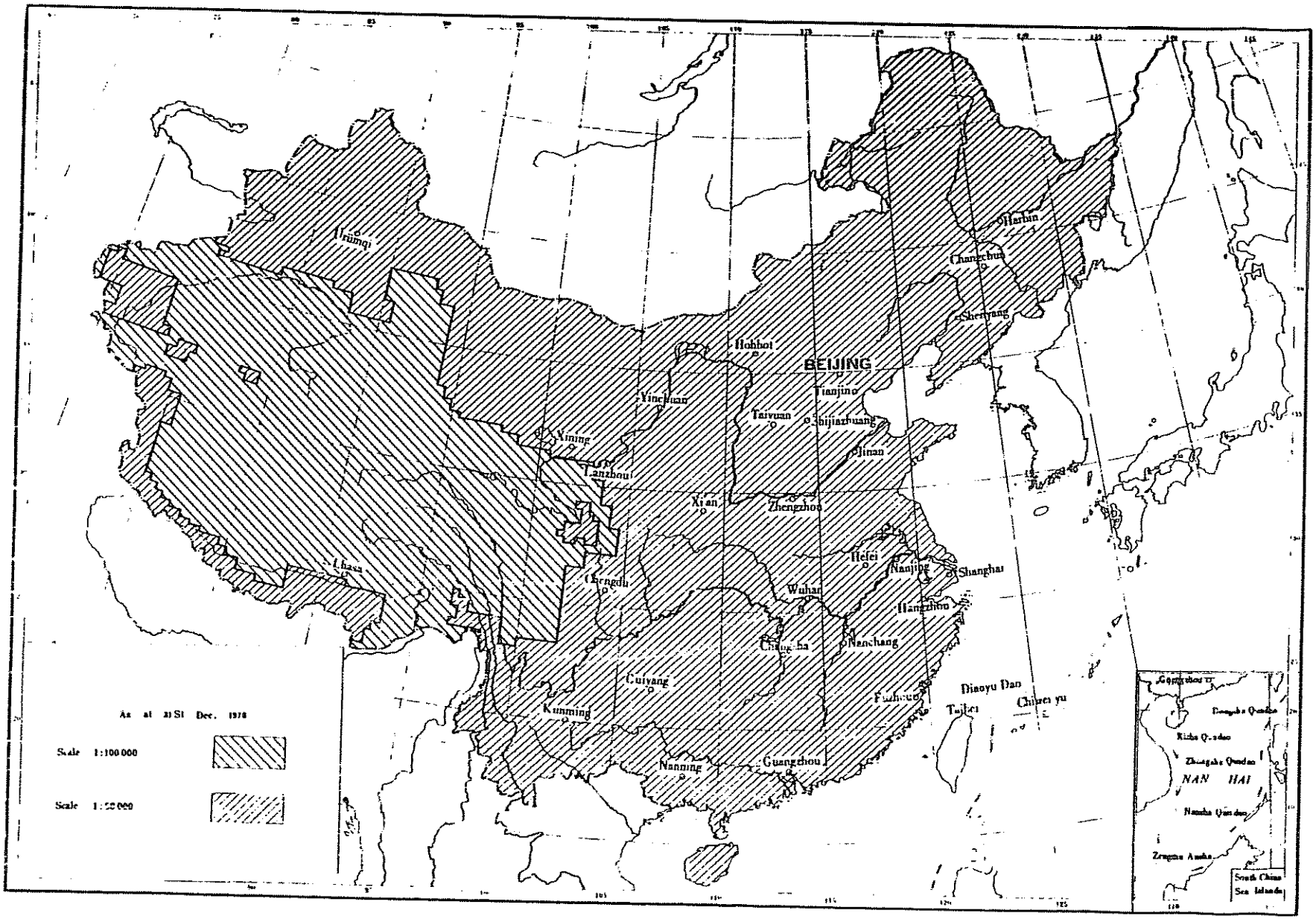

Figure 3. China: map coverage at scales 1:100,000 and 1:50,000

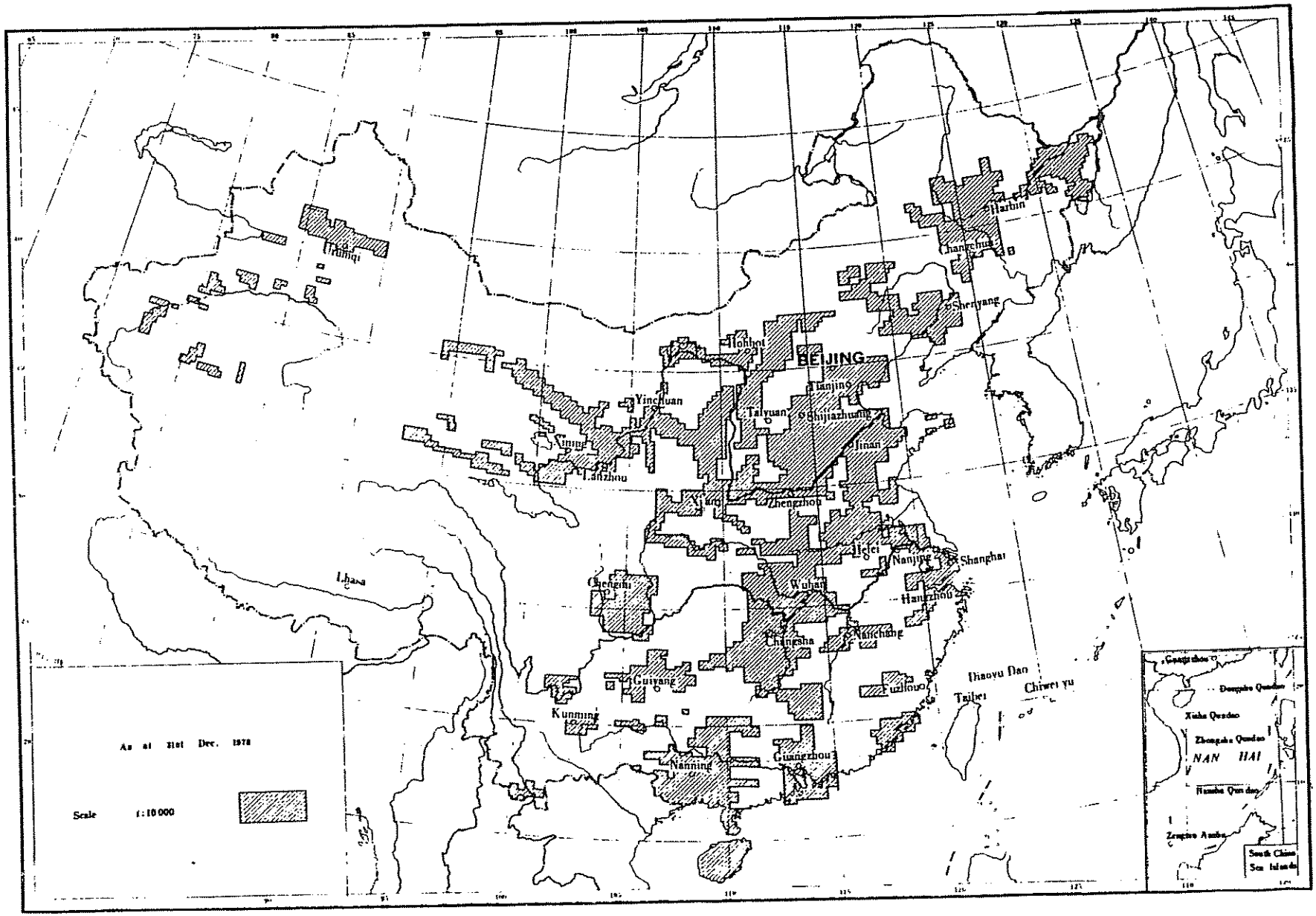

Figure 4. China: map coverage at scale 1:10,000

plan has been worked out for compiling maps of the whole country on the scale of 1:1,000,000. Those for the provinces or autonomous regions are planned on the scale of 1:250,000 or 1:500,000. The compilation of thematic maps is now in progress. Polyester film, transparent notes and engraving have found wide application in cartographic techniques. Offset printing has been applied to multicolour map reproduction. Xerography is in use for the reproduction of the monochromatic maps.

Work on geographical names

Organizations have been established in both the central and local departments to investigate geographical names. We have made a general survey of geographical names in several areas inhabited by minority nationalities, and of the rules for spelling geographical names in the Chinese phonetic alphabet and the rules to transfer geographical names in the minority nationality regions. In addition, we are publishing the map on the scale of 1:6,000,000 in the Chinese phonetic alphabet and "The Atlas of the People's Republic of China in the Chinese Phonetic Alphabet".

Instrument-making

At present we can only produce surveying instruments of low and medium accuracy, while the high-accuracy ones are imported from abroad.

ACTION ON INTERNATIONAL ACADEMIC EXCHANGES

We take pleasure in enhancing and enlarging the cooperation and exchange in surveying science and technology. In recent years, we have established friendly relations with many countries in addition to actively participating in international academic conferences on surveying. We are entrusted by the United Nations Development Programme (UNDP) with aid projects in connection with surveying techniques to other countries. More and more countries and scholars have made and are making direct contact with us in the academic exchange of surveying science and technology. The Chinese Society of Surveying and Mapping has joined the International Union of Geodesy and Geophysics (IUGG) and the International Association of Geodesy (IAG). We attach great importance to the learning of advanced science and technology as well as experiences of other countries, though we consistently adhere to our policy of maintaining independence and keeping the initiative in our own hands and relying on ourselves, the former being in conformity with the latter.

To sum up, appreciable achievements in surveying have been attained. Nevertheless we still lag behind other advanced countries in science and technology. We are very pleased to take advantage of the opportunity provided by the present conference to learn from colleagues from other countries so as to catch up with the advanced world level, do a better job in the service of our four modernizations, and make greater contributions to the world.

A BRIEF REPORT ON THE PROGRESS MADE IN THE FIELD OF SURVEYING AND MAPPING IN CYPRUS DURING THE PAST THREE YEARS*

Paper presented by Cyprus

RÉSUMÉ

La Direction des affaires foncières et des levés qui dépend du Ministère de l'intérieur de Chypre est responsable de l'établissement des cartes cadastrales et topographiques dans l'ensemble de l'île. Cependant, un petit nombre de cartes thématiques sont réalisées par certains autres services officiels, mais toujours à partir d'éléments de base fournis par la Direction des affaires foncières et des levés.

Au cours des trois dernières années, la Direction britannique des levés outre-mer (Directorate of Overseas Surveys) et la Direction chypriote des affaires foncières et des levés ont poursuivi en commun la réalisation de cartes topographiques nationales à l'échelle du 1/5 000.

Outre les efforts qu'elle déploie en vue d'achever les cartes topographiques nationales à l'échelle du 1/5 000, Chypre a entrepris d'établir une nouvelle carte touristique de l'île à l'échelle du 1/250 000.

Dans le domaine de la cartographie à petite échelle, outre la révision de la carte routière et administrative de l'île, une nouvelle carte forestière en six couleurs à l'échelle du 1/250 000 a été réalisée. La Direction des études géologiques a publié une nouvelle édition de la carte géologique de Chypre.

Le Comité chypriote de normalisation des noms géographiques a poursuivi ses travaux sur la collecte, la normalisation et la transcription de tous les noms géographiques de l'île et la rédaction d'une nomenclature toponymique.

Because of the tragic events of July-August 1974, and the fact that 40 per cent of the northern part of Cyprus is still under Turkish Army occupation, no substantial progress has been made in the cartographic field during the period under review.

In the report presented by Cyprus to the Eighth United Nations Regional Cartographic Conference for

*The original text of this paper, prepared by Andreas Christofi, Department of Lands and Surveys, appeared as document E/CONF. 72/L 108

Asia and the Pacific, an outline was given of the tragedy that had befallen the Island and the adverse effect it had had on the Island's social and economic development. The situation is more or less unchanged in spite of all efforts made by the Secretary-General of the United Nations and the Cyprus Government to effect a just and lasting solution of the problem created as a result of the Turkish invasion and occupation.

Responsibility for mapping in Cyprus

As mentioned in previous reports, the Department of Lands and Surveys, under the Ministry of the Interior, is charged with the responsibility for all cadastral and topographic mapping of the Island. Limited thematic mapping is, however, produced by certain other government departments, but this is always done using base material provided by the Department of Lands and Surveys.

For obvious reasons, no cartographic work is carried out by the official organs of the Government in the occupied part of Cyprus. Cartographic activity in the free part of Cyprus is mainly carried out in connection with housing schemes for displaced persons, for other governmental development projects and for tourist development for both the private sector and the Cyprus Tourist Organization.

Topographic map coverage

National topographic mapping at scale 1:5,000, carried out jointly by the United Kingdom Directorate of Overseas Surveys and the Cyprus Department of Lands and Surveys, has continued during the past three years. With the exception of an area of about 350 square miles in the centre of the free part of Cyprus which needs to be photographed, the rest of the area under government control will be completely mapped by the middle of 1980.

Thematic map coverage

On small-scale mapping, in addition to the revision of the Administration and Road Map of the Island, a new Forest Map has been produced in six colours at scale 1:250,000. The Geological Survey Department has produced a new edition of the Geological Map of Cyprus. Both maps have been based on the Administration and Road Map and have replaced older editions at the scale of 4 miles to 1 inch.

A further addition to the street names map series of the towns is the new four-colour map produced for Paphos and a five-colour map for Dhali. The ½ m-scale map of the Island is now available in both English and Greek editions.

Geographical names

The Cyprus Committee for the Standardization of Geographical Names has continued its work on the collection, standardization and transcription of all geographical names on the Island and the compilation of a national gazetteer. The sources for geographical names are the cadastral map series, ancient inscriptions, codes, manuscripts, books and old maps in the Centre for Scientific Research. As is well known, Cyprus has continuous written records of geographical names dating back to 600 B.C.

The difficulty in carrying out cartographic activities in the occupied part of Cyprus adversely affects progress on the standardization of geographical names. The authorities in this part of the Island have changed geographical names into Turkish. Even official Cypriot Turkish names of Turkish villages have been changed. The Government of the Republic of Cyprus and the world at large do not recognize or accept this change.

Future programme

Apart from the effort to complete national topographic mapping at scale 1:5,000, Cyprus is trying to compile a new Tourist Map of the Island at scale 1:250,000. The map, which is expected to be completed by the end of this year, will offer the tourist all the information necessary to make his stay in Cyprus more pleasant.

In our programme is included the compilation of a new street names map of Nicosia, the capital, and the revision of the street names maps of the other towns, which are rapidly expanding. Our main problem is technical staff. Most of our trained staff is occupied with work connected with housing schemes for refugees, which is the Government's main concern. The solution of the Cyprus problem through negotiation, under the auspices of the Secretary-General of the United Nations, will open up new cartographic projects for completing the social and economic development of Cyprus as a whole.

LA TOPOGRAPHIE ET LA CARTOGRAPHIE AU KAMPUCHEA DÉMOCRATIQUE*

Document présenté par le Kampuchea démocratique

SUMMARY

The Kampuchean National Geographic Service, with the co-operation of other countries, has prepared and published maps at scales of 1:100,000 and 1:50,000 covering the whole of Kampuchean territory.

Aerial photogrammetry has been very useful in the preparation of these maps.

The National Geographic Service does not possess enough highly qualified specialists and technicians. One of the tasks of the National Institute for Scientific and Technical Research is to develop teaching techniques which will accelerate

*Le texte original de ce rapport a paru sous la cote E/CONF.72/L.100

mathematical, scientific and technical studies so as to meet the needs of the country in general and of the National Geographic Service in particular.

The different sections of the National Institute for Scientific and Technical Research are as follows:

Chemistry, mineral research and aerial photograph interpretation: former laboratories of the Ministry of Agriculture;

Mechanics and electricity: former Technical School of Russey Keo;

Electricity and electronics: former School of Electricity of Cambodia, at Toek Thla;

Mathematics, physics and research laboratories (chemistry, electricity, electronics, materials resistance etc.): former Polytechnic Institute, on the Poechentong road.

By the middle of 1978, the National Institute for Scientific and Technical Research was able to supply technicians who had enough theoretical and practical training to work in the various technical services of the country. With the help of these locally trained technicians and those who had been trained abroad, the National Geographic Service has constantly improved and diversified its activities and services. It was thus able to play its role effectively and to meet the special requirements of the Ministry of Agriculture, the National Mining Research Service and the Ministry of Industry for hydroelectric dam projects.

The aim was to ensure that by 1990 each technical service and laboratory—and in particular the National Geographic Service—possesses enough qualified specialists and technicians to meet the needs of Democratic Kampuchea in the field of conventional mapping and, if possible, to ensure that the country can adapt itself rapidly to modern mapping techniques.

Le Service géographique national kampuchéen avait établi et publié, avec la coopération de pays tiers, des cartes au 1/100 000 et au 1/50 000 couvrant l'ensemble du territoire du Kampuchea.

La photogrammétrie aérienne avait été fort utile pour la réalisation de ces cartes. Dans certains cas, des précisions supplémentaires ont été apportées par des mesures directes sur le terrain en vue de la réalisation d'avant-projets de développement économique prévoyant entre autres la construction de barrages hydroélectriques.

Le Service géographique national ne possède pas suffisamment de cadres et de techniciens de haute qualification. L'Institut national de recherche scientifique et technique a notamment pour mission de mettre au point des méthodes pédagogiques permettant d'accélérer les études dans le domaine mathématique, scientifique et technique, en fonction des besoins du pays en général et du Service géographique national en particulier.

Les élèves âgés de 13 à 15 ans sont très rapidement formés aux méthodes de raisonnement abstrait et à l'utilisation des symboles et formulations algébriques, en même temps qu'ils suivent un enseignement technique et pratique portant notamment sur des sujets tels que chimie expérimentale, mesures topographiques, électricité, électronique, etc. En trois ans, 50 p. 100 des élèves atteignent le niveau de qualification d'un technicien ou d'un ouvrier qualifié, et 10 p. 100 le niveau de formation scientifique d'un élève de seconde des lycées.

L'implantation des différentes sections de l'Institut national de recherche scientifique et technique était la suivante :

a) Chimie, recherche minérale et interprétation des photos aériennes : anciens locaux des laboratoires du Ministère de l'agriculture;

b) Mécanique et électricité : ancienne école technique de Russey Keo;

c) Electricité et électronique : ancienne Ecole de l'électricité du Cambodge, à Toek Thla;

d) Mathématiques, physique et laboratoires de recherche (chimie, électricité, électronique, résistance de matériaux, etc.) : ancien Institut polytechnique, sur la route de Poechentong.

La bibliothèque comportait plus de 20 000 livres dont 2 000 nouveaux.

Vers le milieu de 1978, l'Institut national de recherche scientifique et technique était en mesure de fournir des techniciens ayant une base théorique et pratique suffisante pour servir dans les divers services techniques du pays. Avec la collaboration des techniciens ainsi formés sur place et celle des intellectuels formés à l'étranger, le Service géographique national était en mesure d'améliorer et de diversifier constamment ses activités et ses prestations. Il pouvait ainsi jouer efficacement son rôle et remplir les conditions de précision requises par le Ministère de l'agriculture, le Service national de recherche minière et le Ministère de l'industrie pour les projets de barrages hydroélectriques.

L'objectif était qu'en 1990 chaque service et laboratoire technique — et, en particulier, le Service géographique national — possède en nombre et en qualité les cadres et techniciens nécessaires aux besoins du pays en matière d'établissement des cartes par les méthodes classiques, et éventuellement en vue d'une adaptation rapide aux méthodes modernes d'exécution et d'impression des cartes.

NATIONAL REPORT*

Paper presented by Egypt

RÉSUMÉ

Dès 1889, tous les travaux de triangulation, de levé cadastral et de cartographie effectués en Egypte étaient réalisés sous l'autorité du Survey Department (Direction des levés), qui porte aujourd'hui le nom d'Egyptian Survey Authority (ESA—Service cartographique égyptien), organisme civil rattaché au Ministère de l'irrigation.

L'ESA a la charge de réaliser systématiquement des cartes à différentes échelles, notamment à grande échelle, aux fins du cadastre et pour les besoins de travaux géodésiques de précision effectués, selon des techniques de pointe, presque exclusivement par sa Division de géodésie.

La Direction des levés militaires du Ministère de la défense est chargée des travaux topographiques de caractère militaire.

La réalisation et la fourniture des photographies aériennes nécessaires aux différents organismes et services publics ou privés est la principale tâche de la Direction des levés militaires.

Le Centre égyptien de télédétection, situé au Caire, a été créé en 1971 en tant que subdivision de l'Académie des sciences et techniques. Il constitue une opération en association entre l'Université d'Etat de l'Oklahoma aux Etats-Unis, la National Foundation of Science des Etats-Unis, et l'Académie égyptienne. Le Centre effectue des travaux de recherche tant pour le secteur public que pour le secteur privé.

Les besoins en topographes et cartographes ont été satisfaits au moyen de stages d'apprentissage, mais ceux-ci ont été remplacés par une formation à l'Institut des techniques topographiques créé en 1968. Les besoins en personnel d'encadrement sont satisfaits à l'aide de diplômés des facultés techniques des universités égyptiennes.

By 1889 all the triangulation, cadastral surveying and mapping were combined under the direction of the Survey Department, now the Egyptian Survey Authority (ESA), a civil organization of the Ministry of Irrigation. Surveys and mapping were carried out by traditional methods before the introduction of photogrammetric techniques in 1954. Since then, work has been developed by using new instruments, tools and materials. ESA is responsible for the systematic coverage of maps at different scales, especially large scales, for cadastral purposes, and the precise and advanced geodesy which is done almost entirely by the Geodetic Department of the Authority.

The Directorate of Military Survey Ministry of Defence undertakes surveying and mapping for military purposes, which before had been carried on in a limited way by the Survey of Egypt. The acquisition and provision of aerial photographs needed by the different organizations and agencies, either governmental or private, is the main task of the Military Survey.

The Egyptian Remote-sensing Centre (RSC Cairo) started in 1971 as a division of the Academy of Science and Technology. This is a co-operative venture between Oklahoma State University of the United States, the United States National Foundation of Science, and the Egyptian Academy. The RSC is involved in research work, for both governmental and private organizations and agencies.

Manpower requirements for survey and mapping technicians had been filled by apprenticeships, but since 1968 these have been replaced by the Institute of Survey Technicians. The requirements for supervisory level personnel are met by the graduates of the engineering faculties of Egyptian universities. Some selected staff receive further advanced courses at internationally recognized establishments.

GEODESY

Doppler satellite has been used in Egypt within the past year to establish over 50 first-order stations. As it stands now, the Eastern Desert area and the Nile Valley are covered with a complete network of first-, second- and third-order triangulation as well as Doppler satellite points. The Western Desert is less fortunate and is covered with a very sparse network with the exception of the New Valley, which covers an area of 350 km^2.

Comprehensive adjustments have not been carried out for the entire triangulation net. Subsequent surveys with more accurate instrumentation and techniques have indicated inconsistencies in the network's first-, second-, third- and fourth-order connections. These were noted in the mapping of the Greater Cairo area at 1:5,000 scale in 1978. The ESA carried out additional observations in that area for the purpose of tying the nets using the least squares method to readjust the geodetic networks. This was done in co-operation with a French consortium set up by the Institut géographique nationale (IGN) and the Société française de stéréotopographie (SFS) within the general scheme of co-operation agreed in 1975 between the Egyptian and French Governments on a special programme of collaboration in cartography. This procedure of readjustment will be conducted for the rest of the Egyptian geodetic nets.

*The original text of this paper appeared as document E/CONF. 72/L.98

Special attention has been paid to our precise levelling. The Research and Development Institute, which was recently established by the Ministry of Irrigation, to which ESA belongs, conducted a study on the effect of the gravity observation on precise levelling. This helped us in computing corrections to the studied levelling points. The ESA will continue the task on all the first-order levelling points.

The control categorized and referenced as fourth-order, or desert, triangulation is not adequate for use in land reclamation and new community projects, which are the aim of the development programmes now being undertaken by the government. Three years ago EDM equipment was introduced and used for densification of control points. In 1979, more than 1,400 points were established by EDM traverses as a basic ground control for aerial triangulation in the Nile mapping project undertaken by the ESA in co-operation with Kentings Surveys of Canada. The area covered by the project was approximately 4,500 km² for topographic mapping at the scale of 1:10,000.

Aerial photography

The Egyptian Survey Authority possesses RC 8 cameras with Avigon, Infragon and Aviotar lenses, platforms with gyroscopic stabilizers, a completely equipped photography laboratory which includes SEG 5 rectifiers and VG 1 enlargers. The ESA has no aircraft but the aerial photography is carried out by the Egyptian Air Force. Otherwise, specifications and general conditions are worked out for international tenders. In the last three years, three survey and mapping bodies, either governmental or private, have performed aerial photography for different areas in Egypt as follows:

	Square Kilometres	*Scale*
Fairey Surveys, United Kingdom	3 000	1:25,000
Kenting Surveys Canada	5 000	1:10,000
	13 000	1:40,000
IGN and SFS France	900	1: 6,000
	7 700	1:15,000
	35 000	1:25,000
	5 000	1:40,000
	25 000	1:50,000

Plotting and drafting

Photogrammetry is used exclusively in mapping at different scales. Orthophotography is not used in Egypt as plane rectification satisfies photo map needs in the developed areas with a gradient of 1.5 degrees at most. Equipment includes photogrammetric plotting instruments; Wild A10, A8, B8 Autographs, Zeiss Jena stereo metrographs type C, point transfer devices, Wild PUG2, PUG4, digitizing and automatic recording equipment, EK5s with IBM typewriters interfaced to two Wild A8s and EK22 with IBM typewriter interfaced to Wild A10.

There is no computing centre; however, data are processed on ICL 1906 computer in the Central Agency for Public Mobilization, Statistics, at Cairo.

Aerial triangulation by the independent model method is used for establishing minor control points. For the adjustment of photogrammetric blocks a second-degree polynomial is used after Schüt. Photogrammetric strips are formed from independent models from analogue instruments using seven parameter similarity transformations. Since recent adjustment programmes are based on similarity transformation of independent models to ground, the ESA will take the necessary steps towards the acquisition of a programme based on this technique.

Direct scribing on plotting instruments is not used. Maps are fair drawn for reproduction using both methods, scribing and inking. A photo lettering machine has been introduced for preparing Arabic toponomy, but some names and titles still have to be handwritten.

Map sheets at large scales are framed by grid lines covering a rectangular area:

6	x 4	km²	for the	1:10,000	scale
3	x 2	"	" "	1: 5,000	"
1.5	x 1	"	" "	1: 2,500	"
0.5	x 0.5	"	" "	1: 500	"

The latter two formats are used for cadastral maps of cultivated land and towns, respectively. For the small and medium scales the map sheet format is based on the multiple of the 1:25,000-scale map which covers an area of 7.5 x 7.5 sexagesimal minutes.

As it stands now, the Nile Valley and its delta, the Suez Canal, the Red Sea coast, the northern Mediterranean Sea coast, the New Valley and scattered areas in the Eastern Desert are covered by mapping at the scale of 1:25,000 which is periodically revised and renewed. In the past three years, mapping for different territories in Egypt was carried out as follows:

Egyptian Survey Authority: 10,760 km² at the scale of 1:25,000;

IGN and SFS France: 6,900 km² at the scale of 1:5,000; 16,900 km² at the scale of 1:5,000;

Digital terrain mapping in the Quattara Depression to provide hydrologists with the necessary data for the creation of an artificial salt lake in the area. The specific data were surface and volume of the depression at levels from −130 to −50 m MSL (Mediterranean Sea at Alexandria), at intervals of 5 m;

Kenting Surveys, Canada: 4,000 km² at the scale of 1:10,000;

Fairey Surveys, U.K.: 1,500 km² at the scale of 1:10,000.

No survey records were obtained from the Military Survey or the private sector.

Cadastral mapping

The first cadastre started in 1898 and lasted 10 years. With no existing triangulation control, it was done by separate surveys, village by village. The control was in the form of rapid traverse round each village. A series of large-scale map sheets were provided to the scale of 1:4,000 then to the scale of 1:2,500. The latter was chosen due to the extreme subdivision of land into small holdings of which 40 per cent were under half a feddan with another 50 per cent under 5 feddans (1 feddan = 4,200.83 m²). In 1899, a systematic triangulation of second order was commenced and a second cadastre took place in Egypt from 1924. By then, radical changes had occurred in the method of surveying. Permanent national traverse nets were controlled by triangulation with a new co-ordinated reference, to allow the whole country to fall into the first quadrant. The traverse points were plotted on 1:1,000 maps. Detailed surveys were undertaken later by field parties. Sheet maps were

then provided at a reduced 1:2,500 scale for public use at a moderate price.

The second cadastre has not so far covered the whole of the cultivated area. The traditional procedure used for the cadastral survey should now be replaced by a new procedure.

The ESA recognized the importance of digital cadastral mapping techniques and the use of computer-controlled drafting tables (Kern AT tables) for fast and accurate production of a cadastral map at 1:1,000 scale. Through a process of generalization and delineation of some features, the ESA has the capability to automatically produce the cadastral map at 1:2,500 scale. It is hoped to create a cadastral data bank based on a polygon structure, the nodes of each polygon to be coded to indicate if the point is a single node or a common node between one or more polygons. Each polygon carries a series of attributes indicating parcel number, ownership, deeds and other survey register data. It is hoped to complete the structure of the data base and to start implementation in the very near future.

Town Mapping

For town mapping, 1:500 and 1:1,000 scales are still surveyed and mapped by traditional methods. A special triangulation net, not projected on the ellipsoid, with invar base measurement of 0.5 km, is the basic control for mapping.

Remote-sensing Centre

The Egyptian Remote-sensing Centre (RSC) offers a full range of earth resources data acquisition and processing services including:

Consulting and planning for application of both satellite and airborne multispectral data;

Data analysis and processing using advanced digital processing, display and recording techniques;

Presentation of results in images, maps and other data formats.

The RSC available facilities and equipment are:

A multispectral data analysis system, developed by Bendix Corporation for the United States NASA space programme;

A complete photographic development unit;

Other remote-sensing equipment for data collection and analysis.

Aircraft equipped with airborne remote-sensing equipment including multispectral digital scanners, infrared thermo-vision cameras, gamma spectral radiometric scanners, four-lens multispectral aerial camera and aeromagnetic systems.

Projects are carried out by the RSC in Egypt and other Near Eastern countries.

Training and Education Facilities in Egypt

There was no degree course in surveying, photogrammetry or geodesy in Egypt prior to the start of the High Polytechnical Institute in 1967. This is now the Faculty of Engineering of Zagazik University. Surveying and mapping in Egypt was carried out and supervised by civil engineers graduated from Egyptian universities after having studied surveying during their undergraduate courses. Some selected staff from among university graduates receive advanced training and post-graduate courses, through government scholarships, at universities abroad or at internationally recognized training centres or through the newly instituted post-graduate courses in surveying at the civil engineering departments of the Egyptian universities.

For technical personnel, special training courses in surveying, photogrammetry and cartography are provided by the Institute of Survey Technicians. The Institute was started in 1968 with a two-year course following secondary education to matriculation standard. Among the subjects taught are cadastral and topographic surveying, photogrammetry, mining surveying, geodesy and office computing as well as related subjects such as mathematics, descriptive geometry and physics. The Institute is open to Arabic-speaking students of different nationalities. There is a similar school in the Military Survey. A training centre was established recently in the ESA for new personnel to attend specific courses before they occupy their positions in the ESA. Established personnel may also take refresher courses or study new techniques at the Centre.

PROGRESS REPORT*

Paper presented by Fiji

RÉSUMÉ

A Fidji, les utilisateurs de cartes ont pris conscience de l'importance de la cartographie en raison de sa contribution au développement systématique du pays. Le Lands and Survey Department (Département des affaires foncières et des levés) procède actuellement à la réalisation d'un grand nombre de cartes à différentes échelles et à différentes fins.

Ce département dispose de suffisamment de personnel compétent dans le domaine de la cartographie, mais, faute de matériel cartographique moderne et de moyens d'impression, ces ressources humaines ne sont pas pleinement employées.

Au cours des trois dernières années, on a réalisé des cartes topographiques répondant à des besoins divers et d'échelles différentes (du 1/500 au 1/20 000). Des cartes topographiques au 1/50 000 (DOS 648), préparées et publiées par le Département et couvrant les principales îles, ont été mises à jour en 1960. On prévoit d'effectuer très prochainement à Fidji une refonte et révision de ces cartes afin d'en accroître la précision.

A l'heure actuelle, toutes les cartes sont imprimées à l'étranger.

The progress made in the field of cartography and its related fields is described below.

In Fiji 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 different scales and for different purposes is being undertaken by the Department of Lands and Survey.

The Lands Department has enough trained and capable personnel in the field of cartography but owing to lack of modern cartographic equipment and printing facilities the manpower resources are not being fully exploited.

AERIAL PHOTOGRAPHY

The Lands Department, through its staff in the Air Survey Section, carries out its own aerial photography using RC 8 6" focal length camera. The Beachcraft Baron from Fiji Air Limited is hired for this purpose. Aerial survey missions in the past three years have been carried out for various reasons ranging from mapping projects to assessment of damage after hurricanes. Aerial photography for statutory bodies like H.A. and private firms have also been carried out, the flying height range being 2,500-10,000 feet. Opportunity was taken to help the Australian Army Corps in taking spot photography with 80 per cent overlap for identifying the satellite stations, which were premarked.

One officer received training in navigation with the New Zealand Aerial Mapping Limited crew while they were here doing the agricultural census photography. The limiting factor in extending aerial coverage is lack of funds. However, the Government is realizing its importance now and funds are being increased annually.

*The original text of this paper appeared as document E/CONF. 72/L.109.

MAPPING

In the preceding three years topographic mapping has been carried out at various scales for a variety of purposes, the scale range being 1:500-1:20,000. Contour interval range is from 1m to 20m. This mapping has been mainly done for the Forestry Department, Public Works Department and Housing Authority, Town Planning, and Civil Aviation. Topographic maps on the scale of 1:50,000 (DOS 648) compiled and printed by the Department of Survey, covering basically the major islands, have been produced and are updated to 1960. It is expected that in the very near future recompilation and revision will be carried out in Fiji, so as to improve map accuracy.

THEMATIC MAPS

There are several thematic maps that have been published by the Department of Lands and Survey and the following are examples:

Electorate map, defining the various ward boundaries;

Census population distribution map;

Street maps of various towns and cities;

200-mile-zone limit map (foreign affairs);

Various information maps for development plan;

Maps for Fiji Road Transport Report;

Maps for feasibility study—Hydroelectric Scheme, Nadrau;

Aeronautical maps for Fiji Airways.

CADASTRAL MAPS

The whole of the group is covered by 1:12,672 (16 chains) series in what is termed Native Land Commission sheets, and based on the same data we have standard sheets showing various holdings. Because of the scale factor, the built-up urban and rural areas were remapped at scales 1:1,584 and 1:6,336, but based on the existing grid pattern, i.e., Cassini projection system.

The Native Land Commission sheets show all the native-owned land.

MAP REPRODUCTION

All our maps are at present printed overseas. However the following appliances are available for various methods of reproduction:

Dyeline copier—720 S.D. Harper and Tunstall;

A.B. Dick printer;

Barcro projection camera;

Contact printer—Dainippon screen vacuum printer;

Microfilm reader/printer (18 x 24) Gaf;

Grants projector—mechanical method for enlarging and reducing.

AERIAL TRIANGULATION

This is being carried out on an A10 plotter which is attached to an EK8 readout system. The machine coordinates are typed on an electronic typewriter connected to an EK8. We are using polynomial adjustment programme (sheets) on an ICL 2904 computer—48K (48,000 words).

METRICATION

Over the past two years proposals have been submitted regarding a Fiji map series of standard scales and contour intervals based on international sheet sizes, with a sheet numbering system and a special transverse mercator grid, but to date no scheme has been adopted.

The maps produced by the Air Survey Section have been in draft form, either in pencil or, more recently, in inked tracings. Because of lack of modern cartographic equipment these maps could not be produced in colour. We have qualified personnel available and our department is seriously thinking of setting up a cartographic section in the near future.

STAFF TRAINING

Two surveyors have completed photogrammetry courses in the Netherlands in the period under review.

One officer completed a technician course in photogrammetry in the Netherlands.

One officer attended and completed a course in cartography in the United Kingdom.

Two officers have just returned from the Netherlands (ITC) after completing a course in cartography.

One officer completed training on geoceiver surveys in Australia.

The photogrammetric equipment currently available is listed below.

PHOTOGRAMMETRIC EQUIPMENT AVAILABLE

Type of equipment	*Number of units*
Wild RC 8 camera	
6" focal length	1
Precision stereoplotters	
Wild A 10	1
Thompson Watts	2
Topographic stereoplotters	
Kern PG2	2
Zeiss stereotope	1
Enlarger	
De Vere 108AF	1
Recording device	
EK8 electronic recorder	1
Contact printers	
Morse contact printer M-21	1
Zeiss KG30	1
Aerial film titling	
Machine type 682 GE	1
Ilfospeed dryer	1

PROJECTS COMPLETED UNDER AID SCHEMES

Under a New Zealand scheme, the whole of Vitilevu, Vanua Levu and six other small islands were photographed at a scale of 1:20,000 for the 1978 agricultural census. One officer from Fiji received navigational training with the New Zealand Aerial Mapping Limited crew who were involved in this work. This whole project was completed in a few months in 1978.

In 1977 the Japanese Government and the Japan International Co-operation Agency carried out a survey —the Analytical Survey of Coconut Forest in the Island of Taveuni, Fiji. As a result of the survey the Japanese team was able to provide 1:10,000 maps of Taveuni Island and presented a report together with aerial triangulation results of the island. The area covered under this mapping totals 10,000 ha consisting of 12 sheets at 1:10,000 with contour interval of 10m.

In 1977, under Australian aid, 22 agricultural areas were photographed from 18,000 feet in colour and from 8,500 feet in black and white for orthophoto mapping in 1978. The orthophoto covers 168,000 ha at a scale of 1:5,000 with contour intervals of 2m up to 20m and 10m up to 100m. This mapping is being extensively used by the Ministry of Agriculture for designing their drainage and irrigation schemes.

Assistance was given by the Australian Army Survey Corps which has completed Doppler observations on 17 stations in the Fiji group of islands. This work was done in conjunction with the establishment of control points for fixing baselines for a 200-mile exclusive economic zone of Fiji.

As an aid in mapping, the Australian Government purchased an A10 precision plotter for our use. This instrument, which was installed in September 1979, is being used for aerial triangulation and large-scale mapping. Our EK8 readout system is connected to the A10, while the EK8 is connected to an electric typewriter.

Under Australian aid, the survey of the ex-CSR land is being carried out. So far, 15,352 ha have been surveyed. About 4,000 ha remain to be surveyed. It is hoped that this will be completed in early 1982.

COUNTRY REPORT*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

En République fédérale d'Allemagne, les services spécialisés des Länder et divers autres organes de l'administration centrale fédérale sont responsables de l'exécution des levés et de l'établissement des cartes à titre officiel. Ils ont créé un Arbeitsgemeinschaft (Comité de travail) chargé de coordonner leurs activités, leurs méthodes et leur production. Des groupes de travail du Comité sont chargés de la recherche-développement dans leurs disciplines respectives comme le font les offices de protection, d'amélioration, de mise en valeur et de remembrement des terres des Länder et leurs comités de travail.

Ces organismes centraux officiels et leurs bureaux locaux sont chargés de l'exécution des levés sur toute l'étendue du territoire national, ainsi que de la réalisation des cartes de caractère officiel et des plans cadastraux. Ils bénéficient, pour ce faire, du concours d'experts-géomètres, qui sont indépendants mais doivent néanmoins se conformer aux lois et règlements applicables. Les services officiels réalisent également toutes sortes de levés d'étude.

La recherche scientifique dans le domaine de la cartographie en général incombe en premier lieu à la Deutsche Geodätische Kommission (Commission géodésique de la République fédérale d'Allemagne), qui a pour mission de lancer et de financer des projets de recherche, d'appliquer en République fédérale d'Allemagne les recommandations de l'Association internationale de géodésie et d'apporter la contribution de ce pays aux projets internationaux. Pour s'acquitter de cette mission, la Commission utilise les services du Deutsche Geodätische Forschungsinstitut (Institut de recherches géodésiques).

La recherche et la formation technique sont aussi l'apanage des universités techniques et des écoles professionnelles, qui dispensent également une formation supérieure en assortissant l'activité professionnelle de colloques scientifiques, de cycles de conférences sur des sujets d'actualité et de stages d'initiation. Ces réunions sont souvent organisées en commun avec des associations scientifiques et techniques qui souhaitent perfectionner ainsi les connaissances techniques de leurs membres.

RESPONSIBILITIES FOR SURVEYING AND MAPPING

In the Federal Republic of Germany, the survey administrations of the federal *Länder* and several central federal institutions are responsible for official surveying and mapping. They established an *Arbeitsgemeinschaft (AdV)* (Working Committee) in order to co-ordinate their tasks, methods and results. Working groups of the AdV carry on research and development in their respective fields of work as do the offices of preservation, improvement, reclamation and consolidation of land of the federal *Länder* and their working committees.

These central public authorities and their local offices carry out national surveying, official cartography, and property cadastre. They are supported by chartered surveyors (registered land surveyors), working on a freelance basis, who nevertheless follow the relevant laws and decrees. They also execute all kinds of engineering surveying.

Scientific research in all fields of cartography is primarily the task of the Deutsche Geodätische Kommission (DGK) (German Geodetic Commission). This task comprises: initiating and supporting research projects, carrying out in Germany the recommendations of the International Association for Geodesy (IAG), and supplying the German contribution to international projects. In order to accomplish these tasks, the DGK uses the Deutsches Geodätisches Forschungsinstitut (DGFI) (German Geodetic Research Institute).

Research and technical training is also carried out at technical universities and professional schools, which also carry on the advanced training for professional work in the form of scientific colloquiums, lectures on current subjects, and contact study courses. Such meetings are frequently held with scientific-technical associations, with the aim of advancing the technical training of their members.

PRACTICAL WORK

Work on national surveying primarily consists of updating the networks of horizontal and vertical control survey stations using modern survey methods and evaluation by electronic computers. For the network of horizontal control survey stations, an evaluation is made involving 354 stations (of which 277 were astronomically determined), 2,760 directions (observed in 804 sets), and 901 triangle sides (with 14,053 single distances). The adjustment (1,518 unknowns) will be completed in 1980. For the network of vertical control survey stations, updating is planned for the period 1980-1985. In addition, the conventional measurements for the densification of the national networks are continuously performed. For all projects, the automatic data flow is planned from the field survey up to the data file for the control survey stations.

*The original text of this paper, prepared by the Institut für Angewandte Geodäsie, appeared as document E/CONF.77/L.72.

The German primary gravity network will be densified up to 1 station per 4 km^2. Topographic national surveying by aerial photogrammetry and—as necessary—tacheometric procedures is reflected on the topographic maps 1:5,000 (in the south of the Federal Republic of Germany, partly 1:2,500). However, only parts of this map series are complete. Owing to the large scale and representation of planimetry and heights according to scale, this map series will best be suited as the basis for various mapping operations.

Until this map series is completed, the topographic map 1:25,000 will be used to show topographic changes and thus constitute the basis for the preparation and revision of the derived scales; this map series is complete and available.

The official map series, in addition to the basic map 1:5,000, published by the survey offices of the *Länder*, are as follows:

The Topographic Map 1: 25,000 (2,095 sheets)

The Topographic Map 1: 50,000 (560 sheets)

The Topographic Map 1:100,000 (151 sheets)

(of which, at present, 84 sheets are available in final edition and 64 in provisional edition).

Each year the following are newly prepared: about 15 sheets 1:25,000; about 5 sheets 1:100,000.

Each year the following are updated: about 270 sheets 1:25,000; about 100 sheets 1:50,000; about 17 sheets 1:100,000.

By order of the federal administration and the survey offices of the *Länder*, the Institut für Angewandte Geodäsie (IfAG) (Institute for Applied Geodesy) publishes:

The Topographic General Map 1:200,000 (44 sheets)

The General Map 1:500,000 (4 sheets)

The International Map of the World on the Millionth Scale (2 sheets)

Maps for air traffic control and military purposes.

From these map series, special maps (combined sheets, maps of towns with environment, district maps etc.) are prepared and thematic maps of different kinds are derived, according to demand.

Private cartographic publishing houses also issue a large number of special maps, atlases and globes of all kinds.

For the automation of the property cadastre, the survey administration decided upon a nominal concept for the tax roll and the property map. Since 1977, they have been carrying out automation of the property map—financed by the Federal Ministry for Research and Technology—aiming at storing the property boundaries and all important planimetric information of the parcels digitally in EDP systems instead of graphically. Data files will be established for planimetry, co-ordinates and measuring elements. For future work, it is planned to store these data files together with the pertinent tax-roll data (descriptions of the parcels) and those of the property register (legal conditions of the parcels). The work has been started and advanced to various extents in the individual federal *Länder*.

In the Federal Republic of Germany, land consolidation is used to promote agricultural and forest production, and general land development. By distributing scattered land property, constructing roads and ditches, breaking up locations and other measures, production is rationalized and the agrarian structure improved. The federal and *Länder* administrations responsible for these measures established a working committee whose task is to deal with general and specific problems, in particular:

(*a*) To elaborate basic material for the promotion of land development and village renewal;

(*b*) To advance technical procedures and indicate guidelines for the performance of the different measures.

SCIENTIFIC RESEARCH

In the past few years, the following research subjects have been dealt with as matters of priority:

In geodesy, the use of earth satellites for geodetic purposes was made central to the work. The *Sonderforschungsbereich* (Department of Special Research) at the Technical University of Munich co-ordinates the work. The University's satellite observation station Wettzell, in the Bavarian forest, uses the most modern equipment:

Nd-YAG laser of the third laser generation equipped for automatic tracking and for day and night use, with a range of 20,000 km, sufficient for all existing and planned satellites but to be extended for distance measurements to the moon

Doppler measuring system CMA-722B for the satellites of NNSS

Doppler measuring system CMA-725 for GEOS satellites

2 ballistic cameras

1 C-band radar system

Automatic weather stations.

Thus, the station serves the large international research projects and observation programmes, as for example, the EDOC-II programme, with 37 stations in western and southern Europe, for the determination of transformation parameters for the ED 77 and for the improvement of the RETrig; and the DÖDÖC, with 21 stations in the Federal Republic of Germany and Austria for the determination of geocentric co-ordinates and transformation parameters.

Other research concerned the use of altimetric data for the determination of the geoid in ocean areas.

Another Department of Special Research, at the University of Hanover, deals with surveying and remote-sensing procedures for the shoreline and the offshore area. One of its projects covers the exact determination of position by satellite measurement as well as scanning of the sea bottom. For this project, the members of the department co-operate with the federal and *Länder* scientific institutions that use surveying and remote sensing in their work.

The European longitudinal network was checked and stabilized by astronomic-geodetic observation performed in central and western Europe.

The readjustment of the European Triangulation of Primary Order (RETrig) resulted in the scientifically calculated determination of the ellipsoidal (two-dimensional) co-ordinates of the stations in a uniform network. This set of co-ordinates was designated European Datum 1977 (ED 77), replacing the ED 50 used previously.

After the introduction by the IAG of the International Gravity Standardization Net 1971 (IGSN 71) as global gravity reference system, it became necessary for the Federal Republic of Germany to renew its previous primary gravity network (with different gravity level and gravity scale). For the new German primary gravity network, 21 stations were selected, each comprising one centre and three excentres. Eleven of these stations are combined with the IGSN 71 in order to determine the level and the scale of the network. This network has been laid down to the most modern standards, and should remain in position for some time to come.

In photogrammetry, the availability of space image and new image-processing and evaluation procedures has led to new research work.

The acquisition of semantic information from aerial and satellite images has resulted in a greater understanding of the reflective characteristics of topographic features which is extremely valuable for discerning features automatically, particularly by remote sensing.

Geoscientific interdisciplinary experiments undertaken partly in connection with the Spacelab programme, shed light on the acquisition of information for map revision, environmental control and many other disciplines by means of multispectral records.

New instrumental orthophoto techniques and use of the image correlator were the subjects of studies which revealed the possibilities, and limits, of using problematic image material.

Research on digital terrain and height models is of special interest for future use in cartography. Programmes have been drawn up and tested for the computational preparation and transmission of the processed photogrammetric values of the measurements to a data base.

Photogrammetric research is done in part in international co-operation, particularly within the scope of the European Organization for Experimental Photogrammetric Research (OEEPE).

The most important development in cartography was the introduction of computer-assisted procedures in various mapping processes.

Research on this subject is done at various university institutes and by public authorities. Special mention must be made of the instrumental systems made available to interested scientists in the Institut für Angewandte Geodäsie (IfAG) in Frankfurt a.M. They comprise:

(*a*) Interactive digitizing system Aristogrid CD 400 with processor, digitizer, Tektronics storage tube, threshold (speech input) and peripheral for the capture, processing and storage of cartographic data;

(*b*) Interactive system Coragraph DC3 with processor, digitizer, Tektronics storage tube, high-precision drawing machine and peripheral with lineprinter for the capture, processing, storage, retrieval and transmission of cartographic data;

(*c*) Concord Control Rasterscanner for studies on cartographic data in grid format.

A further extension is planned.

As the result of detailed studies on the organization of cartographic data files, six different digital data bases with regional, national and international content are currently being used and updated. Access and selection for various users' needs are continuously being improved.

The problems of graphic data capture by scanning have been solved in principle; the instrumental implementation of the procedure has now reached a promising stage. It has also been possible to reduce to a minimum the data for representation of the point sets of scanned objects.

For transformation of geographical co-ordinates from data bases into plane rectangular co-ordinates, programmes have been developed which permit automatic representation on the drawing table of any section of the earth's surface in a number of different projections.

Graphical data output utilizes EDP-assisted placement of map lettering, which allows the data to be moved on the screen and digitizer to the desired position and then exposes them on a photo typesetting instrument.

Programmes have been developed to use EDP for the preparation of gazetteers of geographical names.

FURTHER ACTIVITIES

Scientific-technical associations are making valuable contributions to the development of surveying the Federal Republic of Germany. This is in addition to the work being carried out by scientific research institutions and public administrations. Their aim is to promote their respective disciplines and maintain international co-operation. This purpose is achieved by:

(*a*) Publication of technical journals;

(*b*) Organization of annual congresses, each on a particular subject with a view to amalgamating study, practice and application;

(*c*) Technical events (courses, symposia);

(*d*) Exchange of information and experience among working groups engaged in independent investigations;

(*e*) Co-operation with corresponding commissions of foreign and international associations.

Universities, professional schools, and associations frequently hold courses for advanced training on specific current matters. During the period under discussion the following events were held with considerable success both at home and abroad:

(*a*) A course on high-precision engineering surveying at Bonn;

(*b*) A symposium on land information system, at Darmstadt;

(*c*) A symposium on deformation measurements by geodetic means, at Bonn;

(*d*) The biannual "Photogrammetric week", at Stuttgart;

(*e*) The (cartographic) Arbeitskurse Niederdollendorf (Niederdollendorf work courses), at Karlsruhe.

The Federal Republic of Germany carries out intensive advanced training of foreign specialists and high-level executives, in particular those from developing countries. Individual advanced training is always available at most scientific institutions and from public authorities. Courses covering a longer period have been

held several times for a larger number of participants with remarkable success. Among these were the courses in cartography held in previous years in the Institute für Angewandte Geodäsie and the Interregional Workshop on Cadastral Surveying, Mapping and Land Information, given by the federal Government in co-operation with the United Nations at Hanover in November/December 1978.

Detailed information on development and progress made in German surveying and mapping may be found in a number of publications issued regularly by scientific organizations, public authorities and associations.

CARTOGRAPHIC ACTIVITIES IN INDONESIA 1976-1979*

Paper presented by Indonesia

RÉSUMÉ

Dans le rapport sont résumés les travaux cartographiques réalisés en Indonésie de 1976 à 1979.

Les principales fonctions et responsabilités de l'Office national de coordination des activités topographiques et cartographiques (BAKOSURTANAL) sont la réalisation de collections de cartes topographiques nationales de base englobant la topographie des fonds marins; l'établissement du canevas géodésique national; le tracé et le levé des frontières internationales terrestres et maritimes; et la coordination des activités de levés hydrographiques et de cartographie marine. L'Office est également responsable de l'utilisation des techniques de télédétection par satellite et des techniques de détection aérienne multiphases aux fins de l'inventaire et de l'évaluation des ressources naturelles ainsi que pour la réalisation d'atlas nationaux. Au nombre des tâches ci-dessus figure la mise en place d'un système d'information sur les ressources naturelles, dans le cadre duquel un réseau de terminaux installés dans divers services officiels sera relié au système informatique dont le BAKOSURTANAL est maintenant doté.

Le BAKOSURTANAL a également la responsabilité de coordonner les activités relatives aux noms géographiques en constituant un groupe de travail formé de représentants des organismes qui s'occupent de la question des noms géographiques et de la toponymie. Le Centre de topographie et de cartographie des forces armées coordonne les activités du service topographique de l'armée de terre, du service hydro-océanographique de la marine et du service de prise de vues aériennes de l'armée de l'air. Cet organisme, outre sa propre mission, en tant que service cartographique militaire, collabore avec le BAKOSURTANAL à l'exécution de la plupart des projets cartographiques nationaux.

This report summarizes the cartographic activities in Indonesia for the period 1976-1979.

MAPPING ORGANIZATIONS

The main functions and responsibilities of the National Co-ordination Agency for Surveys and Mapping (BAKOSURTANAL) are the production of the national topographic base map series, including the sea-bottom topography, the establishment of national geodetic control, the delineation and survey of the international land as well as seaward boundaries, and the coordination of hydrographic survey and nautical charting. BAKOSURTANAL is also responsible for utilizing satellite remote sensing as well as airborne multistage sensing techniques for natural resource inventory and evaluation and the production of national atlases. Included in the above-mentioned tasks is the establishment of a natural resources information system, in which a network of terminals at selected departmental agencies is going to be linked with the now installed computer system at BAKOSURTANAL.

BAKOSURTANAL'S office and laboratories have moved to a new site in Cibinong, about 46 km from Jakarta. The laboratories accommodate facilities for photogrammetry, cartography, reproduction, colour photo processing, remote sensing, computer system for resources information system, and, later on, the hardware system for computer-assisted cartography as well as a digital image-processing system.

The Armed Forces Surveys and Mapping Centre coordinates the activities of the Army Topographic Service, the Naval Hydro-Oceanographic Service and the Air Force Aerial Photographic Service. This organization, besides having its own mission as a military mapping organization, renders assistance to BAKOSURTANAL in the execution of most of the national mapping projects, particularly in Sumatera, Irian Jaya and the Maluku Archipelago where Australia grants technical assistance for Doppler surveys, aerial photography and aerial triangulation.

The following agencies also involved in cartographic activities may be mentioned: the Directorate General of Agrarian Affairs of the Department of the Interior for cadastral and land use mapping; the Soil Research Institute of the Department of Agriculture for soil surveys and mapping; the Geological Research and Develop-

*The original text of this paper, prepared by Badan Koordinasi, National Co-ordination Agency for Surveys and Mapping, appeared as document E/CONF.72/L.89.

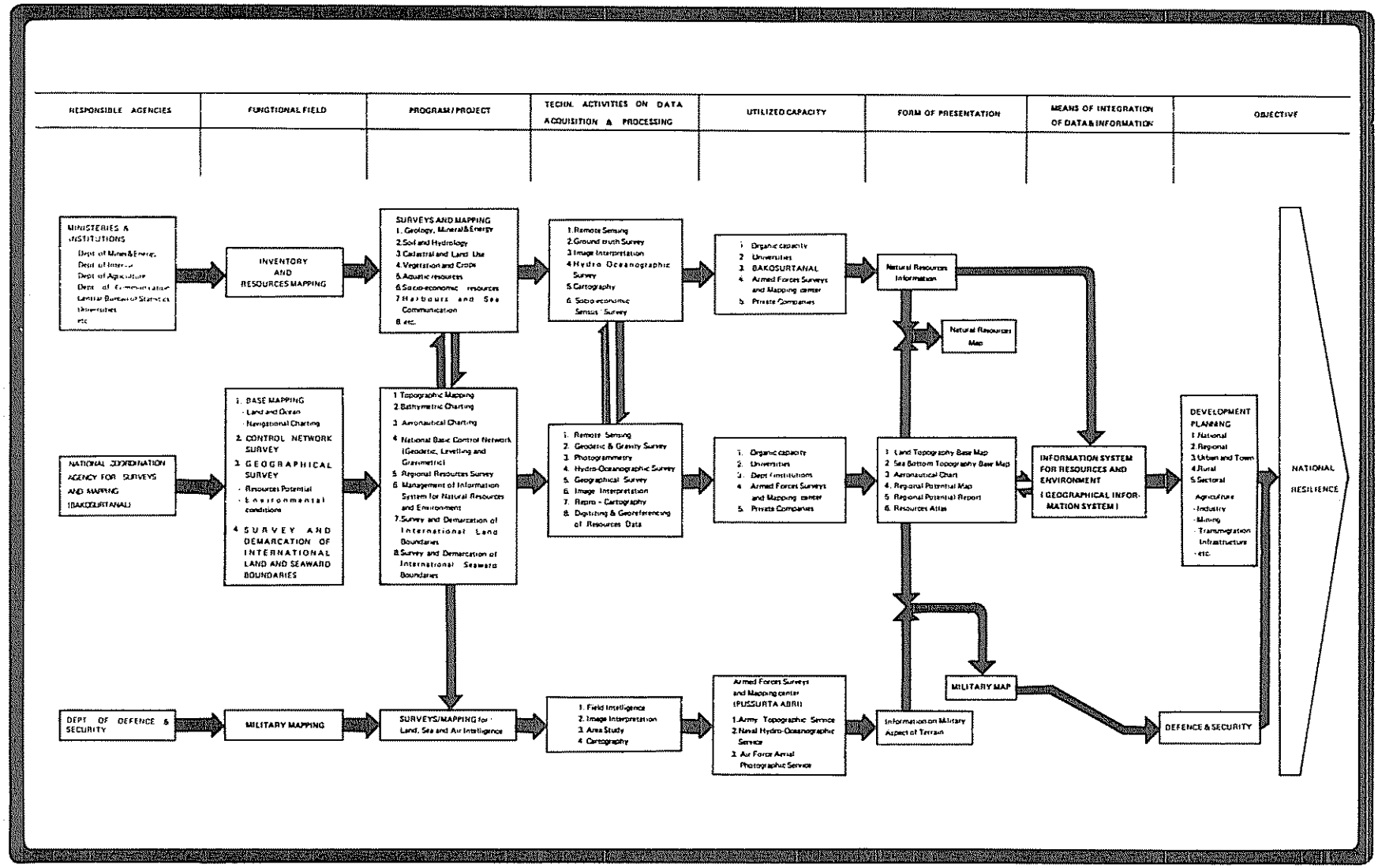

Figure 5. Indonesia: functional relationship between Department/Institutions with regard to surveys/mapping and inventory of natural resources

ment Centre of the Department of Mining and Energy for geological mapping and geophysical surveys; the Department of Public Works for engineering mapping. A Public Works Mapping Centre was established in 1975 at this Department. The establishment of the Jakarta Mapping Centre to deal with urban mapping of the Capital Territory of Jakarta should also be mentioned.

Figure 5 shows the functional relationship between sectoral mapping organizations and BAKOSURTANAL in the framework of co-ordination and integration of activities towards the establishment of a natural resources information system for development planning purposes. The provision of base maps and related information and availability of remote-sensing imageries is the key to successful inventory of natural resources of the country.

It is also the responsibility of BAKOSURTANAL to co-ordinate activities related to geographical names by nominating a working group comprising agencies dealing with the problem of geographical names and toponymy.

Quite a few private companies in the field of surveying and mapping have now organized themselves in the Indonesian Association of Surveying and Mapping Companies, in view of the increasing demand for their services for surveying and mapping for public works, particularly for transmigration projects. A code of ethics and conduct has been prepared by the Association for its members.

GEODETIC ACTIVITIES

Doppler observations and datum definition (figure 7)

One hundred and twenty-seven stations were positioned in Irian Jaya and 78 stations in the northern part of Maluku with Doppler techniques. These stations were observed with single-point positioning mode using precise ephemeris and were carried out in co-operation with Australia.

In Kalimantan and Sulawesi 210 stations were programmed to be observed in 20 months starting July 1979. Up to the date of this report 53 stations had been observed and 83 stations reconnoitred and pillars planted.

These stations were observed in the multistation mode with two Doppler fixed receivers and five roving receivers. The equipment used is the CMA-751 receivers of the Canadian Marconi Company. This undertaking is carried out in the framework of a CIDA Loan Agreement by which only Canadian contractors may comply with the tender. The field operations, however, are carried out jointly with Indonesian Doppler observers. The seven receivers will be turned over to Indonesia at the end of the project.

For the survey and demarcation of the international boundary between Indonesia and Malaysia, 41 stations are to be positioned by Doppler techniques along the 1,200-km border, of which 22 stations were observed in the 1979 survey season. These stations are also observed by multistation mode of operation with Kuching on the Malaysian side and Balikpapan on the Indonesian side as Doppler base stations. The observations and computations are carried out by Indonesia and Malaysia jointly. Here, too, CMA-751-type receivers are deployed. (See also the Indonesia-Malaysia joint progress report below on the survey and demarcation of the international boundary between Indonesia (Kalimantan) and Malaysia (Sabah-Sarawak)). Indonesia has purchased three receivers for this project.

A network of Doppler stations spanning the 3,000-mile long archipelago are to be adjusted simultaneously when they are completed (figure 8). The adjustment will be carried out in combination with terrestrial data and will form the zeroth-order network to tie the now separated geodetic systems into a unified national geodetic system. Some of these stations are now being observed in the ongoing project, of which four Laplace stations were established in the network during the period of this report.

The Indonesian Zeroth Order Network will provide junction stations on a world geodetic system with their variance-covariance values to be used for possible unification of the geodetic system for the South-East Asia and Pacific region.

The connection of individual datums prevailing in the country and the feasibility of readjustment of all geodetic data into a single datum will provide a convenient opportunity to select and define a new datum conforming to some widely accepted international standards. The Indonesian Government adopts the parameters of the Geodetic Reference System 1967 (GRS-67) as that of the Indonesian National Spheroid.

The Indonesian Datum 1974 (ID-74) was defined by adopting the Doppler co-ordinates of the Padang station in West Sumatera as the co-ordinates on the Indonesian National Spheroid with the assumption that both satellite and geodetic datums are tangential at the datum point. Transformation parameters are provided for all Doppler fixes to be transformed into the ID-74, namely:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{\text{ID-74}} = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{\text{NWL-9D}} + \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix}_{\text{at Padang}}$$

where $\Delta X = -2.691$ m, $\Delta Y = +14.757$ m and $\Delta Z = -0.224$ m.

Levelling

In Indonesia there are numerous local level nets, most of them linked to sea level via tide-gauge observations. However, there is no uniformity. Some local systems are related to mean yearly sea level, others to mean high or mean low tides and also relations to the highest high tide or the lowest low tide do occur. Nearly all original tide gauges have disappeared and so have the original readings. As a consequence, the relations between the various local systems are not very accurately known. Even within the local systems the accuracy of the observations varies strongly. Results of the only high-precision levelling, carried out by the Topographic Service in western Java during the years 1925-1930, are still partly available. The other measurements have resulted so far in a number of local systems, badly connected and with insufficient information about the datum on which each separate system has been based.

In order to draw up a well-based proposal for improvement of the present situation, a National Working Group on Geodetic Levelling has been set up to work out specifications and requirements for a homogeneous height system to fulfil the practical as well as the scientific need of such system. Priority is given to the highly

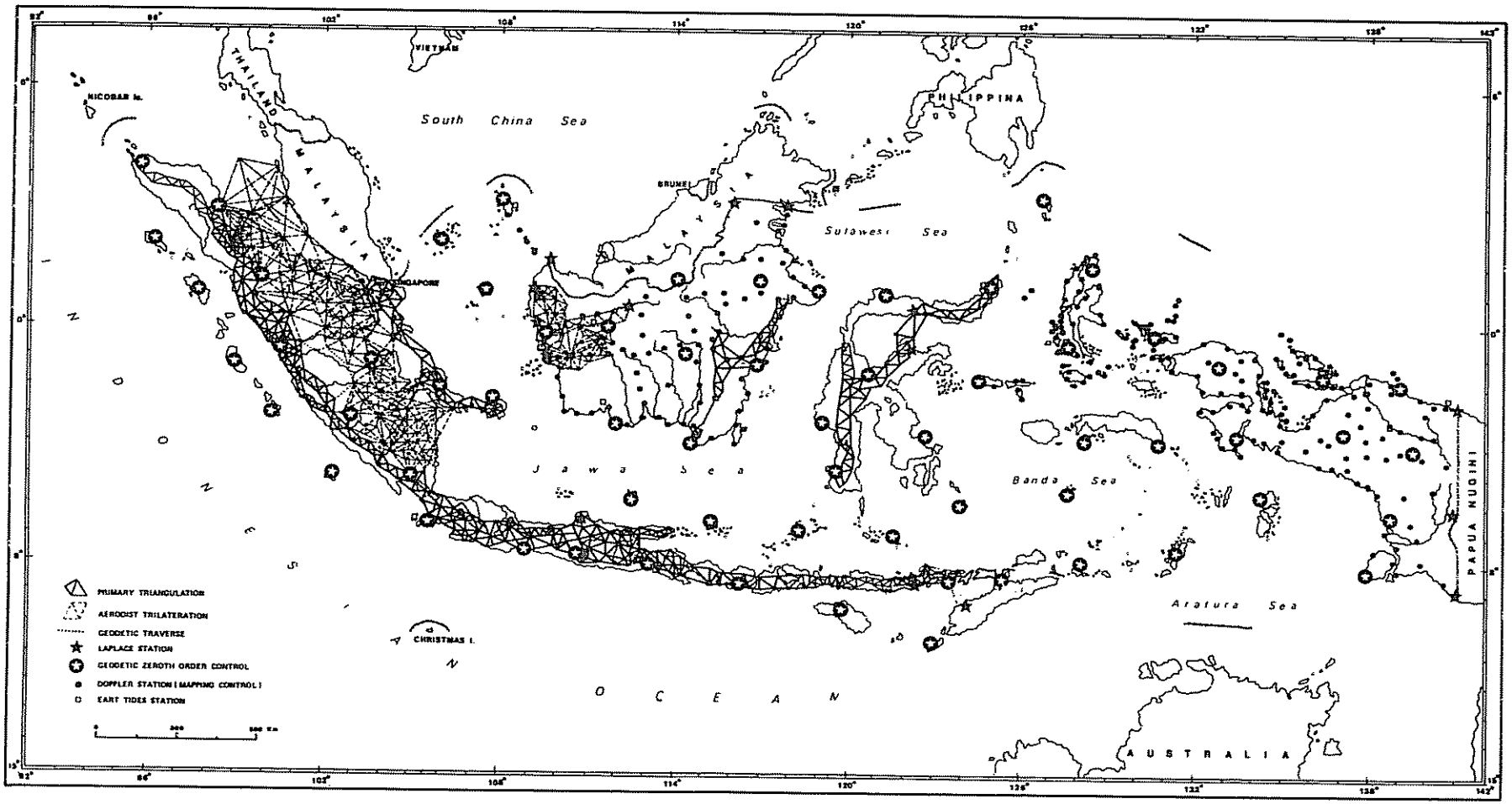

Figure 7. Indonesia: geodetic control surveys as at January 1980

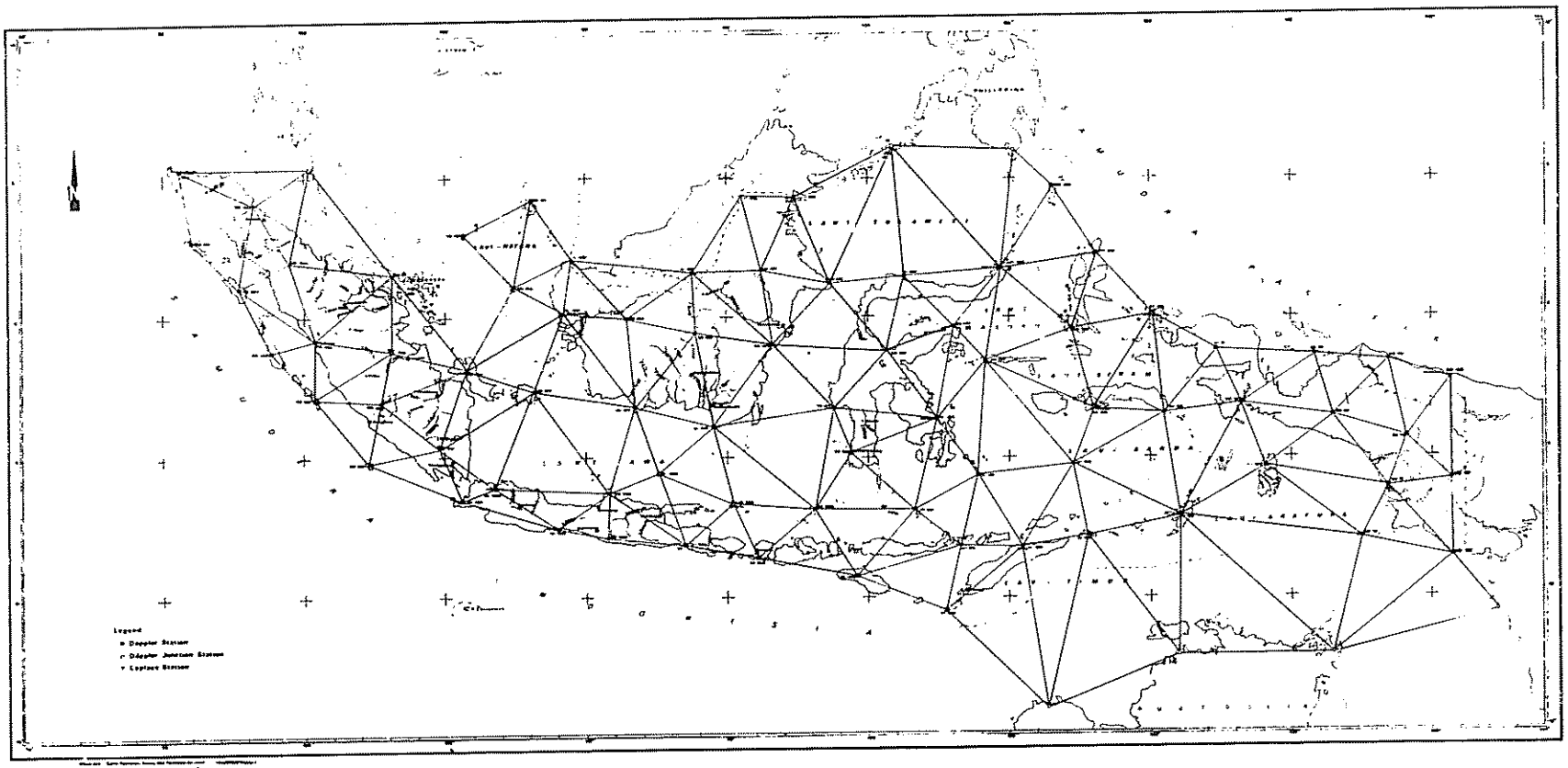

Figure 8. Indonesia: Doppler zeroth-order network as at January 1980

developed Island of Java, where 4,500 km of precise levelling is to be carried out starting in 1980.

Second- and third-order levellings for various engineering projects have been carried out in Sumatera, Kalimantan and Sulawesi by the Department of Public Works. In cases where ordinary levelling is a tedious task in jungle areas, such as for the transmigration projects, barometric heighting is usually carried out for mapping control.

In Irian Jaya, laser airborne altimetry has been used for vertical control for topographic mapping 1:100,000. A similar technique is to be used in Kalimantan and Sulawesi for the 1:50,000-scale mapping.

Laplace observations

Four Laplace stations have been established during the period of this report, two in Kalimantan at the Doppler base stations Pontianak and Balikpapan, and two on the island of Java: at P 126, the time signal station of Jakarta, and the other at Cibinong Doppler base station.

The reobservation of P 126 gives a new value for the meridian of Jakarta with respect to CIO Pole and BIH meridian for timing purposes, which is as follows: latitude, 6°07'40".865 South and longitude, 106°48'27" .6195 East.

Gravity and earth tides observations

The Geological Research and Development Centre has made gravity measurements and is collecting existing gravity data with the purpose of compiling a reliable gravity map of land and offshore areas of Indonesia at 1:2,000,000 scale. Bouguer gravity maps at 1:1,000,000, 1:250,000 and 1:100,000 scales are based on those measurements and data collection is being prepared. A qualitative interpretation of the Java, Madura and Bali Bouguer anomaly map permits the construction of a relevant structural model to the current plate tectonics interpretation of the Indonesian Archipelago.

In Irian Jaya, extensive gravity surveys for geological and geophysical mapping of the island are being undertaken with Australian technical assistance.

During 1976-1980, earth tides observations were made in Bandung, Jayapura, Ujungpandang, Manado and Banjarmasin and the plan is to continue to several stations in Sumatera. This project is part of the Transworld Profile of Earth Tides Stations carried out in co-operation with the International Centre for Earth Tides (ICET).

MAP PRODUCTION

Topographic base maps of 1:50,000 series have been published for the following areas: West Kalimantan, 109 sheets; Sumatera, 231 sheets; South Kalimantan, 34 sheets (see figure 10).

The Sumatera topo sheets will still be produced in the form of line maps, while the rest of the country is planned to be published in the form of orthophoto maps. For this purpose BAKOSURTANAL and the Army Topographic Service have been equipped with Wild OR-1 orthophoto equipment systems. This is with a view to speeding up the production of base maps needed for resource inventory and evaluation.

The total number of sheets covering the entire country at 1:50,000 scale is around 3,198. With the current production at 100 line-map sheets a year (in most cases just 80 sheets a year) one can imagine the pressing problems faced by mapping organizations to cope with the demand for base maps.

Besides the 1:50,000-scale maps, BAKOSURTANAL is also responsible for production of smaller-scale maps and revision of existing ones. To speed up the process and optimize the compilation work, BAKOSURTANAL is in the process of purchasing a computer-assisted cartography hardware system. This system will digitize and store the information while compiling the 1:50,000-scale maps for later compilation of the smaller-scale maps.

For the purpose of familiarization of this new system and introduction into a broader community, a Workshop on Computer-Assisted Cartography is being prepared with the sponsorship of the International Cartography Association (ICA). This Workshop, open to the countries in the South Asia and South-East Asia regions, is to be held in August 1980 at Jakarta.

The schedule for the National Base Mapping Project is shown in figure 6. It will take at least seven to eight years to complete the 1:50,000-scale base mapping, starting from 1980.

AERIAL PHOTOGRAPHY

Up to the date of this report, Sumatera is covered with high-altitude aerial photography at 1:100,000 scale. Small gaps in this photography due to cloud problems are now covered by larger-scale photography and side-looking airborne radar.

In Irian Jaya almost 80 per cent is covered by the same type of aerial photography. The rest will be covered in the 1980 season.

Maluku is 100 per cent covered also by 1:100,000-scale aerial photography (see figure 9).

The rest of the country is envisaged to be flown by dual-camera aerial photography system: Kalimantan and Sulawesi at 1:100,000 scale on panchromatic emulsion and at 1:60,000 scale on false colour infrared. Java and the Nusa Tenggaras will be at 1:50,000 scale on panchromatic emulsion and at 1:30,000 scale on false colour infrared. This undertaking will be carried out under CIDA Loan Agreement, in which Agreement the Government of Indonesia and CIDA have agreed that the aircraft and the cameras purchased under the loan agreement should be turned over to the Government of Indonesia at the end of the project. This brings a change from the original proposal submitted for tender by the awarded Canadian contractor to comply with the new situation and negotiations are in progress to start the photography in the 1981 season.

HYDROGRAPHIC CHARTING

A Memorandum of Understanding between the Government of Indonesia and the Government of the United States of America for co-operation and mutual assistance in joint hydrographic and magnetic survey in selected areas of the Indonesian Archipelago was signed on 28 February 1978.

The first reconnaissance survey operations were carried out for the Strait of Makassar and the Strait of Sunda from 5 July to 17 September 1978, in which 10 radio-positioning stations along the coast of Sulawesi and East Kalimantan were established by Doppler

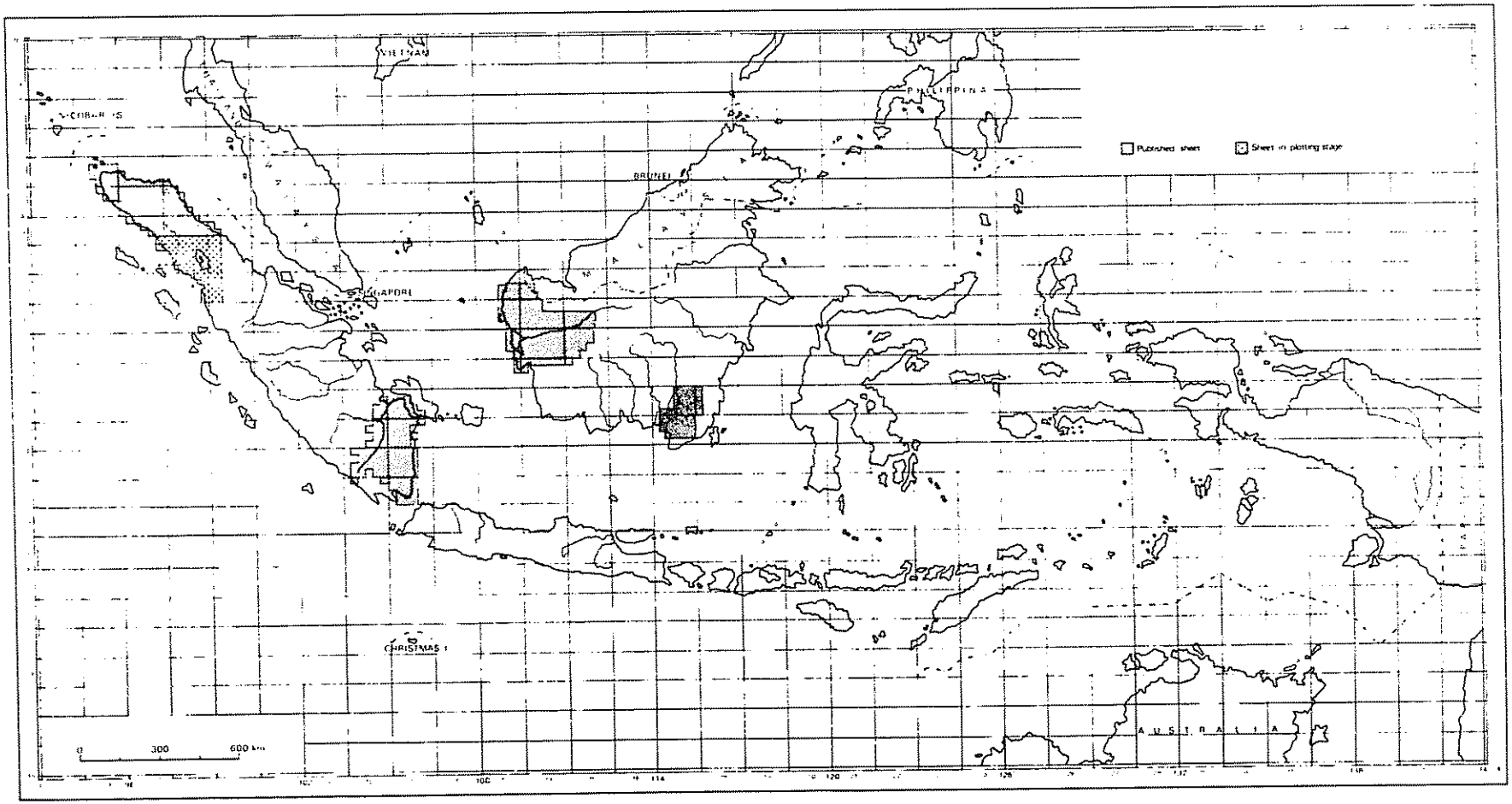

Figure 10. Indonesia: 1:50,000 map series (UTM) as at January 1980

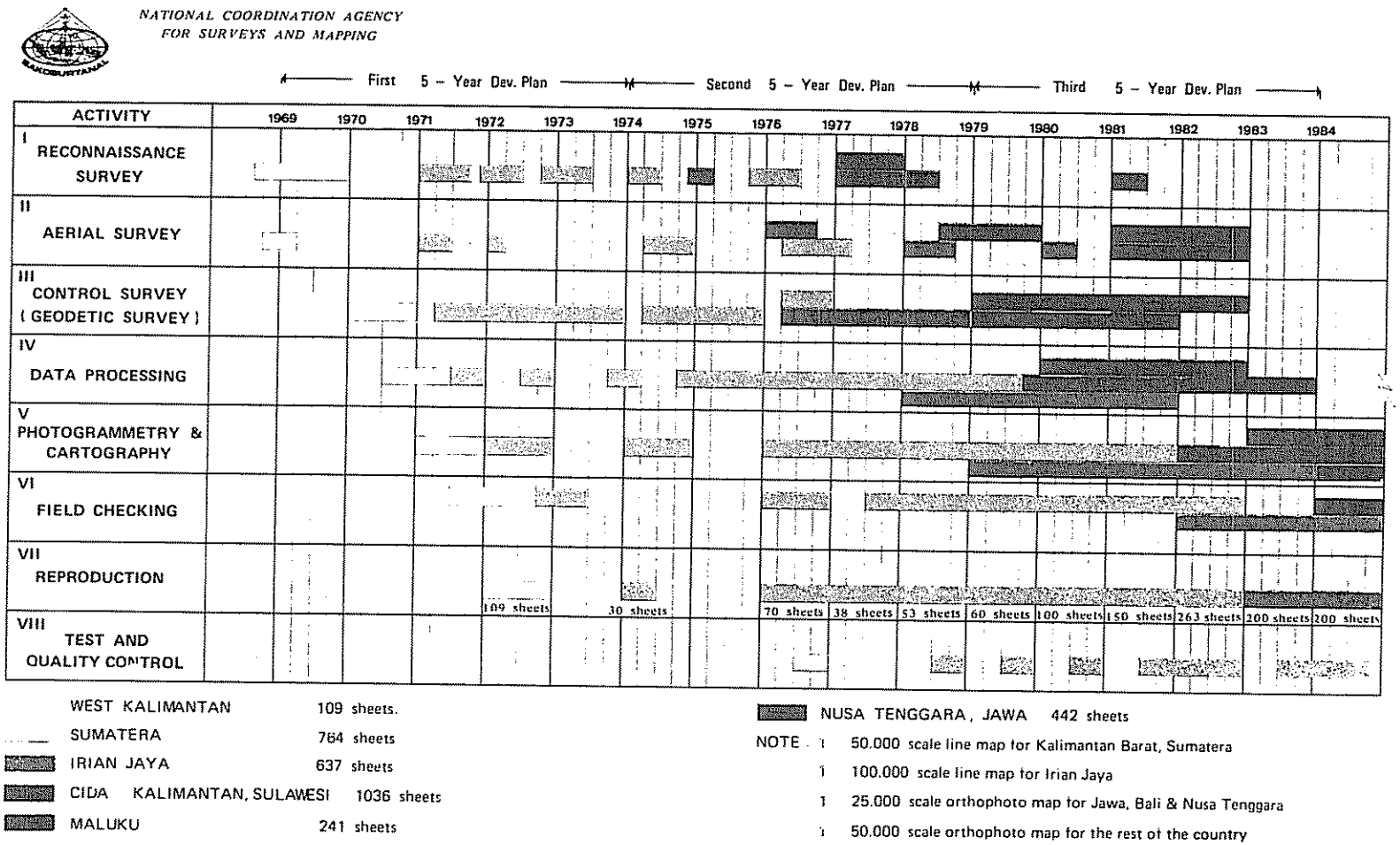

Figure 6. Indonesia: national base mapping project

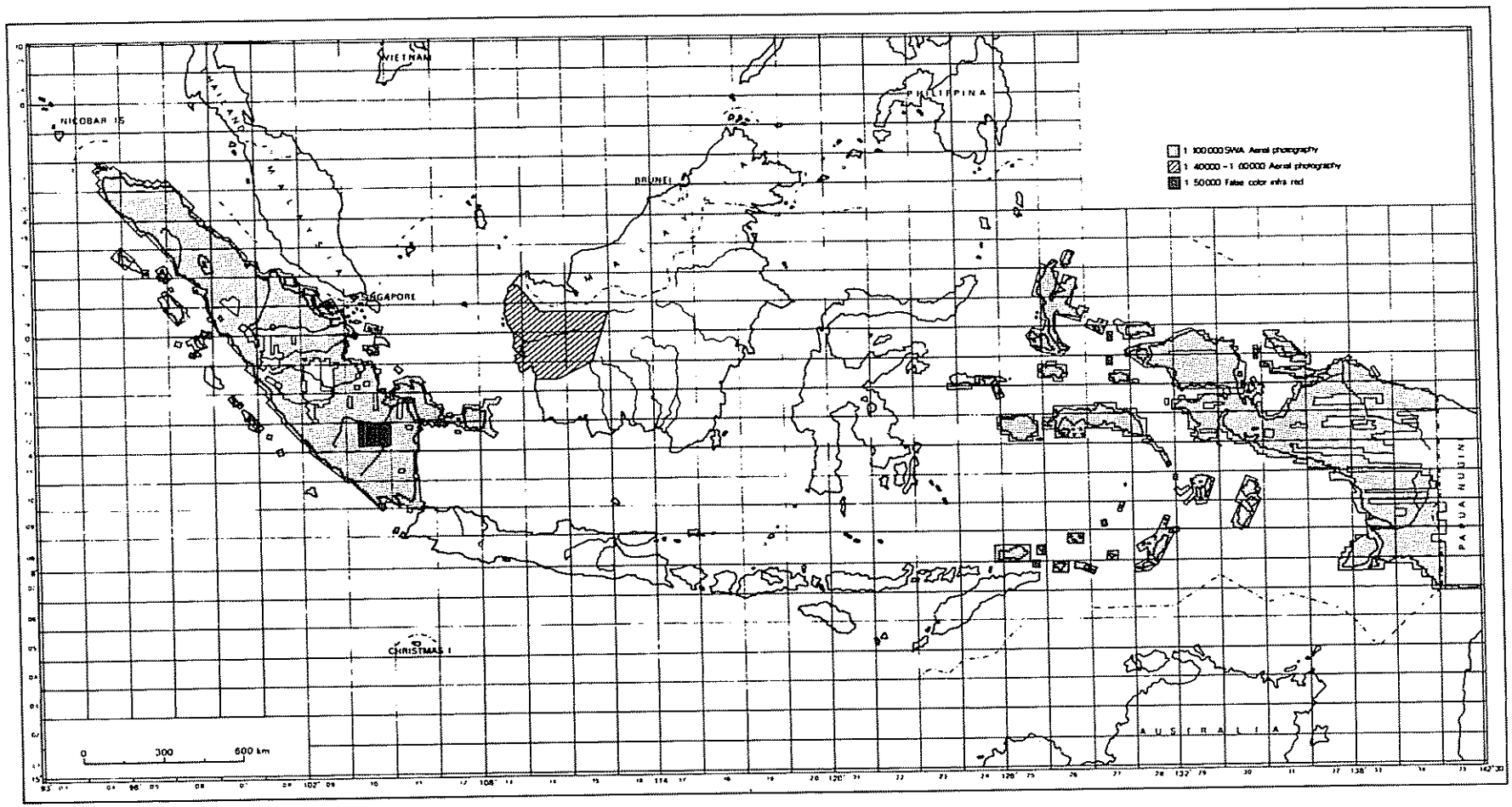

Figure 9. Indonesia: aerial photography as at January 1980

observations with precise ephemeris. The survey was carried out by Indonesian and United States vessels jointly (see the report below on hydro-oceanographic activities in Indonesia, under agenda item 7(*d*). The hydrographic charting programme, as part of the national mapping programme, has been taken up for the first time in the third national five-year development plan; the execution is entrusted to the Armed Forces Surveys and Mapping Centre with its Hydro-Oceanographic Service as existing capabilities to be involved in the national programme.

In the 1979 survey season, the operations were conducted with the main task of covering the earlier-mentioned areas with sounding, tidal observations, current measurements and the taking of sea-bottom samples.

AERONAUTICAL CHARTING

Another Memorandum of Understanding between the Government of Indonesia and the Government of the United States of America for co-operation and mutual assistance in aeronautical charting was signed also on 28 February 1978.

The objective is to assist the Armed Forces Surveys and Mapping Centre in developing a capability to produce and maintain aeronautical charts of Indonesia, from which the US-DMA will provide the necessary technical assistance.

A long-range aeronautical charting programme in this context will cover the following products which are mainly for military purposes:

Joint operation graphic at 1:250,000 scale;

Tactical pilotage chart at 1:50,000 scale.

Aeronautical charting for general use, which will still be co-ordinated by BAKOSURTANAL, comprises the following charts:

Operation navigation chart at 1:1,000,000 scale;

Jet navigation chart at 1:2,000,000 scale.

At present BAKOSURTANAL is preparing photomaps of airfields for compilation of obstruction charts at 1:10,000 scale. Ten photomaps are now in the compilation stage and another 10 are still being photographed.

DATA BASE DEVELOPMENT

SINDESI, an acronym for Sistem Informasi Geodesi (Geodetic Information System) has been designed to accommodate all available geodetic data in the country, to be stored and presented in computer readable form for users.

At present, the horizontal control data base is being developed and all primary and secondary controls of Java have been stored on magnetic tape.

Progress has also been made in the compilation of geodetic control of Sumatera. A working group has been set up to design the data base for vertical control and gravity data.

INDOFOTA System, that is, Sistem Informasi dan Dokumentasi Foto dan Perpetaan (Information and Documentation System for Aerial Photos and Maps), is now in the final stage of development. It is intended to compile all information on existing aerial photos, remote-sensing imageries and published maps in the country in such a system that users may have easy access. A plan is drawn to construct a storage centre in the new compound of BAKOSURTANAL at Cibinong, to store the now scattered aerial films and other imageries in one place. A map depot is also part of the storage centre.

GEOGRAPHICAL NAMES

Activities with regard to geographical names are carried out by a working group set up by BAKOSURTANAL comprising representatives of several departments and universities. A national commission on geographical names (National Geographical Names Authority) is still not realized.

During the period of this report, a *National Gazetteer on Geographical Names* was published in 1978 comprising 9,766 names drawn from the International Map of the World on the Million Scale.

These names are stored on magnetic tape. The next activity will be the development of a data base on geographical names extracted from 1:50,000 base maps.

With regard to regional co-operation in the Asia, South-East Division of the United Nations Group of Experts on Geographical Names, Indonesia contributes the following information: physical marine and submarine features for compilation of a physical map of South-East Asia; geographical names within 30 km along the common boundary between Indonesia and Malaysia for a regional gazetteer. These maps will be printed by the Directorate of National Mapping, Malaysia.

With regard to resolution 15 C of the Eighth United Nations Regional Cartographic Conference for Asia and the Far East at Bangkok about the offer of Indonesia to host a course in toponymy, we must announce with regret that owing to circumstances beyond our control the course must be postponed until 1981 at the earliest.

RESEARCH ACTIVITIES

Several research projects and scientific activities are being conducted in co-operation with universities to support BAKOSURTANAL's operational task in geodesy and mapping. The most important activities are highlighted hereunder:

(*a*) Research in the field of the geoid in Indonesia utilizing a combination of surface gravity data, geopotential coefficient of Goddard Earth Models, and satellite altimetry data. The knowledge of the geoid or its best approximation, together with related accuracy estimates is essential if satellite positioning is to be used to provide tridimensional co-ordinates fully usable for surveying and mapping;

(*b*) A study group was set up to define specifications and requirements as well as the design of a national levelling network of high-order standard of accuracy to provide the country with a homogeneous height system;

(*c*) A Workshop on Oceanic Data Management was held in close co-operation with the National Institute of Oceanology in April 1979. The Workshop concluded that it was timely to establish an information system on oceanic data as part of a national resources information system for which BAKOSURTANAL will co-ordinate the development;

(*d*) A working group is set up to study the integration of large-scale mapping for cadastral and fiscal purposes as well as the integration of this large-scale mapping system with that of the national mapping. The working group consists of scientific staff from the Directorate of

Land Registration (Cadastral Service), IPEDA (the Fiscal Cadastral Service), the Bandung Institute of Technology and BAKOSURTANAL;

(*e*) Co-operation with the Bandung Institute of Technology for assistance in applied research in geodesy and photogrammetry, design and development of mapping systems, and design of equipment systems for photogrammetric and cartographic laboratories;

(*f*) Co-operation with the Gajah Mada University in Yogyakarta for assistance in research in geographic referencing, remote sensing and presentation of resource data;

(*g*) Co-operation with the University of Indonesia in Jakarta for assistance in computer programming, design of resources information system network and its hardware configuration;

(*h*) Co-operation with the Bogor Agriculture Institute (IPB) for assistance in research in remote-sensing applications with respect to the land and vegetative resources; design of models for the inventory and evaluation of land and agriculture resources.

TECHNICAL ASSISTANCE

The manpower development in surveying and mapping is a prerequisite for the successful achievement of the national mapping programme. Besides intake from universities, for which additional training is usually needed prior to involvement in project implementation, the involvement of outside expertise is still required. For this purpose, assistance is acquired from two sources: through engagement of foreign experts, and through co-operation with local universities (see above, Research activities).

Foreign experts have been engaged through bilateral agreements:

(*a*) Since 1969 with Australia, to assist in the planning and management of the joint mapping operations in Sumatera, Irian Jaya and Maluku;

(*b*) Since 1975 with the Netherlands, to assist in the training of technicians in cartography and photogrammetry by setting up a School for Cartographic and Photogrammetric Operators in Bandung, besides fellowships provided by the Netherlands for post-graduate training of Indonesian engineers at ITC;

(*c*) Since 1978 with the United States of America, to assist in hydrographic charting and in the development of aeronautical charting capability.

Through World Bank funding, foreign expertise in the following fields has been acquired since 1976: cartography, photo processing and colour separation (1976-1979); photogrammetry and remote sensing (1977-1978); geography and resource survey (1977-1980); geodetic network adjustment (1979), design of precise levelling network (1980).

Also through World Bank funding, a bilateral arrangement has been made between BAKOSURTANAL and the International Institute for Aerial Survey and Earth Studies (ITC) at Enschede to make experts from the latter available to BAKOSURTANAL either on a short-term visit (three weeks) or short-term assignment (three months). In the field of photogrammetry and aerial triangulation, a resident adviser has been assigned for three years to develop in-house capability in orthophoto mapping production and aerial triangulation processing by PAT-M program. For the latter, an agreement was signed between BAKOSURTANAL and the University of Stuttgart to provide and instal the PAT-M software package in the computer in Jakarta and to train Indonesians in the use of the program, so that large aerial triangulation blocks could be processed in the country.

MANPOWER DEVELOPMENT

The nucleus of BAKOSURTANAL personnel consists of two disciplines, geodesy and geography. In Indonesia there are two universities which offer courses in geodesy and three universities which offer courses in geography. The number of yearly graduates from those universities is limited, whereas the demand from the Government as well as from the private sectors is great. Hence, there is rather strong competition among "consumers" for technically proficient candidates, resulting in still smaller availability of recruitable personnel.

The planned BAKOSURTANAL strength at June 1980 should be 105 and 130 for professionals and technicians, respectively; however, at present, the numbers of professionals and technicians are 68 and 86, respectively, of which 21 personnel work part-time.

A great number of experienced field surveyors are demanded for the extensive large-scale mapping for transmigration projects scattered in the outer islands of Java and for cadastral mapping.

Whereas training and education is a slow process to meet the increased demand of the work force, some breakthrough in technology should be found to meet the requirements of maps and information. The use of satellite imageries and other remote-sensing data is now the solution for selection of potential areas for new settlement and cultivation while orthophotomapping will be introduced for base maps at scale 1:20,000 utilizing control survey by Doppler techniques. Probably inertial surveying also should be studied for use in Indonesia. Short training courses should be organized to comply with the needed manpower in surveying, mapping and resources inventory (see the further report on training and education in surveying and mapping in Indonesia under agenda item 8).

CADASTRAL SURVEYING AND URBAN MAPPING

The Jakarta Mapping Centre is established to deal with urban mapping, including cadastral mapping of the Capital Territory of Jakarta. This Centre is equipped with a photogrammetric laboratory. The number of sheets to cover the Capital Territory at scale 1:5,000 is 115 and at scale 1:1,000, 3,000. The programme is reported to be in progress (see figure 11).

The status of cadastral mapping in Indonesia is reported under agenda item 7(*c*).

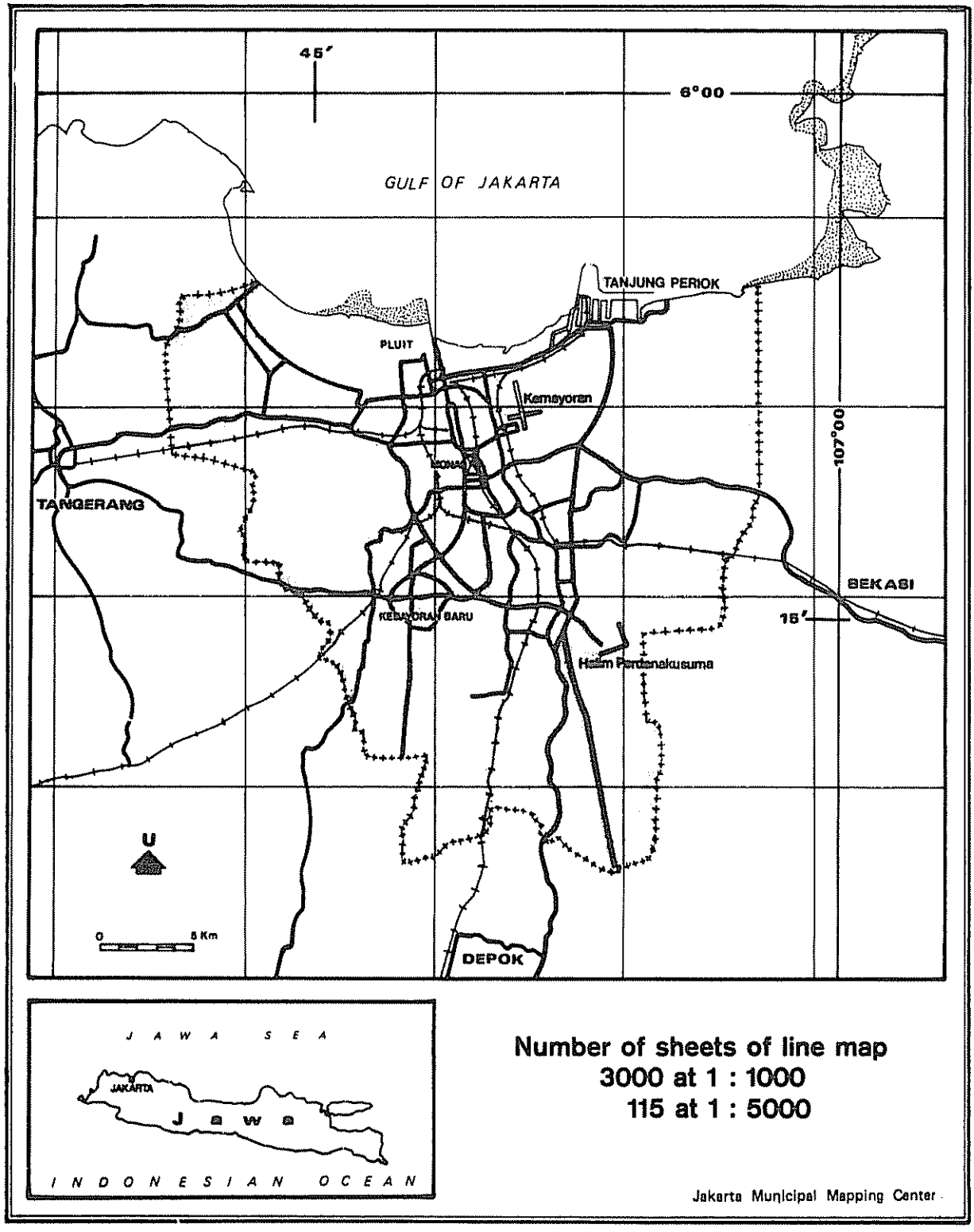

Figure 11. Indonesia: urban mapping of Jakarta Capital Territory

A JOINT REPORT ON THE SURVEY AND DEMARCATION OF THE INTERNATIONAL BOUNDARY BETWEEN INDONESIA (KALIMANTAN) AND MALAYSIA (SABAH-SARAWAK)*

Paper presented by Indonesia and Malaysia

RÉSUMÉ

Le rapport récapitule les progrès enregistrés au cours des cinq dernières années, depuis le commencement des travaux de levés et d'abornement en 1975, et constitue un prolongement du rapport précédent présenté à la huitième Conférence cartographique régionale des Nations Unies pour l'Asie et l'Extrême-Orient, tenue à Bangkok en 1977.

1) *Secteur de Sarawak—Kalimantan Barat*
   a) Abornement: 389,1 km
   b) Nombre de bornes installées:
   Type A: 2; type B: 14; type C: 244; type D: 1294
   c) Station Laplace: 1
2) *Secteur de Sabah—Kalimantan Timur*
   a) Abornement: 333 km
   b) Nombre de bornes installées:
   Type A: 4; type B: 11; type C: 191; type D: 2 148
   c) Stations Laplace: 3

L'Indonésie et la Malaisie ont décidé que, pour les zones non prioritaires, la délimitation de la frontière sera effectuée au moyen des techniques de détermination des positions par méthode Doppler. A cette fin, l'Indonésie a fait l'acquisition de trois récepteurs Doppler et la Malaisie de quatre récepteurs Doppler du type CMA-751, comprenant un système informatique HP 21MX et un sous-ensemble dérouleur de bandes magnétiques.

This report summarizes the progress made in the past five years since the commencement of the survey and demarcation in 1975 and forms a continuation of the previous report presented at the Eighth United Nations Regional Cartographic Conference for Asia and the Far East held at Bangkok in 1977.

(1) *Sarawak—Kalimantan Barat sector*
   (*a*) Demarcation survey: 389.1 km
   (*b*) Number of pillars planted:
   Type A: 2; type B: 14; type C: 244; type D: 1 294
   (*c*) Laplace station: 1
(2) *Sabah—Kalimantan Timur sector*
   (*a*) Demarcation survey: 333 km
   (*b*) Number of pillars planted:
   Type A: 4; type B: 11; type C: 191; type D: 2 148
   (*c*) Laplace stations: 3

DOPPLER STATIONS (SEE FIGURE 12)

Indonesia and Malaysia agreed that for non-priority areas, demarcation of the boundary will be executed by means of Doppler positioning techniques. For this purpose Indonesia purchased three Doppler receivers and Malaysia four Doppler receivers of CMA-751 type, including HP 21MX computer system and magtape subsystem.

The number of stations to be positioned by this technique is 41, about 50 km apart. The observations commenced in August 1979 and, up to the present report, 22 stations have been completed. The rest will be carried out in the 1980 season and are expected to be completed within five months.

The mode of operation is the multistation mode in which two receivers at known stations are observed simultaneously with two or three roving receivers at the new stations.

Since Indonesia and Malaysia have adopted the local East Malaysia Geodetic System, known as Timbalai Datum, with Modified Everest Spheroid reference surface for the co-ordinates of the border markers, the Doppler-based co-ordinates should be transformed to the above-mentioned local datum. For this purpose, three known stations on Timbalai Datum, i.e., Sijingkat (at Kuching), Timbalai Datum Point and Bukit Goram, were observed simultaneously to provide transformation parameters (translation, rotation and scaling) between Timbalai Datum and WGS-72 Datum or NWL-9D Datum, whichever the case may be.

The difficult terrain and dense forest cover are the main hindrances to the survey team movements; hence, winching by helicopter for reconnaissance survey and building of helicopter pads are often necessary.

*The original text of this paper appeared as document E/CONF.72/L.105.

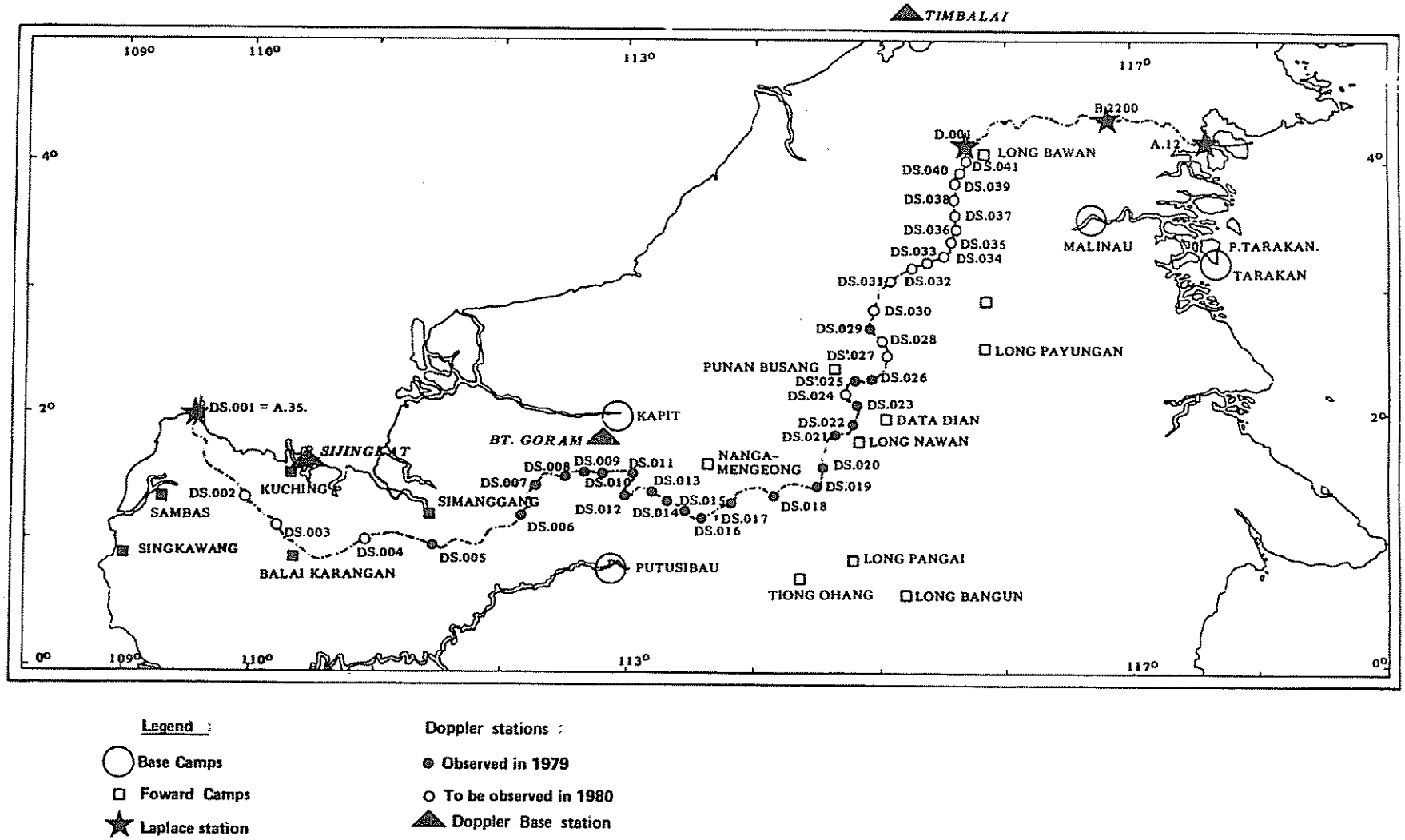

Figure 12. Indonesia: survey and demarcation of the international boundary between Indonesia (Kalimantan) and Malaysia (Sarawak-Sabah)

CARTOGRAPHIC WORK IN JAPAN*

Paper presented by Japan

RÉSUMÉ

La plupart des travaux cartographiques réalisés au Japon sont contrôlés par des organisations gouvernementales et se classent en deux catégories. La première est celle des levés nationaux de base, exécutés par l'Institut cartographique japonais, et la seconde celle des levés publics, réalisés par d'autres organisations gouvernementales ou publiques telles que l'Office de sylviculture, l'Office foncier national, la Societé nationale des chemins de fer japonais, la Société publique des autoroutes et autres organismes publics locaux, etc. Le Service hydrographique de l'Office de sécurité maritime établit diverses sortes de cartes hydrographiques.

Most of the cartographic work done in Japan is controlled by governmental organizations and divided into two categories. The first category is the National Fundamental Survey, executed by the Geographical Survey Institute (GSI), and the second comprises the Public Surveys, which are carried out by other governmental or public organizations such as the Forestry Agency, National Land Agency, Japanese National Railways, Public Highway Co-operation, and other local public bodies etc. Preparation of various kinds of hydrographic charts is executed by the Hydrographic Department, Maritime Safety Agency.

I. National Fundamental Survey

The National Fundamental Survey is being executed under the third 10-year project which started in 1974.

Geodetic works

GSI continues its National Fundamental Survey, which has been in progress for the past century as a basis for mapping and engineering works. The work includes establishing and maintaining triangulation and levelling points throughout Japan. Although these data are still essential for map making, development and conservation of national land, the main purpose of the National Fundamental Survey at the present time is to set up minor points for areas where large-scale mapping or cadastral surveys are planned, and to obtain information on the deformation of the earth's crust by the revision survey. Studies on the crustal deformation are very important in Japan for they are considered to be the most effective means for predicting earthquakes.

Precise geodetic survey

The establishment of first- to third-order triangulation points was started in 1880 and completed in 1916. Since then, revision surveys of the first-order triangulation net have been carried out. The second- and third-order triangulation nets, which have not had systematic revision surveys since their establishment, are no longer functional due to various causes, such as earthquakes, crustal deformation, landslides and artificial causes.

GSI started, in 1974, a Precise Geodetic Network Project in order to switch over from old geodetic data obtained mainly by angular measurement to more accurate new geodetic data, which are obtained by optical ranging instruments.

Work in this project falls into two categories: a revision survey of 6,000 first- and second-order, and 32,700 third-order, triangulation points within 10 years. The data obtained, together with height data from levelling, will serve not only as a framework for mapping and for public works but also as the principal materials for earthquake prediction and research on crustal movement in the Japanese Islands.

Precise traverse survey

In order to establish baselines for satellite geodesy, GSI connected three of the satellite observatories in Japan by precise traverse survey using laser geodimeters from 1968 to 1972. A long arc of approximately 2,000 km was established by this survey along the Pacific coast of Japan. With the precise traverse survey as a contribution to the Geodynamics Project (GDP) which was started in 1972, another long arc along the Japan Sea coast, and six shorter arcs across the Japan Islands, have been established. From 1976 to 1978, the arcs of 1,074 km were measured completing the precise traverse survey plan for the GDP.

The results of these surveys between 1976 and 1978 are shown in table 1.

Table 1. Geodetic work undertaken in 1976-1978

	1976	*1977*	*1978*	*Total*
Revised points by first-order geodetic survey	244	324	440	1 008
Revised points by second-order geodetic survey	187	146	175	508
Precise traverse survey (kilometres)	276	417	381	1 074
Laplace stations	2	4	2	8
Astronomical stations	10	6	10	26
Satellite Doppler positioning:				
Inland	2	3	4	9
Islands	0	1	1	2
Quadrilateral base line measurements	0	1	1	2
Fourth-order stations, including precise geodimeter traverse stations	1 155	1 359	1 478	3 992
Second-order traverse stations	65	52	18	135

Satellite geodesy

As a succeeding work to optical observation of passive geodetic satellites, the Geographical Survey Institute

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started in 1975 to apply the NNSS Doppler observation with JMR receivers in both practical and experimental aspects. In respect of experimental works, five satellite observation stations, Dōdaira, Kanoya, Mizusawa, Shintotsugawa and Tsukuba, are being reoccupied by Doppler receivers, and the results, compared with those of conventional surveys, will provide the necessary data for readjustment of the precise geodetic survey.

For the practical use of the NNSS, the Institute determined, in 1978, positions of two isolated islands, Minamitorishima and Kitaiwojima, in relation to the 1:25,000 topographic map making of the whole, another important project of the Institute.

The Geographical Survey Institute and the Hydrographic Department are now striving for the development of a new geodetic satellite programme, in order to solve several problems which remain in Japan's geodetic work, such as connecting the Japanese Geodetic Network to that of other countries, precise positioning of the islands isolated from the mainland, and so on.

The satellite, named GS-1, and scheduled to be launched in 1983 by the National Space Development Agency of Japan, is a balloon type, 10 metres in diameter and aluminium-coated, to which a large number of laser reflectors are attached, permitting both distance and direction observation by laser ranging instruments and satellite cameras on the ground. An experimental model of the laser ranging instrument was developed and installed at Kanozan Geodetic Observatory in 1976.

Levelling

Most of the first-order levelling routes in Japan are to be repeatedly revised at intervals of about five years. From 1976 to 1978, those in the southern part of the country, including the Kyushu, Shikoku and Chugoku Districts, were revised and the second-order levelling was also carried out in various parts of the country to establish the supplementary network. Table 2 shows the working records of the first- and second-order levelling executed by GSI.

TABLE 2. LEVELLING DURING 1976-1978
(Kilometres)

	1976	*1977*	*1978*	*Total*
Revised first-order levelling . . .	1 554	1 807	2 108	5 469
Established second-order levelling	196	147	30	373

Besides the general revision survey, more frequent revisions are performed in the "specified observation areas" in Japan's earthquake prediction project. The Tokai and the southern part of the Kanto District have been specified as "intensified observation areas" in the project and the repetition of about 600 km of precise levelling has been carried out annually in the peninsulas of Bōsō and Miura and their vicinities.

Ground subsidence in some urban areas has become one of the more serious social problems in Japan, because many large cities have been developed on an alluvium layer along the coast and have suffered damage from ground subsidence. For this investigation, a precise levelling of 12,000 km is carried out every year in those areas by GSI with the co-operation of local governments etc.

Tidal stations are maintained by several governmental organizations. The Coastal Movement Data Centre, which was organized in GSI, collects and publishes records obtained at those stations.

Astronomical survey

From 1976 to 1978, eight Laplace stations were established in the primary geodetic net and the astronomical longitude and latitude of 26 triangulation stations were determined. Up to the present time (1978) 344 triangulation stations have been covered by the astronomical survey and deflections of the vertical of these stations calculated. The observations were made with astrolabes equipped with the electronic transit detecters developed by GSI.

Gravity survey

During the period from 1976 to 1978, the repetitional measurements at three fundamental gravity stations were carried out with GSI pendulum apparatus, and 31 first-order gravity stations were reoccupied with LaCoste and Romberg gravity meters. About 650 second-order gravity stations were occupied along the levelling routes in the Hokkaido District. Gravity measurements at about 950 triangulation stations were carried out to settle at least one station in every 70 km^2, and about two thirds of the whole country was covered.

As part of the Geodynamics Project, about 70 second-order gravity stations were reoccupied in the Nansei, Izu and Ogasawara Archipelagos.

In order to investigate the existence of active faults in the plain area around Tokyo, about 1,300 gravity stations were established in a density of 1 station per 1 km^2.

Precision gravity measurements were conducted in the Tokai District to detect gravity changes related to crustal movement and seismic activity.

Magnetic survey

GSI has been conducting the first- and second-order aeromagnetic surveys. Since 1949, 105 first-order magnetic stations have been established and the repetition surveys have been carried out at appropriate intervals according to the importance of each station. From 1976 to 1978, 119 first-order surveys were carried out.

During the same period, 18 second-order magnetic stations were newly established in the southern islands and south-western archipelago of Japan in connection with the Geodynamic Project, and the measurements of total force were carried out along 56 courses with airborne apparatus in the central and south-western areas of Japan.

Geodesy in hydrographic work

Satellite geodesy

Optical and Doppler observations of artificial earth satellites were conducted on isolated islands in the West Pacific as a programme of GDP which was finished in 1977. The positions of these islands, previously determined astronomically, were connected to Tokyo datum by the observations.

The Hydrographic Department, in co-operation with GSI, manufactured an experimental set of laser ranging systems of the second generation. The set is now under test operation.

Over-seas levelling and observation of vertical deflection

Over-seas levelling is continuing in the Izu islands and Izu peninsula as one of the earthquake prediction programmes. This project was started in 1967 in order to obtain basic data for study on the crustal structure of

that region, which is geologically one of the most active regions.

Observations of vertical deflection are also in continual progress by means of astronomical methods in the Izu islands and in the West Pacific related to the above two projects.

Astronomical observations

Observation data of occultations of stars by the moon are constantly accumulated at the three astronomical observatories of the Hydrographic Department at Shirahama, Simosato and Kurasiki. Results of reductions have been used in the compilation of nautical almanacs. In 1978, observations of grazing occultations were also started in accordance with the requirement for a higher-precision almanac.

Gravity measurements at sea

Gravity measurements at sea have been carried out by the Hydrographic Department for the Basic Map of the Sea in the Continental Shelf series (see sect. V below) and free-air gravity anomaly charts at the scale of 1:200,000 have been produced.

Geomagnetism in hydrographic work

As part of the Geodynamics Project, aeromagnetic surveys were carried out from 1973 to 1977. The results of these surveys, together with those obtained by the surveys carried out for the compilation of the magnetic charts of the adjacent seas of Japan, have been reported in the "Data Report of Hydrographic Observations, Series of Magnetic Survey, No. 3, June 1973" and the "Data Report of Hydrographic Observations, Series of Magnetic Survey, Data Report of Aeromagnetic Survey around Japan by Geodynamics Project, March 1978", MSA, Tokyo, Japan, and the compilation of those magnetic charts for epoch 1975.0 has been carried out.

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. The service on magnetic observation at Simosato Hydrographic Observatory was taken over by the newly established Hatizyō Hydrographic Observatory in March 1978.

Topographic mapping at the 1:25,000 scale

Topographic mapping at the 1:25,000 scale has been carried out since 1964 and the project is nearly completed. The whole area of the country (approximately 370,000 km²), except for several isolated islands, is covered by the new base map of 4,455 sheets.

Revision of these maps is executed at three-, five- or 10-year intervals, according to the amount of change in the map content.

Recompilation of the maps is carried out after three or four revisions. Table 3 shows the amount of the work undertaken over the past three years.

TABLE 3. 1:25,000 TOPOGRAPHIC MAPPING

	1976	1977	1978
New edition	115 sheets	45 sheets	12 sheets
(km²)	(9 786)	(3 716)	(254)
Recompilation	57 sheets	96 sheets	176 sheets
(km²)	(5 065)	(7 958)	(13 287)
Revision	372 sheets	368 sheets	362 sheets
(km²)	(30 879)	(29 647)	(28 042)

National large-scale mapping

The national large-scale mapping project consists of cyclic aerial photographing at three-year intervals for urban areas and five-year intervals for the rest, 1:2,500 and 1:5,000 large-scale mapping and the fourth-order triangulation. The progress of this project is shown in table 4.

TABLE 4. NATIONAL LARGE-SCALE MAPPING
(Square kilometres)

		1976	1977	1978
Photo coverage	1:10,000	1,144	2,255	3,143
	1:20,000	19,824	12,782	4,545
New edition	1:5,000	2,849	3,534	2,396
Revision	1:5,000	588	312	278
New edition	1:2,500	165	240	501
Revision	1:2,500	21	87	296
Photo-map	1:5,000	124	288	132

Aerial colour photography

Aerial colour photography had been carried out from 1974 to 1978. This photography formed the first link in the chain of the National Land Information Service System planned by the National Land Agency.

Photo scales are 1:8,000 for flat terrain and 1:10,000-1:15,000 for hilly and mountainous regions. During the fiscal years 1976/77-1977/78 about 212,608 km² were covered by colour photographs. As a result of the aerial photographing, the whole area of the country was covered by colour photographs.

Compilation and revision of small-scale maps

Topographic maps at the 1:50,000 scale

Topographic maps at the 1:50,000 scale cover the whole country with 1,249 sheets, compiled from 1:25,000 topographic maps. The number of sheets compiled by this method amounted to 1,216 at the end of the 1978 fiscal year.

In addition, there is a regular revision of the 1:50,000 topographic maps and about 100 sheets are revised every year in accordance with revision of the 1:25,000 topographic maps.

Maps at the 1:200,000 scale

The series of 1:200,000 regional maps consists of 129 sheets, and 82 sheets of this series have been recompiled by a revision survey during the period 1976-1978.

District maps at the 1:500,000 scale

The series of 1:500,000 district maps consists of eight sheets; two editions of these maps have been reissued. One edition has layer tints, while the other does not.

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

Maps of Japan at the 1:1,000,000 scale are compiled in accordance with internationally standardized specifications, and cover the whole country with three sheets. These were revised in 1976-1978.

Composite maps

Composite maps which have specially designed neatlines to cover necessary areas in one sheet have been compiled on the 1:50,000 scale, mainly for the purpose of mountain climbing and tourism. Six sheets were compiled during 1976-1978: Aso-Kudzu, Oze, Tateyama, Yari-Hodaka, Kyoto and map of Toyko and vicinity at the 1:100,000 scale.

II. CADASTRAL SURVEYS

The cadastral survey in Japan is carried out by the National Land Agency in conformity with the National Land Survey Law. The main purpose of the law is to clarify the natural characteristics of the country by cadastral surveys, including the establishment of control points for the cadastral surveys, land classification surveys and water resources surveys. Table 5 shows the cadastral work done during 1976-1978. The third 10-year project for execution of the cadastral survey on the basis of the National Land Survey Law will be started in 1979.

TABLE 5. CADASTRAL SURVEY IN JAPAN

	1976	1977	1978	Total carried out
Control point survey (points)	1 052	1 356	1 457	37 217
Cadastral surveys (km²)	3 528	3 534	3 800	60 647

III. PUBLIC SURVEY

The public survey requires a considerable amount of cartographic work and large numbers of maps have been made for public use at the scales of 1:500-1:10,000. These surveys have usually been carried out by private firms in compliance with requests from various public organizations. The number of firms registered by the survey law is shown in table 6.

TABLE 6. NUMBER OF PRIVATE FIRMS

1976	1977	1978
5 719 (65)[a]	6 073 (65)[a]	6 355 (70)[a]

[a]Firms that can perform photogrammetric work.

The quantity of photogrammetric equipment in use in Japan in 1978 is shown in table 7.

TABLE 7. PHOTOGRAMMETRIC EQUIPMENT IN JAPAN, 1978[a]

	1978		
Aircraft for taking aerial photos	G	3	
	P	64	(1)[b]
Cameras	G	14	
	P	76	
First-order instruments	G	8	
	P	35	
Second-order instruments	G	40	
	P	262	
Third-order instruments	G	48	
	P	23	
Comparators	G	1	
	P	41	
Ortho-photo instruments	G	1	
	P	31	
Multiband camera	G	1	
	P	20	
Themal scanner	G	1	
	P	5	
Multispectral scanner	G	1	
	P	3	
Helicopter	G	—	
	P	3	

[a]G indicates government ownership; P indicates ownership by private firms.
[b]Including one jet-engined craft.

Public surveys carried out in the period 1976-1978 are shown in tables 8 and 9.

TABLE 8. AREAS PHOTOGRAPHED IN 1976-1978 FOR PUBLIC SURVEYS
(Square kilometres)

	Photo scale	1976	1977	1978
Forestry survey	1:20,000	41 800	41 800	41 800
Other public surveys	1: 3,000-1: 8,000	7 722	9 187	22 251
	1:10,000-1:12,500	17 115	19 089	14 390
	1:15,000-1:20,000	21 332	33 794	37 133
	1:25,000 and less	5 589	6 123	5 207

TABLE 9. MAPPING AREA OF PUBLIC SURVEYS
(Square kilometres)

	1976	1977	1978
Forestry contour map (1:5,000)	14 730	13 430	13 430
Forestry photo-map (1:5,000)	3 000	3 000	3 000
City planning map	9 580	15 355	8 937
Road planning and improvement map	3 650	1 653	2 512
Railway planning map	1 005	1 299	1 132
River improvement map	1 984	1 167	1 274
Farmland planning map	2 456	1 890	2 228
Sabo planning map	383	346	728
Harbour and seashore planning map	1 105	108	71
Mining and disaster prevention map	1 677	1 086	1 952

IV. THEMATIC MAPS

Land-use maps

In connection with the National Land Information Service, which supplies data needed for national and regional land-use plans under the provisions of the National Land-use Planning Act, the National Land Agency, in co-operation with GSI, commenced production of 1:25,000 scale land-use maps in the fiscal year 1975. The maps will cover the main habitable areas, about one fourth of the whole country (93,800 km²), by 1980. By the end of 1978, about 88,000 km² had been surveyed and more than 700 sheets had been published.

Land classification maps

The National Land Agency established instructions for the land classification survey on the basis of 20 years' experience. The land classification map series consists of three thematic maps: land classification, subsurface geology and soil maps at the 1:50,000 scale with an explanatory text.

In 1970, the National Land Agency started production of a new 1:50,000 scale series as the basic material for each regional project based on the New Comprehensive Development Plan. This new series is a continuation of the earlier series. Two hundred and fifty-two sets of these maps had been compiled by the end of 1978, with the co-operation of the local governments concerned. It is planned to produce 48 further sets in the future.

The National Land Agency is also compiling the 1:200,000 scale land classification map series for each local governmental area. By March 1975, the map series of 46 prefectures had been completed. The entire series should be completed in 1979. This map series consists of the following thematic and overlay maps: geomorphological classification map, subsurface geological map, present land-use map, land-use capability classification map, relief energy, valley density overlay, slope classification overlay, subsurface geological overlay, soil productive capability classification overlay.

Land condition maps

GSI compiles land condition maps to clarify the land condition of main areas for the purpose of preventing natural disasters and for regional land development. The maps show the pattern of landform classification units, ground heights and public facilities.

Sixteen sheets of the 1:25,000 scale land condition maps and three sheets of the 1:10,000 scale land condition maps were compiled during 1976-1978.

Topographical maps and land condition maps of coastal areas

GSI produces topographical maps and land condition maps of coastal areas in order to clarify the land and sea-bottom conditions of coastal areas. Eleven sheets of the topographical maps and the same number of sheets of the land condition maps of the Seto Inland Sea, the west coast of Kyushu etc. were issued in 1976-1978.

Lake charts

Four sheets of the 1:10,000 lake chart series have been compiled for four lakes and one sheet covering a part of Lake Biwa has been revised by GSI during 1976-1978.

Water-use maps

Water-use maps on the 1:50,000 scale have been prepared since 1965 by the National Land Agency, in co-operation with the Institute, for several important river systems in Japan. Twenty-nine sheets were completed for four districts during 1976-1978.

Geological maps

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

The compilation of the series of basic standard geological maps on the 1:50,000 scale has been carried out since 1950 by GSJ, and 30 sheets with explanatory texts have been published during this period. The total area covered by the maps on the scales of 1:50,000, 1:75,000 and 1:100,000 constitutes almost half of the country. The series of geological maps on the scale 1:200,000 are being compiled from the above-mentioned maps and other data and eight sheets including its revision sheets were published during 1976-1978.

In addition to the above basic maps, many types of geological maps have been prepared by GSJ. Maps prepared by GSJ during 1976-1978 are as follows:

(1) Four sheets of hydrogeological maps on the scales of 1:25,000 to 1:50,000;
(2) Seven sheets of marine geological and sedimentological maps, as the marine geological map series, on the 1:200,000 scale;
(3) One sheet of the geological map around Rūkyū Arc on the 1:1,000,000 scale;
(4) One sheet of the geological map of the outer zone of south-west Japan on the 1:1,000,000 scale;
(5) One sheet of the geological map of the Japan and Kuril Trench and surrounding area on the 1:1,000,000 scale;
(6) Two sheets of metallogenic maps of Japan on the 1:2,000,000 scale;
(7) Three sheets of mineral deposits maps of Japan on the 1:2,000,000 scale; and
(8) One sheet of active faults map of Japan on the 1:2,000,000 scale.

Vegetation maps

The Environment Agency researched the distribution of the types of vegetation formation for about one half of the country with the co-operation of local governments in 1978. These results will be completed by printing on the 1:50,000 scale in 1979.

Population maps and population-related maps

The Bureau of Statistics, in the Prime Minister's Office, has prepared various maps of national interest based on statistical data from the national census which is taken every five years.

During the fiscal years 1976-1978, the Bureau of Statistics published many types of population maps based on the 1975 population census results. These are listed below:

(1) Twelve sheets which included the maps of population distribution on the 1:1,000,000 scale series consisting of three sheets;
(2) Eighteen sheets including the maps of ratio of population changes of Japan on the 1:1,500,000 scale series; and
(3) One sheet showing the percentage of workers employed in industries of Japan on the 1:4,500,000 scale.

In addition, on the basis of the 1970 and 1975 population census results, about 250 sheets were produced, using a computer printer, as the regional statistical maps on a grid-square basis with the reports.

Soil maps

Soil maps in Japan are roughly divided into two categories, one for cultivated lands and the other for forest lands. They are prepared by the corresponding organizations in the Ministry of Agriculture and Fisheries.

The 1:50,000 series of soil types and their products for cultivated lands has been prepared by the Agricultural Administration Bureau since 1959 and the entire area of cultivated land, 6,000 km² in all, has already been covered by this series.

The 1:20,000 series of soil types for national forests has been prepared by the Forestry Agency since 1947. The whole area of national forests, corresponding to 75,000 km², was covered by this series by 1978. The agency has also prepared the 1:50,000 series of soil types for private forests in the 10-year project since 1969. About 50 per cent of the private forests, corresponding to 87,000 km² or more, had been covered by this series by 1978.

Traffic volume maps

The new traffic volume map of Japan at the scale of 1:1,200,000 was issued in 1978. It was prepared by the Road Bureau of the Ministry of Construction, in co-operation with GSI, and was based on the General Traffic Volume Survey which is taken every three years. It is to be used as fundamental data for road administration.

V. HYDROGRAPHIC WORK

Hydrographic surveying and charting activities

The numbers of hydrographic surveys carried out between 1976 and 1978 are shown in table 10.

TABLE 10. HYDROGRAPHIC SURVEYS DURING 1976-1978

Type of survey	1976	1977	1978
Harbour survey	4	2	4
Updating survey	190	175	163
Passage survey	0	0	0
Coastal survey	0	0	0
Oceanic survey	1	1	1
Survey for the Basic Map of the Sea:			
1: 200,000	5	0	0
1: 50,000	3	4	7
1: 10,000	2	5	4
Survey of the Earthquake Prediction Programme	1	1	1

The results of the surveys shown in table 10 were used for the production of nautical and other charts, as shown in table 11.

TABLE 11. CHARTING WORK DURING 1976-1978

Type of chart	1976	1977	1978
New charts:			
Nautical charts	35	25	14
Miscellaneous charts	2	5	1
Basic Map of the Sea	40	36	41
Aeronautical charts	0	1	0
New editions:			
Nautical charts	22	56	48
Miscellaneous charts	0	3	2
Basic Map of the Sea	5	0	0
Aeronautical charts	2	1	4
Reprints	0	0	14
TOTAL	106	127	124

Nautical charts

There have been remarkable changes in hydrographic information on ports and harbours in recent years as a result of harbour construction works and dredging operations on shipping routes. Efforts are made to update the charts concerned by issuing new charts and new editions of existing charts as well as by correcting them with correction chartlets promulgated by Notices to Mariners.

With the entry into service of the Kanto Decca system, 15 Decca charts are to be issued to cover the service area, and four of them have already been published.

In accordance with a resolution of the International Hydrographic Organization, international charts in the West Pacific, six in the 1:3,500,000 series and two in the 1:10,000,000 series, are to be published. All of the 1:3,500,000 charts and one of the 1:1,000,000 series have already been published.

Basic Map of the Sea

The Basic Map of the Sea series, which has been produced since 1967, is intended to provide fundamental data for sea-bottom research and ocean development for purposes other than navigation, and is now a principal function of the Hydrographic Department, together with nautical charting. The outline of the Basic Map of the Sea series is shown in table 12.

TABLE 12. BASIC MAP OF THE SEA SERIES

Series	Scale	Coverage	Size	Type
Basic Map of the Sea in Coastal Areas	1:10,000	Coastal areas within 12 miles of the coast	Full	Bathymetric chart Submarine structural chart
Ditto	1:50,000	Ditto	Ditto	Ditto
Basic Map of the Sea in the Continental Shelf	1:200,000	Continental margin	Half	Bathymetric chart Submarine structural chart Total magnetic intensity chart Gravity anomaly chart
Basic Map of the Sea in Ocean Areas[a]	1:500,000	Ocean	Full	

[a]Planned.

Charts issued

The number of charts issued as of March 1979 is shown in table 13.

TABLE 13. NUMBER OF CHARTS ISSUED

Types of chart	Number
Nautical charts:	
General charts	31
Sailing charts	133
General charts of the coast	178
Coast charts	277
Harbour plans	384
TOTAL	1 003
Miscellaneous charts:	
Current charts	11
Current tidal charts	17
Meteorological charts	8
Chart showing positions of set net fisheries	16
Position plotting sheets	32
Pilot charts	12
Others	32
TOTAL	128
Basic Map of the Sea:	
Basic Map of the Sea in the Continental Shelf Areas	213
Basic Map of the Sea in Coastal Areas	124
Others	52
Aeronautical charts	20
GRAND TOTAL	1 540

Oceanography

Oceanographic observations

For the purpose of revealing the status of currents in the adjacent seas of Japan, oceanographic observations were carried out quarterly by the Hydrographic Department in co-operation with the Japan Meteorological Agency, Fisheries Agency and other organizations. In addition, observations of the Kuroshio variations were carried out every month over the Kuroshio region, using aircraft and vessels. The results of these observations are published as "Prompt Report of Oceanographic Conditions" twice a month and disseminated through radio and facsimile broadcasting as well as Notices to Mariners.

Synthetic oceanographic observations for specific regions such as the eastern East China Sea and off the eastern coast of Tohoku District have been carried out by the Hydrographic Department in co-operation with the Japan Meteorological Agency and Fisheries Agency.

Since 1977, the Hydrographic Department has participated in the Kuroshio Exploitation and Utilization Research Project (KER) which is a national co-operative

project sponsored by the Science and Technological Agency.

Continuous tidal observations are carried out at some 100 tidal stations all over the country. The data obtained are being used for tidal predictions, the determination of datum level of charts and the monitoring of crustal movements in the country. In particular, the data obtained from the stations located on the islands in southern Honsyu are also used for the study of the Kuroshio variations.

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

Monitoring of marine pollution

Monitoring of marine pollution by oil, heavy metals, PCB and radioactivity in the seas adjacent to Japan was done by the Hydrographic Department, in co-operation with the other organizations concerned, at 108 stations in 1976, 118 stations in 1977 and 110 stations in 1978, as well as in five areas specially designated as dumping grounds for industrial wastes.

Japanese Oceanographic Data Centre

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

As of 31 March 1979, the Kuroshio Data Centre has received data from 488 cruises and 19,408 stations in countries participating in CSK. Those data and information are processed, and then compiled and published as the "Data Report of CSK", "CSK Newsletter", "CSK Atlas", and "Existing Oceanographic Station Data in the South China Sea", all of which are widely distributed to the organizations participating in CSK, as well as those concerned with oceanography in many countries.

From domestic organizations, such as the Maritime Safety Agency, the Japanese Meteorological Agency, Fisheries Agency, universities etc., oceanographic data are sent to the Japanese Oceanographic Data Centre, where they are processed and preserved in the form of punched cards and magnetic tapes for distribution in compliance with internal and external requests. The data processed up to now are serial station data of about 135,000 stations and current data of about 120,000 stations.

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

In March 1978, a part of these results was published as an atlas entitled "Marine Environmental Atlas, North-western Pacific Ocean II" (monthly) by the Japan Hydrographic Association.

In March 1979, another atlas entitled "Marine Environmental Atlas, Currents—Adjacent Seas of Japan" was published by the same association.

The Japanese Oceanographic Data Centre has been used for work on ROSCOP (Report of Observations/Samples Collected by Oceanographic Programmes) and other similar active programmes, on compilation of the primary information concerning oceanographic observational cruises and their data, such as an international catalogue of ocean data stations and international geological/geophysical cruise inventory etc., within the framework of IOC.

VI. Recent Cartographic Activities

National Atlas of Japan

The compilation of the National Atlas of Japan was completed by GSI in 1976, and the Atlas was published by the Japan Map Centre in early 1977. The standard format of the National Atlas of Japan is as follows:

Size	84.1 cm x 59.4 cm (when open)
Volume	380 pages
Number of colours used	Five to 12
Scale	Thematic maps—1:2,500,000, 1:4,000,000 and 1:8,000,000; Regional maps and city maps—1:1,000,000 and 1:100,000 respectively
Language	The edition for domestic use is in Japanese and the edition for international use is in English
Map projection	Oblique Conformal Secant Conic Projection

The National Atlas of Japan is composed of the following subjects:

(1) General reference (4 pages, 2 themes)
(2) Physical features (68 pages, 36 themes)
(3) National development and conservation (20 pages, 11 themes)
(4) Population (28 pages, 16 themes)
(5) Agriculture, forestry and fisheries (44 pages, 26 themes)
(6) Mining, manufacturing and construction (40 pages, 25 themes)
(7) Transport and communications (40 pages, 21 themes)
(8) Foreign trade and flow of goods (12 pages, 6 themes)
(9) Commerce and banking (16 pages, 11 themes)
(10) Politics and finance (8 pages, 4 themes)
(11) Social conditions (28 pages, 18 themes)
(12) Education, culture and public welfare (32 pages, 31 themes)
(13) Regional maps (13 pages, 8 themes)

Thematic maps are attached with complementary maps, graphs and explanatory notes and with indexes of the place names.

National land information

With a view to establishing a data bank of land information, GSI has been doing research on methods of preparing and storing data, including digital data, on the basis of the national standard grid system, which was laid down for the whole country in 1969; the project to complete the national land information was begun in 1974. Its purpose is to supply basic information on the present state of land of the whole country in the form of digital data which can be processed by computers. Table 14 shows the items of the data and their contents.

Table 14. Digital National Land Information

Item	*Content*	*Data unit*
Local government	Boundary location, Area	City, ward, town, village
Landform	Ground elevation, Relief and Gradient	1/16 km² grid square
	Valley density	4 km² grid square
	Landform	1 km² grid square
Surface geology		Ditto
Soil		Ditto
Levelling data	Bench-mark location (B.L.)	
	Levelling data	
Ground subsidence	Annual subsidence since 1965	
Lake	Location, Area, Elevation, Depth etc.	

TABLE 14 (*continued*)

Item	*Content*	*Data unit*
Mountain	Location, Elevation etc.	
Coastal zone	Shoreline length, Depth etc	
Legally designated zones	City planning areas, National parks etc.	
Land use	15 categories	1 km² grid square
River	River courses, Watershed	
Road, Railroad	Lines location, Road density	
Public facilities	Schools, Hospitals, Public offices etc.	

The source materials of the data are derived from topographic maps, thematic maps such as land-use maps, aerial photographs, observation data such as levelling data, statistical data and various kinds of registers. These data are ready to serve for national and regional land-use planning.

Data for all items except public facilities have been completed.

Geographical names on maps and charts

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

In that time, almost all of the geographical names for the recompiled edition of the 1:500,000 district maps have been unified. Discussions are now under way to determine the unified natural geographical names to represent on various kinds of maps.

A system providing access to national survey information

The national basic survey information which GSI has collected for the past hundred years amounts to about 120,000 control points, 780,000 aerial photo film sheets, 146,000 map sheets and 200,000 national and administrative names. For the purpose of maintaining them effectively and providing them promptly for public use, GSI changed the existing files in book form to a new computerized service system.

VII. OTHER ACTIVITIES

Remote sensing

Research in remote sensing in Japan is conducted by the Science and Technology Agency in the Prime Minister's Office. Several governmental institutes and universities undertake remote-sensing research in many fields. Airborne MSS and multiband photographs are used for interpretation as well as satellite images. The Remote Sensing Technology Centre of Japan was established in 1975 in order to promote investigation into, and research on, remote sensing. In addition to the Earth Observation Centre, the National Space Development Agency of Japan was built in Saitama Prefecture, about 50 km north-west of Tokyo, in October 1978. Its purpose is to contribute to the effective use of natural resources and preservation of the environment. LANDSAT data are received and images are made from those data by image processor. Several private companies are showing a strong interest in remote sensing and in establishing their own systems for processing remote-sensing data.

Overseas technical co-operation

The Japanese Government has been providing education and training for engineers from developing countries since 1954 as part of its overseas technical co-operation under the Colombo Plan. As the governmental organizations concerned with cartographic work, GSI, the Hydrographic Department and GSJ have received engineers from those countries under the sponsorship of the Japan International Co-operation Agency. The subjects taught and total number of engineers trained are shown in table 15.

TABLE 15. TRAINING SUBJECTS AND NUMBER OF TRAINED ENGINEERS

Organization	*Training course*	*Starting date*	*Total students*
GSI	Geodesy Topography Cartography and printing	1963	117
Hydrographic Department	Hydrographic survey Physical oceanographic survey	1971	122
GSJ	Search for coastal mineral resources Development of ground-water resources	1967	259

GSI has also provided technical assistance in surveying and mapping to the developing countries of Asia and elsewhere since 1971, through the Japan International Co-operation Agency. The aspects of this technical co-operation are shown in table 16.

TABLE 16. TECHNICAL CO-OPERATION IN SURVEYING AND MAPPING

Country and area	*Period*	*(km²)*	*Mapping area*	*(Sheets)*
Indonesia (Barito River Basin area)	1971-1976	19 300	1:50,000	34
Unified Republic of Tanzania (Musoma area)	1973-1976	12 700	1:50,000	23
Bolivia (Chapare area)	1973-1977	25 000	1:50,000	44
Kenya (East coast area)	1975-1980	27 000	1:50,000	38
Guinea (Whole country)	1977-1980	240 000	1:50,000 1:50,000 photo-map	16 350
Panama (Caribbean coastal area)	1979-1981	8 000	1:50,000	12
Philippines (Cagayan Valley area)	1979-1982	15 000	1:25,000 1:10,000 ortho-photo	110 19

It is also sending experts in surveying and mapping to developing countries. Long-term experts have been sent to the countries shown in table 17.

TABLE 17. EXPERTS SERVING OVERSEAS

	Field (number of personnel)		*Term*
Indonesia	Photogrammetry	(1)	1978-1980
Saudi Arabia	Geodesy	(1)	1978-1980
	Photogrammetry	(2)	
	Cartography	(1)	
	Photo-processing	(1)	
	Printing	(1)	
Venezuela	Geomorphology	(1)	1978-1980
Liberia	Geodesy	(2)	1978-1980

VIII. EARTHQUAKE PREDICTION

Under the national programme of earthquake prediction, various governmental organizations and universities are carrying out many kinds of observations and surveys, results of which are analysed by each organization or university and then submitted to the Co-ordinating Committee for Earthquake Prediction. As one of the most important methods for earthquake prediction, crustal activities related to precursors of earthquakes have been examined through the repeated surveys of the geodetic networks in Japan by GSI.

In the period 1976-1978, the seismicity and crustal movement of Izu peninsula still remained active and Izu-Oshima-Kinkai Earthquake of M 7.0 occurred in 1978. In the same year, another severe earthquake, Miyagi-ken-Oki Earthquake of M 7.4, occurred.

In 1978, the Large-scale Earthquake Countermeasures Act was enforced in the Tokai and a part of the Kanto area which were designated as an area under intensified measures against earthquake disaster. A programme for telemetry of data by seismometers, strainmeters, tiltmeters, tide-gauges etc. installed in this area is now in progress. Repeated geodetic surveys at short intervals are conducted there by the GSI and the universities.

Besides these, the GSI conducted basic research for studying a method of detecting the active faults under the thick alluvium and classifying their activity by means of geodetic and aerophotographic interpretation techniques in the southern Kanto and Tokai districts in co-operation with the Geological Survey of Japan, National Research Centre for Disaster Prevention and the Kakioka Geomagnetic Observatory.

The Hydrographic Department carried out geological and geophysical surveys around the seas of the Kanto district from 1976 to 1978 in order to reveal active geological structures and past diastrophism in earthquake-prone areas.

In addition to these, the Department continuously carried out geomagnetic observations at Hatizyō Sima, about 300 km south of Tokyo, and Simosato, near the southern extremity of Honsyu Island, in order to detect geomagnetic variations as earthquake precursors.

CARTOGRAPHIC ACTIVITIES IN KUWAIT*

Paper presented by Kuwait

RÉSUMÉ

Le Koweït est situé au nord-est de la péninsule Arabique, en bordure du Golfe. Le pays est actuellement fortement développé et moderne, mais l'expansion des services techniques du Gouvernement n'a commencé qu'après 1950. Le Département cartographique de la municipalité de Koweït est chargé de l'établissement des cartes topographiques et cadastrales. Il comprend quatre sections qui sont responsables, respectivement, des levés sur le terrain, de la photographie, de la cartographie, et des transactions.

RÉSEAU GÉODÉSIQUE

Avant 1950, le territoire du Koweït était couvert par des réseaux fragmentaires de triangulation et de cheminement, principalement par le « Réseau établi sur la base point de contrôle KOC ». En 1951, un « Réseau local » distinct a été établi pour l'établissement des cartes cadastrales de la ville. Par la suite, des cartes couvrant tout le pays ont été établies sur la base du quadrillage UTM. La diversité de ces réseaux de contrôle et le manque de relations entre eux ont entravé la réalisation de progrès planifiés.

PHOTOGRAPHIE ET CARTOGRAPHIE AÉRIENNES

Depuis 1950, des photographies aériennes du Koweït ont été prises à différentes échelles, du 1/2 000 au 1/40 000, afin d'établir des photocartes et des cartes au trait. En particulier, l'ensemble du pays a été couvert par des photocartes à l'échelle du 1/10 000 et des cartes au trait ont été établies uniquement pour la ville à l'échelle du 1/500 et pour les autres zones urbaines à l'échelle du 1/2 000. Ces cartes sont mises à jour tous les cinq ans.

LEVÉ CADASTRAL

Ce levé a été entrepris en 1951. Le territoire de la ville est couvert par des plans cadastraux adéquats à l'échelle du 1/500, et les autres zones urbaines sont couvertes

*The original text of this paper, prepared by the Survey Department, appeared as document E/CONF.72/L.93.

par des plans à l'échelle du 1/1 000 ou 1/2 000. Les zones rurales en développement sont couvertes par des plans à l'échelle du 1/5 000 ou 1/10 000. Ces plans cadastraux indiquent toutes les limites des propriétés ainsi que d'autres détails pertinents et ils sont utilisés pour l'enregistrement des titres de propriété et les transactions immobilières.

PERSONNEL ET INSTRUMENTS

En 1981, la section des levés sur le terrain se compose de 47 géomètres et de 120 ouvriers qualifiés. La section de cartographie a un effectif de 31 dessinateurs et de 10 informaticiens. La section des transactions a des effectifs de 30 personnes, et la section de photographie dispose de 12 techniciens. Le Département a un personnel administratif composé de 28 personnes, y compris les secrétaires. Il dispose de 39 théodolites à cercle en verre, de 3 instruments de mesure électronique des distances, de 25 niveaux, d'un théodolite gyroscopique et d'un laboratoire photographique équipé d'une caméra à procédé Klimsch, de 2 tireuses par contact et d'un redresseur-agrandisseur Wild.

PROGRAMMES FUTURS

Le Département doit établir un système informatisé de cartographie des services de distribution et de banque de données, fondé sur un système de coordination unique, pour tous les besoins en matière de cartographie topographique, cadastrale et relative aux services de distribution. Cet ensemble comprendra les instruments et les systèmes les plus modernes pour les travaux sur le terrain, des systèmes infographiques et l'informatisation de la cartographie et de l'enregistrement des transactions. Les principaux services de distribution visés sont les réseaux souterrains d'eau douce, d'eau saumâtre et d'assainissement, ainsi que les câbles du réseau d'électricité et de plusieurs réseaux de télécommunications.

Kuwait lies at the north-eastern corner of the Arabian Peninsula and the north-western corner of the Arabian Gulf.

Until 1950 technical mapping activities in Kuwait were very limited, but the rapid development of the country made it necessary to establish technical branches in certain departments, such as the Municipality and the Public Works Department.

Foreign personnel and technical companies took part in Kuwait's development schemes. The first group of surveyors joined the Department of Public Works in 1950-1951 and participated in the execution of the first few planning structures. The Survey Department is today one of the technical departments of the Municipality of Kuwait and consists of the following sections: Field Survey Section, Cartography Section, Transactions Section and Photographic Section. The department is charged with the responsibility for carrying out all cadastral and topographic surveys in addition to establishing the horizontal and vertical control stations and carrying out planning schemes.

GEODETIC CONTROL POINT SYSTEM

At present, Kuwait has several kinds of control point networks with stone markers in the field and data on record. These networks have been used in the past for map production, city planning, cadastral purposes etc.

One of these is the KOC control point network. Although this network covers the whole country, it was established many years ago and some of the control point markers have since been destroyed, thereby making its use undesirable in areas of intense development, such as in the City of Kuwait and along the coastal areas, which require a large number of control points.

Another existing network is the "local control point network" which has been used as the basis for cadastral surveys around the City of Kuwait. Owing to the fact that this network does not take into account distortion caused by the curvature of the earth's surface, it can be used only in surveys covering limited areas (such as cadastral surveys and some types of surveys for city planning) and cannot be used for surveys covering large areas (such as surveys for topographic map production).

Still another network, which is currently being used in Kuwait for producing topographic maps at scales of 1:50,000 and 1:2,000, is based on the UTM.

It can be seen that the basic problem in using these systems is that there is no easy way to correlate them with each other if and when the need should arise. A product produced by one method cannot easily be correlated with another product produced by another method. This, of course, results in waste of time, money and energy—and, more importantly, it hinders the country's goal of producing a series of correlated maps with corresponding interrelated data.

CADASTRAL SURVEYING AND MAPPING

Most urban areas have been covered by large-scale cadastral plans at 1:500, 1:1,000 and 1:2,000. The plans show property boundaries and buildings with other details. The first cadastral survey operations were carried out in 1951; later, the plans were revised on the same scale. Revised plans are now used as the basis for registration of title to land and transactions purposes. Surveys for rural areas are generally carried out on smaller scales, 1:5,000 or 1:10,000, using tape and plane table especially where land is reclaimed for cultivation in the northern and southern parts of the country. About 32,000 plans have been completed at different scales (figures 13, 14, 15).

AERIAL PHOTOGRAPHIC COVERAGE

Kuwait has been covered by aerial photography several times during the past 30 years. The sequence was as follows:

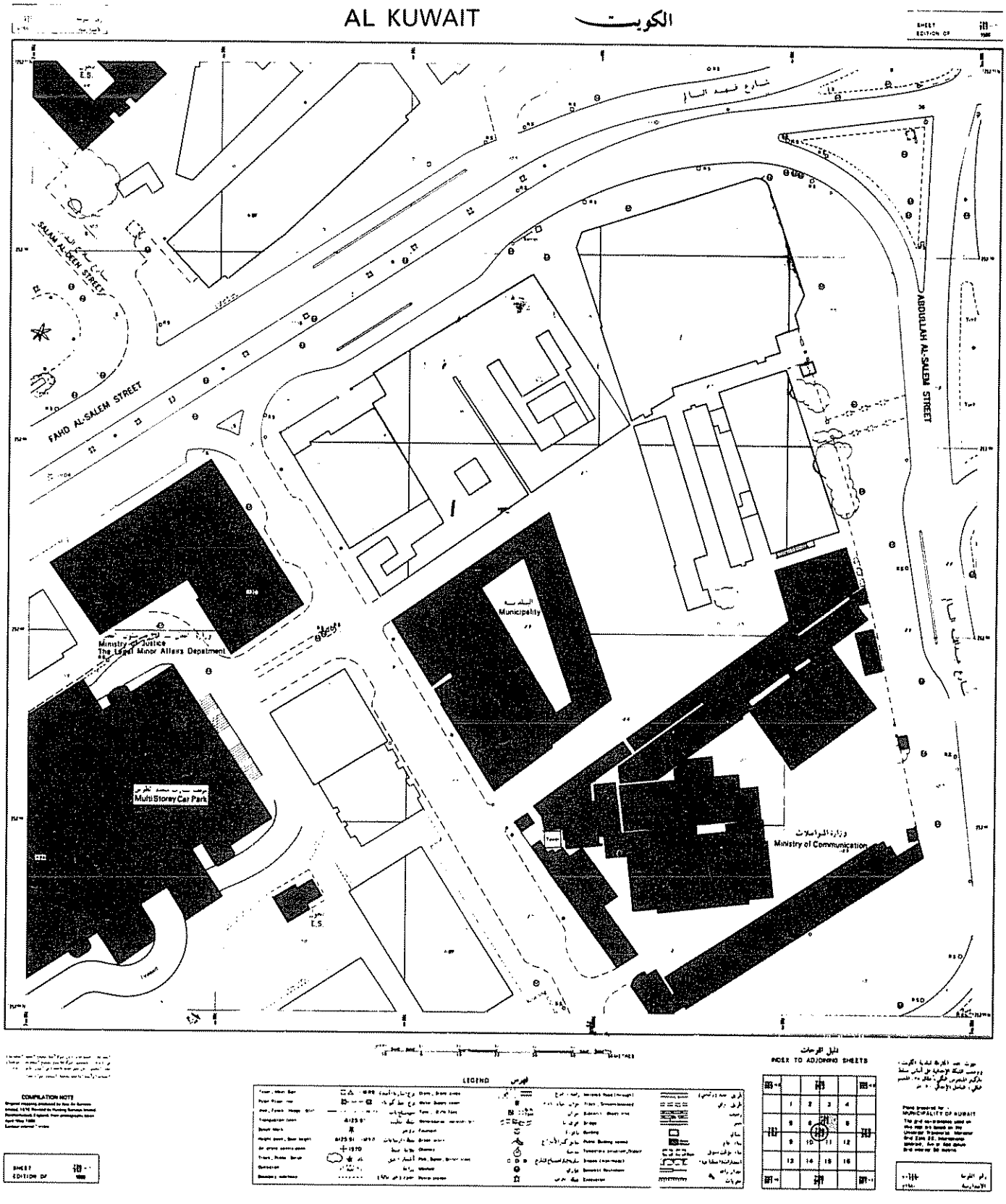


Figure 13. Kuwait: reduction of cadastral plan at scale 1:500

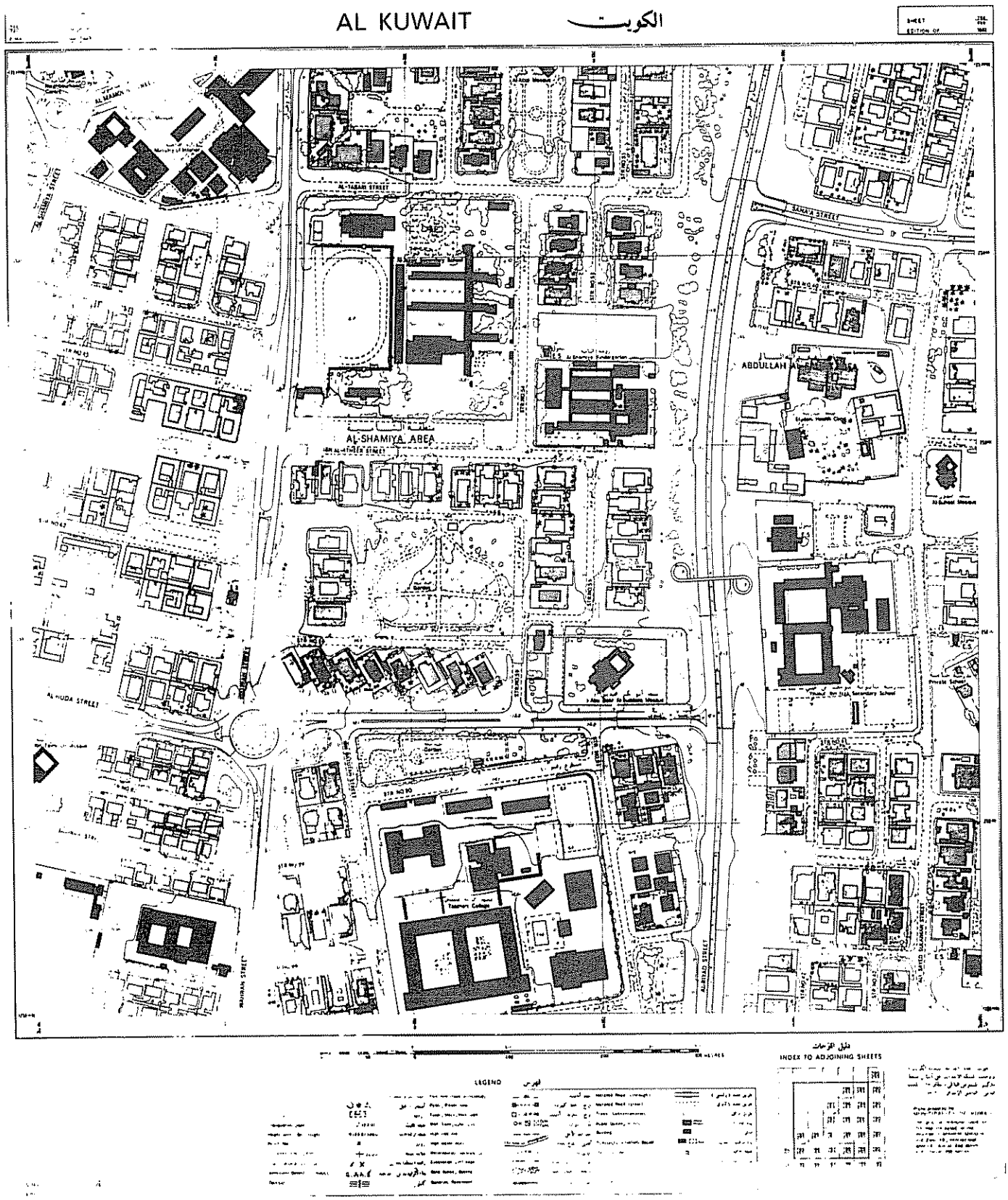


Figure 14. Kuwait: reduction of cadastral plan at scale 1:2,000

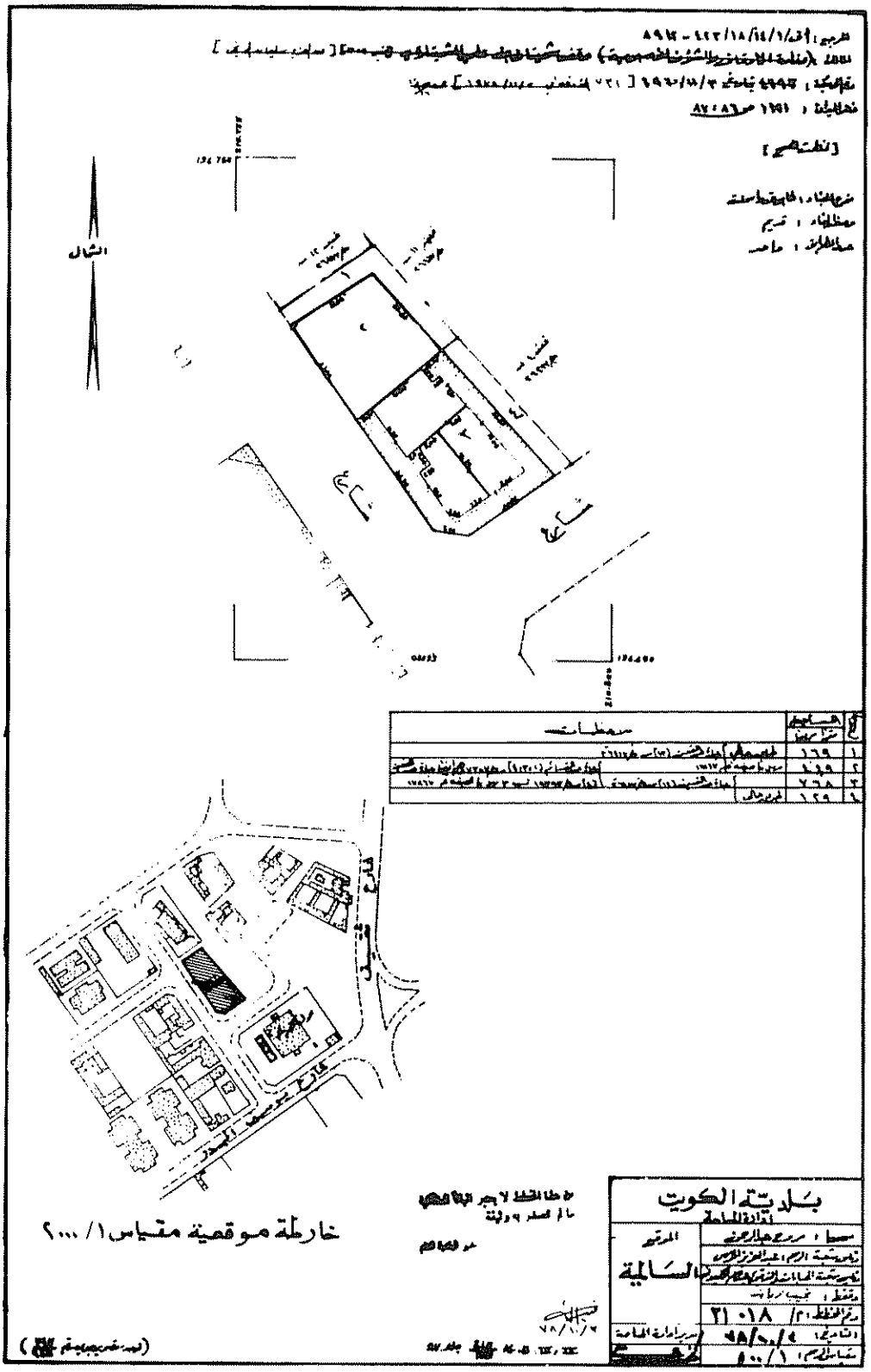


Figure 15. Kuwait: revised cadastral plan at scale 1:2,000 (reduced) for registration of title

1. In 1951, the City of Kuwait was photographed to produce photomosaics at 1:13,000 and 1:2,000 scales, covering 8 km²;
2. In 1960, the City of Kuwait and suburbs were photographed to produce the following scales:
   (*a*) 1:40,000 scale photography;
   (*b*) 1:2,000 scale line maps with 1-m contour intervals;
   (*c*) 1:10,000 scale line maps with 5-m contour intervals;
   (*d*) 1:2,000 scale photography;
3. In 1962, the Neutral Zone between Kuwait and Saudi Arabia was photographed to produce 1:50,000 scale photomosaic;
4. In 1964, the City of Kuwait and a part of the developing area were photographed as follows:
   (*a*) 1:10,000 photographic scale;
   (*b*) 1:10,000 photomosaics for the area from Jahra to south of Shoatba;
   (*c*) 1:20,000 photographic scale;
   (*d*) 1:20,000 scale line maps;
   (*e*) 1:20,000 scale photomosaics for different areas;
5. In 1967, the City of Kuwait was photographed to produce:
   (*a*) 1:10,000 scale photomosaics;
   (*b*) 1:20,000 scale photomosaics of part of the south coast;
   (*c*) 1:40,000 scale photomosaics;
   (*d*) 1:10,000 and 1:2,000 scale photography;
6. In 1971, the Neutral Zone was photographed at 1:10,000 and 1:2,000 scales for photomosaics covering 3,171 km²;
7. In 1974, aerial photography at scale 1:7,500 was carried out for some selected developing areas, producing maps at scale 1:2,000;
8. In 1976, Kuwait State was photographed as follows:
   (*a*) 1:3,000 scale aerial photography for the City of Kuwait to produce 1:500 line maps, covering 53 km²;
   (*b*) 1:7,500 scale aerial photography of the developing area of approximately 1,000 km² to produce 1:2,000 line maps;
   (*c*) 1:32,000 scale aerial photography to produce 1:10,000 photomaps and orthophoto maps of some areas of the State.

In April 1980 the developing areas of Kuwait will be aerially photographed at two different scales, 1:7,500 and 1:3,000, in order to revise the 1:500 and 1:2,000 scale maps.

All aerial photography and mapping in Kuwait is done by foreign companies.

FUTURE PLANS

Underground utilities mapping. The Kuwait Municipality Surveying Department decided that a programme should be prepared during 1980 to map underground utilities in order to eliminate the problems of locating and storing the enormous amount of data in connection with those utilities.

The Survey Department has chosen a pilot area for the following reasons:

(*a*) To determine the feasibility of such a system;

(*b*) To demonstrate its utility to the Municipality;

(*c*) To raise the level of understanding of the capabilities of such systems among the employees and staff of the Municipality;

(*d*) To choose the most appropriate interactive graphics and computer system for the Municipality;

(*e*) To test the system in a working environment;

(*f*) To evaluate data file structures prior to the selection of a final file structure for the entire interactive municipal data management system;

(*g*) To develop recommendations regarding the cost of a municipality-wide system.

The following underground utilities are involved:

1. *Drinking water pipe system*
   Depth, diameter, type of material and direction of water flow
   Ground reservoirs
   Pumping stations
2. *Gas pipe system*
   Depth, diameter, type of material and direction of flow
   Valves for different uses
   Pumping stations
   Pressure-reducing stations
   Metering stations
3. *Rainwater drainage pipe system*
   Depth, diameter, type of material and directions of flow (gravity or pressure)
   Locations of all levels of siphons
4. *Sewerage pipe system*
5. *Electric power supply network*
   Kinds of electric cables
   Number of cores
   Ground cables, depth, diameter and type of material
6. *Telephone cables and telexes network*

PERSONNEL AND EQUIPMENT

The Field Survey Section has 49 surveyors and 120 labourers.

The Cartographic Section consists of 25 draftsmen, 10 technicians for computations and drawings check and 8 personnel for map and sheet storage.

The Transactions Section has 30 personnel for land registration and filing.

The Photographic Section consists of 12 technicians.

The Field Survey Section uses the following equipment:

	Make	*Quantity*
Theodolites		
Wild T3		2
Wild T2		16
Wild T1		4
Wild T16		5
Wild RDH		4
Wild Distomat D135		2
M.D. 60 Siemens Albis		1
Watts 2		8
Gyroscopic		1

Make	Quantity
Levels	
Wild NA	3
Wild N	15
Plane tables	
Watts	3
Kern	2

Instruments used by the Photographic Section

Klimsch super Authorica 101 copy camera
Pictorial contact printer 127 cm x 163 cm conventional
Milligan electronic contact printer for aerial films
Wild E-1 rectifier enlarger
DR 70-Agfa film drier
Pictorial film drier

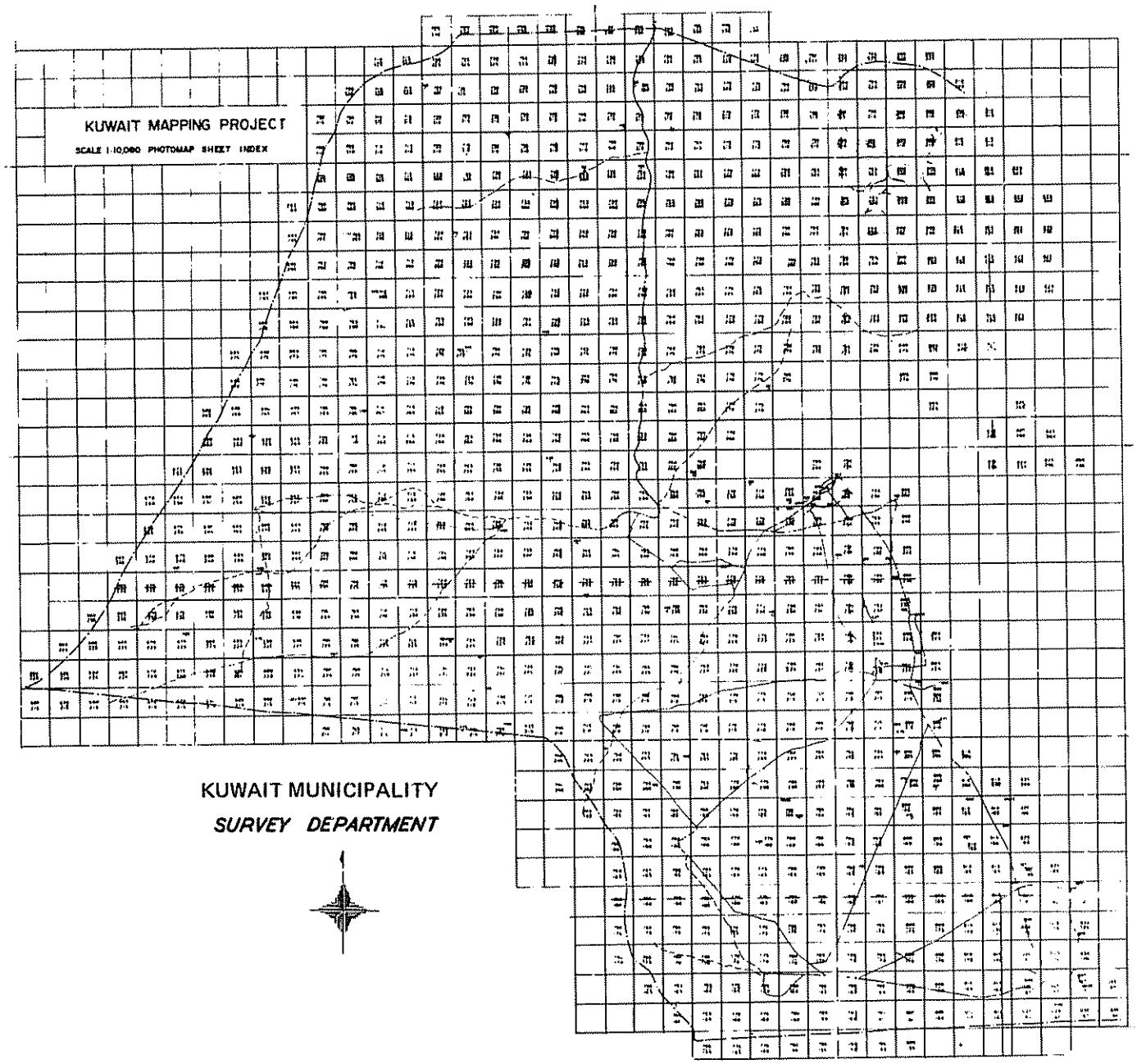


Figure 16. Kuwait: sheet index for photomap at scale 1:10,000, 1976

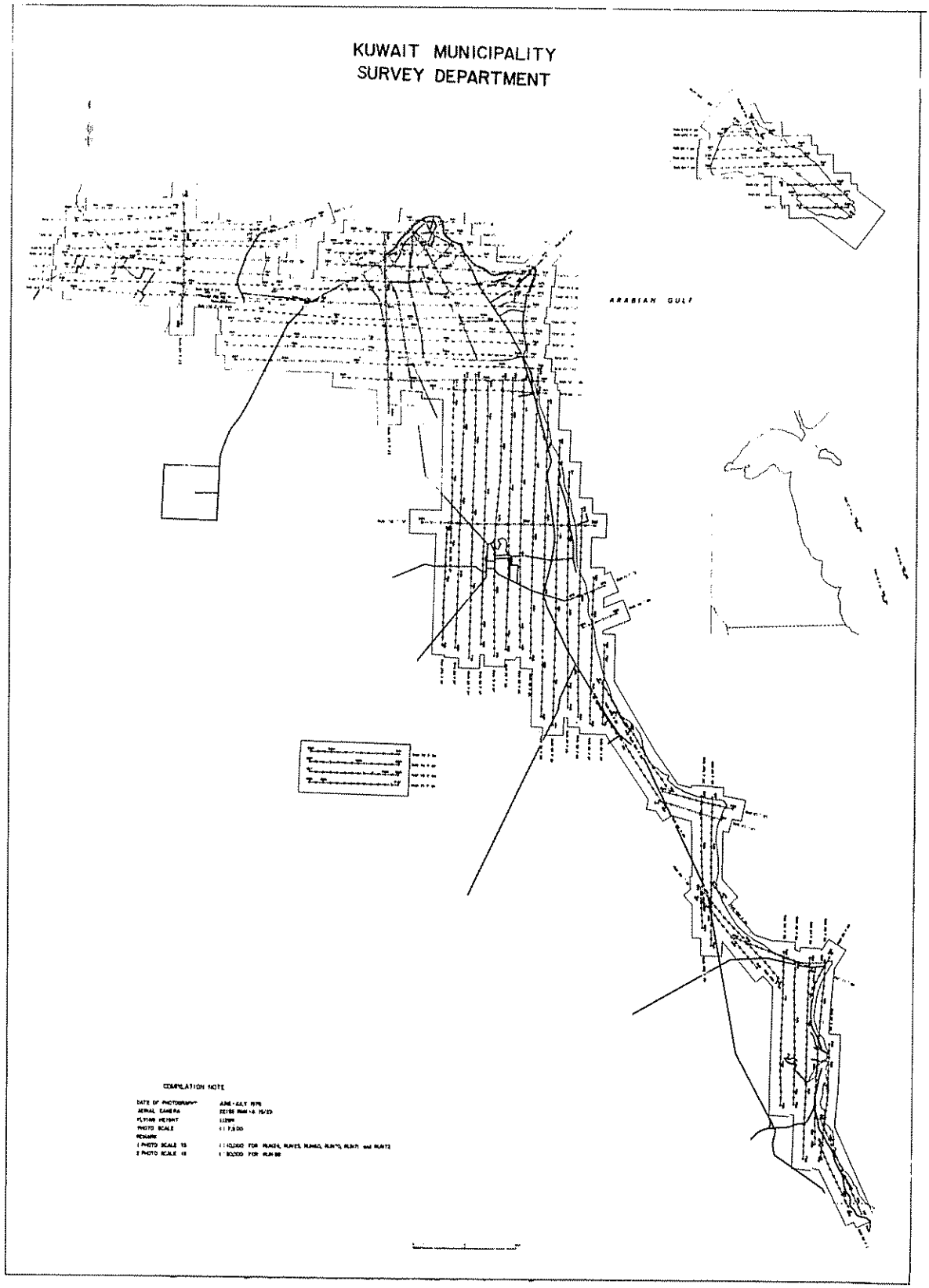


Figure 17. Kuwait: mapping project (development area); index map for aerial photographs at scale 1:7,500, 1976

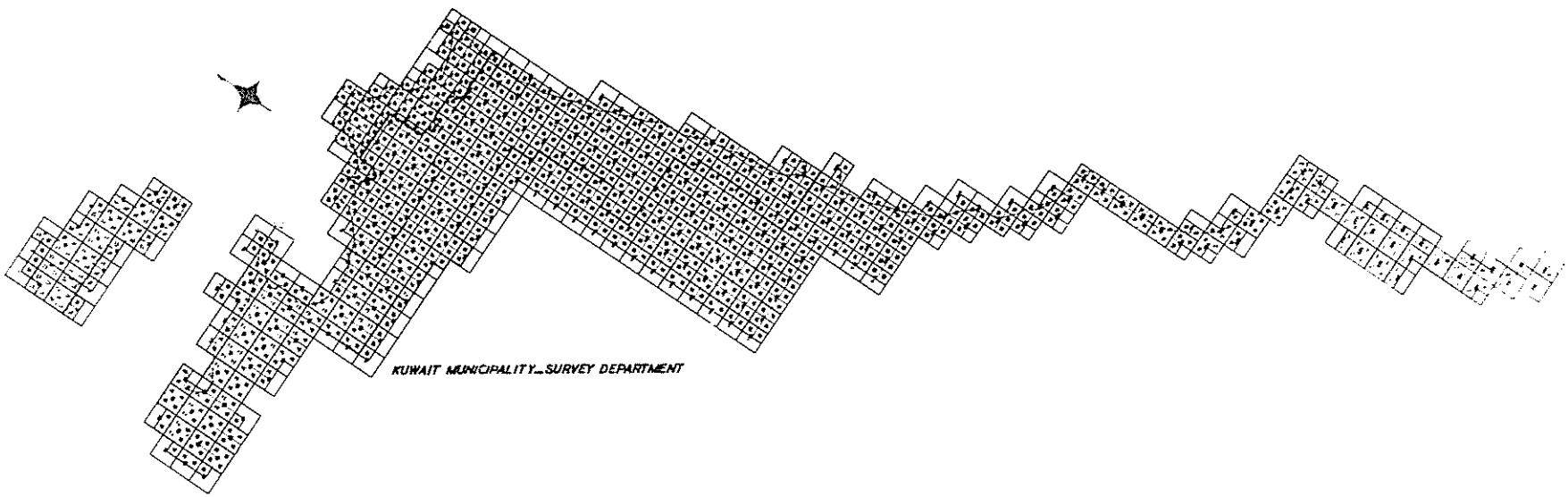


Figure 18. Kuwait: line map sheet index for scale 1:2,000, 1976

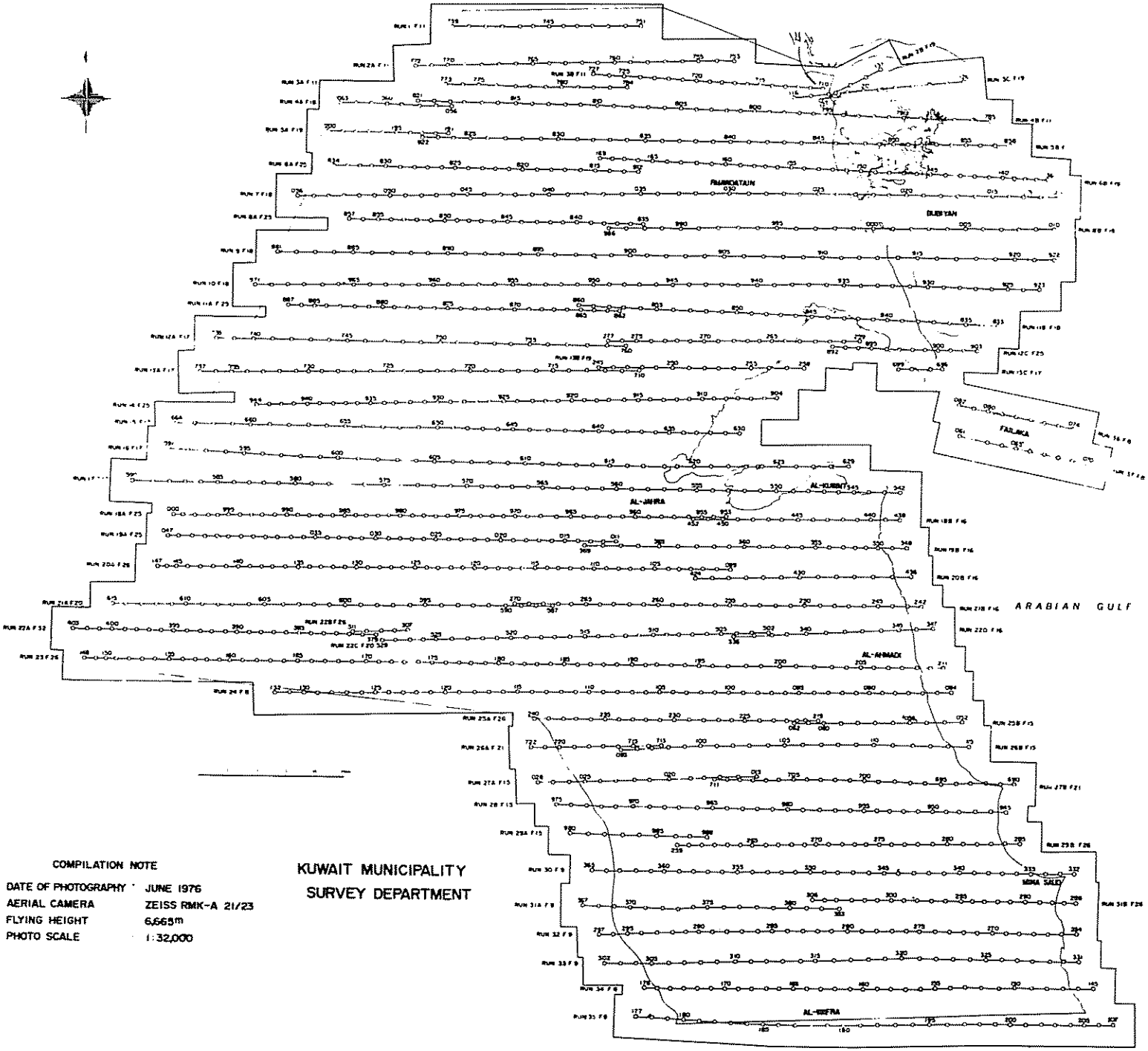


Figure 19. Kuwait: index map for aerial photographs at scale 1:32,000

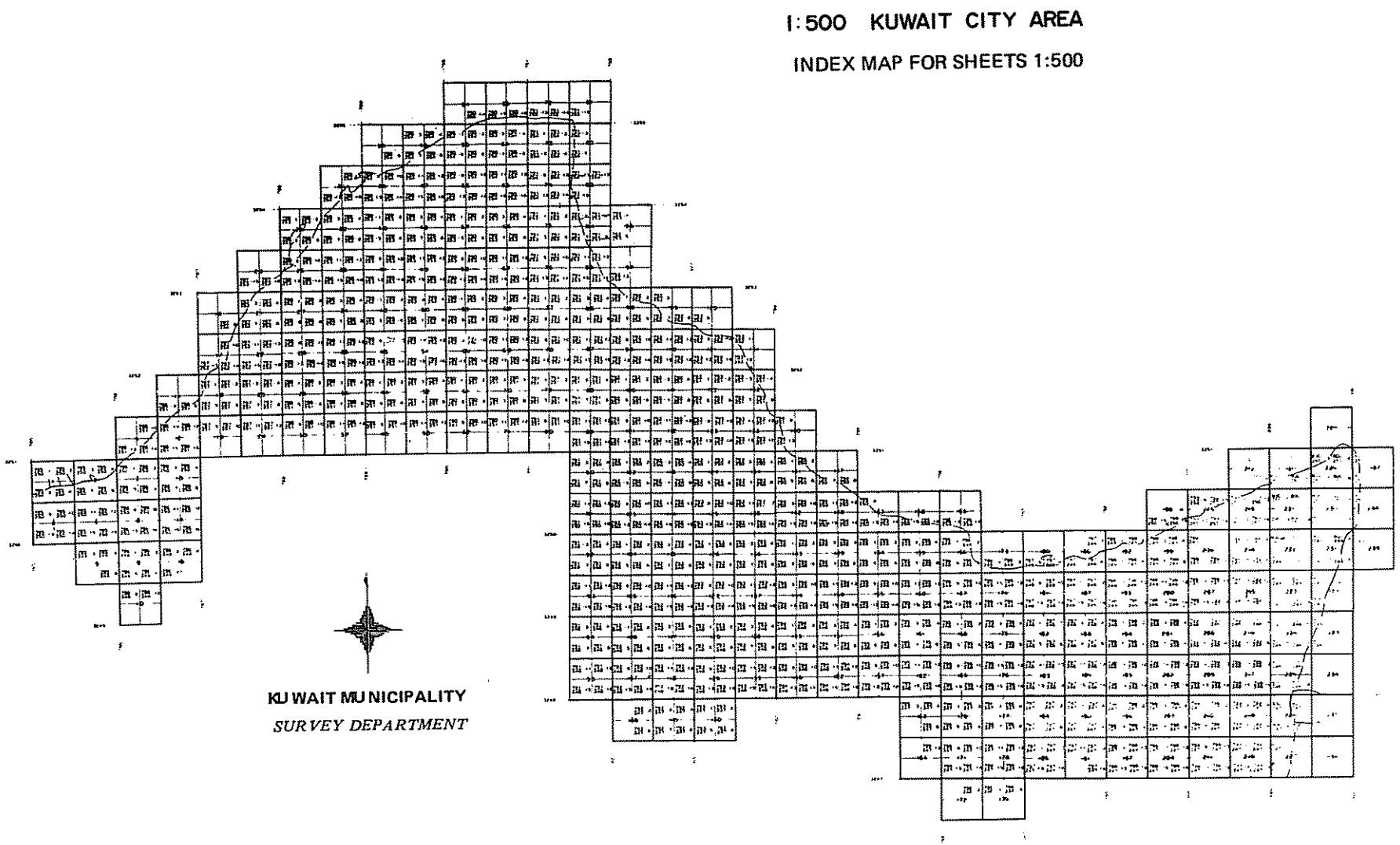


Figure 20. City of Kuwait: index map for sheets at scale 1:500

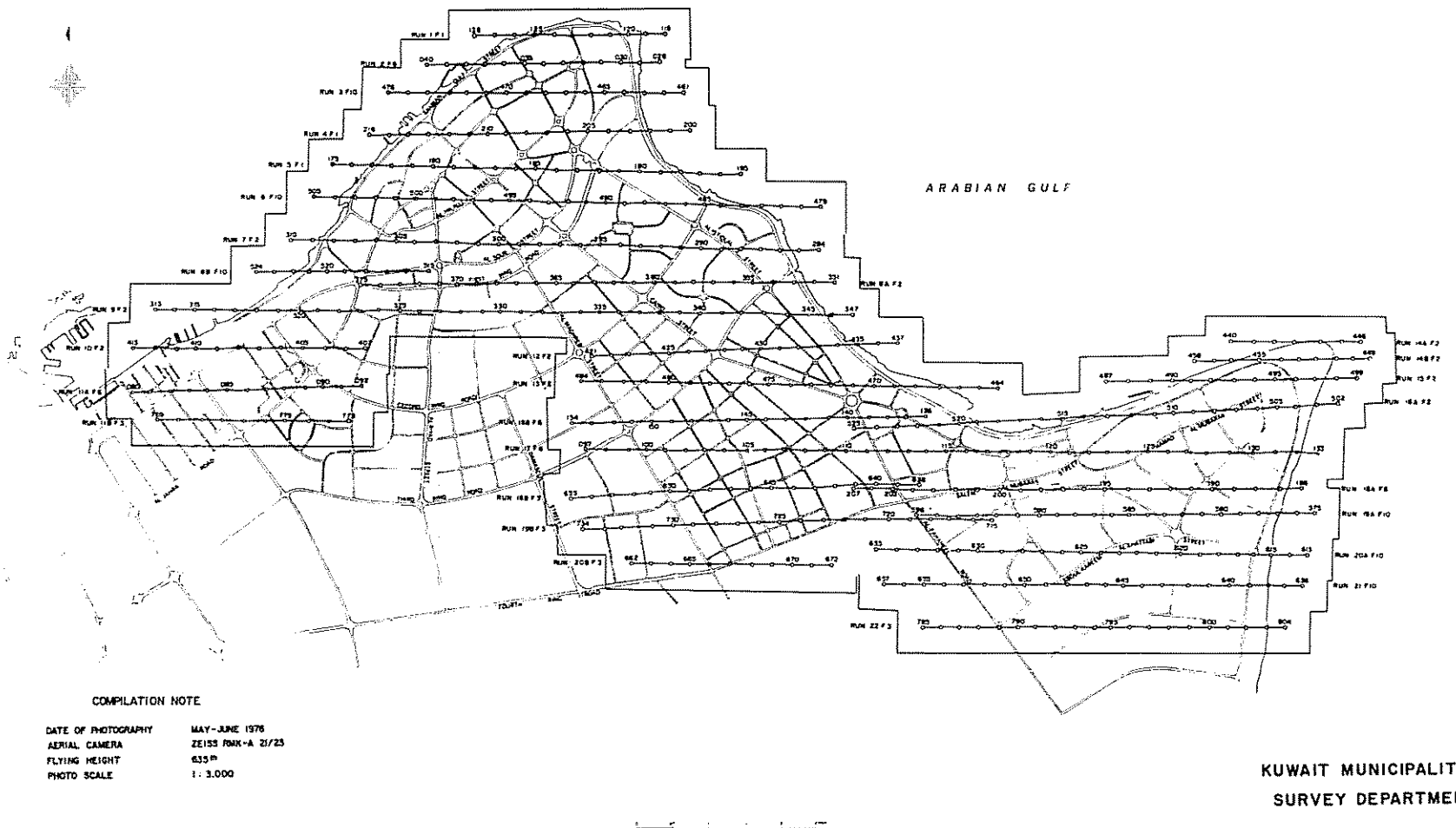


Figure 21. City of Kuwait: index map of aerial photographs at scale 1:3,000

REPORT ON CARTOGRAPHIC AND HYDROGRAPHIC ACTIVITIES IN MACAO*

Paper presented by Portugal

RÉSUMÉ

Outre les réalisations de 1977 à 1979, dans les domaines de la cartographie, de l'hydrographie et du cadastre, on indique dans ce rapport la position géographique du territoire de Macao, les travaux en cours et les projets soit à bref soit à long délai — toute entreprise étant faite dans le but de procurer au territoire les bases cartographiques nécessaires à son développement —, la carte au 1/1 000 de tout le territoire et des plans spécifiques à échelles plus grandes, pour servir d'appui à des entreprises en voie de réalisation.

On met particulièrement en relief la formation du personnel à l'Ecole de topographie et de cadastre et, par le moyen de stages, dans les centres de formation à l'étranger — l'Ecole suisse pour opérateurs photogrammètres, l'Institut international de levés aériens et sciences de la terre, et l'Université des Philippines.

Dans le domaine de l'hydrographie, on indique la publication annuelle *Agenda dos portos de Macau* et la collaboration avec l'Institut hydrographique de Lisbonne.

MACAO TERRITORY

Macao Territory has been under Portuguese administration since the end of the sixteenth century. It is made up of a small peninsula, completely covered by the town of Macao, and of two islands, Taipa and Coloane. It is approximately 16 km² in area.

Geographically, the Territory is designated by the coordinates of Farol da Guia (Guia Lighthouse) which are 22° 11′ 51″ N latitude and 113° 32′ 48″ E longitude.

Cartographic antecedents

The insular nature of the Territory and the economic importance of Macao harbour, including nearly all of the peninsula coast, led to an early recognition of the need for hydrographic studies to combat the constant silting of the coastline and offshore area. Portuguese expertise provided the solution and the first hydrographic cartographic work made its appearance a long time ago. The continuity of the work was assured by the Marine Department which gathered the data essential for maintaining the functioning of the harbour.

This was not the case with terrestrial cartography.

It has been only since the beginning of the present century that, slowly, the islands came to be systematically occupied owing to the shallowness of the sea near the coast, which allowed the passage of only small boats.

The first terrestrial cartographic works appeared only in 1955, done by army officers. These were the geodetic connections between the islands themselves and between the islands and the peninsula, and also a map of the islands at scale 1:2,000. Prior to that date, there seem to have been only some local maps.

The Public Works Department also produced some cartographic works of the city of Macao, namely, a plan at scale 1:1,000, which is now completely obsolete.

Most of the above-mentioned terrestrial cartographic works were done not only without specialized staff, but also without adequate material. The result was that their quality was not always of the best and even if they fulfilled earlier needs, they are no longer adequate.

Current cartographic demands

The construction of the bridge connecting the Macao peninsula with Taipa Island and the overpass from Taipa to Coloane unified the Territory, making the islands more valuable and opening the Territory to new development possibilities. This gave rise to many new demands for cartography on larger scales, 1:1,000 and 1:500, which led the Macao Government to create the necessary infrastructure.

In 1975 the Cartographic Department was created provisionally for the purpose of taking stock of existing work and equipment, studying the structures to be created and training technical staff in order to have them ready to work on the proposed structures.

The result of this last was the creation, in 1975, of the Macao Topographic and Cadastral School for the training of topographers, calculators and drafters.

CARTOGRAPHY

Activities for the period 1977-1979

Cartographic activities in the Territory since the last Conference were as follows:

Training of technical staff

The Topographic and Cadastral School granted 86 certificates for its general topographic course. Of these, 25 went to students from the Portuguese Department and 61 to Chinese students.

A topographic refresher course was given in 1978, granting certificates to 26 students (15 from the Portuguese Department and 11 from the Chinese).

Scholarships were given by the Topographic School to three graduates to follow a photogrammetry operator's course at the Ecole suisse pour opérateurs photogrammètres in Switzerland; one scholarship was given to another to follow a photo-interpretation course at the University of the Philippines; and a further one was given for a photogrammetry course at the International Institute for Aerial Survey and Earth Sciences (ITC) in the Netherlands.

This last student is still finishing his studies. The other four have been graduated with high grades.

*The original text of this paper appeared as document E/CONF.72/L.75.

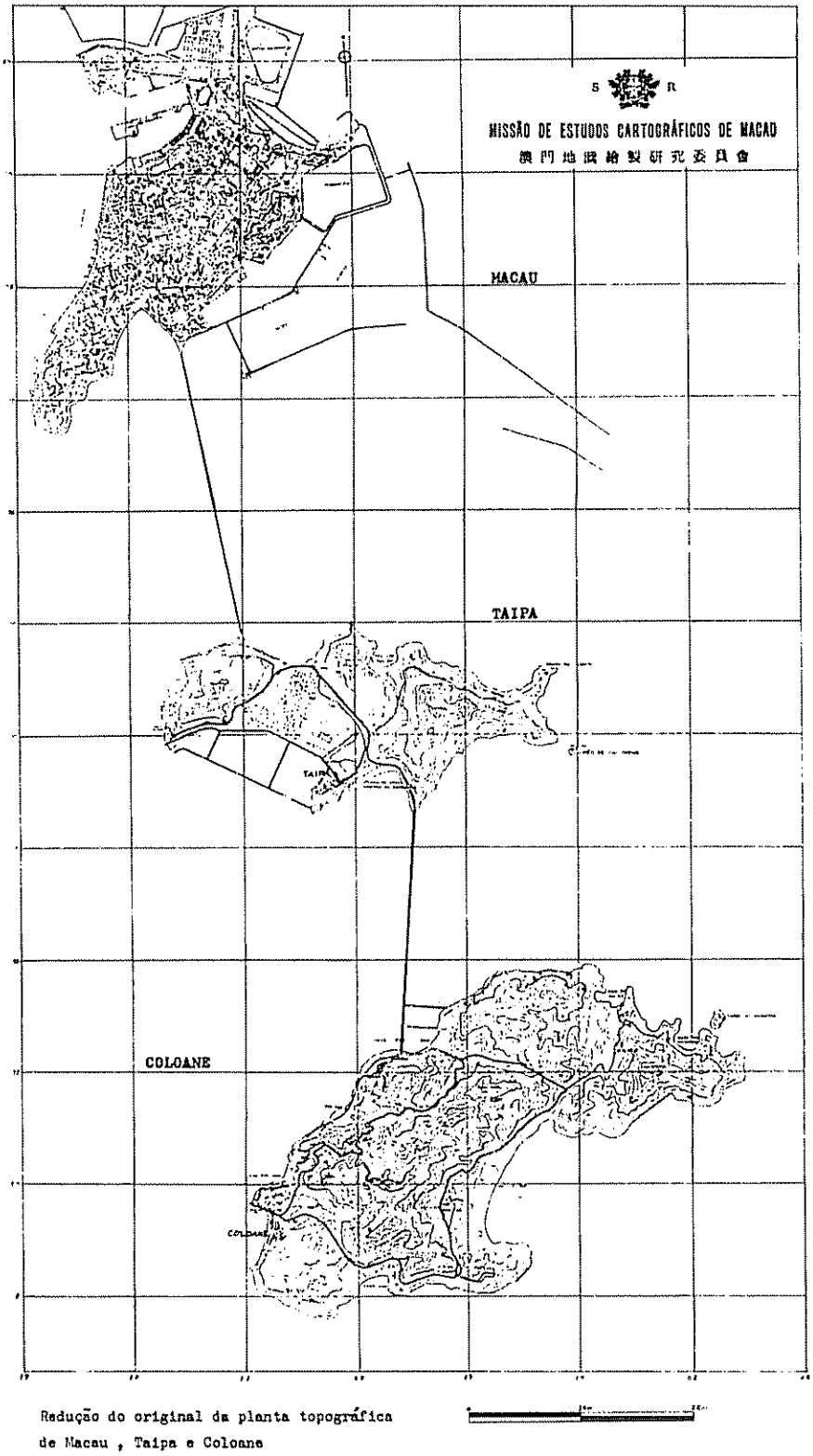


Figure 22. Reduction of the topographic map of Macao, Taipa and Coloane

Equipment

Macao has attempted to acquire the necessary equipment, in particular Wild and Sokkisha, for its Topographic School, and also equipment needed for cartographic work.

Triangulation and topographic survey

Triangulation and land survey have been done in connection with the islands' maps at scale 1:1,000, which will soon be completed.

Geometric precision levelling work has been carried on, closing some circuits and referring all the heights above the medium sea level, as given by the Macao tide gauge.

To serve as support to the Territory Ordinance Plan and also to public-interest enterprises, some local maps have been done on the islands and the city of Macao at scales of 1:1,000 and 1:500.

Investigations have been made for the study of soil settlement and of the stability of public works engineering and for possible deformation studies.

Cadastre

Activities in this field were directed towards training of staff, informing the public and equipping the service.

The absence of an appropriate soil law suitable for local conditions prevented any further progress. The Legislative Assembly of the Territory is in process of shaping such a law, which is expected to be published shortly.

Future projects

In general, future projects will consist of completing work in hand and improving existing works. The following activities are planned:

Near-term projects

(*a*) Establishment of a Cartographic and Cadastral Department, replacing the present service created temporarily in 1975;

(*b*) Reorganization of the Topographic and Cadastral School, raising the technical level and improving its studies and programmes in order to obtain international recognition of its certification;

(*c*) Granting scholarships in Portugal and other countries for staff improvement particularly in cartographic drawing and map printing;

(*d*) Conclusion of the work on the map of the islands at the scale of 1:1,000;

(*e*) Commencement of work on the property cadastre, rural and urban;

(*f*) Support of the study on public-interest enterprises.

Long-term projects

(*a*) Execution of maps of the city of Macao at scales of 1:1,000 and 1:500 by photogrammetry. We are at present trying to obtain from China authorization for the necessary flight;

(*b*) Establishment of the Tombo (documents archive and data bank);

(*c*) Studies on the establishment of the digital map of the Territory.

HYDROGRAPHY

The activities of the Territory's Hydrographic Service, which is part of the Marine Department, are as follows:

Training of technical staff

As this section is at present being restructured, and more technical staff will be needed, a training programme is being drawn up.

The Macao Topographic and Cadastral School has been very helpful in the field of technical training, allowing some of the staff of this Service to follow its General Topographic Course. The Lisbon Hydrographic Institute has also been helpful in allowing staff from Macao to improve their skills by training with its teams (field and workshop) since 1979.

Fields of activity

The Hydrographic Service carries out the following activities:

(*a*) Navigational channels: The Territory of Macao is situated between two large rivers that discharge their sediment along the east and west coasts. This creates a constant struggle to maintain the navigability of the channels. One of the Hydrographic Service's activities is to control the hydrographic depths of the various channels, in order to keep the basins and docks free. To achieve this purpose hydrographic surveying is done every six months, covering all the areas shown in figure 23.

(*b*) Hydrographic plans: preparation of maps of all areas for both official and private purposes. Hydrographic maps of various areas are drawn to the following scales:

Docks	1:500
Manoeuvring basins	1:1,000
Channels	1:2,500 and 1:5,000

(*c*) Buoyage: support of the channels' buoyage by frequent checking of the buoys' positions, beacons and signals;

(*d*) Tides and currents: permanent observation of the tides, especially at the approach of tropical storms. For this purpose, the Service has one tide gauge (see figure 24) in the position shown in figure 23.

Equipment

For the execution of hydrographic works, the Service has several topographic and surveying instruments for field and office activities. Besides the tide gauge mentioned above, it also has two small outboards (*sampanas*) (figure 25) and a Trisponder (see figure 27) which would appear to meet the Territory's needs although at present on an experimental basis. This equipment is on board a small craft (figure 26).

Publications

The Macao harbour agenda (tide table) is published annually.

The tide forecast is made by the Lisbon Hydrographic Institute and, a daily comparison is made by the Hydrographic Service between the estimated and the observed tide values. These elements are reported regularly to Lisbon for study.

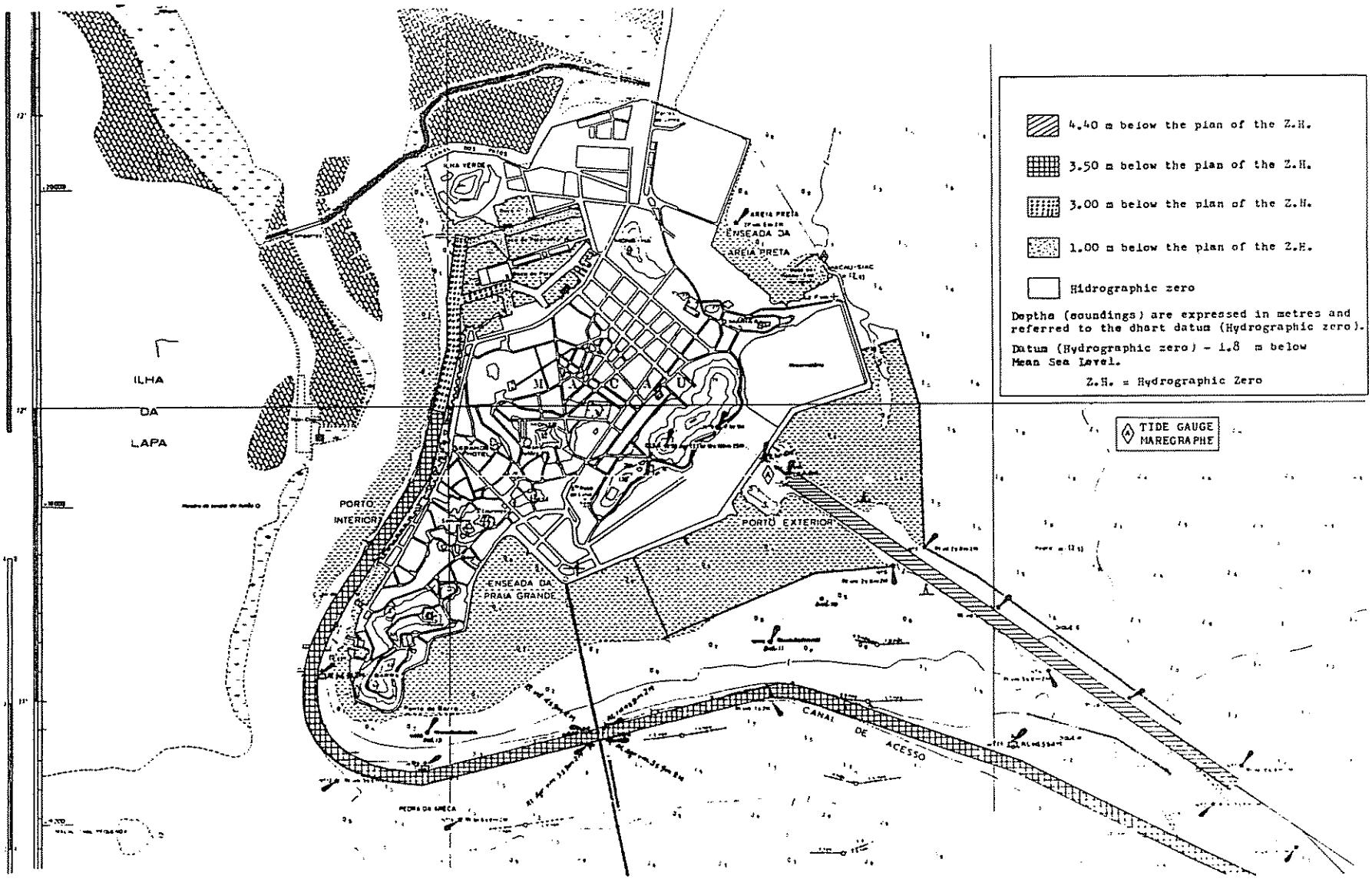


Figure 23. Macao: areas of hydrographic control

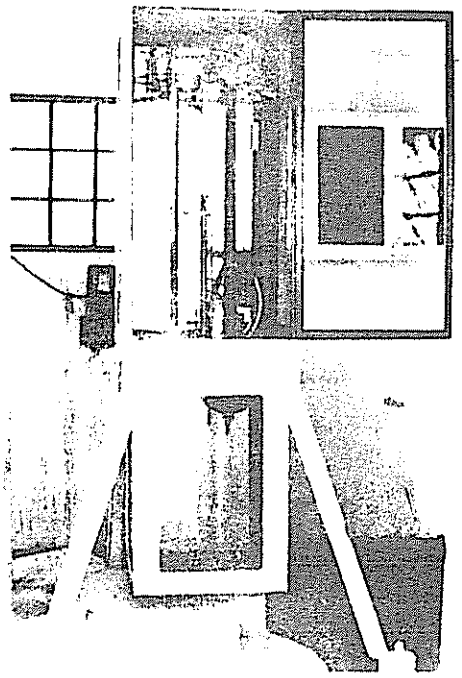


Figure 24. Macao: tide gauge mark George Merck

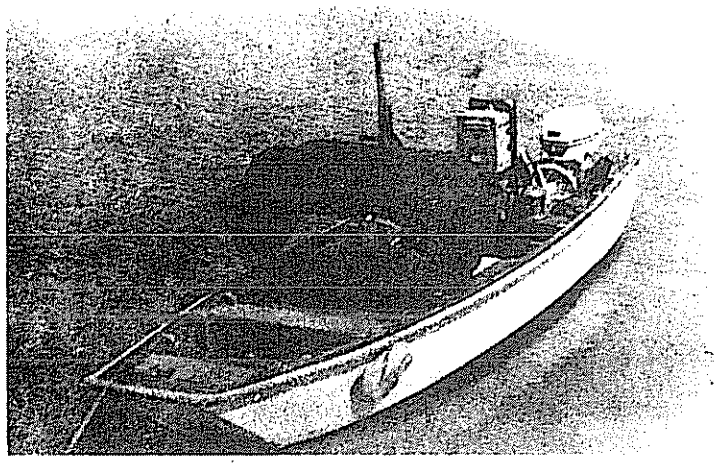


Figure 25. Macao: hydrographic sampan with depth sounder on board

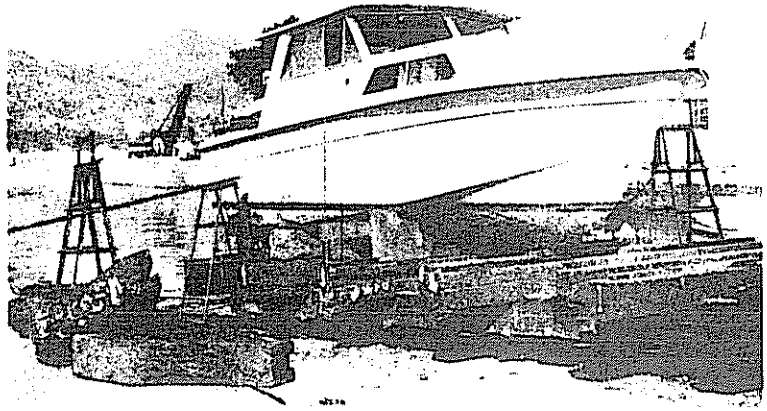


Figure 26. Macao: launch used as main station for the Trisponder 202

- 80-km range
- 0.5-metre resolution
- ±3 metre accuracy
- battery operation
- field maintainability
- rugged waterproof construction
- measurements in feet or metres
- simple, automatic operation
- immunity to interference
- 10/100 sum digital averaging
- specialized gain control circuitry

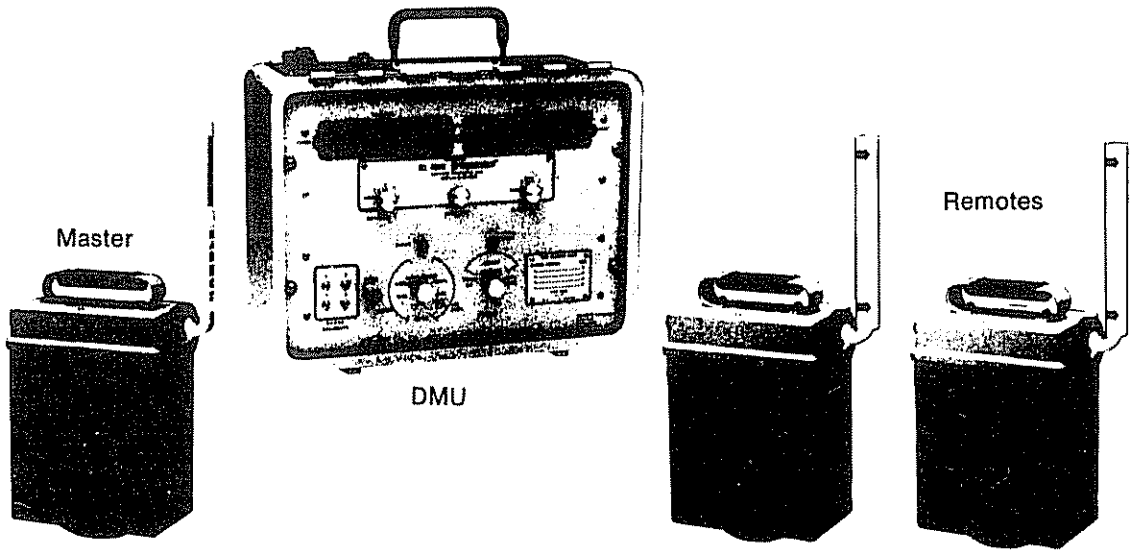


Figure 27. Macao: Trisponder with dual and multichannel control for accurate positioning of air, sea and land vehicles

Future Projects

It is expected that the new hydrographic maps of the Territory at scales 1:10,000 and 1:20,000 will be published shortly with the collaboration of the Hydrographic Institute.

It is intended in 1981 to start work again on further studies of streams. To perform this work it will be necessary to train staff (1980) and purchase the technical equipment, including two current meters.

CONCLUSIONS

Geodesy

This report has not dealt with geodesy because of the small size of the Territory. The established cartographic net is only of second order. The longer length is no more than 5 km. It may only be necessary to re-observe a few points. This is not the case with the universal net connection and its orientation, which can only be done in collaboration with neighbouring countries or areas, namely, China and Hong Kong. This matter is receiving attention.

Training of technical staff

Geodesy, cartography and cadastral studies are all included in the theoretical preparation given to students by the Topographic and Cadastral School. The training in workshops and particularly in field work is based on the Territory's needs and the existing equipment. However, the staff may be considered well prepared and competent to deal with any problem in these fields. This fact may be of interest to neighbouring territories, which lack technical staff at this level; also the fact that most of them speak Chinese (Cantonese) and English.

CARTOGRAPHIC ACTIVITIES IN MALAYSIA, 1977-1979*

Paper presented by Malaysia

RÉSUMÉ

En Malaisie, les activités cartographiques ont été dirigées par le Comité national de cartographie. Ce dernier, qui a été créé avec l'accord du Cabinet au début des années 60, a contribué au succès et aux résultats obtenus dans le domaine de la cartographie considérée en tant qu'instrument à la fois du développement national et de la défense nationale. Le Directeur de la cartographie nationale malaisienne est le président de ce comité, qui se compose de fonctionnaires de divers départements gouvernementaux ainsi que des Directeurs des affaires foncières et des levés du Sabah et du Sarawak. Le Comité se réunit deux fois par an avec le mandat suivant :

a) Fournir au Directeur de la cartographie nationale des avis sur les questions relevant de la politique cartographique;

b) Fournir au Directeur de la cartographie nationale des avis sur les priorités en matière de cartographie.

Sur l'avis du Comité national de cartographie, la Direction de la cartographie nationale a effectué des levés topographiques et géodésiques et établi et mis à jour des cartes topographiques et urbaines de territoires malaisiens à des échelles prédéterminées.

Le Directeur de la cartographie nationale est également Directeur honoraire du Service topographique militaire et, en cette qualité, assure l'obtention et la fourniture de cartes à l'intention des forces armées malaisiennes.

Cartographic activities in Malaysia have been guided by the National Mapping Committee. This Committee, set up with Cabinet approval in the early 1960s, has been instrumental in the success and achievements of mapping as a tool of both national development and national defence. The Director of National Mapping, Malaysia, is the Chairman of the Committee; its members are from various governmental departments as well as the Directors of Land and Survey, Sabah and Sarawak. The Committee meets twice a year with the following terms of reference: To advise the Director of National Mapping on matters relating to mapping policy: To advise the Director of National Mapping on mapping priorities.

On the advice of the National Mapping Committee, the Directorate of National Mapping has been carrying out topographical and geodetic surveys and producing and maintaining topographical and town maps of Malaysian territories at predetermined scales.

The Director of National Mapping is also the Honorary Director of Military Survey and in this capacity he obtains and provides maps for the armed forces of Malaysia.

*The original text of this paper, prepared by the Directorate of National Mapping, appeared as document E/CONF.72/L.74.

JOINT PROJECTS

A project to demarcate and survey the common international boundary between Malaysia and Thailand was undertaken jointly by the Directorate of National Mapping, Malaysia (DNMM), and the Royal Thai Survey Department. The project commenced in 1973. So far 10 priority areas, totalling 248 km of the 576-km long common land boundary, have been demarcated and surveyed.

The demarcation and survey of an approximately 1,800-km long common land boundary between Malaysia (Sabah and Sarawak) and Indonesia (Kalimantan Timur and Kalimantan Barat) were undertaken jointly by DNMM and the Co-ordinating Board for National Survey and Mapping of Indonesia (BAKOSURTANAL). Project A (reconnaissance) and Project B (demarcation of straight-line boundary) commenced in 1975.

Sabah-Kalimantan Timur sector

Progress achieved: Project A: 333 km;
Project B: 154.2 km.

Sarawak-Kalimantan Barat sector

Four priority areas totalling 389.1 km were completed by the end of 1978. Position fixing by satellite Doppler survey techniques has been used in this sector since July 1979. To date, 15 Doppler stations have been observed out of a total of 41.

TRIANGULATIONS

In Peninsular Malaysia, the existing network is adequate for current mapping purposes and will be further improved to make it compatible with scientific research which is being planned now between the University of Technology, Malaysia, and DNMM.

For the purpose of the Malaysia-Thailand border demarcation survey, extensions of the existing network were carried out to fix major control points, and have now been successfully completed.

All other control points being used in the Malaysian-Thai boundary demarcation have been established using EDM traverse methods tied to triangulation points. This method has proved to be more efficient and is adaptable to the prevailing security situation.

DOPPLER SATELLITE FIXES

With the assistance of the Directorate of Military Surveys, United Kingdom, precise Doppler satellite fixes were taken on a total of 12 geodetic and primary trig. stations in Malaysia: five in Peninsular Malaysia, four in Sabah and three in Sarawak. All computations were based on the WGS 72 datum.

Doppler satellite fixes are currently being used in the position fixing of the control points in the boundary demarcation and survey project between Malaysia and Indonesia in the Sarawak-Kalimantan Barat sector.

With the assistance of the Australian Army Mapping Service, satellite fixes were also taken at points along the Straits of Malacca, one of which is a common datum point between Malaysia and Indonesia.

Plans are in hand to put several of the points in the Malaysian triangulation network, including its extensions being used as major controls along the Malaysian-Thai border, on a satellite-based datum.

LEVELLING

The datum established at Port Kelang in 1912 is still being used.

A more accurate value of mean sea level will be determined once eight more tide gauges are established around the country in the near future.

MAP COMPILATION

A new metric map series, the L 7030 at a scale of 1:50,000, was launched in 1979, and to date two sheets have been photogrammetrically plotted. A total of 211 sheets have been planned to cover Peninsular Malaysia in a target time frame of 10 years.

Compilations on several special mapping projects for the various local (state) governments for urban development purposes at scales ranging from 1:5,000 to 1:10,000 are in process.

Compilations on several development projects undertaken by the Federal Land Development Authority (FELDA) have, in the past three years, produced maps at a scale of 1:6,336 with 10-ft contours for 164 rural land development schemes totalling 385,004 acres. Mapping for rural development projects takes up a considerable amount of DNMM's resources.

Compilations for 44 towns for the map series L 905 at various scales from 1:5,000 to 1:10,000 were completed in 1975, and is continuing for 64 more towns in the current phase. Simultaneously, 42 sheets of series L 808 at scale 1:10,000 are being compiled.

The mapping of the city of Kuala Lumpur and the Federal Capital Territory was completed in October 1979. The map is at a scale of 1 inch = 2 chains (1:1,584) with 10-ft contours. As part of the Territory's Master Plan for future development, up-to-date cadastral survey information was plotted on transparent overlays such that each "cadastral map" is of the same scale and shares the same grids as its corresponding topographic sheet. Cadastral survey information within the Federal Capital Territory was digitized and automatically plotted on the flatbed EAI electronic plotter. An overlay of a topographic sheet and its corresponding cadastral survey sheet will thus depict topographical features situated within the confines of their cadastral survey boundaries. A total of 384 topographic sheets were produced to cover 134,400 acres.

COMPUTERIZED/SEMI-COMPUTERIZED CARTOGRAPHY

A study is being made on the various systems (hardware and software configurations) available in the mar-

ket today in the field of computerized/semi-computerized cartography. It is felt that it is imperative for the Directorate to move in this direction if it is to be able to meet the demands that are being made upon it by the rapid rate of development that is taking place in the country today. For the first time in its history, the Directorate will be requiring consultancy services in the setting up of such a system.

MAP PRODUCTION

The table lists the number of map sheets produced by the Directorate of National Mapping for the period December 1976 to December 1979.

MAP SHEETS PRODUCED BY THE DIRECTORATE OF NATIONAL MAPPING, MALAYSIA, FOR THE PERIOD DECEMBER 1976-DECEMBER 1979

	Number of new maps sheets printed	*Number of revised map sheets printed*	*Reprinted*	*Total number of copies printed*
Series L 7010 and L 707 1:63,360	—	16	67	415,000
Series L 8010 1:25,000	72	9	—	243,000
Series T 735 1:50,000	—	45	—	180,000
Misc. maps and charts	3	15	1	13,200
Series L 905, T 931, L 808	8	10	—	40,000

CARTOGRAPHIC ACTIVITIES IN NEPAL*

Paper presented by Nepal

RÉSUMÉ

Aux fins du plan et du programme de développement, le Népal est divisé en quatre régions de développement : la région orientale, la région centrale, la région occidentale et la région extrême-occidentale. Diverses activités de développement économique et social sont en cours dans ces quatre régions. En conséquence, la demande en matière de levés et de cartes augmente de jour en jour. Pour répondre à cette demande, le Service cartographique du Gouvernement royal népalais, qui est l'organisme national responsable de tous les levés topographiques, géodésiques et cadastraux ainsi que de la formation dans ce domaine, a intensifié son activité en matière de topographie et de cartographie depuis la huitième conférence, tenue à Bangkok en 1977. Les subdivisions actuelles du Service cartographique (section géodésique, section du cadastre, section topographique et Centre de formation) ont été élargies au cours des trois dernières années. Le rapport récapitule les activités cartographiques réalisées ainsi que les progrès accomplis et certains des problèmes rencontrés par les trois sections organiques du Service cartographique dans l'exécution de différents levés.

For the purpose of the development plan and programme, Nepal is divided into four development regions, eastern, central, western and far western. In all four regions various economic and social development works are in process. The demands for surveys and maps are therefore increasing day by day. To meet these demands the Survey Department of His Majesty's Government of Nepal, which is the national agency for all topographic, geodetic and cadastral surveys and survey training, has become more active in the field of surveying and mapping since the last conference at Bangkok in 1977. The existing survey branches, the geodetic survey, cadastral survey, topographic survey and the training centre under the Survey Department have been further enlarged during the past three years. This report summarizes the cartographic activities carried out together with the progress made and some of the problems faced on different surveys by the three branches of the Survey Department.

GEODETIC SURVEY BRANCH

The Geodetic Survey was established within the existing Survey Department in 1969 and is assigned to carry out geodetic survey operations in Nepal. It consists of three main divisions, namely, Trigonometric Survey, Levelling Survey and Astronomical Survey. It has not yet started the gravity survey due to the lack of necessary equipment and trained personnel. It is planned to set up a gravity division as soon as the instruments and trained personnel are available.

The Geodetic Survey Branch with its three divisions is at present engaged in the following activities:

(*a*) To establish the basic first order trigonometric network and break down the existing triangulation points into lower-order control points to provide controls for the cadastral survey and other large-scale surveys;

(*b*) To carry out precise levelling and establish benchmarks;

(*c*) To establish astronomical stations of different orders.

As the country is in need of more accurate geodetic controls for the surveying and mapping required by development projects and for scientific research, a basic first-order network has been planned for the whole Kingdom. It consists of 39 stations including seven Laplace stations and 14 azimuth stations. These stations

*The original text of this paper, prepared by A. B. Basnyat, Survey Department, appeared as document E/CONF.72/L.106.

are spread over the mountainous belt up to an altitude of about 5,500 m at distances of 32 km to 61 km. The heights of those stations vary from 1,200 m to 5,500 m. The distances are measured by laser AGA geodimeter model 8 and angles are observed by Wild T3 theodolite. There is a plan to set up 16 Doppler stations at various appropriate places. The existing seven Laplace stations will be included in the Doppler stations.

At present the trigonometric surveys of lower orders are mostly concentrated in the areas where cadastral surveys are planned. Under the programme to establish lower-order control points, the progress made before and since the conference at Bangkok in 1977 is as follows:

(*a*) Before 1977: 32,847 trigonometric control points in seven years;

(*b*) After 1977: 14,257 trigonometric control points in three years.

Two first-order bench-marks were established at two places, one at Birgunj (84° 51′ 07″ E, 27° 01′ 22″ N) and the other at Bhairhawa (83° 27′ 10″ E, 27° 30′ 22″ N) near the Nepal-India border, by the Survey of India in 1975. Based on these MSL datum stations 800 km of first-order levelling traverse has already been completed along the highways that run between Birgunj and Kathmandu and between Kathmandu and Bhairhawa. The bench-marks are established at intervals of 1 km. At present the precise levelling is continuing along the eastern section of the east-west highway of Nepal. To meet the demand for lower-accuracy level points for the various development projects, this division is planning to run a lower-accuracy levelling line in the near future.

Under the astronomical survey plan and programme, seven Laplace stations were observed and established in 1976 along with 14 azimuth stations with the help of the Geodetic Office of Czechoslovakia in order to tie the first-order triangulation network. The division responsible for this kind of survey is at Nagarkot, where the Geodetic Observatory of Nepal is situated. It is about 35 km from Kathmandu at an altitude of 2,166 m.

Cadastral Survey Branch

The cadastral survey has had a long history in Nepal. For fiscal purposes particularly, surveys of cultivated lands have been made from time to time under the direction of the Army. Forty years ago the Military Survey unit was enlarged by the addition of civilians who were trained in cadastral work. Since then, the survey has been carried out by plane table, using a simple sight rule, chain and trough compass. Gradually, in addition to the cultivated areas, measuring and mapping of other areas, such as residential areas, towns etc., have been started together with the preparation of land registers based on cadastral maps. The cadastral surveys were not based on permanently marked points connected to a national triangulation system until 1970. In the past nine years, improved methods of land measurement and documentation have been introduced. At present, all cadastral surveys in Nepal are based on permanently marked trigonometric controls.

Method

The Kingdom of Nepal does not wish to have an expensive survey, nor does it wish to waste its large, inexpensive, labour force. In many cases dual ownership of agricultural land by landowner and tenant farmer still exists. The average size of the ownership parcel is less than a hectare. The boundaries of parcels are not marked. Therefore in the context of the conditions in Nepal, the method of ground survey has been adopted. The present method of cadastral survey is also a graphical one. It is carried out by plane table using telescopic alidade. The scale of plan varies between 1:1,250 and 1:2,500, according to the size of the parcel. Land parcels are demarcated on the basis of tenant where there are tenancy rights. The identification and listing of the tenants are done by the Department of Land Reform under the provisions of the Land Act, 1964. Under the Land (Survey and Measurement) Act, 1963, it is the duty of the cadastral survey field party to identify and survey the tenants' and landowners' plots, classify the lands, identify the owners and prepare registers of owners and certificates of ownership.

Though the cadastral survey programme is now concentrated in the agricultural areas, cadastral survey of Kathmandu has been carried out since 1976. The method introduced in this town survey is ground survey using plane table and steel tape. The scale of plan (map) varies between 1:500 and 1:1,250 depending on land values. As far as the plan of the building is concerned, only the ground floor plan is prepared and ownership is so registered. But for information, multiple rights of different extents on different floors of the building are measured and recorded in the field book. On the basis of this, certificates are issued as a security to right of property.

Land register

The records of cadastral survey start in the surveyor's field book. There is a very close relation between the field book and cadastral plan, as the field book contains the names of the landowners and tenants, and other descriptions of the parcels of land. Field books are treated as legal documents. On the basis of information derived from the field book, land ownership rights are prepared. Each landowner is given a separate form and the different plots he owns in each panchayat area are listed under his name. The land ownership register forms are arranged by panchayat in alphabetical order. The panchayat is the village-level administrative unit in Nepal. These registers are in loose-leaf form. The certificates of registration are filled in by copying the registers and they are distributed to the landowners. The issue of the certificate serves as a notice of the cadastral survey decision. Any landowner or tenant who disagrees with the decision contained in his certificate of registration is referred to the district revenue offices where the land dealings are recorded. The deeds registration system is replaced by a land registration system where the cadastral survey is completed.

Plan and progress

It is planned to complete the 75 districts of the Kingdom by 1987. Of these, cadastral surveys of 41 districts have so far been completed and land register prepared. Thus a total of 2,656,429 ha of land has been covered by cadastral survey in the past 15 years, of which 1,829,561 ha are cultivated land. Up to the last conference at Bangkok, 32 districts had been covered by this survey and during the past three years, nine more districts have been covered.

Maintenance of records

On completion of the cadastral survey of a district, the land registers are submitted to the district revenue office which is also responsible for land administration. A maintenance survey unit is attached to this office in order to assist it on matters dealing with the survey, whereas the cadastral plan and field book are kept in the survey unit. When any change or transfer of land occurs the information is furnished to the unit by the revenue office and is accordingly corrected on the corresponding plan and up-dated. The survey unit consists of one survey inspector and 5-8 *amis* (surveyors).

Cost

The average cost of the current general cadastral survey registration and land classification work is of the order of $15 per ha. This also includes the cost of the departmental headquarters training and trigonometric survey. All the costs are born by His Majesty's Government. The landowner and the tenant do not have to share the costs of the survey.

Topographic Survey Branch

Establishment

Maps at various scales are essential for scientific and all-round development of the country. In order to meet these requirements, the Topographic Survey Branch was established in 1975 with United Nations Development Programme assistance for major equipment, expert services and training of national staff.

Past mapping activities

The mapping and topographic survey activities were carried out in a piecemeal manner. Complete map coverage of the whole country for planning and administrative purposes was not available.

In order to obtain modern basic medium-scale topographic map coverage of Nepal, arrangements were made in the 1950s under the Colombo Plan for the Survey of India to undertake the survey and publication at scale of 1:63,360 (1 inch = 1 mile) topographic maps of the country. The field work was completed 20 years ago. Up to the present 95 per cent of the map sheets have been received. Revision of these maps is badly needed where development activities have accelerated over the past 20 years.

Thematic maps, like forest maps, soil maps etc., have been compiled by the respective departments of the Government. However, complete coverage of the whole country does not exist. A national economic atlas has been compiled recently reflecting the economic activities of the Kingdom.

Activities

The Topographic Survey Branch has the following divisions and at present their activities are limited to training and some production:

Field Survey Division. This division is equipped with five electronic distance-measuring instruments, theodolites, levels, tacheometers, alidades etc., to carry out geodetic control point extension to survey areas and "post pointing" photo control work, field annotation and completion of internal boundary delineation and collection of place names.

Photogrammetric Division. This division is equipped with an aerial photographic processing laboratory, automatic processor, two contact printers, one rectifier (E4), one PG3 stereoplotter for aerial triangulation, nine stereoplotters, including four that have recently been purchased, and other minor instruments and accessories to provide the required aerial photographs for the various development projects, to carry out semi-analytical aerial triangulation with planimetric strip adjustment using the computer of the national computer centre, and to carry out photo revision of existing topographic base maps.

Computation and Records Division. This small division is equipped with co-ordinatographs, a programmable calculator and other measuring tools to check field observations, measure areas and lengths, and publish and record information.

Cartographic Division. This division is equipped with various drafting and scribing tools, one pantograph and diaz copy machine to compile small-scale, political and thematic maps, draft medium- and large-scale topographic maps, analyse place names, draft land resources maps, supply intermediate products (diazo prints) and assist in drafting atlases and other thematic maps.

Map Reproduction Division. This division is equipped with one process camera, contact printers, one colour offset press, one gelatine paper cutter and other plate-making equipment to carry out process and contact photography and to print maps prepared in the Branch as well as in other government departments.

Present activities

Most of the major equipment was only recently installed. Modern techniques of compilation and drafting and precise photography were introduced. As the developmental project urgently requires maps on short notice, the Branch is doing its best to fulfil these requirements in time though the maps produced are not technically of the best standard. The Branch is also doing its best to improve map quality by introducing modern techniques and instruments.

Map compilation

To meet the demand for administrative maps of the country, the following provisional maps have been compiled in Devanagari script, and large- and small-scale maps have been compiled either in Devanagari or Roman script according to the needs of the development projects:

1:2,000,000 map of Nepal	1 sheet
1:125,000 district maps	42 sheets
1:2,500-1:15,000 project maps	54,000 ha
Photo maps and other special maps	7 sheets

Photo revision of map sheets has been carried out on 1:50,000 enlarged sheets. The field work for a new 1:50,000 topographic series is in progress.

Aerial photography

Aerial photography work at scale 1:50,000 of the lower part of Nepal, i.e., below 15,000 feet, was carried out during the photographic seasons of 1978 and 1979, using Wild RC 10 with wide- and superwide-angle lens.

Aerial photography at the scale of 1:20,000 was also carried out during that period using precision mapping cameras mainly with 6" lenses.

The aerial photographic coverage index map is attached (figure 28).

These photographs are available for use in all development projects.

Satellite imagery

Satellite imageries, both colour and black and white, are extensively used in inventory surveys.

The Topographic Survey Branch is using these imageries to revise drainage patterns and extent of forest in the flat lowlands of which recent aerial photography is not available. Recently the Branch has been experimenting with superimposing satellite imagery as background hill shading on small-scale maps, especially those at 1:2,000,000 scale.

Geographical names and equivalent terminology

Important geographical names are standardized, and names collected on the spot during the field survey have been verified by local authorities.

A provisional equivalent terminology of common surveying words has been compiled. The transliteration of geographical names has been carried out very much as recommended by the United Nations conference, with a few modifications to make it easier for general users.

Land resources mapping

The compilation of the land resources maps of western Nepal, the far western region below 15,000 ft, started after the completion of 1:50,000 and 1:20,000 scales of aerial photography. The following maps will be available to plan land use policies for that region.

Climatological maps	4-5 sheets at a scale of 1:250,000
Land use maps	80 sheets at a scale of 1:50,000
	21 sheets at a scale of 1:125,000
Photogeological maps	21 sheets at a scale of 1:125,000
Land system maps	21 sheets at a scale of 1:125,000
Land capability maps	21 sheets at a scale of 1:125,000

These works are planned to be completed during 1982.

Natural hazard maps

Sample sheets of natural hazard maps are being prepared with the assistance of the United Nations University.

Problems of present mapping

(*a*) Difficult terrain. Despite the extreme climate and variation in altitude in very short distances, persons can adjust to the situation, but it is difficult to get instruments that are sufficiently versatile;

(*b*) Training. In a developing country with a developing economy and technology, it is extremely difficult to train persons for multidisciplinary work such as land resource mapping;

(*c*) The demand for maps for planning and project implementation is so far beyond the planned programmes that it is almost impossible to meet. Frequently maps are needed so urgently that mapping has to be carried out at the sacrifice of some standard procedure.

Future programmes

1. Large-scale maps (up to 1:25,000 scale) of certain areas of Nepal will be produced according to the development and planning requirements of that area.
2. The old 1 inch = 1 mile maps will be blown up to 1:50,000 and revised and printed as interim products.
3. The whole country will be covered by 1:50,000-scale maps.
4. Small-scale maps will be compiled from the standard 1:50,000-scale maps and will be produced at the scales of 1:125,000, 1:250,000, 1:500,000, 1:1,000,000 and 1:2,000,000.
5. Land resources mapping and other types of thematic maps will be produced as required.

Survey education and training

The Survey Department, with the objective of producing skilled and medium-grade survey technical manpower, established a Survey Training Centre in 1968 within its framework. At present, the Centre holds three courses, namely, Recruit (*amin*) Course, Junior Survey Course and Senior Survey Course. For training at the technical and professional levels in the various branches of surveying, Nepalese students are sent abroad.

The Recruit (*amin*) Course covers all that a field surveyor or cadastral survey team should know. This is an eight-month course which is scheduled twice a year from 1 November to 30 June and from 15 July to 14 March. Eighty to ninety trainees take this course, the entrance qualifications for which are class X completed, with mathematics.

In the Junior Survey Course trainees are taught minor triangulation, tertiary traversing and levelling, chain surveying, large- and medium-scale plane table surveying, contouring and draughtsmanship. The entrance qualifications for this course are Intermediate Science or completed equivalent examination with mathematics, or completed Recruit Course and five years' service in a survey organization. It is a full one-year course scheduled once a year from 1 November to 31 October. About sixty trainees are admitted to this course every year.

In the Senior Survey Course, the trainees are given training in various branches of survey, namely, triangulation, traversing, levelling, medium- and small-scale plane table survey, field astronomy, triangulation computation etc. The prerequisites for this training course are completed Bachelor of Science (B.Sc.) with mathematics. About 14 trainees take this course, which is a one-year course, from 1 November to 31 October.

In addition to the above course, four other specific courses on cartography, photogrammetry, map reproduction and trigonometric survey have recently been designed under the existing survey training course. These are three- to six-month courses. It is expected that the new courses will start at the end of this year. These courses are considered to be extremely valuable to the topographic and geodetic projects in Nepal.

Conclusion

As regards funds and equipment, the Survey Department has just enough to meet the requirements to carry out the cartographic activities under its responsibility, except for the gravity survey (see above). But there is still an acute shortage of medium-grade manpower such as photogrammetric operators and lithographers for the Map Reproduction Section in the Topographic Survey Project. Hence, fellowships for such courses from friendly countries would be very much appreciated. The present organization of the Survey Training Centre in Nepal is not adequate to undertake the operators' and lithographers' courses.

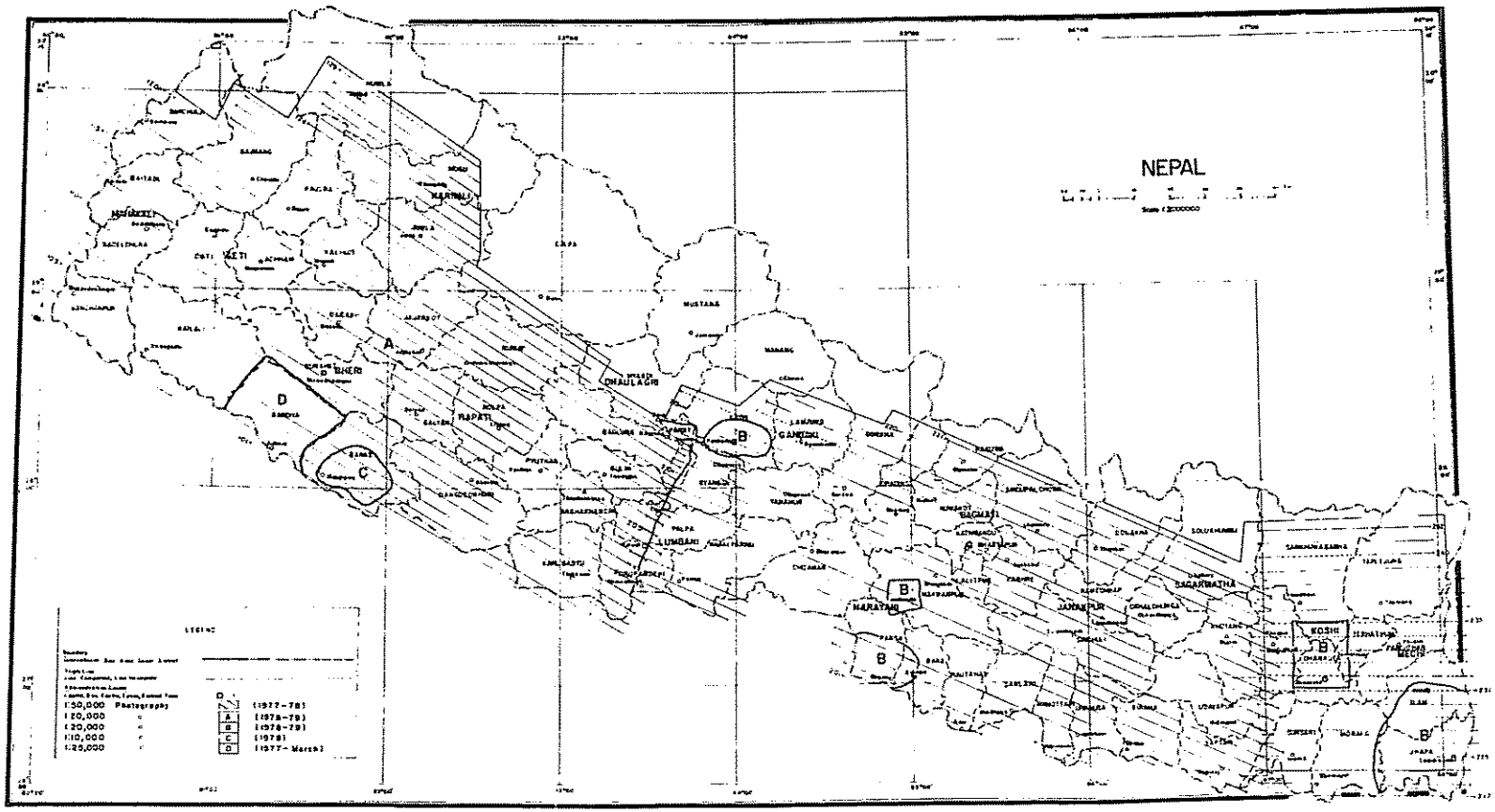


Figure 28. Nepal: air photo coverage at scale 1:2,000,000

REPORT ON CARTOGRAPHIC ACTIVITIES IN NEW ZEALAND*

Paper presented by New Zealand

RÉSUMÉ

Le rapport de la Nouvelle-Zélande résume les activités cartographiques entreprises dans le pays au cours des quatre dernières années par le Department of Lands and Survey (Département des affaires foncières et des levés), le Service forestier, le Service hydrographique et le Département de la recherche scientifique et industrielle.

Il rend compte d'activités relatives à l'établissement de canevas géodésiques, à l'établissement et à l'enregistrement de relevés cadastraux, à l'établissement de cartes topographiques, aux observations par satellites, à la photographie aérienne, à la télédétection et à l'établissement de cartes hydrographiques, scientifiques, administratives et aéronautiques.

This report records progress and developments in New Zealand since 1977.

I. Cartographic activities of Department of Lands and Survey

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

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

Triangulation, urban and rural control surveys, including precise levelling and selected earth deformation surveys;

Topographical mapping for engineering purposes as well as for basic mapping;

Aerial photography with emphasis on regular coverage and the national index;

Aeronautical charting;

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 Head Office are three branches providing specialized services in photogrammetry, cartography and computing, and also map depot and distribution centre, photo laboratory and technical workshop. In addition, Lands and Survey cartographic staff are seconded to the Department of Scientific and Industrial Research, the organization responsible for the preparation and publication of geological, geophysical, oceanographic and soil survey maps, as detailed in part IV.

Mapping work related to forestry and forest management in New Zealand is undertaken by the New Zealand Forest Service, as detailed in part II of this report, while hydrographic surveys and hydrographic charting are carried out by the Hydrographic Office of the Royal New Zealand Navy, as detailed in part III.

Most of the 14,000 plans added each year to the land survey records of the Department of Lands and Survey are produced by private practising surveyors who undertake work for the State as well as for private land holders.

The land survey system

The conduct of cadastral surveys in New Zealand is defined and governed by the Survey Regulations which are regularly reviewed and updated to meet the changing needs of the land survey system. A two-plan system (survey and title) operates satisfactorily and all plans are available on microfilm either as prints or copycards. The introduction of copying machines using non-sensitized paper has offered big savings in overseas funds. To meet the increasing use of computers and EDM equipment regulatory standards are continually under investigation. All new survey data approved is automatically recorded on record sheets which form the basis for the publication of cadastral maps.

Triangulation and control surveys

The development and introduction of new distance-measuring equipment has led to alternative methods of establishing survey control with greater reliability, increased speed and improved economy.

The extension and densification of trig control in areas devoid of reliable modern triangulation continues and although there has been a slowdown in urban development the opportunity is being taken to extend and upgrade both urban and rural control in anticipation of increased activity.

The need for accurate height control continues and the precise levelling programme has been given priority in areas of national importance and has been co-ordinated with projects related to crustal movement determinations. Improved instrumentation and methods developed in conjunction with the earth deformation studies programme has seen a marked improvement in progress towards the determination of a precise datum for New Zealand.

Under the Earth Deformation Studies programme developed by the New Zealand Royal Society and undertaken in conjunction with the Department of Scientific and Industrial Research, the Department of Lands and Survey has been responsible for establishing a series of narrow belts of first-order triangulation patterns and the measurement of a series of precise-level circuits or routes across the country. To date, four cross-country belts of first-order triangulation have been completed between Gisborne and Raglan, Dunedin and Te Anau, Christchurch and Hokitika, and Auckland and Coromandel. A further local pattern of high-order measurement and observation has been

*The original text of this paper, prepared by the Department of Lands and Survey, appeared as document E/CONF.72/L.8.

completed over the Hawkes Bay area, the scene of a major earthquake in 1931. Reconnaissance is well advanced for a further route between Castle Point and New Plymouth early in 1980 with two further projects planned for completion by 1983. This will complete the first measurement, and from 1986 monitoring of all networks on a 10-year cycle will commence.

Five precise levelling circuits over the volcanic plateau of the North Island have been completed in addition to one coast-to-coast route between Castle Point and New Plymouth. The North Island has now been covered with bases on which to monitor further movement. One major route in the South Island between Dunedin and Haast will be completed by 1980 and a further route between Christchurch and Westport is at present being reconnoitred and blocked.

The availability of satellite position-fixing equipment on a loan basis in New Zealand has resulted in 15 stations being occupied with a further four in the Chatham Islands. In general the pattern complies with the IUGG Commission's 10 requirements of stations approximately 200-km apart. The work was done in conjunction with a United States GEOS team stationed in New Zealand and by courtesy of the agents for Magnavox Limited who made their MX1502 equipment available.

The recent purchase of an astronomical theodolite and accessories will enhance the capability of the Department to undertake more precision work.

DETAILS OF SURVEY CONTROL FOR THE YEAR ENDING 31 MARCH

	1977	1978	1979
Triangulation (km²)	47 784	13 620	19 724
Rural control traverse (km)	595	600	636
Urban control traverse (km)	371	270	370
Precise levelling (km)	739	930	907

Basic mapping

Metric mapping specifications for an integrated series of topographical maps and cadastral records designed to upgrade existing maps to standards adequate to meet the needs of the future have been prepared. The scales selected for the maps are 1:250,000; 1:50,000 and 1:10,000 with contour intervals of 20 m for the 1:50,000 and 5 m for the 1:10,000 series. The 1:50,000 map sheets cover an area 30 km × 40 km and are bled to the edge north and east.

The new maps are patterned on the New Zealand Map Grid which enables the maps of both the North and South Islands to be compiled on a single projection and co-ordinate system. Some 80,000 km² of new photogrammetric mapping has been completed at 1:25,000 scale and fair drawings have been completed for maps at both 1:50,000 and 1:250,000 scales. Sixteen sheets have been printed and published.

Engineering mapping

Most project mapping requirements for all government agencies are now produced by photogrammetric methods. Scales range from 1:500 to 1:10,000. Since the last report in 1976, the special emphasis on hydroelectric investigation and irrigation schemes has continued. To aid the programme, a block adjustment programme and orthophoto equipment has been installed and is in use.

Cadastral maps

New Zealand with full cadastral map coverage has found value in having a counterpart cadastral map to match the one mile to an inch topographical map. This principle is continued with the metric 1:50,000 and 1:10,000 series.

In the former series 287 sheets of the 312 sheets covering the country have been published and the remaining sheets are to be printed by 1980.

The 1:10,000 record map and its breakdown in urban areas to 1:2,000 and 1:1,000 scales are available as up-to-date plan prints. Line drawing data only are also available for these maps.

Aerial photography

The Department of Lands and Survey handles and co-ordinates aerial photography for all government needs and, with full coverage achieved, the objective in recent years has been to re-cover rural areas at least every 10 years and some 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 government departments and public bodies. Combined records are kept of Crown copyright and private copyright photography. Photography scale for basic mapping is 1:50,000, for resource and interpretation photography, 1:50,000 and 1:25,000, and for urban areas, 1:10,000.

Remote sensing

Investigations are continuing on the application of remote-sensing techniques utilizing both aircraft and satellite-borne sensing systems.

LANDSAT imagery is being used within the mapping organization, as an aid to relief shading, to assist definition of vegetation boundaries, shapes of hydroelectric storage lakes and canals, to locate offshore islands and reefs, and as base material for reconnaissance mapping in Antarctica.

Research (in conjunction with the Department of Scientific and Industrial Research) is in progress into land use mapping, within New Zealand, from satellite imagery. The Department of Lands and Survey is also the distribution agency within New Zealand for all LANDSAT products, prints, transparencies and slides.

Aeronautical charts

All approach and landing charts are now produced in an A5 size flip format. Separate publications are produced and maintained on a monthly basis for Instrument, Visual and South Pacific Flight Guides, as well as a Flight Guide for RNZAF. The large amount of joint civil/military charting has continued.

Visual terminal and visual en-route charts at 1:250,000, 1:500,000 and 1:1,000,000 scales have been revised at eight-month intervals. Radio navigation and terminal charts have been revised at four-month intervals. Plotting charts at scales of 1:1,000,000 (New Zealand) and 1:3,000,000 (Pacific) have been redrawn, and 1:6,000,000 (Pacific) revised.

A new series of aeronautical charts covering New Zealand at 1:250,000 scale is in preparation.

General-purpose and special maps

During the period the programme of mapping in the South-west Pacific has progressed with the mapping of a number of islands completed. The final drawings of a number of these are in preparation and some maps have been printed.

A map defining the Exclusive Economic Zone of New Zealand has been published.

A new 1:1,000,000 topographical map is being drawn to IMW specifications and will be metric when published. Also a 1:2,000,000 map is in preparation and the 1:4,000,000 is already published.

The Atlas of the South Pacific was published in 1979 mainly for government use but is also available to any user.

A major change has been made to the street map specifications and the production methods have been simplified. The ongoing programme of redrawing, based on the New Zealand Map Grid, is carried out with the change to new specifications.

To meet the demand for scientific mapping some special maps have been prepared by enlarging the existing topographical map (1:63,360) to 1:50,000 and adapting this to the New Zealand Map Grid.

Resource mapping

The New Zealand Land Inventory at the scale 1:100,000 is progressing in priority areas throughout the country. Surveys are now carried out on standardized sheet lines, based on the 1:50,000 Topographic Series sheet layout.

Redesigned mapping specifications and input data have been largely derived from experiences gained in preparing the King Country Land Use Study, where six basic data themes and five suitability transparent overlays were produced for each of the three sheets covering the region.

New Zealand Land Inventory priority areas are: Northland area, 11 sheets, to be mapped in five basic themes, and the Upper Waitaki-Mackenzie basin, five sheets mapped in three basic data themes plus suitability overlays.

II. New Zealand Forest Service Cartographic Activities

Mapping activities are primarily restricted to providing a wide range of services for departmental administrative, planning, scientific and publicity purposes.

Department of Lands and Survey maps are utilized as the base for Forest Service publications wherever possible.

One map series, Forest Parks, is compiled jointly by agreement by both the Department of Lands and Survey and the Forest Service while all other map series are compiled variously in seven Conservancy Offices, the Forest Research Institute and Head Office.

Basic mapping

Basic topographical stereoplots at a scale of 1:10,000 are produced by the Department of Lands and Survey from survey control established by either Forest Service or Lands and Survey Department survey staff. Final map compilation is carried out in Conservancy Offices and these maps form the basis for most departmental map records. Updating of these basic map records is carried out using three photogrammetric plotting instruments operated within the Department.

Aerial photography

Vertical aerial photography is now used in practically every aspect of forest planning, and for many purposes the use of 70-mm cameras is more suitable and economic than the larger focal-length cameras normally associated with photogrammetric mapping.

This 70-mm photography is acquired on a regional basis using hired aircraft of the Cessna 172 single-engine type and departmental camera operators and navigators.

Remote sensing

The Forest Service is currently evaluating the use of LANDSAT imagery and computer-compatible tapes to map indigenous forest areas in the central North Island.

While no firm conclusions have been reached, the work already done is promising and the indications are that LANDSAT imagery could be used to map indigenous forest resources on a national basis.

Model making

The use of scale dimension 3D topographical models of forest areas in forest planning and development has proved valuable and demand for these models is increasing.

The models, which are made of layers of polystyrene patterned off basic topographical stereoplots are generally produced at scales between 1:25,000-1:50,000. At our present state of the art the production of these models is very labour-intensive but investigations are being carried out to see if it is possible to develop equipment to speed up production. Development work also includes studies to produce moulds from these models so duplicate copies can be produced.

Scientific mapping

Fifteen of the 27 sheets of the 1:250,000 Forest Class map series have now been printed but six of these cannot be issued until the explanatory notes which accompany them are available.

In addition to this series a considerable number of maps, graphs and diagrams are produced to illustrate scientific reports and bulletins published by the Forest Research Institute.

Administrative maps

Conservancy maps at scale 1:250,000 illustrating cadastral information continue to be revised and there is now good coverage except for the south-west of the South Island and Stewart Island.

The Forests of New Zealand map at scale 1:2,000,000 has been published and the 1:1,000,000 version is almost ready for printing.

The 1:2,000,000 is used as a base for overprinting planning districts.

Work continues on communications maps in selected areas.

Public information maps

The first NZMS 274 Forest Park map has been published and a second is awaiting printing.

Illustrative mapping for public information brochures on state forests has an important role and a special set to illustrate a high-quality publication describing forest parks is in preparation.

III. Hydrographic Activities

The Hydrographic Office of the Royal New Zealand Navy is responsible for:

Hydrographic surveys of New Zealand coastal waters and adjacent ocean areas;

Preparation and publication of navigational charts;

Collection and publication of random sounding data from international sources for a large part of the South Pacific Ocean as part of the International Hydrographic Organization, General Bathymetric Chart of the Oceans;

Production of international charts for areas of the South Pacific Ocean;

Issue of Weekly Notices to Mariners and promulgation of Long-range Navigational Warnings (NAVAREA 14);

Distribution of New Zealand Charts throughout the world and British Admiralty and Australian Charts on an agency basis;

Maintenance of national hydrographic and tidal archives;

Records and preparation of definitive charts showing base lines, territorial waters, fishing zones and exclusive economic zones. Publication of charts illustrating territorial sea and fishing zones, exclusive economic zones of New Zealand, Niue, Cook Islands and Tokelau.

The major survey unit is HMNZS Monowai (3,200 tons displacement). This vessel has the full range of coastal and ocean-surveying equipment, with automated data logging, plotting facilities and the capacity for collection of selected geophysical data. Since arrival in New Zealand waters in 1978, Monowai's main task has been a large resurvey of the Approaches to Whangarei to Bay of Plenty, in addition to which she has undertaken various other tasks on the west coast of the South Island, in the Foveaux Strait and the South-west Pacific. Two aged 72-ft survey motor launches have been replaced by two new-construction 85-ft inshore survey craft. Built in New Zealand, they incorporate modern concepts of electronic position-fixing systems and are to be employed on coastal surveys within New Zealand waters. Thus, within a space of two years, the hydrographic service, RNZN, has completely replaced and modernized its seagoing fleet.

In the three-year period since 1976, the Hydrographic Office has published 22 new charts and new editions and revised and reprinted 107 charts. Metrication of fathoms charts has progressed, six charts having been converted to metric units.

Seven British Admiralty charts have been withdrawn in favour of modern New Zealand charts.

Production of a new series of charts on a scale of 1:1,250,000 covering the New Zealand Exclusive Economic Zone has been started and four have been published. The acquisition of ocean-sounding data continues and they have largely formed the basis for the compilation of this series.

A correction service is maintained to ensure that all charts are corrected from Notices to Mariners up to the date of issue.

A modern silk-screen printing machine has been installed to improve the efficiency and economy of this service. Charting and Notices to Mariners are co-ordinated with the United Kingdom and Australia to maintain integrated world cover. Cartography is in accordance with the requirements of this arrangement and generally in agreement with International Hydrographic Organization resolutions. Progress is being made towards the adoption of an international set of chart specifications for all chart scales.

Reproduction material is supplied to the United Kingdom Hydrographic Department in terms of the Charting Arrangement and internationally for those charts produced under the small-scale international chart scheme.

IV. Department of Scientific and Industrial Research

The Cartographic Group within the Science Information Division has a staff of 25 to 30 including a cartographer in each of the three main divisions for whom mapping work is carried out.

Output can be divided into two main groupings: large dimension, usually multicolour soil, geological, oceanographic and geophysical maps and charts, and small maps, graphs and associated diagrams which form part of scientific articles in DSIR publications. Since 1977 the most significant factors have been the rapidly accelerating demand for a greater volume of work in the "publication" category and the adoption of improved screening and general draughting techniques to increase overall efficiency.

Soil mapping

Approximately 25 multicolour soil maps have been produced over the past three years on mainly imperial scales of 1, 2 or 4 inches to 1 mile. A roundly equal number have covered county areas and areas of special interest (i.e., geographical areas such as valleys etc.) while a smaller number have covered city areas in considerable detail. Present production reflects a change to mainly metric scales and a broadening interest in the Pacific Region (soil mapping of the Cook Islands is at present nearing completion).

Future concentration will be on basic soil maps of arable lands at 1:50,000 or larger, accompanied by interpretative maps derived from basic soil maps and displaying suitability of soils for a variety of uses. A soil map series at 1:250,000 is under revision.

Geological mapping

Approximately 32 multicolour geological maps have been produced since 1977. The majority of these are at 1 inch to 1 mile scale and are on the standard NZMS 1 topographical series as their base although the sheetlines vary to cover areas of interest. These are extremely detailed maps representing a great proportion of total DSIR cartographic effort. A smaller number of tectonic maps have been produced and approximately 10 maps

of a miscellaneous nature, i.e., industrial, coalfields, small scale covering New Zealand etc.

During the period a considerable number of the 1:250,000 and 1 inch to 1 mile geological maps have been reprinted.

A great deal of cartographic effort is involved in the provision of the best possible field sheets from enlarged photogrammetric plots and other sources.

The future research programme includes production of geological map cover at 1:50,000 scale and 1:250,000 scale as work progresses. Also, Late Quaternary Tectonic maps at 1:50,000 and many individual miscellaneous project maps.

Oceanographic charting

Bathymetric and sediment charts of the seas around New Zealand from a scientific rather than hydrographic, navigational aspect are produced. There are two major bathymetric series: coastal maps at 1:200,000 scale right around New Zealand and an oceanic series for the South-west Pacific at 1:1,000,000; also, a 1:200,000 Island Series dealing with offshore islands in the New Zealand-Pacific-Antarctic Region. Sediment charts are produced at similar scales.

A miscellaneous series includes detailed harbour and field bathymetry of features at appropriate scales, mineral deposits in the South-west Pacific (1:25,000,000), sea-floor temperatures and salinity distributions (1:6,000,000), and charts of primary productivity, currents and water movements and sea-floor tectonics.

Marine surveying expertise has been used to produce a lake series of bathymetry charts at scales from 1:2,168 to 1:63,360 depending on lake size.

Geophysical mapping

The basic mapping scale is 1:250,000 showing gravity anomalies over the New Zealand landmass and magnetic total force anomalies. These are also mapped at 1:1,000,000 and a 1:1,000,000 Mercator oceanic series covers these phenomena for the surrounding sea area.

Various miscellaneous maps are produced (for example, magnetic field of the earth and seismicity). A 1:250,000 geothermal series and an electrical resistivity series are planned. Computer assistance is an important and developing facet in this area.

Aerial photography and remote sensing

Aerial photographic plotting, in addition to normally available photogrammetric products, has been used for various surveys. Some of this has been in mosaic form while more recently orthophotography has been used to provide a rectified photographic base for field work on a detailed soil survey. Some lake series charts have a photomap base.

Little direct cartographic use has so far been made of available LANDSAT imagery: this is an area which should receive closer examination in the near future.

Publication maps and diagrams

The cartographers work very closely with scientific authors and editors to produce an extremely wide range of scientific maps and diagrams for various journals, bulletins and other DSIR publications, as well as for overseas publications. The annual throughput is in the order of 2,500 figures. A 20" x 24" camera and full darkroom screening and processing facilities assist not only with this work but also in the pre-plate processing of the larger maps.

COUNTRY REPORT*

Paper presented by the Philippines

RÉSUMÉ

Le rapport sur les activités menées aux Philippines dans diverses disciplines de la cartographie couvre la période allant de 1977 à 1980 (depuis la huitième Conférence, tenue en janvier 1977). Au cours de cette période, les Philippines se sont lancées dans un vaste programme de développement industriel et commercial ainsi que dans la mise en place d'infrastructures importantes. Cette activité de développement à grande échelle a créé un besoin accru de cartes en tant qu'outils de planification et d'élaboration des politiques. Cette demande à son tour a nécessité d'importantes activités topographiques et cartographiques, dont le rapport intérimaire du pays fait état à propos de diverses disciplines de la cartographie.

This report on Philippine activities in various disciplines of cartography covers the period from 1977 to 1980, since the Eighth United Nations Conference in January 1977. During this period, the Philippines has entered into an extensive programme of industrial and commercial development as well as the building of major infrastructures. This extensive developmental activity resulted in an increased demand for charts and maps as tools for planning and policy-making. This, in turn, necessitated major surveying and mapping activities which are reflected in the progress report of the country in the various disciplines of cartography.

*The original text of this paper appeared as document E/CONF. 72/L.110.

GEODESY

Even before the Eighth United Nations Cartographic Conference, the Philippines had already prepared a geodetic control scheme aimed at strengthening the second-order triangulation then existing in the country. Since then, the scheme has been modified several times in the light of recent advances in instrumentation and technique. The latest change reflected observation of several principal stations using Geoceiver Doppler satellite observations. The Philippines was fortunate to acquire a JMR Doppler instrument. During the period, some 25 stations have been observed on the Philippine geodetic control network. The computation of these stations at the Defense Mapping Agency in the United States, using the Precise Ephemeris, has recently been completed. Additional geodetic control observations are still in progress especially in the north-eastern part of the country and in the Visayan area. It may be interesting to know that the report on the progress of the Philippine JMR satellite observations has been included in the report of the Sub-Commission on Satellite Geodesy of the International Association of Geodesy.

On vertical control, extensive mapping projects always require vertical control observations. The Bureau of Coast and Geodetic Survey in the Philippines carried out first-order levelling with 430 bench-marks established throughout the major islands of the archipelago. Some 209 bench-marks of second-order and 692 of third-order were also established. The lower-order control stations were mostly for mapping purposes.

GEOMAGNETISM

During the period under review the Magnetic Observatory at Muntinlupa, Rizal, was continuously operated for the observation of the magnetic elements: horizontal intensity, vertical intensity and declination. The results of these observations as well as the computation of indices have been furnished to the World Data Centres in the United States and the Soviet Union, to the Danish Meteorological Institute and to some other places upon request.

In addition to these observations at Muntinlupa, geomagnetic observations have been conducted at several places on the Island of Luzon with the intention of publishing an isogonic chart for the epoch 1980. These observations are ongoing at the end of the period.

TOPOGRAPHIC MAPPING

It is in the area of topographic mapping that tremendous activity has been centred. Among this activity was the completion of the topographic maps of the Bicol River Basin at the scale of 1:4,000 for some 128,000 ha on the Island of Luzon, consisting of more than 300 map sheets. These large-scale maps are now used extensively in integrated development feasibility studies in the region.

During the period under review, large-scale topographic maps of the Laguna Lake area, approximately 30 km south-east of Manila, were also compiled at the scale of 1:4,000. The area covers 60,000 ha and consists of 164 map sheets. These maps are now also used for integrated development of the area.

Early in 1979, the preparation of topographic maps on the scale of 1:25,000 for western Pangasinan, western Philippines, was started. The aerial photography was on the scales of 1:28,000 and 1:15,000. It was also during this period that an extensive mapping project in the Cagayan Valley in the northern Philippines was started with the co-operation of the Japanese Government. The aim of this project is the preparation of topographic maps on the scale of 1:25,000 with new photography at the scale of 1:28,000. Approximately 15,000 km^2 of the area will be covered in this new mapping project. It may be interesting to know that orthophoto maps are being projected for some of the area under this programme. Several maps on the scale of 1:10,000 are now under preparation mostly for urban centres of population at selected places.

The progress in topographic mapping in the Philippines has been aided immensely by the acquisition of modern instruments by the principal mapping agency of the Philippines, the Bureau of Coast and Geodetic Survey. These instruments, consisting of stereoplotters, orthophoto instruments, rectifiers, cameras etc., were acquired through a United Nations Development Programme-assisted project aimed at strengthening the mapping capability of the country.

CADASTRAL SURVEYS-LAND INFORMATION SYSTEMS

Cadastral surveys in the Philippines are executed primarily under the Bureau of Lands. During the period under review, 273,592 cadastral surveys were conducted in the various provinces and municipalities of the country. Also issued during the period were 185,006 land titles. To hasten the distribution of small lots to the tenants, parcellary mapping has also been resorted to. This programme is under the management of the Ministry of Agrarian Reform and is aimed at the even distribution of public lands to as large a segment of the citizenry as possible.

HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING

In the field of hydrographic surveying and nautical charting, the Philippines published over 170 nautical charts consisting of general and sailing charts of small scale, coastal charts of medium scale and harbour charts of large scale. As an archipelagic nation the Philippines has extensive maritime areas and this is reflected in the large number of nautical charts issued for the safety of maritime navigation. During the period under review, extensive hydrographic/oceanographic surveys were carried out in important bays and harbours, the different waterways, and in the unsurveyed waters of the Kalayaan Group in the South China Sea. The updating and the publication of new editions of charts were also undertaken.

This, in brief, is a report on the progress in the Philippines in the various disciplines of cartography. The accomplishments are perhaps impressive. However, much more remains to be done. It is our hope that in the coming years this objective will be attained.

REPORT ON CARTOGRAPHIC ACTIVITIES IN SOLOMON ISLANDS*

Paper presented by Solomon Islands

RÉSUMÉ

Aux Iles Salomon, tous les levés de terrain sont effectués par la Division de topographie et de cartographie du Ministère de l'agriculture et des affaires foncières.

Les levés sont effectués avec un degré de précision du deuxième ordre, qui a été fixé par la Direction britannique des levés outre-mer (Directorate of Overseas Surveys) dans les années 60.

Une couverture au 1/50 000 de l'ensemble des îles, à l'exception des îles périphériques de Ontong Java, Rennell, Bellona et Sikaiana, a été établie par la Direction des levés outre-mer dans les années 60. Des cartes au 1/150 000 en ont été dérivées localement. La Division a également établi plus de 50 feuilles au 1/10 000 couvrant les zones qui présentent de l'intérêt du point de vue agricole. A l'heure actuelle, la Division révise la couverture cartographique au 1/2 500 de la capitale, Honiara, et établit des feuilles supplémentaires devant servir de base à l'aménagement urbain. L'établissement de cartes d'autres zones urbaines au 1/2 500 et à des échelles plus grandes est également en cours. Toutes les cartes sont imprimées au sein de la Division. Toutes les parcelles urbaines sont maintenant levées et tracées au 1/1 500, et 80 p. 100 environ des parcelles rurales ont également été rattachées au réseau national et restituées soit au 1/2 500, soit au 1/10 000.

GENERAL

All land surveying in Solomon Islands is carried out by the Survey and Mapping Division of the Ministry of Agriculture and Lands. At present there are no private land surveyors.

STAFF

The Division employs five professional surveyors and 13 assistant surveyors plus 26 cartographic draughtsmen and six reprographic staff. With the exception of the Chief Surveyor and his deputy, all staff are Solomon Islanders.

GEODETIC CONTROL

All survey work is based on second-order control fixed by the Directorate of Overseas Surveys in the 1960s. A number of Doppler fixes have been made by 512 Specialist Team, Royal Engineers and Australia's Directorate of Military Survey. It is hoped that an Australian team will return during 1980 to fix a series of stations through the whole island group, and subsequently readjust the whole control network.

TOPOGRAPHIC MAPPING

1:50,000 cover of the whole group with the exception of the outlying islands of Ontong Java, Rennell, Bellona and Sikaiana was produced by the Directorate of Overseas Surveys in the 1960s. Derived maps at 1:150,000 have been produced in house. The Division has also produced over 50 sheets at 1:10,000 scale covering areas of agricultural interest. Currently the Division is revising the 1:2,500 map cover of the capital, Honiara, and producing additional sheets as a basic for urban planning. Mapping of other urban areas at 1:2,500 and larger scales is also in hand. All maps are printed within the Division.

CADASTRAL SURVEYS AND MAPPING

Until the Directorate of Overseas Surveys control was made available in the 1960s cadastral surveys were necessarily piecemeal. A programme to bring them on to the National Grid and to produce a uniform series of Cadastral plans at appropriate scales commenced about 1968. As a result all urban parcels are now surveyed and drawn at 1:500, and an estimated 80 per cent of rural parcels have also been connected to the national grid and plotted at either 1:2,500 or 1:10,000. A proportion of the unconnected parcels is complete islands and cadastral mapping of these is not contemplated unless subdivision takes place.

EQUIPMENT

The Division has the normal range of theodolites and levels. We rely mainly on MRA 101 tellurometers for rural distance measurement, supplemented by the CA 1,000 tellurometer. For urban work steel-taping is still the main method, but we also employ one Aga geodimeter 12. As far as funds permit all surveyors are provided with Hewlett Packard 25 or 33 hand calculators, and an HP 9820 is used for final computations. During the next few years the Division expects to have access to a main-frame computer which is to be installed in the Ministry of Finance.

TRAINING

Technician training is obtained in Honiara where New Zealand runs a course for students from the South Pacific. Diploma and degree students attend the University of Technology at Lae, PNG. Present needs are for advanced technician training, especially on-the-job training.

*The original text of this paper appeared as document E/CONF. 72/L.114.

PROGRESS REPORT ON CARTOGRAPHIC ACTIVITIES IN SWITZERLAND*

Paper presented by Switzerland

RÉSUMÉ

La série de cartes nationales au 1/25 000, commencée en 1935, a été terminée en 1979. Le coût s'est élevé à 46 millions de francs suisses, et 3,8 millions d'heures y ont été consacrées.

La mise à jour de ces feuilles est faite tous les six ans et il faut compter environ deux ans depuis le début de prise de vue par clichés aériens jusqu'à la publication. Divers tests ont prouvé que les méthodes conventionnelles de prise de vue sont supérieures, et plus économiques que l'emploi d'orthophotographies pour la révision.

L'Atlas de la Suisse, qui contient 97 feuilles, vient d'être complété et un *Atlas climatique de la Suisse* est en élaboration.

Les mensurations cadastrales sont entreprises par des géomètres privés sous la surveillance des autorités cantonales et fédérales. Ces mensurations ont débuté en 1923 et devaient être terminées en 1976. En janvier 1979, le pourcentage complété était le suivant : mensuration de parcelle, 63,4 p. 100; mensuration d'origine, 93,5 p. 100; reproduction, 54,2 p. 100.

La Commission suisse de géodésie s'occupe des contrôles de la triangulation de premier ordre par trilatération, et de la détermination des points Laplace, de la géoïde, et du réseau gravimétrique au sein du réseau européen.

De nouvelles directives en accord avec la loi fédérale sur la planification territoriale ont été introduites et sont employées pour la planification urbaine, régionale et nationale. Diverses cartes—transports touristiques, climat et agriculture, structure thermale du pays et zones dangereuses—ont été publiées.

L'Ecole polytechnique fédérale à Zurich a accueilli une conférence en juillet 1979 concernant la technologie digitale de la production des cartes topographiques.

L'Ecole polytechnique de Lausanne, en coopération avec le Département fédéral de la recherche forestière, s'occupe d'analyser les images prévues pour l'inventaire national des forêts et une statistique des terrains productifs. L'interprétation conventionnelle de la photographie, soutenue par le traitement électronique des données, est considérée comme la méthode la plus appropriée.

L'Ecole suisse pour opérateurs photogrammètres a donné des cours de méthodes modernes d'acquisition digitale des données pour la triangulation aérienne et autres applications et d'application de la photogrammétrie à courte distance.

SWISS FEDERAL TOPOGRAPHIC SERVICE

The National Base Map Series on the scale of 1:25,000 was completed early in 1979 after more than 43 years. Maps at the scales of 1:50,000, 1:100,000, 1:200,000 and 1:500,000 had been published earlier.

The re-mapping project for the scales 1:25,000, 1:50,000 and 1:100,000 was started in 1935 with an allocated budget of SWF 24.5 million. However, the final expenditure was SWF 46 million and a total of 3.8 million working hours were spent.

Revision of the National Map Series is based on the revision of the 1:25,000 map scale. Revision is done on a six-year cycle and during one cycle a block of three to four 1:100,000 map sheets is revised. The time required for one revision, from the survey flight to the publication of the revised map, is approximately two years.

Tests have been made in the past to use orthophotographs for revision of maps with the aim of making the task more economical. However, results have shown that conventional photogrammetric mapping methods are superior for interpretation of details and more economical.

In the spring of 1978, the *Atlas of Switzerland,* consisting of 97 sheets, was, for the time being, completed. The first sheets were published in 1965.

Work has started on a *Climate Atlas of Switzerland.* This project, undertaken jointly with the Meteorological Institute and the University of Berne, will be completed in approximately 10 years.

SWISS FEDERAL DIRECTORATE OF CADASTRAL SURVEYS

The Directorate of Cadastral Surveys is a supervisory authority which commissions, in co-operation with the Cantonal Survey Authorities, private licensed surveyors for the execution of cadastral surveys. On 13 November 1923, the Federal Council adopted a resolution on a general plan for the realization of cadastral surveys. At that time it was estimated that in 1976, in approximately 50 years, the project would have been completed. However, owing to various obstructions, progress has been delayed. Progress achieved as at 1 January 1979 is as follows:

*The original text of this paper, prepared by M Duddek, appeared as document E/CONF.72/L.85.

	General Map 1:5,000/1:10,000		
	Parcel survey	*Original survey*	*Reproduction*
Surveys completed	63.4 per cent	93.5 per cent	54.2 per cent
Work in progress	5.5 per cent	1.7 per cent	4.5 per cent
Still to be done	31.1 per cent	4.8 per cent	41.3 per cent
Total area to be surveyed km²	38 812	39 943	39 943

If the work-load still on hand is executed with the same average intensity as in the period from 1912 until 1978, it will take approximately 40 to 50 additional years to complete the survey of parcels alone.

However, as the General Map Series 1:5,000/1:10,000 is the basis for all planning purposes, the rate of progress achieved so far is unacceptable for future requirements.

Hence, the Federal Directorate of Cadastral Surveys, in co-operation with cantonal survey authorities and the private surveying sector, has drawn up a programme calling for the accelerated completion of outstanding surveying and mapping tasks in the period from 1978 to 2000.

To achieve the target set, the Federal Government and the cantonal authorities will considerably increase their financial contributions. In addition, the number of surveyors in the private sector will gradually be stepped up and the latest surveying techniques and equipment, such as electronic tacheometers, will be utilized. It is further emphasized that the use of photogrammetry, which up to now has mainly been employed in areas where third-order accuracy (instruction zone III) is required, will be expanded into instruction zone II regions wherever terrain conditions permit.

Swiss Geodetic Commission

The Swiss Geodetic Commission is a branch of the Swiss Society for Nature Research. It concerns itself with fundamental geodetic problems and co-operates closely with the Geodetic Department of the Swiss Federal Institute of Technology, the Swiss Federal Topographic Service, the Satellite Observation Station at Zimmerwald and other organizations.

The Geodetic Commission and the other organizations are undertaking the following programmes:

Checking the first-order triangulation by trilateration;

Determining additional Laplace points;

Determining the geoid;

Determining a gravimetric net within the European network.

Federal Department for Territorial Planning

The Federal Department for Territorial Planning at the end of 1979 introduced guidelines in accordance with the newly introduced federal law on territorial planning. These guidelines will serve cantonal planning authorities in their multiple planning tasks and moreover help to establish favourable working relations on matters of urban, regional and national planning.

Since 1976 the following maps have been published by the Federal Department in support of the various planning activities:

1977, danger area map (situation as of 1975), 22 sheets, scale 1:100,000;

1978, inventory of tourist transportation facilities including map, scale 1:300,000;

1977, map of climate suitability for agriculture, 4 sheets, scale 1:200,000;

1977, map of climate suitability for grain, 1 sheet, 1:500,000;

1977, thermal structure of Switzerland, 4 sheets, scale 1:200,000.

On the cantonal and regional levels, a variety of maps underlining planning activities have also been published. These, however, concentrate mainly on the presentation of privileged locations for specific purposes in such fields as tourism, industry and agriculture.

Other Activities

The *Swiss Federal Institute of Technology, Zurich*, hosted a joint conference between delegates of the International Society for Photogrammetry (ISP), which initiated the conference, the International Cartographic Association (ICA) and the Fédération internationale des géometres (FIG), from 9 to 13 July 1979. The theme of the joint working session was Digital Technology in the Production of Topographic Maps.

The aim of the conference was to establish guidelines for closer co-operation of the three sister societies in the future and to outline the main subjects of interest in the field of digital mapping which should be attended to by working groups during future congresses of the three societies and in a technical symposium to be organized in the period to 1984.

The *Federal Institute of Technology, Lausanne,* in co-operation with the Federal Establishment for Forest Research and other institutions, has been actively engaged in the field of image analysis. The investigation concerned a National Forest Inventory and a Land-use Statistic for regional planning in Switzerland, two projects which have recently been implemented.

The methods taken into consideration are the use of multispectral images in conjunction with image processing, texture analysis and sampling from aerial photographs by pure visual interpretation. After careful consideration of the variety of technical and financial aspects involved, it was concluded that greater efficiency could be obtained from conventional photo-interpretation sustained by facilities of electronic data processing.

The *Swiss School for Photogrammetric Operators* (SSPO) is conducting an advanced course for a limited number of participants on "Modern Methods of Digital Data Acquisition for Aerial Triangulation and other Applications", from 14 April to 11 July 1980, and a further advanced course on "The Application of Close-range Photogrammetry" from 2 to 20 June 1980 with the possibility of an extension for one to two weeks.

RAPPORT SUR LES ACTIVITÉS CARTOGRAPHIQUES EN RÉPUBLIQUE ARABE SYRIENNE*

Document présenté par la République arabe syrienne

SUMMARY

The Geographic Service was founded in 1955, and since then it has endeavoured to fulfil the growing cartographic needs of the country. This Service has established a precise geodetic and levelling network, including the building of a tide gauge. The scale chosen for the base map of the country is 1:25,000. At this scale almost all the non-desertic areas have been covered. The Geographic Service is now envisaging the introduction of automation and the use of satellite imagery for small-scale cartography.

Le Service géographique syrien a été fondé en 1955. Il avait une lourde charge car il ne disposait à ce moment-là que d'un petit nombre de cartes irrégulières, faites à toute vitesse, au 1/50 000 et au 1/200 000. Ces cartes s'appuyaient, d'une part, sur un réseau géodésique de premier ordre non homogène et, d'autre part, sur un réseau de nivellement de précision faible et divergent.

Dans ces circonstances, le Service a été obligé d'établir un réseau géodésique homogène et précis de premier, deuxième et troisième ordre, et d'utiliser la méthode des moindres carrés pour la compensation.

Le Service a ensuite construit un marégraphe sur la côte syrienne pour relier le réseau de nivellement de précision. La carte de base adoptée a été celle de l'échelle du 1/25 000 avec les dimensions de 7′ 30″. L'établissement de cette carte a débuté en utilisant les méthodes classiques : photographies aériennes, préparation des photographies sur le terrain, restitution des photographies en utilisant les appareils de restitution de premier ordre les plus modernes.

La seconde étape était d'établir la carte du désert au 1/50 000 en se servant de photographies aériennes au 1/70 000 et en utilisant les méthodes d'aérotriangulations, surtout la méthode JERIE. La restitution a été faite par des appareils Wild B9.

Actuellement, la carte du désert au 1/50 000 est achevée et la carte de base au 1/25 000 est sur le point d'être finie pour les régions non désertiques; quant aux autres échelles résultantes de ces deux échelles, c'est-à-dire 1/100 000, 1/250 000 et 1/500 000, elles sont établies au fur et à mesure, en utilisant la généralisation de la carte de base.

Depuis quelques années, le Service s'est mis à la disposition des ministères et des établissements de l'Etat pour leur préparer les cartes et les plans nécessaires à l'accomplissement des plans quinquennaux. Il prépare des plans au 1/5 000 pour le Ministère des communications pour les axes routiers qu'on prévoit de construire, et à la même échelle pour le Ministère de l'électricité aux fins de l'implantation de signaux de haute tension.

De plus, le Service prépare des plans au 1/2 000, au 1/1 000 et au 1/500 pour lever les villes et les villages au compte du Ministère du logement dans le but de les réorganiser avec des procédés modernes.

Le Service pense sérieusement introduire la cartographie automatique dans ses travaux; il pense également utiliser la photographie par satellites artificiels afin de compléter les cartes à petite échelle.

Le Service essaye de devenir un établissement indépendant pour pouvoir surmonter les difficultés rencontrées et exécuter les divers projets de l'Etat dans les délais demandés.

*Le texte original de ce rapport a paru sous la cote E/CONF. 72/L.107.

PROGRESS REPORT ON CARTOGRAPHIC ACTIVITIES IN THAILAND, 1977-1979*

Paper presented by Thailand

RÉSUMÉ

Le document constitue un rapport succinct sur les activités cartographiques menées par les services gouvernementaux thaïlandais au cours des années 1977 à 1979. Les services gouvernementaux jouant un rôle important dans le domaine cartographique et les activités connexes sont le Département royal de topographie, le Département d'hydrographie, le Département des affaires foncières, le Département des forêts royales, l'Office de la réforme agraire, le Département royal de l'irrigation, le Département de la mise en valeur des terres, le Département des ressources minérales, l'Administration nationale de l'énergie, le Conseil national de la recherche et l'Université de Chulalongkorn.

Au cours de la période considérée, la Thaïlande a réalisé dans le domaine cartographique des progrès qui peuvent être sommairement classés en cinq grandes catégories, à savoir :

Catégorie I, « Levés géodésiques et géophysiques » : La densité des canevas géodésique et géophysique a été augmentée dans différentes parties du pays.

Catégorie II, « Photogrammétrie aérienne » : On a amélioré la couverture photographique aérienne du territoire à différentes échelles en vue de l'établissement de cartes photogrammétriques et pour l'exécution de projets nationaux de développement.

Catégorie III, « Activités cartographiques » : On a établi différents types de cartes et documents connexes à usage militaire et aux fins du développement national, tels que des cartes topographiques à différentes échelles, des photocartes, des cartes thématiques, l'Atlas national des ressources naturelles et des cartes marines.

ROYAL THAI SURVEY DEPARTMENT

Geodetic and geophysical survey

During the reporting period the Royal Thai Survey Department has conducted the following geodetic and geophysical surveys.

First-order traverse

The electromagnetic distance measurement (EDM) traverse has been used on an extensive scale for establishing first-order horizontal controls. First-order traverse has been chosen in order to ease the difficulty of laying out the chains of triangulation. The traverse lines were run and connected to the existing first-order triangulation network throughout the mountainous terrain in the northern part of the country. The aforementioned traverse has established 111 additional controls.

Geodetic astronomy

In order to strengthen the existing geodetic network and determine the geoid profile, 10 Laplace stations have been established at the existing first-order traverse and triangulation stations located in the northern and north-eastern parts of the country.

Satellite geodesy

The Doppler geodetic point positioning programme was initiated in Thailand in 1971. The receiving signals from transit satellites at various locations will be monitored to DMAHTC, Washington D.C., for computation of co-ordinates in geocentric datum and local geodetic datum. A total of 42 Doppler stations have been established during the period 1971-1979.

Geodetic levelling

Six lines of first-order levelling have been run in order to densify the existing national network. A total of 76 BMP and 368 BMS have been established along a line of 884 km.

Land gravity survey

Gravimetric observation has been carried out in the northern, central, eastern and southern parts of the country. A total of 440 stations have been established at an approximate interval of 7 km.

Geomagnetic survey

The geomagnetic survey has been carried out in order to reobserve the geomagnetic elements at the existing stations located in the north, north-eastern and southern parts of the country. This is to provide data for the geomagnetic variations. A total of 52 stations have been reobserved.

Aerial photography

Aerial photography for mapping and national development projects in Thailand, which is the responsibility of the Royal Thai Survey Department, consists of the following activities:

For the mapping purposes of the Royal Thai Survey Department aerial photography has been flown for eight different projects at scales ranging from 1:6,000 to 1:40,000. The area covered was about 70,000 km^2.

Aerial photography for other governmental agencies has been flown at scales ranging from 1:4,000 to 1:30,000 with coverage of about 195,200 km^2.

In order to meet the increasing needs for aerial photographs, the Royal Thai Survey Department had by the end of 1979 procured an additional Merlin III B aircraft and a Zeiss RMK-A 15/23 aerial camera.

*The original text of this paper appeared as document E/CONF.72/L.73.

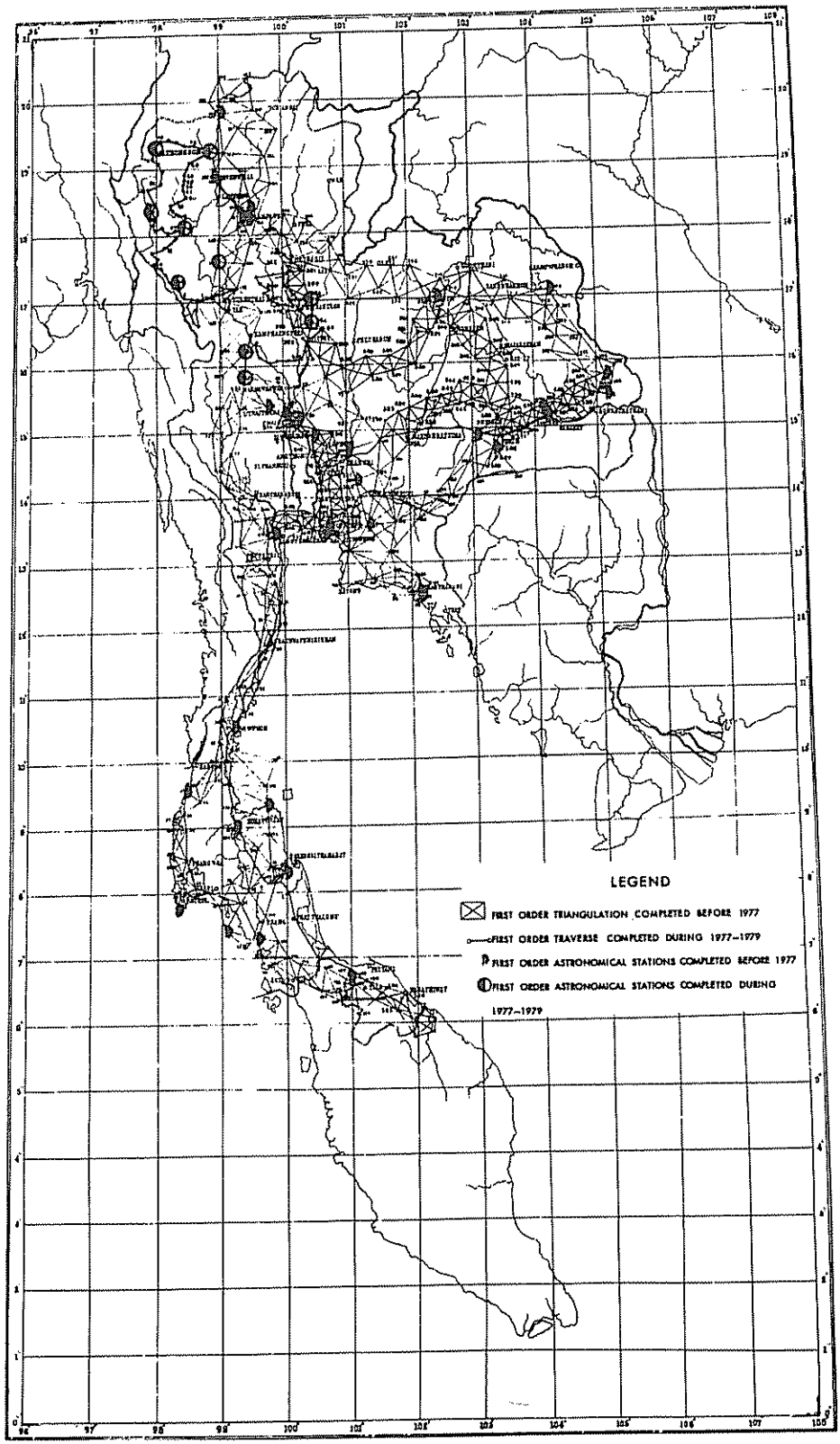


Figure 29. Thailand: first-order geodetic horizontal network

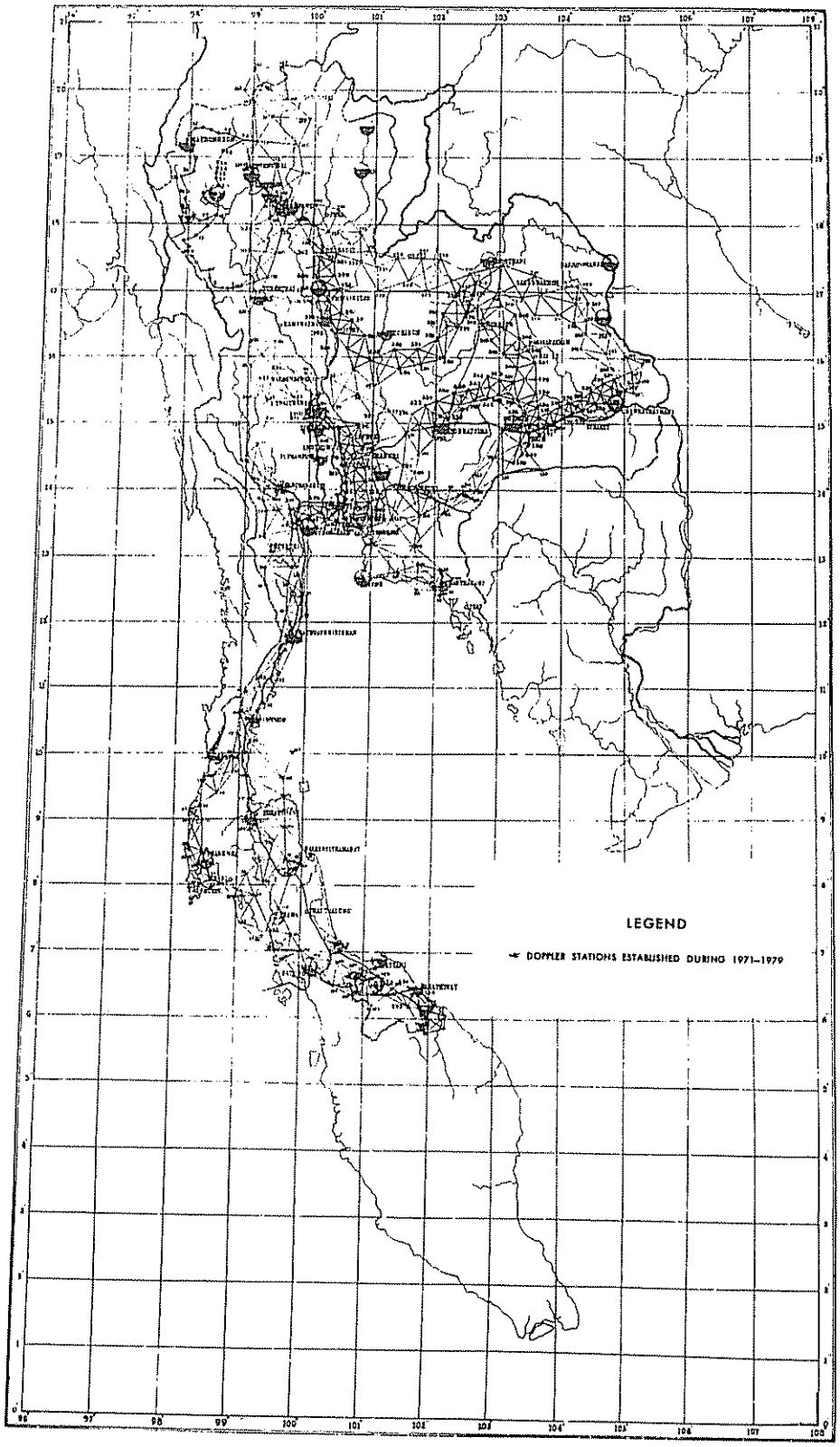


Figure 30. Thailand: Doppler stations established during 1971-1979

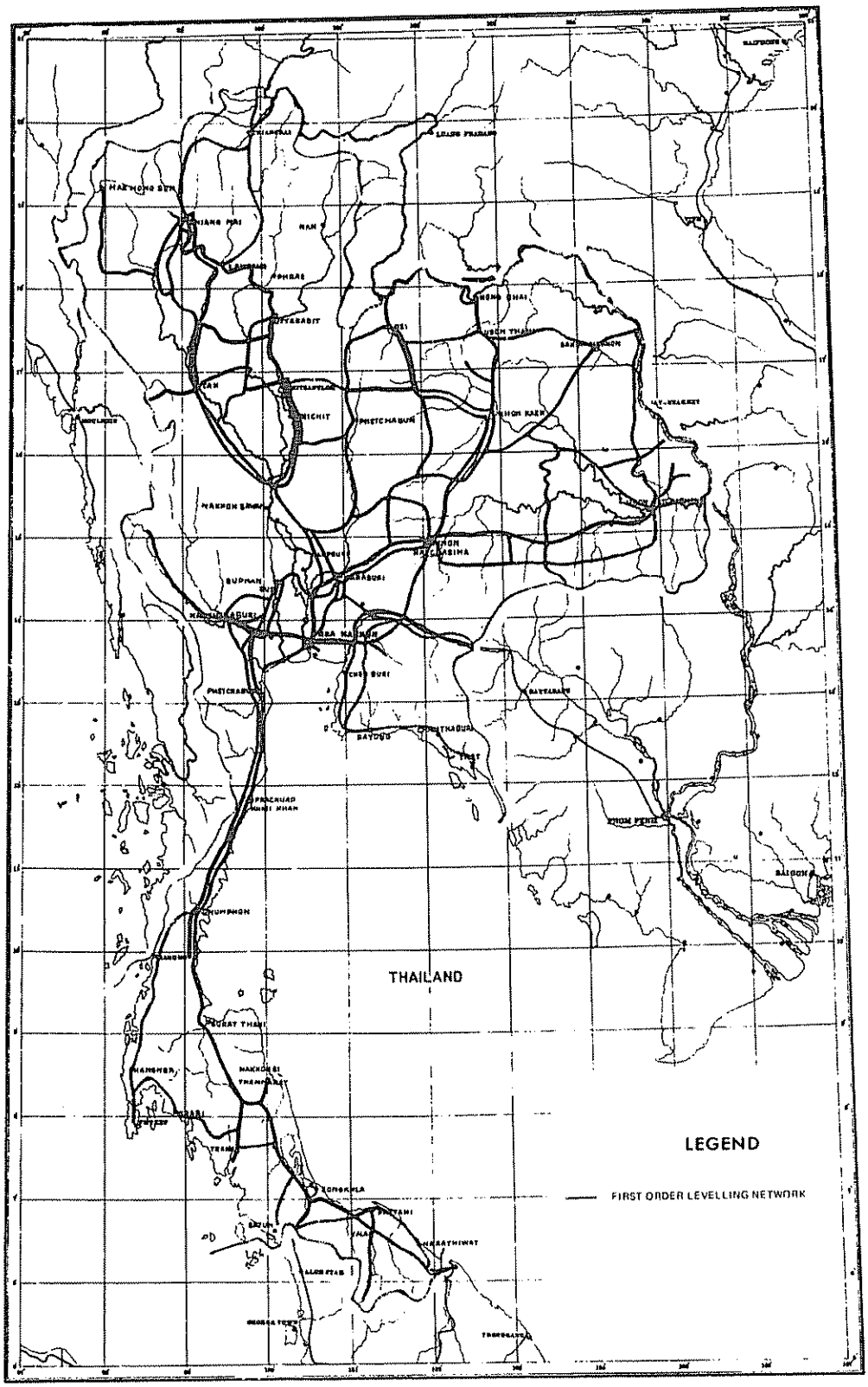


Figure 31. Thailand: first-order levelling network

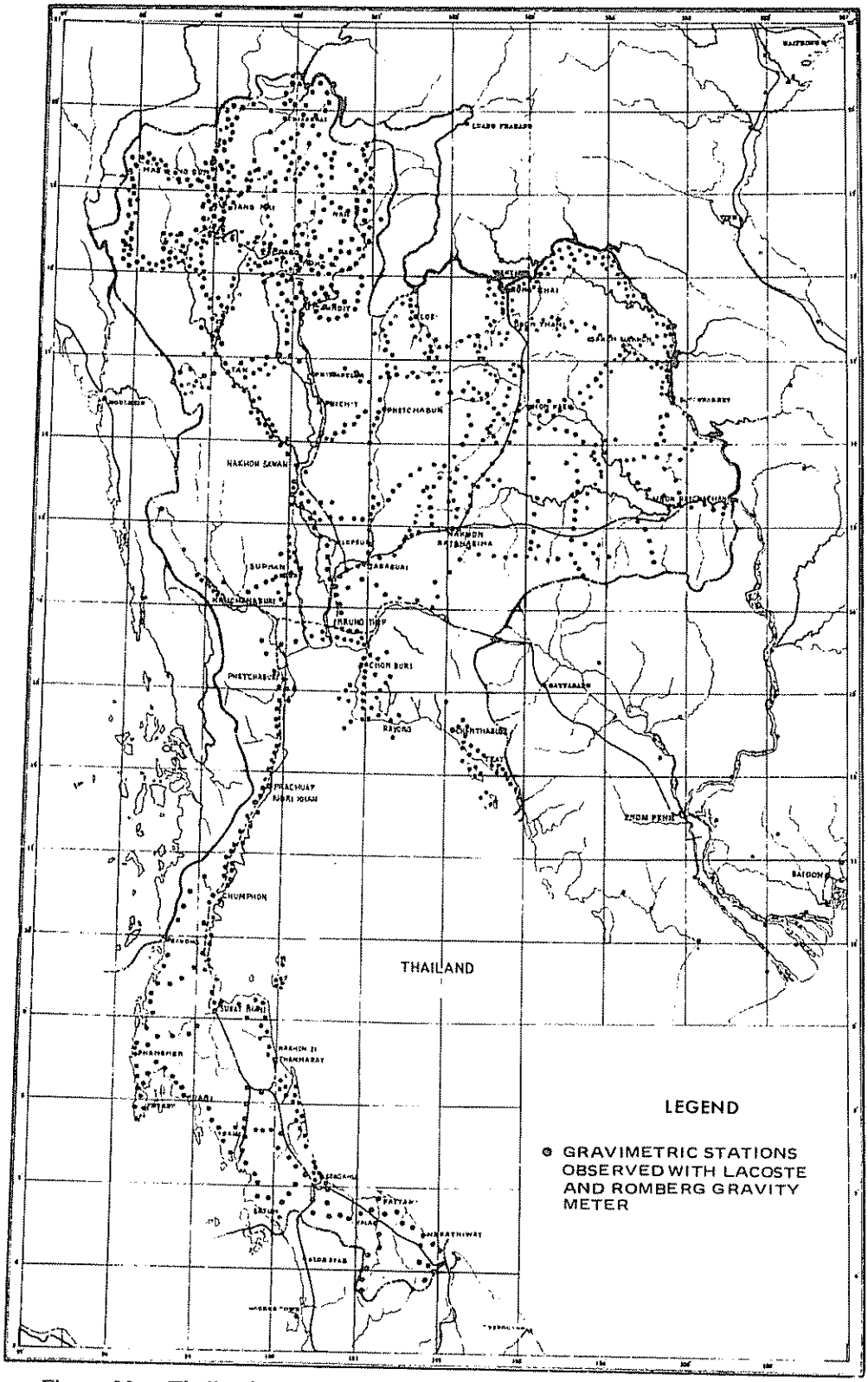


Figure 32. Thailand: gravimetric stations observed with Lacoste and Romberg gravity meter

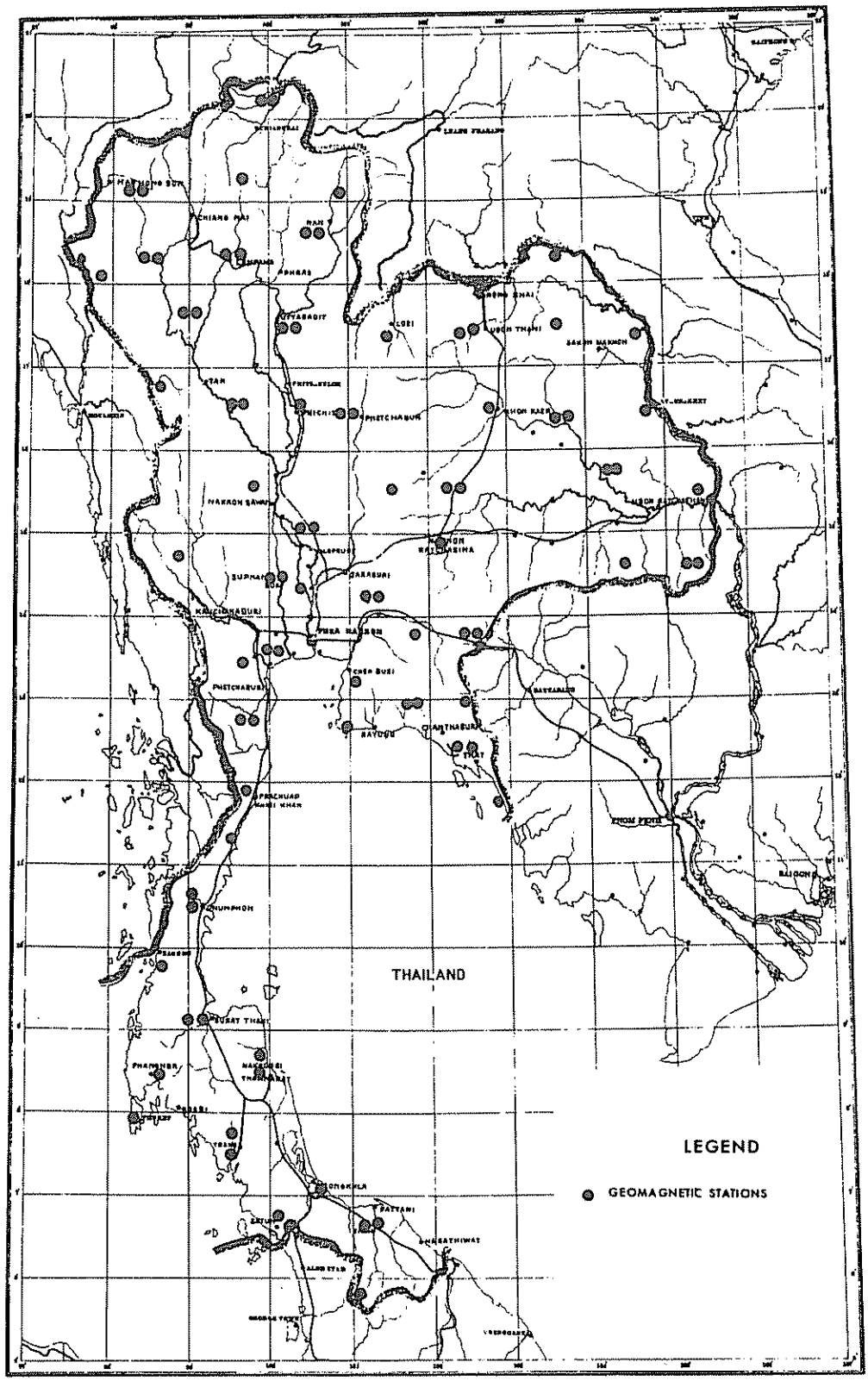


Figure 33. Thailand: geomagnetic stations

Mapping

Standard topographic maps

A bilingual topographic map series L 7017 was produced at the scale of 1:50,000 covering the entire country. The total coverage of the series, which consists of 772 sheets in a 15′ x 15′ format, was completed in 1973. Following the map evaluation, some sheets were found to be of a standard accuracy of US class C. The sheets were later recompiled.

Up to the present 75 sheets have been recompiled, 59 sheets of which have been published.

Owing to the fact that some Thailand border sheets were not contained in series L 7017 but in series L 7015 (Laos) and L 7016 (Cambodia), it was decided that those 58 border sheets should be added to the existing series L 7017. The total coverage of the series would then be 830 sheets.

Other topographic maps

Bilingual topographic mapping at 1:25,000 has been performed since 1970. The areas covered by these maps are specified in accordance with a particular purpose. Up to the present, 253 sheets have been published.

A bilingual city map at 1:12,500 has been published covering the urban areas in 153 sheets. These maps have been updated from time to time, resulting in 22 revised sheets being published and six sheets being in revision.

Fifty-two sheets of the bilingual topographic map at the scale of 1:250,000, series 1501 and 1501 A, covering the entire area of Thailand were produced, some of which have been revised from time to time. Since series 1501 and 1501 A have been produced for military use, the RTSD will have to produce another special series, 1501 S, for the public.

Thematic maps and atlases

The National Resources Atlas of Thailand (NRA)

The latest revised edition of NRA was published by RTSD in 1976. The revised edition, in loose-leaf form, consists of 51 sheets divided into three sections which are colour coded: natural resources (green), human resources (red), economic resources (purple). About 40 sheets have already been published.

The Regional Economic Atlas of Asia and the Far East (REA)

In accordance with resolution 12 of the Eighth United Nations Conference, held at Bangkok, RTSD has tried to complete this project, but owing to inadequate support from the countries of the ESCAP region, only some sheets of the atlas have been produced. During the reporting period, the Transportation Map (six-sheet set), the Forestry Map (sheets 4, 5, 6) and the Population Distribution Map (sheets 4, 5, 6) have been published.

The Topographic Atlas of Thailand (TAT)

Further to the report submitted to the last Conference, held at Bangkok, in which it was stated that the TAT will consist of 114 carefully selected sections of various kinds of topographic maps of Thailand with interpretation and explanation in Thai and English, 106 sheets have now been published. The texts, however, are only at the drafting stage.

General-purpose maps and road maps

The city plan of Bangkok Metropolis at the scale of 1:20,000 consists of 20 sheets, of which 15 sheets have so far been published.

A road map at the scale of 1:2 million showing the road network throughout the country was renewed during the reporting period.

Map reproduction

The Royal Thai Survey Department's new map reproduction plant is the largest in Thailand. It serves the principal needs of governmental agencies for the final stages of map production.

The capability of the plant has been increased from time to time. One additional unit of the Miller Perfecting Offset Press, Type TP 36, printing size 65 cm x 92 cm, was procured for the completion of the six-colour press.

During the reporting period, about 5.8 million copies of various types of maps were published. Of these, 85 per cent were maps at different scales which had been compiled by the Department.

Geographical names

With reference to the report submitted to the last Conference, held at Bangkok, it was anticipated that the final compilation of the Gazetteer would be completed in 1976. Owing to the publication of an up-dated edition of map series 1501 at the scale of 1:250,000, the compilation could not be finished as expected. To the present, a list of preliminary names, obtained from nine sheets of the series, has been recompiled.

During the reporting period, Thailand has participated in the Fourth Meeting of the United Nations Divisional Group of Experts on Geographical Names, South-east Asia Division, at Kuala Lumpur, Malaysia, and in the Third United Nations Conference on the Standardization of Geographical Names, held at Athens.

Map Information Centre (MIC)

The Map Information Centre of the Royal Thai Survey Department, which was established pursuant to resolution 5 of the Third Conference, held at Bangkok, has been supplied by various United Nations Member countries with maps, information, documents and other relevant materials.

During the reporting period, the Map Information Centre received about 700 map sheets and 250 other related documents from 25 countries.

Education and training

During the reporting period, various courses have been offered by the Survey School of the Royal Thai Survey Department, as follows:

(1) Three classes of a five-year survey engineering course for military cadets;

(2) Three classes of a two-year surveying course for non-commissioned officer students;

(3) Two classes of a 26-week advanced surveying course for senior commissioned officers;

(4) One class of a 26-week surveying course for master sergeants;

(5) One class of a 26-week associated surveying course for junior commissioned officers who have not attended the five-year survey engineering course;

(6) One class of a 24-week basic surveying course for non-commissioned officers who have not attended a surveying course for non-commissioned officer students;

(7) One class of a 14-week geography course for commissioned officers.

Scholarships were granted to the Royal Thai Survey Department by the Thai Government and various foreign countries during the reporting period resulting in 12 officers being trained abroad on eight OJT courses, two officers attending two post-graduate courses at ITC, the Netherlands, and 13 officers taking Master's degree programmes at universities in Thailand and the United States, from which five have already graduated.

HYDROGRAPHIC DEPARTMENT

Hydrographic surveys

West coast of the Gulf of Thailand

Songkhla Harbour was resurveyed in order to update the nautical charts, and for the harbour development project.

Andaman Sea

The offshore area from Ranong to Satun was surveyed for the production of small-scale nautical charts.

Similan Island, Surin Island and vicinities were surveyed for the production of large-scale nautical charts.

Phuket Harbour was resurveyed for further harbour development.

The total sounding area observed during 1978-1979 was 19,527 km^2.

Nautical and aeronautical charts

Nautical charts

Two new nautical charts were published and 25 charts were revised.

Aeronautical charts

One new aeronautical chart at the scale of 1:500,000 was produced, and 12 existing aeronautical charts were revised.

THE DEPARTMENT OF LANDS

With reference to the country report submitted to the last Conference, held at Bangkok, a photogrammetric procedure was selected to produce series of graphical cadastral photomaps for the issuance of land titles and certificates of land use to the landowners. During the reporting period, the Department of Lands issued 52,072 land titles to the landowners, covering a developed area of 301,716 *rai* (482.7 km^2), and 4,716,443 certificates of land use, covering a developed area of 26,943,595 *rai* (43,109.8 km^2).

ROYAL THAI FOREST DEPARTMENT

The Royal Thai Forest Department has compiled large-area land-use and forest-type maps from medium-scale aerial photographs and from LANDSAT imagery. These maps are used by the Royal Forest Department for plantation and reserved forest management and by other agencies for other types of land-use planning.

Specific work done since the Eighth Conference includes the following.

Forest-type and land-use maps of southern Thailand

These maps were produced by means of 1:15,000 black-and-white aerial photographs. The final maps were reduced to 1:50,000 with a format of 15′ x 10′. Up to the present, 196 sheets printed in four colours covering nearly 70,000 km^2 have been completed.

Forest-cover maps of the northern and eastern regions of Thailand

These maps were produced by means of LANDSAT image covering an area of about 208,000 km^2. (Thailand's total area is about 514,000 km^2.)

Maps of forest land use in selected watershed areas of northern Thailand

These maps were produced with the combined information obtained from the Royal Thai Survey Department.

ROYAL IRRIGATION DEPARTMENT

The progress made in the field of cartography and related activities during the reporting period is as follows.

Aerial triangulation

Mapping activity in the Royal Irrigation Department (RID) since 1976 has been greatly improved in both quantity and quality, especially the aerial triangulation phase. The so-called independent model block adjustment was introduced in early 1979 by using the computer program provided by the International Institute for Aerial Survey and Earth Sciences (ITC), the Netherlands. With this program and Wild AMH, equipped with EK22 and magnetic tape for data recording, the aerial mapping production rate has increased by a factor of 2. Moreover, absolute accuracy is achieved up to 50 microns on photo scale. That accuracy is sufficient for present purposes because most of the maps produced in 1979 were rectified photographs, orthophotographs and topographic line maps of 1:4,000 and 1:10,000 from aerial photographs at the scale of 1:10,000 and 1:15,000, respectively.

Topographic line maps

At present, RID possesses three B8S Wild stereoplotters. Most of the maps compiled from these plotters are 1:10,000 scale with 1 m contour interval from existing 1:15,000-scale photographs. The photographs of this scale are considered inadequate in altimetric accuracy. As a consequence, RTSD has been requested to fly, under favourable conditions, for new photographs at 1:10,000 scale.

During the reporting period, the coverage area of topographic line maps compiled by photogrammetric method was about 4,200 km^2.

Generally, aerial mapping is preferred to the conventional method. In a very few cases, as for construction, very large-scale maps ranging from 1:2,000 to 1:500 with 0.25m contour interval have been produced by the conventional method with the result that an area of about 7,800 km^2 has been so covered.

Photomaps

Since May 1978, RID has been able to produce rectified photographs by using a Wild E4 rectifier. The production is sufficient for the work of the Department as well as for other governmental agencies, such as the Agricultural Land Reform Office, Central Land Consolidation Office, Department of Land Development etc.

Photomaps produced by RID are at the scale of either 1:10,000 or 1:4,000. The latter is more desirable for the on-farm development project where spot height and cadastral surveys are essential.

The area of coverage of photomaps is about 5,700 km^2.

Cadastral survey

The cadastral survey conducted by RID is for the purpose of locating the property boundaries to facilitate suitable layout and procurement of lands within the irrigation project right of way. RID personnel are occasionally appointed by the Department of Lands to engage in the issuance of landowners' certificates in the irrigation projects. The use of photomaps for cadastral survey has proved to be much more efficient than the conventional method.

During the reporting period, the coverage area of cadastral survey was about 1,900 km^2.

Spot height survey

This type of survey is essential for every on-farm development project where accurate height data are required for a contour interval of 0.25 m. In the past, the costly and time-consuming grid method was solely employed by RID. At present, this method is almost obsolete due to the substitution of the spot height survey which is more flexible in selecting and identifying all of the spot heights on the photomap.

During the report period, the coverage area of spot height survey was about 5,900 km^2.

DEPARTMENT OF LAND DEVELOPMENT

Cartographic activities in the Department of Land Development have been conducted by the Soil Survey Division since 1963. At first, soil maps were reproduced to be attached to soil survey reports. With the assistance of FAO/UNDP between 1969 and 1974, the Soil Survey Division installed cartographic equipment and established a complete Cartography Section in which it organizes the production of maps, reports and other materials. The Soil Survey Division is now able to handle modern cartographic work.

The most recent maps reproduced in the Division are as follows.

General Soil Map of Thailand

This map is in the processing stage in the Cartography Section. It will eventually be multicoloured at the scale of 1:1 million. There are 89 soil-mapping units that have been classified at the major group level of USDA Soil Taxonomy. This map shows the broad geographical relations among soils indicating contrast between regions. Its main use is for regional and national agricultural planning.

Detailed reconnaissance soil maps

At present, most of the soil survey maps in Thailand are detailed reconnaissance surveys of provinces with a publishing scale of 1:100,000. Topographic maps of the Royal Thai Survey Department were used as the base. Soil boundaries were printed in red, others in black. About 60 detailed reconnaissance soil maps of provinces have been reproduced up to the present and about 10 maps are still in process. Soil mapping units are soil series, soil variants, soil association of soil series or variants with some phases of each and some land types. These maps are mainly used in provincial and regional development planning and for the evaluation of large irrigation or drainage projects.

Soil suitability maps of Thailand for paddy growing

This map is still in process. The scale is the same as that of the General Soil Map of Thailand which is being used as its base. It is a multicoloured map made from soil survey interpretation for paddy growing.

Land capability map of Thailand for upland crops

This multicoloured map is interpreted directly from the General Soil Map. The published scale will be at 1:1 million. It is being drafted and will be finished within the next few months. This capability map will be useful mainly in national planning for growing various kinds of crops in Thailand.

Potential land-use map of Thailand for crop production

According to data obtained from the maps described above, a potential land-use map for crop production was made in multicolour at the scale of 1:1 million. This is one of the simplified land-use maps that can be applied to broad national agricultural development programmes.

Geomorphological maps

Apart from the national soil survey, the Soil Survey Division has also conducted the geomorphological study in various provinces. Geomorphological surveys of three provinces have been completed so far.

AGRICULTURAL LAND REFORM OFFICE

The Agricultural Land Reform Office (ALRO) in the Ministry of Agriculture and Co-operatives has, since 1979, carried out mapping as the basis for planning and implementing 72 land reform and rural development projects throughout Thailand. Mapping is required for a total area of 5,121,069 *rai* (8,193.7 km^2) which is divided between two types of projects, as follows:

1. Public land, mainly open or reserved forest; 40 projects totalling 4,519,069 *rai* (7,230.5 km^2);

2. Private land, 32 projects totalling 602,000 *rai* (963.2 km^2).

ALRO undertakes three mapping phases for each of the proposed projects, as follows.

Reconnaissance surveys

Reconnaissance surveys for feasibility studies of proposed projects have been conducted by using RTSD 1:250,000 and 1:50,000-scale maps and some 1:15,000-scale aerial photographs as the base for the general study of topography, vegetation, existing

communication network, water resources and location of communities.

Project surveys

During the reporting period, ALRO has produced the following two types of maps:

(*a*) *Topographic map* at the scale of 1:10,000 with 1-2 m contour interval covering 1,752,104 *rai* (2,803.4 km^2);

(*b*) *Cadastral map* at the scale of 1:5,000, in which the ownership and area of each plot of land in the project were determined and registered, covering 1,965,909 *rai* (3,145.5 km^2).

(*c*) *Location and design surveys*

Suitable alternative routes for roads, waterways and other infrastructures were planned by the engineers on topographic maps of 1:10,000 in which the proposed reallotment of farmers' plots will be designed. During the reporting period, ALRO produced reallotment maps covering an area of 19,919 *rai* (31.9 km^2).

NATIONAL ENERGY ADMINISTRATION

With reference to the report submitted to the last Conference, held at Bangkok, the Surveying and Mapping Section has been upgraded to the Surveying and Mapping Branch in the Investigation and Planning Division. The main task of the Branch is to collect all information connected with the topography of the energy resource development project areas. During the reporting period, surveying and mapping work in this field has been widely expanded to cope with the increasing rate of indigenous energy resource development. The projects are intended not only to replace imported fossil fuel but also to supply the country's rapidly increasing energy demands.

Map production has been improved and expanded both technically and by means of modern equipment. Maps at various scales ranging from 1:1,000 to 1:20,000 with contour intervals ranging from 1 to 5 m can be produced by aerial photogrammetry in NEA. Topographic maps of dam sites, resource deposits, power plants, access roads, transmission lines, power routes, as well as a hydrographic map for improvement of navigation in the International Mekong Project, which are accomplished by the usual surveys, are also being carried out by the Branch. The final products distributed to other departments are in blueprint. However, the map at the scale of 1:50,000 produced by the Royal Thai Survey Department is still found to be suitable for all desk study.

NATIONAL RESEARCH COUNCIL

With the advent of remote sensing by Earth Resources Technology Satellites (ERTS), a National Remote Sensing Co-ordinating Committee was appointed by the Cabinet in September 1971 to advise the Government concerning application of remote-sensing data and co-ordinate functions with NASA and international bodies. Since 1972 Thailand has joined other nations in entering the age of satellite remote sensing by participating actively in NASA LANDSAT 1, Skylab EREP and LANDSAT 2 follow-on programmes. The first LANDSAT 1 imagery of Thailand taken in September 1972 was received from NASA in November 1972. The research and development activities using the remote-sensing data have been conducted successfully in various disciplines. The Government is therefore aware of the importance and potential benefit of these remote-sensing data for the development of the country. In September 1978, the Cabinet approved the installation of a receiving station in Thailand which is expected to be in operation in 1981. By then, the real time data will be very valuable in managing and planning the use of natural resources.

The ERTS programme in Thailand may be divided into three phases as follows.

First phase

The first phase of the programme began after NASA had accepted Thailand to participate in the ERTS programme in September 1971 up to the launching of LANDSAT 2 in January 1975. At this stage of the programme, an intensive training course in remote sensing was offered to the multidisciplinary representatives of various governmental agencies at the National Resources Council (NRC) with the assistance of the United States Operations Missions to Thailand (USOM) and the United States Geological Survey. The training activities also included the South-east Asia Subregional Seminar on ERTS, organized by NRC, and a yearly workshop on automatic data processing of LANDSAT Computer Compatible Tapes (CCT), held at the Regional Computing Centre of the Asian Institute of Technology (AIT), Thailand, for Thai user agencies. These scientists also participated in the international workshops and other training courses.

Participation in the NASA LANDSAT and Skylab investigation programme has allowed Thailand to diversify its research and development activities in agriculture, forestry, land-use, geology, hydrology, oceanography and ecology. At this stage the work was done by means of visual interpretation with the help of ground truth surveys. In order to fulfil this programme a National Remote Sensing Co-ordination Centre was established at NRC to carry out the administrative and co-ordinating functions of the National Remote Sensing Co-ordinating Committee. It also provides users' service in the photographic reproduction of LANDSAT imagery, including research support.

Second phase

The second phase of the programme started in 1975 and ended in 1978. This period arose out of the successful research in the application of remote sensing to several disciplines, such as forestry, land development etc. The results of the research and development were published and distributed to all the government offices concerned and to international agencies. It was found that the cost/benefit ratio of using LANDSAT imagery compared very favourably with that of aerial photographs for the purposes of economic development planning. LANDSAT imagery has therefore come to be extensively used by government offices. The most important result of this phase was that the Royal Thai Government agreed to become a participant in the Earth Resources Technology Satellite programme and is now constructing a receiving station in Thailand. The station is expected to be in service in 1981. The real time data received by this station should prove to be very valuable in the development of the country, especially of its agriculture.

In addition to the work successfully carried out by visual interpretation in various fields, some comparable

research has been done on processing data by computer. The research was conducted so that the Service would be able to handle a larger volume of data when the receiving station is completed.

Third phase

The third phase of operation was started in 1978 after the Government had approved the establishment of the receiving station. A data bank was prepared by extracting from previous results, aerial photographs and ground truth surveys. This data bank will be very useful in planning future economic development. Furthermore, the Regional Remote Sensing Training Centre will be established in 1980 at AIT with the assistance of the United States Government which is to provide experts for the training. This Centre will also co-operate closely with the receiving station in analysing the data by computer.

Finally, it is expected that the Earth Resources Technology Satellite programme in Thailand will be in the fourth phase within the next few years when the higher-quality and more detailed data are received from new satellites such as LANDSAT D, Space Shuttle and the like.

CHULALONGKORN UNIVERSITY

During the reporting period, a post-graduate programme was offered by the Department of Survey Engineering in the Faculty of Engineering at Chulalongkorn University. Before undertaking the post-graduate programme, the objective of the Department is to provide knowledge of the basic principles of engineering measurements along with the appropriate practical work in order to enable the students to:

(*a*) Understand the structures and requirements of mapping;

(*b*) Apply theories and techniques to general surveying tasks;

(*c*) Analyse the mechanics of evaluating the accuracy attained.

The surveying courses at present being offered by the Department in conformity with the resolutions of the United Nations cartographic conferences may be described as follows.

The bachelor degree course

The entrance examination requires the national high-school qualification. The course takes eight semesters with a total of 142 credits, and an average grade point of 2 for graduation.

The post-graduate course

The post-graduate programme in surveying, which leads to the Master of Engineering degree, was initiated in 1979. It fits into the economic level of the country by providing access to higher learning to local students who hold a Bachelor's degree in science or engineering, or its equivalent. The total of 48 credits, of which 18 credits are for thesis or research, and 30 for course work, are spread over three areas:

(*a*) Required course of 9 credits for surveying graduates, or 12 credits for non-survey graduates;

(*b*) Mathematical courses of 6 credits;

(*c*) Electives of 15 credits, in 2 disciplines:

(i) Civil engineering of not more than 6 credits;

(ii) Survey engineering of not more than 9 credits.

The syllabuses of the degree courses were carefully drawn up with the help of information from international academic institutions. The Bachelor's degree course provides general knowledge of engineering plus basic surveying and conforms to the requirements of the National Board of Engineering Professions, with which survey engineers are registered as associate civil engineers.

TOPOGRAPHY, GEODESY AND CARTOGRAPHY IN THE UNION OF SOVIET SOCIALIST REPUBLICS*

Paper presented by the Union of Soviet Socialist Republics

RÉSUMÉ

Au cours de ces dernières années, le Service géodésique national de l'Union soviétique a poursuivi ses travaux dans le domaine de la géodésie et de la cartographie afin de satisfaire aux demandes de l'économie nationale et de la population en matière de données géodésiques, de cartes et plans topographiques, de cartes et atlas de référence et de formation, ainsi que de données de télédétection permettant l'étude des ressources naturelles.

On s'est attaché particulièrement à effectuer des levés détaillés de la région qui longe la voie ferrée Baïkal-Amour, de la zone des terres non noires de la République fédérative de Russie, ainsi que des régions mises en valeur, et à satisfaire la demande locale de données topographiques.

TOPOGRAPHY, GEODESY AND CARTOGRAPHY IN THE USSR

Over the past years the National Geodetic Service of the Soviet Union has continued its geodetic and cartographic work with a view to meeting the requirements of the national economy and the population for geodetic data, topographic maps and plans, training and reference maps and atlases, and remote-sensing data for studying natural resources.

Special attention has been paid to carrying out detailed surveys in the area along the Baikal-Amur Rail-

*The original text of this paper appeared as part of document E/CONF.72/L.86.

way, on the non-black-soil area of the Russian Federation and in land reclamation regions, and also to meeting local demands for topographic data.

Geodesy

It is necessary for mapping on different scales to establish the geodetic foundation over the whole country in accordance with scientific, topographic and engineering principles. A geodetic horizontal and vertical foundation is now available in the USSR. The well-known Soviet scientist-geodesist Krasovskij F.N. established the main principles of a geodetic foundation that provides accurate mathematical treatment of the geodetic network and meets all the requirements for all types of topographic surveys.

Most of the country is covered by a continuous triangulation network of first, second and third orders with maximum density in localities and developing regions.

The accuracy of the network is characterized by the accuracy of reciprocal positions of adjacent points or any other points of the network. This accuracy depends on measurement errors, structure of the network and rigorousness of the mathematical treatment.

The resultant observation accuracy of the USSR astro-geodetic network makes it possible to determine the reciprocal positions of adjacent points at an arbitrary site of the network with an accuracy better than 1:100,000 and transfer co-ordinates to 8,000-9,000 km with an accuracy of 3-4 m. This may be carried out in the future after a new adjustment of the astro-geodetic network as a unified continuous first- and second-order network of triangulation and traversing.

The main vertical control—the national levelling network of the first and second order—of different densities covers the whole territory of the USSR, forming a unified vertical framework, fulfilling various economic purposes. It is used to study the Earth's figure and its gravity field, the recent vertical movements of the Earth's crust, to determine differences of heights and inclinations of the mean-level surfaces of seas and oceans, and evaluate and forecast the influence of industrial processes on the environment.

The severe consequences of earthquakes, whose prediction is an unsolved problem, are well known. The geodetic data available concerning the tectonic deformations of the Earth's crust give reason to hope that the precise numerical results of vertical and horizontal movements of the Earth's crust together with geophysical, geological and other data will help in future to solve the problem of earthquake prediction.

For this it would be necessary to increase the accuracy of geodetic measurements, determine regions of seismic hazard, establish repetition frequency of geodetic measurements and automate the geodetic measurements and the treatment of the geodetic results.

At present in nearly all the seismoactive regions of the USSR the "epoch" of the geodetic data is determined. Research on deformations of the Earth's crust is being carried out at many geodynamic and ecological test areas.

New geodetic methods and instruments have been developed for different branches of civil and industrial engineering. The special geodetic methods were developed for assembling, adjusting and controlling large radiotelescopes, i.e., Ratan-600. Great attention has been paid to automating the systems monitoring deformations of engineering structures. Such systems make it possible to improve the accuracy of geodetic measurements and considerably increase productivity.

The rapid progress in geodesy is closely connected with the development of the geodetic instrument industry. During the past year the old geodetic instruments were replaced by new, more sophisticated ones, produced in this country.

The "Volna" radio distance meter has been developed with a range of 15-20 km and an accuracy of $\pm(3 + 3 \cdot 10^{-6}D)$ cm.

A topographic optical rangefinder SM-5 with a range up to 700 m and an accuracy of ± 3 cm has also been developed. The decimal reading can be taken from a five-digit display. The instrument needs 6 W energy supply and its weight is 3.7 kg.

Topography

At present the geodetic service of the USSR is focusing attention on mapping at scales 1:25,000 and larger, revising maps, surveying the shelf and protecting the environment. This work is usually carried out with air survey methods and instruments developed by Soviet scientists.

The initial data for phototopography are taken from aerial photography. The main guidelines for improving the phototopographic instruments are to obtain the maximum possible accuracy and information yield of the pictures and also to gain additional data about flight conditions. To this end, airphoto cameras type AFA-TES with focal lengths of 70 and 100 mm and type TE with focal length of 350 mm have been developed. These cameras have frame edge resolution of 36-40 lines per mm and photogrammetric distortion of less than 10-15 mm. The use of panoramic pictures is under study.

The increase in the accuracy and quality of photographic images has considerably decreased the scales of the images in comparison with the scales of topographic materials. This requires higher accuracy of the photogrammetric instruments. Digital mapping methods are widespread, so new photogrammetric instruments and methods are being put into production.

The new photogrammetric instruments are developed to automate photoplotting, raise productivity and facilitate labour. The new Soviet universal stereoplotters meet these requirements. Among these are: stereographs SC, instruments for orthophotomapping OFPD, automated co-ordinate registers "Onega" simultaneously serving up to five stereoplotters, instruments for identification of the conjugate points of the equal scale airphotographs of types DSI-T and NT, providing identification accuracy of 3 μm with scale ratio of a pair of airphotos from 1 to 8.

Analytical methods of modelling block networks are widely used for photogrammetric bridging. Computer software now developed has opened up new possibilities for compensation of image errors and the use of additional information from instruments mounted on aircraft.

Digital modelling with automated co-ordinatographs provided with computer software is also used. The further development of photogrammetric instruments and methods makes it possible to increase automation and approach photogrammetric and topographic problems analytically.

Cartography

The purpose of cartographic production is to meet the requirements for various cartographic materials of the national economy, the population and of science and education.

During the past year the need has grown for thematic maps for different purposes and of different contents. This is particularly so in those spheres of scientific and engineering activity which concern the rational utilization of natural resources and protection of the environment.

New types of thematic maps make it possible to inventory natural resources, record protective measures and forecast the effects of industrial processes.

Remote-sensing methods are used for researching natural resources and monitoring the environment and are widely used for thematic mapping. Among them the most promising is taking photographs from space orbital stations and from manned and unmanned spacecraft. The information received by TV cameras and scanner sensors installed on board the satellites (i.e., "Meteor" satellites) is also of great importance. Mapping of relief, geological structure, hydrography, soils, vegetation, natural and artificial landscapes is carried out with maximum success.

In small-scale cartography, special emphasis is placed on producing various reference materials for the construction of the Baikal-Amur Railway, economic development of the non-black-soil area and mechanized agricultural complexes.

Production of geographical, political and administrative reference maps of continents, foreign countries and the USSR is continuing. There is great demand for these maps and they are published in large editions and revised systematically.

Cartographic materials are also widely used for educational purposes. A comprehensive system of teaching aids has been developed to meet the needs of curricula. Much attention is being paid to improving the quality of aids and their variety (i.e., transparent maps, relief maps and globes etc.). Sixteen historical and geographical atlases and more than 500 varieties of wall maps are published for schools in editions of several million copies. Many tourist maps are also published in the USSR.

The demand for tourist and educational maps and atlases has now been completely satisfied. The major cartographic works published in the USSR during the past year are listed below:

Geologic-geophysic Atlas of the Indian Ocean (1975);
Atlas of the Atlantic and Indian Oceans (1978);
Atlas of the USSR Areas and Resources of Medicinal Herbs (1976);
Atlas of the USSR in the Tenth Five-year Plan (1978).

Over the past year a number of maps have been made for purposes of economic development of new regions. For instance, "The Baikal-Amur Railway, Climatic Map" was published at the scale of 1:2,500,000 (1976); a series of maps for planning the development of agriculture in the non-black-soil area of the Russian Federation was published at the scale of 1:1,500,000.

Deformation-resistant plastics of domestic make are widely used in map production. Map originals are drafted or scribed on plastic plates. Scribing instruments, among which are semi-automated instruments, and scribing texture have been developed for this purpose. The variety of scribing instruments available is growing steadily. The production of name plates and discrete conventional signs is carried out through the agency of semi-automatic and automatic photocomposers, special photomontage instruments recently developed. Transfer printing is also widely used.

For mechanizing map transformation at the map compilation stage a special auxiliary appliance to the phototransformer has been developed.

Contact, photomechanical and electronic colour separation techniques have been developed for printing maps in a reduced number of colours in order to cut expenses, save labour and make more efficient use of equipment.

New methods of compiling original maps suitable for the requirements of rapid and efficient colour separation and special printing inks have made it possible to implement multicolour printing using four basic colours and to produce maps in a shorter time.

Over the past decade the mapping of the Moon and planets has emerged as a new independent area of cartography. The work is being carried out on the basis of astrogeodetic studies with the use of photographs taken from space probes.

The processing of the photographic materials provided by the Soviet space probes "Mars-4 and 5", "Luna-22" and "Venera-9 and 10" posed new problems which are being solved by means of cartography.

Thus surveying and mapping in the USSR fully meet the demands of the national economy for topographic maps and geodetic data. Research is aimed at solving problems of automated multipurpose map production and at developing techniques for the acquisition and processing of space data to be used to study the natural resources of the Earth.

UNITED KINGDOM REPORT ON ACTIVITIES*

Paper presented by the United Kingdom of Great Britain and Northern Ireland

RÉSUMÉ

Le rapport sur la contribution des organismes gouvernementaux du Royaume-Uni aux activités topographiques et cartographiques en Asie et dans le Pacifique couvre la période allant du 1er septembre 1976 au 30 septembre 1979.

Les travaux ont été menés par :

a) Le Directorate of Overseas Surveys (DOS-Direction des levés outre-mer), dans le cadre d'arrangements mutuels de coopération technique. Le DOS fait partie de l'United Kingdom Overseas Development Administration (administration du Royaume-Uni pour le développement outre-mer);

b) Le Directorate of Military Survey (Service topographique militaire) et l'Hydrographic Department (Service hydrographique) du Ministère de la défense, sur demande.

La suite du rapport décrit les travaux effectués sur le terrain, la production cartographique, la formation, et le détachement d'experts.

This report on the contribution to the surveying, mapping and charting of Asia and the Pacific by United Kingdom government agencies covers the period from 1 September 1976 to 30 September 1979.

Work has been carried out by:

The Directorate of Overseas Surveys (DOS) under mutual technical co-operation arrangements. DOS is part of the United Kingdom Overseas Development Administration;

The Directorate of Military Survey and the Hydrographic Department, Ministry of Defence, on request.

Field work and map and chart production, training and the secondment of experts are described in subsequent parts of the report.

I. AIR PHOTOGRAPHY, FIELD SURVEY AND MAPPING

A. *Air photography*

The Directorate of Overseas Surveys (DOS) arranged for air photography to be taken of parts of Cyprus (1976) and of the Yemen Arab Republic (1978 and 1979) to support current mapping programmes. In addition, small areas were photographed to assist forest rehabilitation in Cyprus (1976) and a rural development project, settlement schemes, tea growing and forest development in Nepal (1978 and 1979).

B. *Field survey*

Throughout the period a DOS field party worked in the Yemen Arab Republic establishing a main survey framework and observing control for 1:50,000 contoured mapping of an extensive area in the south and west of the country. During the past year considerable effort was devoted by both Yemeni and DOS staff to collecting names and field completion data for the new 1:500,000 map of the whole country and for the first 29 1:50,000 sheets. Large-scale surveys were carried out in and around the towns of Dhamàr, Ibb and Sana to assist local mapping and survey projects.

British military surveyors were requested to provide precise Doppler fixes in a number of countries including Brunei (1), Dubai (3), Iran (12 fixes to support hydrographic work, see part II.A below) Malaysia (11 on primary stations including the datum stations at Timbalai and Kertau) and Sri Lanka (6). At one of the Malaysian stations experiments were carried out in using data from GEOS 3 to obtain coverage of the Bay of Bengal and South China Sea areas. A number of gravity traverses were run from the international gravity base stations in Colombo and a first-order gravity transfer was carried out from Colombo (Sri Lanka) to Kathmandu (Nepal).

C. *Topographical mapping*

Maps published by the Directorate of Overseas Surveys are listed at annex I; six sheets of the World Series 1404 were produced by the Directorate of Military Survey.

Topographical mapping was carried out by DOS for eight countries in the region and in four of them current programmes were completed, i.e., in Fiji, the New Hebrides, the Solomon Islands and Tonga.

Work continued in the Cyprus Lands and Surveys Department and at DOS on the joint 1:5,000 contoured mapping programme. Preparation and aerotriangulation of all sheets were done in the United Kingdom and all field completion was carried out by Cyprus; the remaining stages were undertaken in both countries. At the end of the period a total of 256 sheets had been produced and printed in the United Kingdom and work was continuing there on a further 78 sheets.

The first sheets of the basic photomap series of Kiribati and of Tuvalu were published and preliminary mosaics of all the islands were sent to their respective governments. All the remaining sheets should be published during 1980.

After publication of the English edition of the single-sheet 1:500,000 map of the Yemen Arab Republic, an Arabic edition was prepared. Work commenced on 54 1:50,000 contoured maps and the first sheets were ready for proofing at the end of the period.

D. *Thematic mapping*

Maps published by the Directorate of Overseas Surveys are listed at annex I.

*The original text of this paper, prepared by the Directorate of Overseas Surveys, appeared as document E/CONF.72/L.53.

Programmes of geological mapping requested by the United Kingdom Institute of Geological Sciences were completed of Burma and of the Solomon Islands. A series of land capability maps of Malaysia (Sabah) and maps illustrating land resource investigations in the Solomon Islands were completed for the Overseas Development Administration's (ODA) Land Resources Development Centre.

Current programmes of geological mapping include the 1:100,000 series of the New Hebrides for the government of the Condominium; and two new series, one at 1:100,000 to illustrate the results of an ODA-sponsored research project into the Oman ophiolite, and a second at 1:50,000 of the Salt Range in Pakistan.

In all these cases DOS prepares the maps from specialist data gathered and collated by the organization concerned.

II. HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING

A. *Hydrographic surveying*

Since August 1976 the only hydrographic surveying carried out by the Royal Navy in Asian, Far Eastern and Western Pacific waters has been concentrated in the Gulf of Oman.

Three ships, HMS *Hecate*, *Hydra* and *Beagle*, were deployed to survey in Iranian waters for the Iranian Government between November 1977 and May 1978, as the start of a three-year agreement between the two Governments, when it was planned to carry out modern surveys of a large proportion of Iran's coastal waters both inside the Persian Gulf and in the Gulf of Oman. Four more ships, HMS *Hydra*, *Herald*, *Fox* and *Fawn*, commenced the second phase of this operation in October 1978 but, owing to the change in the Government of Iran, the deployment was ended in February 1979 and the agreement subsequently terminated. By that time, almost all the work, funded by Iran, in the Gulf of Oman had been completed. A list of these surveys is in annex II.

B. *Radio Navigational Warning Service*

The IMCO-sponsored World-wide Radio Navigational Warning Service has been implemented throughout the area with the exception of Navarea XI covering the north-west Pacific, South China Sea, Malaysia and Indonesia. This area is expected to become operational with Japan as the Area Co-ordinator in March 1980. Then the UK-originated Naveast series, which with the US-originated Hydropac series at present covers the area, will be phased out.

C. *Nautical charting*

Some considerable progress has been made in replacing Admiralty charts of Asia and the Far East with new ones redrawn in modern format and using metric units. Nearly all the charts of the Persian Gulf and of the approaches to Singapore are now in new format. During 1979 more resources were deployed on this modernization programme in Far Eastern waters, with particular attention being given to the busier areas, such as the routes between Japan and Singapore.

All Admiralty charts, both old and new, are subject to continuous maintenance and in the past few years this task has been greatly increased by IALA's programme to standardize buoyage throughout the world. In Asia and the Far East, IALA System "A" buoyage has been introduced by Australia and Singapore, and a start has been made in the Persian Gulf.

The modernization of Admiralty charts of this area has been assisted by chart exchange agreements with Australia, New Zealand and India. Two hundred and eight Australian and New Zealand charts are reprinted in the Admiralty series and 111 of these are metric. On 1 January 1980 the Australian-New Zealand-United Kingdom charting arrangement will be amended and New Zealand will take over from the United Kingdom charting responsibility for the Cook Islands, Niue and Western Samoa. Modified facsimile versions of 21 modern Indian charts have been incorporated into the Admiralty series under a bilateral exchange agreement.

All but one of the sheets covering the waters of Asia and the Far East in the 1:3,500,000 International chart series are now published. In addition to the UK-produced sheets many of the others have been printed in the Admiralty series and work is in hand to adapt the remaining charts. The United Kingdom published sheet 70 in the International chart series at 1:10,000,000 in October 1977, and sheets 72 and 73 in June 1979. These provide cover of the Indian Ocean at this scale and complete the United Kingdom's contribution to the series in this area.

III. AERONAUTICAL CHARTS

Details of production of ONC and TPC series are given in annex III.

En Route Charts continued to be produced regularly as part of the Flight Information Publications Programme. Sheets covered parts of the Middle East, South Asia, the Indian Ocean, the East Indies and the Pacific. Their revision cycles vary from eight to 52 weeks.

IV. TRAINING AND SECONDMENT OF EXPERTS

A. *Training*

Training in cartography and in photography continued to be provided by DOS. Courses were tailored to meet the needs of individual departments. Trainees were funded either by United Kingdom Technical Co-operation Training Awards, by United Nations Fellowships or by their own governments. Annex IV shows the countries from which they came.

Hydrographic training was provided at the RN Hydrographic School and trainees from the region followed a number of different courses: details are given in annex V.

Some training in nautical chart cartography was provided in the Hydrographic Department at Taunton. Two officers and four civilian draughtsmen from the National Geographic Organization, Tehran, received training in chart compilation and maintenance for periods of up to 18 months as part of the agreement with the Iranian Government. An officer from the Indian Hydrographic Office was given eight months' training in all aspects of automated cartography, including advice on the purchase of equipment suitable for his organization. Two draughtsmen from the Marine Department of Sarawak, Malaysia, each underwent three months' training in compilation methods, and a short general course was provided for an officer from Indonesia's Directorate of Sea Communications.

B. *Secondments and recruitment*

Senior professional and technical staff have continued to be seconded to various countries in the region for periods of two years or more. Details are given in annex VI. Secondments were normally to fill posts in government departments, but those in Indonesia were specifically to the Indonesia/United Kingdom Transmigration Project (Cartographer) and to the Krueng Jreue and Krueng Baro Irrigation Project (Surveyor).

In addition, the Overseas Development Administration has continued, at the request of overseas countries, to recruit experts to fill specialist posts and to finance salary supplementation schemes as necessary.

Annex I

SUMMARY OF MAPS OF ASIA AND THE PACIFIC PRODUCED BY THE DIRECTORATE OF OVERSEAS SURVEYS BETWEEN SEPTEMBER 1976 AND OCTOBER 1979

Burma			
1:100,000	N. Shan States	Geological	1
1:125,000	N. Shan States	Geological	1
Cyprus			
1:5,000	Southern part of the island	Contoured	234
Fiji			
1:50,000	Vanua Levu	Revision	3
Kiribati			
1:2,500	Tarawa		5
1:25,000	Beru, Butaritari, Kuria, Little Makin, Maiana, Nikunua	Photomaps	8
Malaysia			
1:250,000	Sabah	Land capability	10
New Hebrides			
1:2,500	Port Vila	Contoured	56
	Luganville/Santo	Contoured	
1:100,000	Pentecost and Ambrym, S. Santo, Tanna, Aneityum, Futuna, Banks Group	Geological	4
Solomon Islands			
1:50,000	Guadalcanal	Contoured	1
1:150,000	Guadalcanal	Geological	1
1:150,000 / 1:250,000 / 1:1M	New Georgia, Russell Is., San Cristobal, Outer Is., Santa Isabel, Choiseul, Shortlands	Land use, forest types, soils etc.	40
Tonga			
1:25,000	Remaining areas of the whole Group	Contoured	15
Tuvalu			
1:2,500	Funafuti	—	8
1:12,500	Nukulaelae and Niulakita	Photomap	1
Yemen Arab Republic			
1:500,000	Whole country	Layered and contoured	1

Annex II

HYDROGRAPHIC SURVEYS CARRIED OUT BY THE ROYAL NAVAL SURVEYING SERVICE SINCE AUGUST 1976 IN ASIAN AND FAR EASTERN WATERS

Gulf of Oman		
Bandar Sirik to Ras Garnan	1:75,000	Nov. 1977 to May 1978
		Oct. 1978 to Jan. 1979
Jask Bay	1:10,000	Dec. 1977 to May 1978
Approaches to Jask	1:25,000	Feb. 1978 to May 1978
Chah Bahar	1:25,000	Oct. 1978 to Feb. 1979
Govatar Bay	1:25,000	Dec. 1978 to Feb. 1979

Annex III

AERONAUTICAL CHART PRODUCTION, SEPTEMBER 1976 TO OCTOBER 1979

Series	*Scale*	*Published*	*In production*
ONC	1:1,000,000	J.7	H.6
		L.11	J.6
TPC	1:500,000	H6A-D	G4C + D
		J6A-D	H5A + B
			H7D
			J7A + C

Annex IV

TRAINING AT THE DIRECTORATE OF OVERSEAS SURVEYS: TRAINEES FROM THE REGION, SEPTEMBER 1976-OCTOBER 1979

	1976	*1977*	*1978*	*1979*
	SOND	*JFMAMJJASOND*	*JFMAMJJASOND*	*JFMAMJJAS*
Brunei		0------0		0-
Cyprus		0 ----------0		
Fiji			0----------	
Indonesia	----------0			
Iran			0---0	
Nepal	----0		0--0	
Sri Lanka			0---0	

Annex V

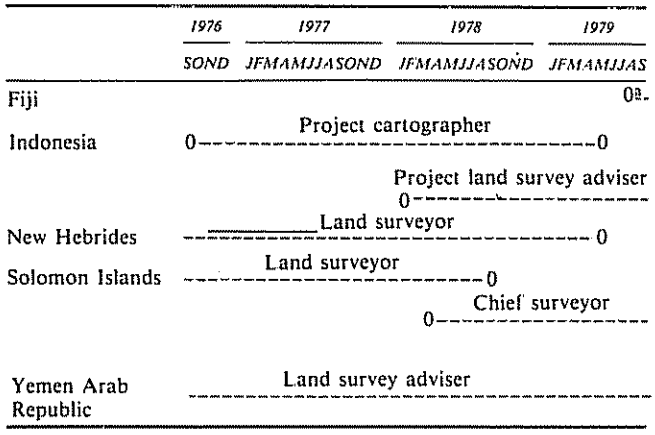
TRAINING AT THE RN HYDROGRAPHIC SCHOOL: COURSES TAKEN BY STUDENTS FROM ASIAN, FAR EASTERN AND PACIFIC COUNTRIES

	1976	*1977*	*1978*	*1979*	*1980*
Officers' Basic Course	1 Malaysia	3 Malaysia			
Officers' Long Course	2 Malaysia 1 New Zealand	1 Australia	1 Malaysia	1 Malaysia 1 Australia	6 Malaysia 1 Australia 1 New Zealand
Officers' Advanced Course		1 Malaysia			
POSR[a] Course				1 Sarawak (civilian)	4 Malaysia
LSSR[b] Course		4 Malaysia 1 Sarawak (civilian)	1 Sarawak (civilian)	4 Malaysia	12 Malaysia

[a] Petty Officers' Surveying Recorder.
[b] Leading Seamen's Surveying Recorder.

Annex VI

SECONDMENTS OF EXPERTS, SEPTEMBER 1976-OCTOBER 1979



[a] Hydrographic surveyor.

Annex VII

LIST OF TECHNICAL PAPERS ON SURVEYING, MAPPING AND CHARTING PRESENTED TO UNITED NATIONS CONFERENCES BY THE UNITED KINGDOM SINCE THE EIGHTH UNITED NATIONS REGIONAL CARTOGRAPHIC CONFERENCE FOR ASIA AND THE FAR EAST IN 1977

THEMATIC AND SMALL-SCALE MAPPING
(INCLUDING GEOGRAPHICAL NAMES)

E/CONF.69/L.23 — Romanization.
Third United Nations Conference on the Standardization of Geographical Names, 1977.

CADASTRAL SURVEYING AND URBAN MAPPING
(INCLUDING LAND INFORMATION SYSTEMS)

E/CONF.71/L.9 — Land registration projects in the Caribbean region, by P. W. Wesley.
Second United Nations Regional Cartographic Conference for the Americas, 1979.

E/CONF.71/L.26 — The Ordnance Survey topographic data base, concepts for the 1980s, by C. N. Thompson and P. A. Woodsford.
Second United Nations Regional Cartographic Conference for the Americas, 1979.

TECHNICAL ASSISTANCE (INCLUDING TRAINING)

ECA/CART/INF/79/27 — Technical co-operation in surveying and mapping in Africa—the role of Britain's Directorate of Overseas Surveys, by M. B. McHugo.
Fourth United Nations Regional Cartographic Conference for Africa, 1979.

REPORT ON THE CARTOGRAPHIC ACTIVITIES OF THE UNITED STATES OF AMERICA*

Paper presented by the United States of America

RÉSUMÉ

Les Etats-Unis d'Amérique s'efforcent de mener à bonne fin leur part des travaux d'ajustement relatifs au North American Horizontal Geodetic Datum (niveau horizontal de référence géodésique pour l'Amérique du Nord) et de rendre pleinement opérationnelle la base de données du National Geodetic Survey (Service national de géodésie). Les recherches techniques sur la géodésie par satellite et les systèmes de positionnement par inertie se poursuivent. Il est prévu que les observations gravimétriques conduisant au réajustement du National Vertical Datum (système national de référence verticale) continueront pendant les sept prochaines années. La Défense Mapping Agency (Service cartographique du Defense Department) s'occupe de trois grands projets dans le domaine géomagnétique.

La mise à jour des séries de cartes aéronautiques se poursuit dans le cadre de la coopération internationale. L'échelle de ces cartes varie du 1/5 000 000 au 1/500 000. Les cartes des procédures d'approche aux instruments sont maintenant disponibles en volumes reliés destinés à l'aviation civile. Un nouveau répertoire des aéroports et installations a remplacé les deuxième et troisième parties de l'Airman's Information Manual (Manuel d'information des navigateurs aériens).

La DMA a publié plus de 700 cartes marines nouvelles ou révisées du secteur Asie-Pacifique. Le Naval Oceanographic Office (Bureau d'océanographie des forces navales) effectue des levés dans l'océan Pacifique. Le National Ocean Survey (Service océanographique national) établit des cartes bathymétriques à l'échelle du 1/250 000 de la bordure extérieure du plateau continental des Etats-Unis et poursuit la mise à jour des cartes marines des côtes des Etats-Unis et de leurs possessions en publiant près de 300 nouvelles éditions chaque année. Les NOS publie également 19 nouveaux Coast Pilots (Guides côtiers) et travaille à l'établissement d'un système automatisé d'établissement des cartes marines.

La DMA a publié plus de 700 cartes topographiques à grande échelle d'installations et de zones d'entraînement militaires et fournit des données numériques à des fins telles que l'analyse du terrain et la surveillance des obstacles à la navigation aérienne. Le United States Geological Survey (Service géologique des Etats-Unis) a publié 3 598 nouvelles cartes topographiques normales à l'usage du public. Parmi ses projets spéciaux figure une carte pour les treizième Jeux olympiques d'hiver et une carte tectonique de l'archipel indonésien.

Le Service géologique des Etats-Unis procède à l'établissement d'une série de cartes d'utilisation des sols pour le territoire des Etats-Unis et étudie la précision des données obtenues dans ce domaine au moyen de la télédétection par satellite et par les méthodes de détection des modifications de l'utilisation des sols et de la couverture végétale.

Le Programme de systèmes d'observation des ressources terrestres du Service géologique des Etats-Unis étudie les méthodes et les effets de renforcement du contraste des images LANDSAT et a commencé à travailler à un « Atlas des images de glaciers obtenues par satellite ».

Le United States Board on Geographic Names (Bureau des noms géographiques des Etats-Unis) se met en devoir d'adopter les graphies en caractères latins des noms de lieux chinois selon la méthode de translittération établie par la Chine.

GEODESY

Adjustment of the North American Horizontal Datum

The new adjustment and redefinition of the North American Horizontal Geodetic Datum will span the United States, Canada, Greenland, Mexico and the republics of Central America, and perhaps a substantial part of the Caribbean area. This enormous task requires converting about 2,500,000 field observations to computer-readable form. Approximately 1,500,000 observations, representing 145,000 stations, have been keyed and validated.

Portions of the National Geodetic Survey (NGS) data base are operational, including 175,000 geodetic positions, and about 150,000 descriptions have been keypunched and edited. Observations that have been digitized and adjusted on a field-project basis will also be entered into the data base.

Satellite geodesy

The United States is supporting technological investigations covering a broad spectrum of geodetic disciplines, including radar altimetry data from GEOS-3,

*The original text of this paper appeared as document E/CONF. 72/L. 4.

which will contribute significantly to the upgrading of the geoidal model over the open ocean areas of the world. A preliminary ocean geoid from GEOS-3 altimetry has been provided to the International Gravity Bureau (IGB), Paris, France.

Along with the satellite altimetry developments, the United States has continuing efforts in satellite to satellite tracking, having developed the NAVPAC receiver for use with the Navy Navigation Satellite System and the GPSPAC receiver under development for eventual employment with the Global Positioning System. Both the NAVPAC and the GPSPAC will provide an enhanced capability for space platform positioning to high accuracy in three dimensions.

Horizontal control

Constrained adjustments

During the reporting period, data for 18,860 stations determined from the adjustments of 220 projects were constrained to the NAD 1927 and added to the published files. Two very large multi-network systems were adjusted in single computations. One network was in south-western Alaska and involved 1,700 stations; the second network was in southern Louisiana and involved 1,750 stations. In addition, all data for the high-precision transcontinental traverse have been adjusted to the NAD 1927.

Blue book

The programme to incorporate survey data into the National Geodetic Data Center (NGDC) continued. To be acceptable for NGDC, surveys must conform to national standards and the results must be in computer-readable format. Projects received from the Bureau of Land Management (BLM), United States Geological Survey (USGS), International Boundary Commission (IBC), North Carolina Geodetic Survey, and state and local governments are being processed according to priority.

Inertial positioning systems

A Litton Auto-Surveyor owned by the Bureau of Land Management was brought to Denver for tests oriented to USGS map control requirements; the resulting horizontal positions generally agreed within half a metre, but vertical accuracy was inadequate for most 1:24,000-scale mapping. A military version of the system, on loan from the Defense Mapping Agency (DMA), was used for the first production test in Maine, a mapping project requiring ground data for a 21,300-km^2 area, nearly one quarter of the state.

Fabrication of the Aerial Profiling of Terrain surveying system to be used in light aircraft has begun for USGS. A three-co-ordinate scheme of reference with an accuracy of 0.15 m vertically and 0.60 m horizontally is provided by an inertial navigation subsystem using a laser unit for airborne calibration. The ground profile is determined by a laser altimeter whose readings are related to aircraft position by computer. Design of the system was prompted by a need for obtaining terrain profiles for flood-plain delineation. Other field applications include establishing survey points for the control of new maps or for evaluating the accuracy of old maps.

Gravity

By 1 January 1976, the reobservations of the United States Gravity Base Network were completed. A complete report of this project will be prepared by NGS. Gravity observations were repeated in 1976 and again in 1977 over level lines in southern California in the continuing investigation of gravity changes associated with land subsidence. In the spring of 1978, repeat observations were made along level lines in the Houston-Galveston area, also for the purpose of investigating land subsidence. Between 20 January 1978 and 20 May 1978, survey teams from several federal agencies made high-precision gravity observations over the level lines of the Southern California Releveling Project (SCRP).

Gravity observations in the north-eastern United States were begun in August 1978 in conjunction with relevelling operations, leading to a readjustment of the National Vertical Datum. This project is scheduled to continue over the next seven years and will consist of some 60,000 gravity point values.

Geomagnetics

Three major geomagnetics projects were undertaken during the reporting period. First, a review of all user needs and applications for geomagnetic data is being conducted. This analysis should help to determine areas for future supporting research and development. Secondly, DMA is conducting an investigation of the temporal variations in the Earth's geomagnetic field. These variations will be analysed by the Naval Oceanographic Office and will consider both the time-varying properties of the field and the casual factors associated therewith. Thirdly, DMA is sponsoring the Naval Research Laboratory effort to derive bathymetry from deep ocean aeromagnetic survey data. This will be done by means of an algorithm which indicates the distance between the sensor and the magnetic basement rock beneath the sea floor.

AERONAUTICAL CHARTING

Aeronautical charting summary

The Tactical Pilotage Charts (TPCs), 1:500,000 scale, cover the United States, Europe, eastern Asia, Japan, Indonesia and the Philippines. This series is designed primarily for low-altitude, high-speed radar and visual air navigation. Charts are produced and maintained by the joint efforts of DMA/NOS/United States, DMS/United Kingdom, DMS/Australia and DMC/Canada.

The Operational Navigation Charts (ONC), 1:1,000,000 scale, at present cover all land areas of the world except Antarctica and a few isolated islands. This chart series is designed for medium en-route navigation by dead reckoning, visual pilotage, celestial, radar and other electronic techniques. Charts are produced and maintained by the joint efforts of DMA/NOS/United States, DMS/Australia, DLS/New Zealand, DMC/Canada and DMS/United Kingdom.

The Jet Navigation Charts (JNCs), 1:2,000,000 scale, together with the older JN series, cover a major portion of the world except South America, Antarctica and some ocean areas, which charts are yet to be completed. This chart series is designed for high-altitude long-range, radar, celestial and visual navigation. The older JN series and V-30 series are being replaced as new JNC charts become available. Charts are produced and maintained by the joint efforts of DMA/United States and DMS/Australia.

The Global Navigation and Planning Charts (GNCs), 1:5,000,000 scale, cover the world. This series of charts

is designed for extended long-range, high-speed, high-altitude aerospace navigation with secondary consideration given to mission planning and general briefings. All 26 charts of this series have been published and are maintained by DMA.

The Global LORAN Navigation Charts (GLC), 1:5,000,000 scale, cover a major portion of the Northern Hemisphere including the Atlantic and Pacific Ocean areas. This series of charts contains LORAN A and CONSOL/CONSOLAN information overprints for use in high-speed extended long-range aircraft navigation requirements over large expanses of water.

The Global LORAN Navigation Charts (GLCC), 1:5,000,000 scale, have the same coverage as the GLC charts (indicated above) and in addition have land charts covering Europe and North Africa. This series of charts contains LORAN C information overprints for use in extended long-range aircraft navigation requirements.

Instrument Approach Procedure Charts in bound volumes

Instrument Approach Procedure Charts are now available in bound volumes designed for civil aviation—the bound volume format replaces the looseleaf version. The 15 bound volumes provide complete coterminous United States (48 states) coverage (plus Puerto Rico and the Virgin Islands). The bound volumes are issued every 56 days. A Change Notice is issued 28 days later.

Airport/Facility Directory

The new Airport/Facility Directory replaces parts II and III of the Airman's Information Manual. The directory is available in seven volumes each covering a specific geographical region of the coterminous United States. These bound volumes provide information on each airport's associated city and state, runway characteristics, and lighting, communications and radio navigation aids. Each volume is reissued every 56 days.

HYDROGRAPHY AND OCEANOGRAPHY

Hydrographic charts

Since January 1976, DMA has published 715 new or revised nautical charts of the Asia-Pacific area which would include some modified facsimile reproductions of charts produced by Australia, Indonesia, Japan, the Philippines, the Republic of Korea and Taiwan Province. Of the total number, 231 are classified as large-scale harbour and approach charts (larger than 1:75,000 scale), 289 are classified as medium-scale coastal charts (1:75,000 to 1:600,000 scale) and 195 are small-scale general ocean and sailing charts smaller than 1:600,000 scale. Of the small-scale charts, 18 are of the international series and 12 are general sailing charts.

International exchange of charts

To provide global chart coverage to mariners, the United States has agreed with 20 other nations to sell modified facsimile reproductions of each other's nautical charts. Agreements are in effect with Australia, Indonesia, Japan, the Philippines and the Republic of Korea as well as with 21 countries in other parts of the world. These agreements are in accordance with IHB resolutions.

International organization

To co-ordinate and establish standard procedures in charting United States and Canadian waters, the United States/Canada Hydrographic Commission was established in April 1977. The Commission consists of committees and groups that are responsible for planning design, specification, and other cartographic/hydrographic functions. Exchanges of personnel between NOS and the Canadian Hydrographic Service are taking place. This on-site training provides a better insight into the cartographic concepts used by both countries.

Hydrographic surveys

Hydrographic survey ships under technical control of the Naval Oceanographic Office continue surveys in the Pacific area. Survey operations have been completed in the Philippine Islands, and also off the Pacific Coast of Panama. Operations are currently being conducted with Indonesia in the Makassar Straits area. Support of hydrographic operations conducted by the Republic of Korea in its waters continues on an annual basis.

Bathymetric maps of the United States Outer Continental Shelf (OCS)

To support the United States offshore energy development programme, NOS produced 16 1:250,000-scale bathymetric maps covering potential leasing areas in the Gulf of Mexico and north and south-east Atlantic Ocean. These 16 maps, together with 38 others previously produced, bring to 54 the number of new, detailed bathymetric maps prepared under this programme. All the maps are produced in metric units and contain the Bureau of Land Management (BLM) offshore lease block grid. BLM is responsible for administering the United States OCS lease-sale programme, and uses the bathymetric maps to prepare environmental impact statements for the lease areas. NOS has an ongoing commitment to provide bathymetric maps to support the OCS programmes and other United States deep-ocean resource development projects.

Navigational charts

During 1977 and 1978, the United States 200-mile Fishery Conservation Zone limit was printed on 38 selected nautical charts (1:600,000 scale and smaller) which will provide complete coverage of the offshore waters of Alaska, Hawaii, Puerto Rico and the contiguous United States. The three-nautical-mile (territorial sea) and 12-nautical-mile (contiguous zone) seaward boundaries were printed on 80 selected navigational charts (scale range between 1:80,000 and 1:200,000) covering the coastal waters off the contiguous United States, Alaska, Hawaii, Guam and Puerto Rico.

A new 1:100,000-scale metric and English version nautical chart (18460) covering the Strait of Juan de Fuca was published. The chart is printed in a back-to-back format—metric side and English (fathoms) side. This chart can be classified as a bathymetric/nautical chart because more bottom contours are combined with the soundings to show the water depths. This concept provides the user with a more detailed picture of the bottom topography, to aid deep-draft vessels in selecting better navigational routes. Production of this chart was made possible through the co-operation of the Canadian Hydrography Service, which conducted hydrographic surveys covering the Canadian waters of

the strait. The shoreline, low-water lines, soundings, depth contours, land contours and symbols on this chart were compiled and constructed in reproducible form by the NOS Automated Nautical Chart System.

During this period maintenance of the nautical charts covering the United States and its possessions, including the Great Lakes, was continued and 1,186 new editions were published. There are nearly 300 charts for which new editions are published every 12 months.

Reformatting of the 86 NOS small-craft charts for recreational boaters into the road-map type design continues. This redesign will save cost in reproduction and is easier for the recreational boater to use and store.

New colours for improved visibility of charted detail were adopted for all nautical charts in that the 13 colours originally used in printing nautical charts have been reduced to five standard colours.

Notice to Mariners

The Notice to Mariners is an official document issued weekly to advise mariners of important matters affecting navigational safety, including new hydrographic discoveries, changes in channels and navigational aids. The information in the Notice to Mariners is presented in a format that allows easy correction of charts, Sailing Directions, the Light List and other nautical publications, aboard ocean-going ships. NOS issued over 9,000 notices and 230 chartlets for publication in the 17 United States Coast Guard Local Notices to Mariners and the DMA weekly Notice to Mariners. To expedite the printing and reduce the cost of publishing chartlets, they are now being printed in monochrome.

Coast Pilot

This series of publications consists of nine books. A total of 19 new editions were published during the reporting period. The Coast Pilots are published from a variety of information, and field inspection surveys performed by the NOAA Corps Officers attached to the Coast Pilot Branch. A field inspection was completed covering the Great Lakes area and Dixon Entrance to Cape Spencer, Alaska.

Aerial photographs are being shown in NOS Coast Pilots better to familiarize users with harbour entrances and significant navigation features. The photographs now appear in Coast Pilot Nos. 3, 7 and 9. A new edition of "Distance Between U.S. Ports" was also published.

Computer-assisted nautical charting

The NOS objectives for the Marine Data Systems Project (MDSP) are to design, develop and operate a balanced automated nautical charting system. The Project is scheduled for completion in 1980.

Data acquisition

The hydrographic survey data acquisition systems HYDROPLOT and digital sextant systems are fully operational and have been transitioned by MDSP to the National Ocean Survey Office of Fleet Operations. At this reporting a 30 per cent improvement in overall data acquisition operations has been realized by use of the HYDROPLOT equipment and software system. An upgraded data-processing system has been installed at the Atlantic Marine Center (AMC), Norfolk, Virginia, and when fully on line will be compatible with the system at the Pacific Marine Center (PMC).

Evaluation, storage and compilation

Conversion of the active nautical chart file of 3,207 hydrographic surveys from graphic to digital format is complete.

Automated graphics

NOS completed implementation of a five-table computer-controlled graphic digitizing system. This system also has CRT displays to facilitate and verify accuracy of conversion of data from graphic to digital format. Special overlays for oil pipelines and mineral lease blocks have been automated for incorporation into existing chart publications for the Gulf of Mexico.

Coastal mapping

NOS and USGS combine their mapping skills to produce jointly a new modern series of 1:24,000- (1:25,000), 1:100,000- and 1:250,000-scale topo/bathy maps covering the coastal zone of the United States. These multipurpose maps show on the one single map USGS land topography and NOS bathymetry, thus providing a detailed picture of the total physical environment in a specific area. Orthophoto imagery will be used on the 1:24,000 maps when possible to provide more land detail. Depth gradient tints are used to enhance the bathymetric contours.

Special operations

Two air photo missions accomplished over 30,000 miles of photography as part of the Shoreline Mapping and Airport Obstruction Programs. This included colour, infrared and panchromatic.

The Marine Boundary Program continued in Florida with a targeted completion date of 1980. The programme is about 50 per cent complete.

Research and development

A new, highly precise mensuration system using laser light was installed on the NOS Mann Automatic Stellar Comparator (MASC). The laser system uses a Hewlett-Packard dual-frequency design that is capable of recording positional accuracies of better than 0.5 micrometres in the controlled environment of the MASC. In the retrofit design, MASC lead-screws were retained for transport of the stages, and the laser system was mounted so as to adhere to Abbe's principle and provide positional information through the use of interferometers. The interferometers have the capability of detecting changes in distance of one fourth the wavelength of the laser light, or about 0.2 micrometres. The project is at present in the system calibration phase.

TOPOGRAPHIC MAPPING

Military topographic mapping

During the period under review, defense mapping programmes for the United States primarily involved the revision and reformatting of published maps of military installations and training areas. A total of 746 large-scale topographic maps were published.

Digital-data programmes

DMA is now producing digital data for a number of products and users. These digital programmes are described below.

Digital Landmass Simulation (DLMS)

Digital Feature Analysis and Terrain Elevation Data are derived for aircraft simulators. This data base provides surface cultural features for the simulators. The terrain data base depicts features normally shown on 1:250,000-scale charts plus additional radar-significant points, such as isolated features and airfields. This data base covers broad areas.

DMA Vertical Obstruction File (DVOF)

Vertical obstruction data is required for low-level aircraft. DMA has been producing limited amounts of vertical obstruction information for low-level aircraft flights for the past two to three years. This effort was primarily a fall-out of data from other programmes.

A comprehensive programme was started in October 1979, to produce vertical obstruction data over selected areas. The first year's production will provide data for studies/analyses and serve as a baseline for future efforts.

Photogrammetry

The current trend towards automation is most evident in photogrammetry, as witnessed by the development of the experimental AS-11B-X automated stereomapper. The production version of the AS-11B-X, along with its supporting data-processing system, will provide an order-of-magnitude improvement in production times for digital terrain elevation data. Currently under design is an advanced interactive editing system to optimize editing of both raw and processed terrain data.

DMA also has several other equipments relying on automatic stereo image matching. The Optical Power Spectrum Analyzer (OPSA) is being developed to support these systems by screening photographs before input, with the objective of identifying problem areas prior to processing.

Photogrammetric systems are now being designed to accept imagery in either film or digital format. Currently under consideration is the Universal Rectifier, which is a departure from the specialized electro-optical design of current rectifiers to provide a much more flexible capability.

Civilian topographic mapping

Aerial photography

During the reporting period USGS contracted for 2.6 million km² of aerial photography. Three fourths of the photographs were taken from altitudes higher than 11,700 m for use in photo-inspection and photo-revision of published maps and for photomapping. The aerial mapping cameras used by private contractors on photomissions for civilian government agencies were tested by the USGS Optical Calibration Laboratory. The laboratory tested and calibrated 265 complete cameras and 27 lenses.

Photogrammetry

Advanced image-correlation system. USGS acquired a Gestalt Photo Mapper II (GPM2), the first production model in the world. The GPM2 automatically corrects for the distortion in aerial imagery and concurrently produces orthophotographs and the corresponding terrain data in contour and digital (magnetic-tape) form. The entire process is executed under computer control with the operator intervening occasionally to assist in correlating the images. Production time is related to various characteristics of the aerial photographs and of the terrain pictured. Production trials led to several improvements in software to improve performance and in physical conditions to provide a clean-room environment for the photograph scanning and printing elements.

Large-scale mapping

During the reporting period, 3,598 new standard USGS topographic maps were published, covering 531,136 km². Most of the maps were in the 7.5-minute series, 1:24,000 scale (15-minute series, 1:62,500 scale until replaced; 1:63,360 and 1:25,000 in Alaska). In addition to meeting the needs of many users, these are the basic maps from which smaller-scale and special maps are usually derived. As national coverage in the 7.5-minute series increases, the revision mapping workload increases. With special emphasis on coverage of urban, coastal-zone, transportation corridor and other areas where changes in culture are rapid, published maps are checked against current aerial photographs at appropriate intervals and, if necessary, revised. About 3,200 revised 7.5-minute maps were published in the reporting period. Besides line maps, about 1,200 orthophotoquads were prepared. Thirteen of the 50 states now have complete map coverage at 1:24,000 scale.

Intermediate-scale mapping

To meet the need for basic map data at various levels of detail and at scales between 1:24,000 and 1:250,000, the intermediate-scale map series was introduced in 1975. These maps are prepared with up to 26 feature-separation drawings, any combination of which can be used to produce a special map with a desired level of content. The feature symbolization was specially designed to facilitate digitization. By the end of 1978, intermediate-scale maps for about one third of the coterminous United States were either completed or in production. Under a 1978 joint USGS-DMA agreement, USGS will complete about 2,100 15-minute metric topographic maps at 1:50,000 scale.

Small-scale mapping

The 1:250,000 topographic map series provides the largest scale of complete coverage available for the United States and is thus valuable to many federal and state agencies. The maps are also used by USGS for preparing state base maps, various geologic maps and special-purpose maps, such as those showing land use and land cover information. In the reporting period, 105 revisions were published. Terrain data digitized from the contours on the 1:250,000-scale maps are available on magnetic tape.

Special maps

Map users seem to want a more definitive map representation of United States wetlands based on a standard wetland classification system. USGS is investigating the problem by experimentally mapping wetlands in Florida, Georgia, Mississippi and South Dakota—areas which vary significantly in vegetation and other characteristics.

USGS also produces national park maps, normally standard topographic maps combined into one or more sheets covering the park area with companion shaded-relief editions in some cases. During the reporting period, four park maps were revised. Some of these maps

are designed to be folded and packaged in pocket-size plastic jackets.

A special Adirondack Region, New York, map was designed for the Thirteenth Olympic Winter Games. The Olympic area is mapped in shaded relief at 1:100,000 and 1:50,000 scales and includes large-scale insets of the actual game sites colour-coded to the various tickets sold.

International co-operation

USGS provided technical assistance and training in surveying and mapping to a number of countries including France, Lesotho, Mali, Nepal, Nigeria, Saudi Arabia and Trinidad and Tobago, and to Inter American Geodetic Survey employees from Panama.

During the period 1976-1979, the United States Geological Survey produced or was instrumental in producing cartographic products of all or parts of Indonesia, Saudi Arabia and the Pacific Ocean basin and its fringing areas. A technical assistance project in geologic mapping was conducted under the auspices of the United States Agency for International Development (AID) from 1970 to 1975. A product of that activity was the publication in 1978 of a tectonic map of the entire Indonesian archipelago at 1:5,000,000 scale. Twenty geologic quadrangle maps of Saudi Arabia at 1:100,000 scale were published during the period. In addition 14 other sheets including geochemical reconnaissance maps, geographic maps, magnetic anomaly maps, satellite imagery maps and reconnaissance geology maps, were either compiled and published or revised and reprinted. Three correlated black/white film mosaics of LANDSAT bands 4, 5 and 7 were prepared and used as a base for a geographic map of the Yemen Arab Republic published in a multicolour bilingual edition (English and Arabic) in 1978. The mosaic of band 7 was also used as a base for publication of a companion geologic map. These maps are co-operative editions prepared and published under the auspices of AID.

USGS continued to support the Circum-Pacific Map Project and related activities of the Circum-Pacific Council on Energy and Mineral Resources. USGS participation is to co-ordinate the work of five panels of earth scientists from various countries and direct cartographic finishing and publication of the project maps and develop a better understanding of the known and possible resources of the Pacific region. Results of the project are in a series of geographic-bathymetric, geologic, tectonic and energy and mineral resources maps in five separate quadrants covering the Pacific region and Antarctica at 1:10,000,000 scale. A sixth map at 1:20,000,000 shows relationships of energy and mineral resources to the geotectonic and geophysical features of the whole basin. The six geographic maps were published in 1978.

USGS is in its twenty-second consecutive year of providing surveying and cartographic support to the United States Antarctic Research Program sponsored by the National Science Foundation. One Antarctic project to obtain control for LANDSAT image maps in western Antarctica was a co-operative effort with the British Antarctic Survey.

Digital cartographic data

In 1977, USGS formed a Digital Applications Team to consider the problems of digital cartography, design the data bank, select and design equipment and plan the system for supplying data to users on request. The products supplied may or may not be in graphic form. For example, they can consist of digital elevation models recorded on magnetic tape. Nine pilot production projects covering various parts of the country are in progress at USGS.

The USGS camera calibration data bank now contains measurements for over 400 camera-magazine combinations; 157 are suitable for fully analytical aerotriangulation. Additional information in the data bank as of 1978 is the platen identification required on all magazines used on USGS aerial photography contracts. The platen number appears in all camera exposures. The data bank also contains information on fiducial-mark co-ordinates, radial lens distortion correction tables, focal length, lens type, lens number, nominal focal length code, camera owner, manufacturer, camera number, magazine or platen number, calibration date and model-flatness test results.

Metric maps

Metric maps of some areas of the United States, primarily in the coastal zones, require a 1-m contour interval to depict properly the hypsographic features. To determine the time and cost of producing 1-m contours, two projects are being compiled by different methods, one by field surveying and the other by photogrammetric methods using photographs taken with a camera with a 15-cm focal length at a flight height of 1,500 m. The areas selected are representative of the general landform types that require 1-m contours, that is, primarily tidal marshes and low-lying farmland.

The Saranac Lake, New York, quadrangle is the first of a series of metric topographic maps being prepared in a new format by USGS, 7.5 minutes of latitude by 15 minutes of longitude, at 1:25,000 scale. The map contains newly designed symbols and has a redesigned border. In addition to traditional data, such as the credit legend, bar scale, contour interval and declination diagram, the border contains a legend explaining topographic map symbols, a metric-customary unit conversion table and other data pertinent to metric mapping. All map elements—grid, contours, elevations, distances and bathymetry—are in metric units. The 1:25,000-scale metric series is printed on the same size paper and uses the same feature-separate sequence as the 1:100,000-scale metric series.

National Cartographic Information Center

The National Cartographic Information Center (NCIC) of USGS collects and distributes information concerning the availability of cartographic data for the United States. Besides the headquarters, NCIC has seven regional offices throughout the United States and during the reporting period 12 affiliate offices were established. NCIC has agreements with 11 federal agencies and 12 states for collecting and storing information about the availability of cartographic data.

THEMATIC CARTOGRAPHY

The first colour-coded land-use and land-cover map, Kansas City, Missouri/Kansas, was published in 1978. Level I land uses are colour-coded using a modified version of the World Land Use Survey colour scheme. Level II land uses are classified using a two-digit numeral such as "21", which signifies cropland and pasture. This is the first of a projected group of maps of

selected areas of the United States to be published in full colour to illustrate land-use and land-cover patterns.

A land-use and land-cover map of the Atlanta metropolitan region, compiled by conventional photo-interpretation, was chosen to demonstrate the use of laser scanning and plotting equipment to prepare a polygon-style thematic map for publication. A byproduct of the scan-digitizing for this map is area measurement of the land-cover classes, which are included on the published maps.

Using LANDSAT digital data, the USGS Geography Program has mapped vegetation in the 100,000 km² National Petroleum Reserve in Alaska (NPR-A). Multispectral scanner data from 10 LANDSAT scenes were analysed, then each spectral class determined through the computer analysis was identified with a specific class of vegetation using an interactive colour display system. Recent colour-infrared, high-altitude photographs and other information were used to establish a uniform classification system of 10 classes that would consistently characterize vegetation over the NPR-A using LANDSAT digital data. The vegetation classification obtained from LANDSAT was generalized and edited to match the uniform classification system. The resulting land-cover map was prepared as an uncontrolled colour mosaic at the scale of 1:500,000 for preliminary evaluation by agencies interested in the region. A 1978 field trip verified the reliability of the preliminary map and provided additional information for the final map and statistical products.

Accuracy analyses were made for the land-use and land-cover maps at 1:100,000 scale and at 1:24,000 scale for the Atlanta area, and land-use and land-cover maps at 1:24,000, 1:100,000 and 1:250,000 scales of the central Atlantic region. Land-use change maps for the period 1970-1972, prepared from high-resolution, high-altitude aerial photographs of the Central Atlantic Regional Ecological Test Site were also analysed. In the Atlanta study there was an accuracy of 90 per cent at the scale of 1:100,000; 87 per cent at 1:24,000 scale. The accuracy of the interpretations was consistent from category to category.

USGS has conducted extensive research into the various aspects of land-use and land-cover change detection as a first step towards establishing an operational programme of map updating. In addition to general research into alternative approaches, several specific studies were undertaken. To establish an appropriate time frame for updating land-use maps in a dynamic urban area, land-use changes in an 880-km² area of Phoenix, Arizona, were analysed. An optimum cycle of three to four years was indicated. In a second study, changes for a different land-use environment were analysed as part of a study of the impact of phosphate mining on the landscape in a three-county area in southeastern Idaho. Significant observations included the conversion of land from agricultural to intensive mining and industrial uses; accumulation of massive amounts of tailings; the construction of public service facilities; and the proliferation of mobile homes in urban centres. A third area of investigation dealt with an Applications Systems Verification and Transfer project conducted jointly with NASA. The primary objective was to test the operational feasibility and effectiveness of using LANDSAT digital data for change detection and map revision. The results showed that LANDSAT digital analysis techniques were adequate for identifying changes where they were substantial and where they occurred over large areas. However, the results were marginal in small areas or in those with little change. A number of "false changes" were identified from the LANDSAT analysis. The difficulties encountered suggest that continued development and testing are needed.

Duval County, Florida, including the Jacksonville metropolitan area, was selected for an experiment to interface Geological Survey land-use and land-cover data with Bureau of the Census population and related demographic data using a computer. Results of this experiment showed that residential population density patterns are more meaningful than the usual density patterns for urban areas as a whole.

Land-use and land-cover change measurements on most of the barrier islands along the Atlantic and Gulf coasts were prepared by USGS for the Heritage Conservation and Recreation Service. Measurements for the period 1945-1955 were prepared from aerial photographs taken during those years and compared with land-use and land-cover measurements prepared in 1978. Urbanization and other types of development were tabulated as an aid in recreation planning.

HYDROGRAPHY

State hydrologic unit maps

A series of uniform, nationally consistent state hydrologic unit maps that accurately delineate the hydrographic boundaries of major river basins in the United States was published by USGS in co-operation with the United States Water Resources Council. These maps provide a standardized base at 1:500,000 scale for use by water resources organizations throughout the 50 states and Puerto Rico.

REMOTE SENSING AND EARTH RESOURCES STUDIES

Earth Resources Observation Systems Program

A 1:500,000-scale satellite image mosaic of the State of Georgia that shows the general extent of the flood plains was prepared by USGS for state use in regional geologic studies. A fundamental problem is determining the best way to process LANDSAT data for distribution in image form. A second edition of the Upper Chesapeake Bay satellite image map shows the improvement due to digital image processing. Other experiments indicated that conventional photo-processing of spectral records into a colour composite may not be optimum for some mapping purposes.

Success in applying colour to LANDSAT multispectral imagery shifted attention back to the earliest method of obtaining colour pictures from black-and-white records. That method is to obtain at least two spectrally filtered records of the same area on black-and-white film and apply suitable colour inks on a printing press. In this way, USGS is experimentally adding colour to orthophotoquads. This technique was used to prepare image maps for the United States Customs Service along a 320-km strip of the United States-Canada border.

Information content of LANDSAT cartographic products has been studied with respect to image enhance-

ment techniques. Landmarks chosen from Geological Survey topographic quadrangle maps of northern Virginia were compared with the corresponding points on four differently processed colour images of the Upper Chesapeake Bay. The original LANDSAT image was recorded in 1972. The variations in detectability of selected features on the small-scale images indicate that enhancement materially increased the informational content of the images. Edge enhancement, although it causes anomalies, further increases the interpretability of cultural and natural features that have continuous edges. An unexpected finding is that one-dimensional edge enhancement approaches the results obtained by two-dimensional edge enhancement.

As part of a continuing investigation of possible applications of LANDSAT imagery to cartographic problems, experimental editions have demonstrated that small-scale charts of shallow-sea areas can be prepared quickly and accurately. These areas are difficult and expensive to chart by conventional methods. This finding is of interest to the agencies responsible for nautical charting.

LANDSAT images that show the maximum extent of ice coverage in the Chesapeake Bay, Potomac River and Washington, D.C., vicinity on 7 and 8 February 1977 were processed as a 1:500,000-scale colour-image map. The images were digitally enhanced at the EROS Data Center, Sioux Falls, South Dakota, to emphasize ice distribution. Comparison of the two images demonstrates LANDSAT capability to record temporal phenomena of general interest for historical purposes.

Design work has been completed for the large-format (23 cm x 46 cm) cartographic camera to be carried aboard an early space shuttle mission. USGS photographic specialists reviewed the camera specifications with NASA and Itek Corporation representatives and recommended technical improvements. After the camera is built by Itek, it will be tested, calibrated and certified in the USGS optical laboratory.

Sufficient LANDSAT, NOAA and other satellite data now exist to compile a "Satellite Image Atlas of Glaciers" and the preparation of such an atlas is under way. The primary objective of the atlas is to provide a pictorial inventory, in the form of either a LANDSAT or other satellite image or a tabular listing of the best available LANDSAT or other satellite images of existent glaciers.

GEOGRAPHICAL NAMES

Since the last conference, the United States has continued to be active in programmes concerning geographical names of the area under consideration. The most important programme focused on the requirement to adopt Roman-alphabet spellings of names officially promulgated by the People's Republic of China. As indicated in a paper delivered at the last conference by the United States, China announced a few years ago its intention to adopt the Roman alphabet for its writing system and to render geographical names in that alphabet according to the Pinyin romanization system. At the Third United Nations Conference on Geographical Names held at Athens in 1977, the new system was approved for international usage by an overwhelming majority of nations. Subsequently, the United States approved the new Roman-alphabet names for official purposes. To assist federal agencies and other organizations in the United States to change from the Wade-Giles forms of Chinese place names (in use for many years in the United States and other countries) to the new names, the United States recently produced a gazetteer containing some 22,000 Pinyin names along with equivalent Wade-Giles and English conventional names. This document of over 900 pages is based on an atlas produced in 1977 by China, and features latitude and longitude and other locational data for each entry. Early in 1979, representatives of China came to Washington, D.C., after a meeting of the United Nations Group of Experts on Geographical Names in New York, to help in resolving certain questions the staff had encountered while compiling the gazetteer. With the gazetteer as the source, United States cartographic agencies are converting to Pinyin names. Since the gazetteer represents only a small percentage of names in China, the United States looks forward to receiving additional names from Chinese authorities as the basis for expanded gazetteers.

It is estimated that more than 3 million geographical names are in active use in the United States. An automated information system, the Geographic Names Information System (GNIS), was designed by USGS, and will eventually encompass all those names, together with related information such as location, size and type of feature. The files are organized primarily by state, with complete files now available for several states. Another file contains all the formal decisions of the Board on Geographic Names since its founding in 1890.

AGENDA ITEM 7

Review of the latest techniques and developments related to various areas of cartography

(a) *Geodesy (including satellite) and topographic mapping (including satellite imagery and conventional photography)*

REVISION OF THE NATIONAL TOPOGRAPHIC MAP SERIES*

Paper presented by Australia

La Division of National Mapping (Service cartographique national) a adopté, en matière de révision des cartes, une politique conforme à la résolution 372 du National Mapping Council (Conseil national de la cartographie), aux termes de laquelle celui-ci a décidé que, dans la Série nationale de cartes topographiques au 1/100 000, la révision des cartes existantes à des intervalles de 10 ans au maximum devait passer, en principe, avant l'établissement de nouvelles cartes.

Toutes les cartes publiées dans la zone de publication limitée au 1/100 000 et non remises à jour postérieurement à 1972 ont été classées en vue de leur révision, par ordre de priorité compte tenu du développement de la région, des stocks existants et de la consommation annuelle. Une priorité élevée a été attribuée à la révision de la série R 502, qui doit être remplacée par la Série nationale de cartes topographiques au 1/250 000.

Un «modèle de révision des cartes» est en cours d'élaboration; il permettra de classer les cartes par ordre de priorité en vue de leur révision future. D'autre part, on réexamine actuellement la «politique en matière de stocks de cartes», compte tenu des ventes et de la consommation courantes.

Le Service cartographique national révisera continuellement les cartes au 1/100 000 et publiera à la fois des cartes au 1/100 000 et au 1/250 000, ou uniquement au 1/250 000, si la carte se trouve en dehors de la zone de publication limitée au 1/100 000.

Le Service continuera de réexaminer les cartes devant être publiées ou révisées, tant au 1/100 000 qu'au 1/250 000, en se conformant à la politique actuelle et aux besoins des utilisateurs.

The Division of National Mapping has established a map revision policy in accordance with National Mapping Council resolution 372 in which the Council resolved that in the National Topographic Map Series (NTMS) at 1:100,000 scale, revision of existing maps at intervals of not more than 10 years should, as a principle, take precedence over the production of new maps.

All published maps in the curtailed 1:100,000 publication area with reliability dates of 1972 or earlier have been ranked for revision priority by rating the development in the area and combining with current stocks and annual usage. Revision of the R502 series by replacement with NTMS 1:250,000 is being given high priority.

A "map revision model" is being developed by which maps will be ranked in order of priority for revision in the future, and the "map stock policy" is being revised in the light of current sales and usage.

At all times the Division of National Mapping will revise at 1:100,000 scale and publish both 1:100,000 and 1:250,000 at the same time, or 1:250,000 only, if the map is outside the curtailed 1:100,000 publication area.

The Division will continue to review the maps to be published and revised at both 1:100,000 and 1:250,000 scales in accordance with current policy and user needs.

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF.72/L.28.

TOPOGRAPHIC MAPPING*

Paper presented by Australia

La dernière des cartes topographiques au 1/250 000 établies à partir de photographies aériennes pour réaliser la couverture complète du territoire australien est parue en 1967.

Au moment du lancement du programme cartographique au 1/100 000, il était prévu de couvrir l'ensemble du pays en 10 ans avec des cartes à cette échelle, comportant des courbes de niveau à équidistance de 20 mètres.

La couverture complète du pays (3 071 cartes) au 1/100 000 dans un délai plus long demeure le programme cartographique de base, mais le temps et les

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circonstances ont obligé à modifier le programme de publication.

Le programme de publication a été réduit à l'impression de cartes au 1/100 000 couvrant une grande partie de la périphérie du territoire australien (1 646 cartes), la partie centrale faisant l'objet de cartes imprimées au 1/250 000, étayées par des orthophotocartes au 1/100 000. La Division of National Mapping (Service cartographique national) a continué de réexaminer sa politique de publication de cartes en fonction des ressources disponibles.

Les réductions continuelles de personnel et de crédits et le transfert de ceux-ci à des programmes autres que le programme cartographique à long terme ont confirmé le bien-fondé de la décision d'accorder à la révision des cartes périmées existantes une priorité plus élevée qu'à l'établissement de nouvelles cartes.

Le programme de publication a été remanié et les objectifs en sont désormais, par ordre de priorité :

a) Publication de nouvelles cartes au 1/100 000 en cas de besoin particulier.

b) Etablissement d'une couverture continue en cartes au 1/100 000 sur une superficie limitée correspondant aux régions les plus développées du pays, d'abord pour celles de ces régions pour lesquelles il n'existe pas de cartes à grande échelle, puis pour celles pour lesquelles il existe des cartes au 1/25 000 ou au 1/50 000, afin de répondre aux besoins des utilisateurs nonspécialisés.

c) Révision, dès que les ressources le permettront, de la série de cartes au 1/250 000 couvrant l'ensemble du territoire australien.

La « superficie limitée correspondant aux régions les plus développés du pays », ramenée actuellement à 1 646 cartes, représente une couverture réduite pour la publication de cartes au 1/100 000 et a été déterminée sur la base des éléments suivants : *a*) Utilisation annuelle prévue de cartes; *b*) Niveau de développement; *c*) Loisirs et tourisme; *d*) Couverture continue minimale.

On estime que l'étendue de la couverture réduite pour la publication de cartes au 1/100 000 est à la mesure des ressources actuelles du Service cartographique national.

The last of the 1:250,000 scale topographic maps compiled from air photographs to complete the coverage of Australia was produced in 1967.

At the outset of the 1:100,000 scale mapping programme it was intended that in 10 years the whole country would be covered with maps compiled at 1:100,000 scale with 20-metre contours. Complete coverage (3,071 maps) at 1:100,000 scale over a longer period remains the basic compilation programme, but time and circumstances have forced alterations to the publication programme, which has been reduced to printing maps at 1:100,000 scale over a large peripheral area of Australia (1,646 maps), with the central area covered by printed maps at 1:250,000 scale, supported by 1:100,000 scale orthophotomaps.

The Division of National Mapping has continued to review its map publication policy in relation to available resources.

Continued reduction in staff and funds and their diversion from the long-term mapping programme has confirmed the wisdom of the decision to raise the priority of revising existing out-of-date maps at the expense of making new ones.

The publication programme has been reviewed and the objectives, in order of priority, are now:

(*a*) To publish new 1:100,000 maps wherever a specific need exists;

(*b*) To provide continuous 1:100,000 map cover over a limited area of the more developed parts of Australia, first where no large-scale maps are available, and then where there is 1:25,000 or 1:50,000 map cover, to meet the needs of general map users;

(*c*) To revise the 1:250,000 map series over the whole of Australia as quickly as resources permit.

The "limited area of the more developed parts of Australia", which is now reduced to 1,646 maps, represents a curtailed 1:100,000 map publication area, and has been designed to prescribe parameters which include (*a*) estimated annual map usage; (*b*) degree of development; (*c*) recreation and tourism; and (*d*) minimal continuous cover.

It is believed that the extent of the curtailed 1:100,000 publication area matches current resources of the Division of National Mapping.

REVISION CYCLE FORECAST MODEL*

Paper presented by Australia

Afin de fixer rationnellement des priorités en vue d'une mise à jour ordonnée des cartes publiées, la Division of National Mapping (Service cartographique national) est en train d'élaborer un modèle informatique ayant pour but d'assigner un indice de classement hiérarchisé sur une base partiellement empirique à chaque carte publiée.

Il sera ensuite procédé chaque année, dans la limite des ressources disponibles, à la révision des cartes classées en tête de liste. Pour faciliter l'élaboration d'un programme rationnalisé de travail sur le terrain et de travail de bureau, tous les indices de classement seront soit portés manuellement sur une carte de base couvrant l'ensemble de la zone de compétence, soit regroupés sous la forme d'un index graphique établi par ordinateur. Le programme prévu pour l'année pourra alors être ajusté du point de vue opérationnel afin de permettre des regroupements géographiques ou de tenir compte de facteurs logistiques.

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF.72/L.34.

Les paramètres et problèmes supplémentaires mis en lumière par l'examen du modèle géographique seront alors incorporés, et le modèle sera repassé sur le mini-ordinateur PDP 11 pour établir le programme de révision progressive désiré. On espère, en répétant l'opération périodiquement, disposer en permanence d'un programme acceptable, suffisamment ferme à court terme et susceptible d'être rapidement mis à jour à mesure de l'expiration des délais successifs et de l'évolution de la situation.

Les paramètres jusqu'ici établis pour le modèle sont les suivants :

Date de fiabilité des cartes;

Rythme d'évolution des détails culturels;

Changements particuliers;

Indices de qualité;

Demande des clients;

Stocks de cartes — quantités détenues en réserve ou imprimées à une date donnée, et consommation annuelle;

Cartes récemment établies à des échelles plus grandes par d'autres services cartographiques;

Documentation photographique à jour disponible.

In an attempt to rationalize the problem of setting priorities for the orderly, sequential revision of published maps, the Division of National Mapping is developing a computer-manipulated model which will assign a hierarchical rating, partly empirical, for each published map.

The number of maps that can be processed during the year by available resources is then taken from the top of the list. To assist in producing a rationalized field and office program, all the hierarchical ratings will be either plotted manually on a key map encompassing the entire area of responsibility or a computer-plotted graphical index will be produced. Operational smoothing of the year's program can then be carried out for geographical grouping and logistic feasibility.

The additional parameters and constraints emerging from the inspection of the geographic model will then be fed in and the model re-run on the PDP 11 minicomputer to give the sequential planning program. By periodic iteration, it is hoped to have a reasonable program available at all times, firm in the short term and capable of rapid updating with the effluxion of time and changing circumstances.

Model parameters so far established are:

Reliability date of map;

Rate of cultural change;

Specific development;

Quality rating;

Client request;

Map stocks (number held or printed at a certain date, and annual usage);

Recent mapping at larger scales by other mapping authorities;

Availability of up-to-date photography.

HIGH ALTITUDE WIDE-ANGLE PHOTOGRAPHY*

Paper presented by Australia

La couverture du territoire australien est assurée en majeure partie au moyen de photographies cartographiques anciennes en noir et blanc prises au super-grand-angulaire à l'échelle nominale du 1/84 000 et un canevas planimétrique a été établi pour cette échelle. Des photographies cartographiques supplémentaires ont été prises dans certaines régions sans relief à bord d'un avion Gates Learjet volant à 13 000 mètres, au moyen d'appareils équipés d'un super-grand-angulaire permettant d'obtenir des photographies au 1/150 000. Cette expérience a mis en lumière les possibilités des prises de vues à haute altitude au grand-angulaire, à l'échelle nominale du 1/84 000, le long des mêmes lignes de vol que pour la couverture au super-grand-angulaire réalisée à une altitude inférieure, en particulier dans les zones à accidents de terrain marqués où la photographie au super-grand-angulaire n'est pas la solution idéale. Cette méthode permettrait de conserver une bonne partie du canevas existant.

On a obtenu quelques photographies au 1/80 000 au moyen d'appareils équipés d'un grand-angulaire, et elles ont été utilisées pour la révision des cartes au 1/100 000. Jusqu'à présent, aucune nouvelle carte n'a été établie à partir de ces photographies.

Pour les prises de vues, on a muni le Learjet d'une platine porte-appareil photo comportant une lame à faces parallèles et permettant l'utilisation de grands-angulaires et de super-grands-angulaires. Une fenêtre incorporée prévue pour deux appareils offrirait une plus grande souplesse. On a utilisé un système de navigation global 500 A avec affichage numérique de la latitude et de la longitude et dérivomètre Wild NF2, relié à l'appareil de prise de vues RC 10. Le maintien du niveau des appareils a été amélioré en asservissant leur moteur de platine à un système gyroscopique.

Si les programmes sont bien conçus et si les conditions atmosphériques sont bonnes, cette méthode de prise de vues est économique et permet de produire des photographies d'une grande netteté à l'échelle nominale du 1/80 000.

La pellicule couleur à infrarouges Kodak 2443 a donné de bons résultats et s'est révélée bien adaptée aux conditions locales. Kodak recommande le traitement de cette pellicule par inversion, mais du fait que le matériel conçu pour l'application de ce procédé n'est pas courant en Australie, la pellicule n'a été traitée qu'en négatif; les négatifs ont permis d'obtenir des tirages couleur et noir et blanc de bonne qualité. Une légère perte des caracté-

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ristiques infrarouges de la pellicule peut résulter de ce traitement en négatif, mais on a pu améliorer la netteté grâce à une meilleure pénétration du voile. Les détails se détachent plus clairement que sur une pellicule classique et le modèle stéréoscopique construit à l'aide de diapositives tirées à partir de la pellicule couleur à infrarouges semble plus saturé et plus net.

La photographie aérienne à partir d'avions à réaction volant à haute altitude est un procédé efficace et économique de collecte de données si les conditions atmosphériques sont bonnes, mais si elles sont mauvaises le coût élevé du temps d'attente des appareils le rend onéreux.

Toutefois, une coordination judicieuse entre les services du Commonwealth et ceux de l'Etat pourrait permettre de réaliser un programme de grande ampleur s'occupant de photographies aériennes, dans le cadre duquel il serait possible de mettre à profit la vitesse des avions à réaction pour les réaffecter à des zones de temps clair, et donc de réduire les incidences de mauvaises conditions atmosphériques.

Australia is covered generally with older black-and-white super-wide-angle mapping photography at a nominal scale of 1:84,000, and ground control has been provided for this format. Additional mapping photography has been obtained in some flat areas from a Gates Learjet at 13,000 metres, using super-wide-angle cameras producing photos at 1:150,000 scale. This experience has highlighted the potential of wide-angle high-altitude photography at a nominal 1:84,000 scale, flown along the same flight lines as the original lower level super-wide-angle photography, particularly in areas of large terrain elevations where super-wide-angle photography is not ideal. This approach would enable the retention and utilization of much of the established control.

Some photography has been obtained with wide-angle cameras at 1:80,000 scale and has been used for the revision of 1:100,000 maps. So far, no new maps have been compiled from this photography.

As an operational expedient, a "camera door" has been fitted to the Learjet, incorporating an optical flat and allowing the use of wide-angle and super-wide-angle lenses. For flexibility, a two-camera in-built port would be preferable.

A Global Navigation System 500A was used with a digital co-ordinate display of latitude and longitude and a Wild NF2 drift sight, linked to the RC 10 camera. Camera levelling has been improved by controlling the camera servo motors from a gyroscopic sensory device.

With suitably designed programmes and good weather, this method of acquisition of aerial photography is economical and is capable of producing high-resolution photographs at a nominal scale of 1:80,000.

Kodak 2443 Colour Infrared film has proved successful under Australian conditions. Kodak recommends that this film be processed to positive, but as this processing is not readily available in Australia the film has been processed to negative, from which good quality colour and black-and-white prints can be obtained. There may be a slight loss of infrared characteristics of the film by processing to negative, but improved resolution due to better haze penetration has been achieved. The image detail stands out more clearly than on conventional film and a stereo model, formed with diapositives made from colour infrared film, appears more solid, with a sharper surface.

Aerial photography from high-altitude jet aircraft is a powerful and economical information-gathering system in good weather, but is expensive in bad weather owing to the high stand-by charges for the aircraft.

However, careful integration of Commonwealth and state photographic requirements could provide a widespread programme which would capitalize on the speed of the jet in reaching alternative target areas and minimize the effects of bad weather.

GEODESY IN THE DIVISION OF NATIONAL MAPPING*

Paper presented by Australia

RÉSUMÉ

La Division of National Mapping (Service cartographique national australien) procède toujours à la compensation des levés géodésiques planimétriques de l'ellipsoïde australien de référence au moyen du programme VARYCORD, mais une variante du programme CHAOS a été utilisée pour l'établissement du modèle géodésique de l'Australie de 1979 (GMA 79). Ce nouveau programme, qui permet de procéder à une compensation rigoureuse des grands réseaux, est brièvement décrit.

Le niveau de référence altimétrique australien a été mis en place en Tasmanie. On procède actuellement au transfert sur ordinateur de la base de données géodésiques australienne.

Les observations par satellite au moyen de la méthode Doppler sont désormais utilisées pour la plupart des travaux de levés géodésiques en Australie. Le Service

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cartographique national utilise des récepteurs JMR et traite toutes les données obtenues par l'Australie au moyen de ce matériel.

Le Service cartographique a continué à recueillir des données pour les études internationales sur l'heure et les mouvements polaires au moyen d'une lunette photographique zénithale et a commencé à le faire à l'aide d'un laser de télémesure par réflexion lunaire. Les mises au point apportées à ce système de télémesure depuis son transfert de l'Arizona à Canberra sont passées en revue.

Field surveys

The instruments used for conventional geodetic surveys continue to be the AGA Model 8 laser geodimeter, and Wild T3 and Kern DKM3A theodolites. Little first-order geodetic work with theodolite and EDM equipment is now done. Geodetic and mapping control in Australia, its islands and in Antarctica are obtained almost exclusively by Doppler satellite observations (see below).

A little first-order levelling was carried out during the period.

Computations and adjustments

Adjustments of new horizontal and vertical control continue to be computed by the Division of National Mapping for members of the National Mapping Council.

Routine adjustments of control surveys, and surveys for inclusion in the Australian Geodetic Survey, continue to be carried out using program VARYCORD (Bomford, 1967). For work of this nature the program has proved useful, but for continental network adjustments it has now been superseded: it adjusts angles, not directions; it does not accept Doppler latitudes and longitudes; and it does not produce a variance-covariance matrix.

J. S. Allman, Associate Professor of Surveying at the University of New South Wales, has developed program CHAOS for major adjustments. This program is based on a Canadian program which Dr. Allman has refined and further developed. Stage 1 of CHAOS adjusts blocks of data individually to give co-ordinates of all points and the variance-covariance matrix for all points common to other blocks. Stage 2 gives unique co-ordinates for all common points, and Stage 3 gives unique values for all stations in every block. The total adjustment is rigorous and the program accepts Doppler latitudes and longitudes with their variances.

Dr. Allman's CHAOS was used to readjust the data used to determine the Australian Geodetic Datum in 1966 (Allman *et al.*, 1979).

Data observed since 1966, which includes geodimeter distances, Laplace azimuths and Doppler satellite fixes, have been added to the 1966 data and were adjusted by CHAOS in 1979 to create the Geodetic Model of Australia 1979 (GMA 79).

For adjusting levelling to the Australian Height Datum, programs ORTHO LEVELONE and LINADJ (Roelse, Granger and Graham, 1971) continue to be used. Until October 1978 all computations were done on the Cyber 76 of Csiro, but since then routine work has been performed in-house on an HP 1000 minicomputer. The Central Mapping Authority of New South Wales now computes and adjusts its own levelling and sends the results, on magnetic tape, to the Division of National Mapping for distribution to other Commonwealth authorities. The adjustment of the Tasmanian levelling network resulted in the formation of the Australian Height Datum (Tasmania), February 1979.

In December 1978, a working group of the National Mapping Council prepared a report on the establishment of an Australian computerized geodetic data base. The report recommended development of the data base in stages. Stage 1, a pilot scheme of 100 stations to test the feasibility of using Hewlett-Packard's IMAGE database management system, was completed in 1978. Work was also completed on Stage 2, 1,000 stations, and the writing of all input, output and update programs. Stage 3 will cater for 30,000 stations.

"Electronic survey computing" continued to be published in July each year, bulletin No. 22 being published in July 1979.

Doppler

The Navy Navigation Satellite System for the determination of position from Doppler satellites has become the standard method of geodetic position fixing in Australia and Antarctica, where Doppler surveys are also made by staff from the Antarctic Division.

The Division of National Mapping had computed more than 500 Doppler fixes, using precise ephemeris data by the end of 1979.

The Division owns four JMR-1 sets, used mainly for:

(*a*) Map control for 1:250,000 bathymetric map compilation and for spot-checking and revising the national mapping series;

(*b*) Positions for connecting islands and reefs to the mainland network, especially in areas where seabed boundaries are to be negotiated with neighbouring countries and territories;

(*c*) Fixing of mining leases in remote parts of Australia;

(*d*) Map control and fixes for glaciological studies in Antarctica.

The reduction of all JMR data has been the responsibility of National Mapping.

Pre-processing software designed and written in-house (Lloyd, 1979) was brought into use.

A report on the Australian Doppler survey was published (Leppert, 1978).

The Lunar Laser Ranger and PZT

The Division's Lunar Laser Ranger (LLR) was first test-fired at the Orroral site, near Canberra, in June 1976, after the move from Tucson, Arizona. The move required modifications to the instrument to account for the need to drive the telescope in the opposite direction

as well as to account for the latitude change between Tucson and Orroral. On the electronic side, nearly everything is new. The mode of control and operation was changed from discrete-component-hardware logic to software-controlled logic, using a Hewlett Packard 21MX computer system, with Fortran and a disc-based real-time operating system. This latter feature has been the key to the interactive control developed for the LLR.

Test firings continued sporadically during 1976-77 while the numerous system problems and software tasks were tackled. The approaches taken in both the hardware and software areas were discussed by Eric Silverberg of McDonald Observatory who visited Orroral in mid-1977. Following his visit, acquisition attempts became more frequent and system failures became fewer. The laser remained the most troublesome element in the system. In early 1978 the Q-switch mechanism of the laser was changed from the saturated-dye principle to a Pockels cell, which made the system more reliable.

By mid-1978 acquisition attempts were scheduled for ten nights per month. The data received at this point sometimes produced statistical events which looked like real lunar ranges, some of which appeared to fit the lunar model, and others which did not. With both the laser and the software now more reliable, attention moved to the receiver segment of the LLR. Slowly and systematically components were reviewed, and with the advent of a new etalon frequency filter, and the attainment of noise curves that obeyed Poisson statistics, statistical events that fitted the lunar ephemeris were obtained in November 1978. Since that time real ranges have been obtained with increasing frequency.

The LLR has been strongly tied in to both the Australian Geodetic Datum (AGD) and the Australian Height Datum (AHD), and linked to satellite and astronomical equipment at Tidbinbilla, Orroral, Honeysuckle and Mount Stromlo, all close to Canberra.

The advent of data from the LLR has enabled the Division of National Mapping to refine the NWL 9D Doppler co-ordinates of the LLR and to make direct comparisons over intercontinental distances between the Doppler range-rate system possessing no intrinsic origin and the LLR range system possessing a defined origin. Comparative work is also being done with the Photographic Zenith Telescope (PZT).

The PZT continued to be operated by the Division. It continues to be one of the main contributors to the Bureau international de l'heure in Paris and the International Polar Motion Service in Tokyo.

REFERENCES

Allman, J. S., I. D. Lloyd and J. B. Steed (1979), "A readjustment of the Australian Geodetic Survey, 1979", paper prepared for the General Assembly of the International Union for Geodesy and Geophysics, Canberra, December 1979.

Bomford, A. G. (1967), "VARYCORD: A Fortran program for the least squares adjustment of horizontal control surveys", National Mapping technical report 6.

Leppert, K. (1978), "The Australian Doppler Satellite Survey, 1975-77", National Mapping technical report 21.

Lloyd, I. D. (1979), "DOPACK, Doppler software package, stage I: design and preprocessing", National Mapping technical report 25.

Roelse, A., H. W. Granger and J. W. Graham (1971), "The adjustment of the Australian Levelling Survey, 1970-72", National Mapping technical report 12.

ORTHOPHOTOMAPPING: A DIGITAL DATA COMPANION*

Paper presented by Australia

RÉSUMÉ

Une carte thématique au trait d'une région déterminée, destinée à représenter certaines données à des fins particulières, est établie avec discernement.

Le région même que représente la carte au trait peut aussi apparaître sur une photographie aérienne ou sur une image obtenue par satellite mais on pourra reprocher à ces dernières de représenter sans discernement une quantité excessive de données.

Le document reconnaît à l'orthophotocartographie cette absence de discernement et étudie ses caractéristiques à travers diverses applications aux cartes thématiques en soulignant ses qualités particulières en tant que complément des méthodes d'acquisition des données numériques.

The demands of planners and decision makers for fast response information are placing pressures on mapping authorities and private agencies which they find it difficult to relieve by the traditional methods of line mapping.

Governmental organizations are already well aware of the constant need for information to aid the decision making processes involved in planning and resources management. They must also be convinced of the expenditures necessary for the successful solution to the problem by a realistic appraisement of the worth of maps.

The value of mapping is an intangible asset, often best seen in default when information urgently required is not available. In retrospect the value of rapid response mapping may be immense, a priceless commodity which Governments can ill afford to neglect or treat parsimoniously.

Government mapping authorities can afford to adopt a more altruistic motive towards mapping than can the private agency. The prime objective in providing official

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maps is the collection and dissemination of terrain data in a form that will most usefully serve a varied market of both lay and professional users. They must be concerned with efficiency and service to the extent that they will take the lead in implementing change when traditional methods become expensive or inadequate.

Already the demand for information has stimulated the development of rectified terrain imagery, from airborne and space-borne platforms and the digital terrain data bank with its store of information on such features as terrain relief, stream patterns and cadastral information.

Whether Government has the means to pursue the mapping programme does not alter the fact that mapping is an expensive enterprise. New digital technology will allow them to collect, display and distribute information as it is required and with maximum economy when the results of the digital information can be related directly or indirectly to an image of the ground concerned.

THE ORTHOPHOTOMAP

The orthophotomap (OPM) is a direct construction of a map which possesses orthographic characteristics and is assembled by optical means in contrast to the manual piecing together of the photo mosaic. It provides the photographic imagery with the planimetric accuracy necessary to produce a product capable of manipulation in the same sense as the line map. Yet while a conventional map is enhanced by cartographic symbolization and generalization, it certainly displays an incomplete characterization of reality. On the other hand the orthophotomap will present the actual patterns and images visible in the landscape, unabridged and without selective opinion. The map reader who has overcome the problem of a change from conventional representation will be faced with the reality of the earth's surface. He will appreciate the innumerable variations of texture and pattern exhibited simply and familiarly by the photographic image, rather than by the limited symbol categories available to the draftsman. Although distances and areas can be calculated directly, the OPM will also supply a wealth of point information, and provide a suitable control base from which thematic data may be extracted or upon which it may be recorded.

SATELLITE IMAGERY

Satellite imagery in contrast to the products of airborne optical systems, cannot supply the same volume of topographic and planimetric information available in the aerial photograph. Although satellite imagery can be made to possess the same orthographic characteristics as the orthophotomap, and is extremely useful for the extraction of broad area information, it does not at this time have the capability of supplying ground elevation data. Nor is it possible to consistently extract line and point information for routine cartographic applications, due to the design contingencies of the sensors and the scene contrast within the imaged area. Any likelihood of pure cartographic application to topographic and planimetric mapping will be delayed until the anticipated launch of the space shuttle programme, and the development of the space borne large-format camera. Even so, the use of the currently available satellite imagery, and the manipulation of their multispectral and multitemporal characteristics, is a major contribution to the collection and display of terrain information. The need for rectification and mapping into the AMG referencing network in Australia must be the major consideration, particularly in respect of the complexity of errors found in the images.

RECTIFICATION PROCESSES

Rectification of both aerial photography and satellite imagery is such that with satellite imagery we begin with a computer compatible tape (CCT) in which digital reflectance values relating to imaged areas of the ground are recorded in sequential order. This is in contrast to the analogue record of the aerial photograph. Rectification is achieved by transformation of the co-ordinate image address (recorded in the tape) into the AMG, by the identification and co-ordinate measurement of ground control points (GCPs). It is essentially a computer based process which will reformat and resample the total record of picture elements (pixels) comprising a scene area of 30,000,000 bytes in 4 spectral bands, or a part scene of the required area of interest. The rectified CCT in which the pixel address grid has been distorted to fit the AMG is outputted by plot programs, to hard copy rectified imagery on a photo write device, or alternatively to theme data extraction plots, on an automatic plotter.

In the case of the aerial photography the technical process involved in the rectification procedure involves the orientation of a stereoscopic model in a photogrammetric instrument. The orientation process derives data for the image transfer which is a correction for the attitude of the image system and for terrain relief. The orientation parameters of the exposure which is to form the orthophotomap are set in the image transfer device, and exposure made to a latent image on film. This is achieved in a strip scan fashion in such instruments as the Zeiss GZ1 orthoprojector and the Wild OR1 or as a patch array in the Gestalt photomapper, and is controlled by a data record of terrain relief profiles. The resultant image is the orthogonal characteristic referred to above which can be presented as a map product, with contour information, map grid, annotation, and base note information in map sheet form.

AVAILABLE ORTHOPHOTO SYSTEMS

The orthophoto experiment carried out under the auspices of Working Group II-4 of the International Society of Photogrammetry (ISP), 1972-1976, identified three distinct methods of image transfer achieved in either "on line" or "off line" mode. Each method utilized an analog or digital record to control the rectification process. Although the working group did not make a recommendation as to the performance or accuracy of individual equipment configurations, it did conclude that from all the OPM's evaluated from the various instruments available, there was an over-all excellency in respect to geometric quality.

The table lists the various major equipments in use in Australia together with their image transfer method, control data recording and mode of operation.

Orthophotomapping in Australia is confined to the various state and Federal mapping authorities and to two only of the private mapping agencies. Equipment housed varies in accordance with the date of entry into the orthophoto field of activity. If budgets were suffi-

cient to allow an unrestricted choice today, selection would undoubtedly be influenced by the freedom of equipment to undertake digital profiling.

Equipment	*Mode*	*Control data record*	*Transfer method*
Zeiss GZ1	Off line	Analog	Optical projection
Zeiss Jema orthophot	On line	None	Direct optical
Wild OR1	Off line	Digital	Direct optical
Wild PPO8	On line	None	Direct optical
Gestalt photomapper[a]	On line	None	Electronic

[a] The products of the Gestalt orthophotomapper are available in Australia only by customer service from the company's Canadian organization; no production is carried out in Australia. The system is included in the table as it is an example of the electronic image transfer technique.

It is a considered opinion that the direct image transfer technique produces better overall image quality, and that the digital off-line control of one OPM containing sufficient data for two stereo-models will provide the most economical solution for the mapping authorities that can afford the capital expenditure for purchase of both equipment and software.

Approach to the Orthophoto Image

The OPM does not aim to achieve cartographic perfection. In this paper it is presented as an efficient and economical system, aiding the process of data extraction and display. The ability of the system to supply information is a function of image scale, the characteristics of the imaging system, and the vagaries of the human observer. Presentation of the image is approached as one of user requirement and of the contingencies of technical methodology.

The relationship of image scale to resolution and image evaluation can be regarded as a problem for which solutions can be found in a uniform variation to the altitude above the terrain, or by changing the focal length of the imaging system, whereas the characteristics of the imaging system are absolutely related to the system itself.

Lens-oriented photographic systems have the greatest capacity for resolving and recording terrain image information economically. Although digital recording systems are capable of some mind-bending performances, the complexities of the sensors and the large computers required to store and manipulate this data for routine procedures, are at the time of writing beyond the reach of most organizations in Australia.

The potential of lens-oriented systems for extraction of information by the human observer is not only based upon the resolving power of the image but is greatly enhanced by the ability of subjective analysis, by association of image relationships, to identify and record small point detail and complex area boundaries. In contrast again, computer based systems can handle some of these interpretative and extractive processes, in this particular case, quite economically, but are limited to objective analysis at a low level of the interpretation process, to broad area boundaries such as water and vegetation. If at the higher level of the interpretation process, the recognition and ultimate extraction of complex areas, such as buildings and small point detail is required, methods for the present time must return to a subjective analysis of products from a lens-oriented system.

If the OPM is to become an economical solution to mapping problems, the user must be able to extract the information he requires. The producer, for his part, must supply the best possible image, bearing in mind that the flexibility of the orthophotomapping technique can allow the time element, so vital in many mapping requirements, to be manipulated more easily than the equivalent line mapping procedure. In effect the OPM can present topo-map information in a short time, whereas cartographic processes will delay the presentation of a traditional line map.

Image quality with photographic-imaging systems and the degradation in resolution of a terrain image, through the various reproduction stages towards a presentation image, is no greater than at the point of capture on the negative plane. It is generally accepted that the photographic emulsion will degrade the resolving power of the camera lens by a factor of 0.5 and further significant loss is dependent upon approach to method before and after the image transfer process begins. For example some Australian mapping authorities, rather than cut the original negative from the aerial film roll, prefer to make a copy diapositive and again accept a further reduction of image resolution by a factor of 0.2. During the majority of subsequent photographic procedures and under normal controls and conditions, further loss had been observed to be insignificant.

Presentation Quality and Production Efficiency

Experience indicates that a combination of these characteristics involving the final presentation of OPMs, make an effective contribution to expediting the supply of map information. Although this is a paramount consideration if the OPM is to be considered in the context of an information system, there are problems involving controls on image processing and on the work flow between the various production areas which must be overcome. It is considered that a solution to these problems can be found in re-organizing work areas. Where the expertise to perform the various functions of the singular specialized task of OPM construction can be gathered, as a team, in the one area, production turn-around time and image quality can be improved.

The Department of Lands and Surveys, Western Australia, has utilized this team/task concept to some degree whereby the data profile capture, image transfer and cartographic stages are performed in the one work area under a single supervisory control or team leader. Where direct liaison with the photographic processing areas has occurred, considerable improvement in presentation quality has been achieved.

This type of organization of the work area has allowed an orthophotomapping team of 3 or 4 trained personnel to map, consistently on an annual basis, 60,000 hectares (ha) at 1:5,000 x 2m V.I. of the Perth Metropolitan area and selected country towns and 163,000 ha, at 1:25,000 x 10m or 5m V.I. This mapping costs the Government authority a factor of 10, of which only 1.5 is recoverable by direct map sales, but a poten-

tial for cost saving can be recognized and has yet to be exploited.

Reproduction Methods

Methods of reproduction have a considerable bearing on the amount of information that can be extracted from the OPM, but the image scale bears some degree of influence on these methods. While large-scale products have economical advantages in the use of diazo or photographic reproduction methods and are the subject of distribution and revision contingencies, small scale presentation generally employs a planigraphic colour technique, combining the OPM image with a certain degree of cartographic symbolization. Some large-scale orthophotomaps have also been produced from this technique to show cadastral information with the photo background. But the choice is dependent on the particular mapping authority and the available printing press facilities. The image produced by planigraphic techniques is certainly more durable than that produced by other methods and more convenient in terms of the number of copies that can be immediately available.

Diazo reproduction

An indication of the value of the diazo reproduction method can be gained from the results in an evaluation of the cartographic qualities of orthophotomaps carried out in the United Kingdom during 1970-74. In relation to user preference, the comparison of an image produced by the photographic method and also of a line map, the diazo reproduction of the orthophotomap carrying a high level of annotation, i.e. contours, main village names, road symbols and water features, come out best on average. The research team reported, however, that the conclusions were by no means decisive and the results obtained had perhaps tended to reflect individual user performance to the nature of the landscape and the map information observed, rather than the propriety of the OPM as a map product.

The diazo process has economic advantages in both printing and storage and although the quality of interpretation can be diminished due to the half-tone screen placed over the image during its processing, the use of a high quality diazo dry developer paper can achieve very satisfactory printing results. Possibilities of improved reproduction will be available in the further development of continuous tone diazo coatings.

Photographic reproduction

The use of the OMP image as a data extraction base must rely on a photographic reproduction process to enable the interpretation of both point and complex area information. This extraction process can be assisted by the stereoscopic analysis of images using a "stereomate". The stereomate is a reconstruction of the OPM image, into which the planimetric errors of X parallax relating to the terrain relief have been re-introduced. It utilizes the same processing equipment and a modified profile record to produce the new image, which when viewed stereoscopically with the original orthophotograph introduces the third dimension and the subsequent aid to conventional interpretation and recording methods. This approach, particularly for large-scale work could assist and support digital data acquisition systems in the extraction of non-systematic information on demand, i.e. vegetation boundaries, buildings etc., rather than using a photogrammetric data acquisition method for the digitizing and recording of this type of terrain information. The consequential time savings can expedite access to the relief profile record for the control of the rectification and image transfer process and also expedite map user access to the systematic data bank record, i.e. contours, stream patterns, road casement, cadastral information etc., and present the opportunity to recover the non-systematic information by interpretation processes from the OPM images.

At this time there is no knowledge of any stereomate production in Australia, and if the OPM is to be recognized as an information system this particular product must be considered as an aid to the data collection process. In addition, production is well suited to image rectification systems operating off line to the digital profile data record. Development has reached a high standard in European countries where manufacturers are recognizing a demand for this product.

Planigraphic reproduction

Orthophotomaps reproduced by this technique show a loss of detail, due to the process, but are useful for the presentation of terrain characteristics and broad area boundaries. More importantly they can provide the cartographer with the opportunity to produce perceptive realistic map presentations, using the imagery to depict the landscape with stylized thematic data. The Directorate of Overseas Surveys of the United Kingdom have produced some very fine examples of this type of presentation using the orthophoto and photomap image to extract and symbolize communication links and settlement patterns.

Long printing runs of these map sheets make this reproductive method more economically viable in medium- and small-scale series maps, where the revision cycle is generally longer than for larger-scale presentations. To this end, economical solutions for the future will probably be in the use of silk-screen printing techniques where printing runs of small numbers of copies of a map sheet will be a feasible proposition.

A Concept for Cost Benefit

It has been indicated that the OPM does not replace cartographic line presentations but can be used to enhance the product or as a control base or source data to compile such presentations.

A practical time/cost comparison

A Western Australian study suggests that in the comparison of large-scale (1:2,000) conventional photogrammetric mapping with orthophotomapping, time savings favoured orthophotomapping by a factor of 0.62. The equipment configuration utilized in the comparison included Wild A8 stereoplotters and the Zeiss Planimat used in an off-line configuration with the GZ1 orthoprojector.

Compilation of 1:2,000 plots, at the time of the study, required full detail, contours, road casements, buildings, vegetation and street furniture, for local government planning purposes.

In a digital data capture context this 0.62[1] saving can

[1]This figure includes contour information but excludes road casement and discontinuity lines (stream patterns), that it is anticipated would be included in the data acquisition procedure.

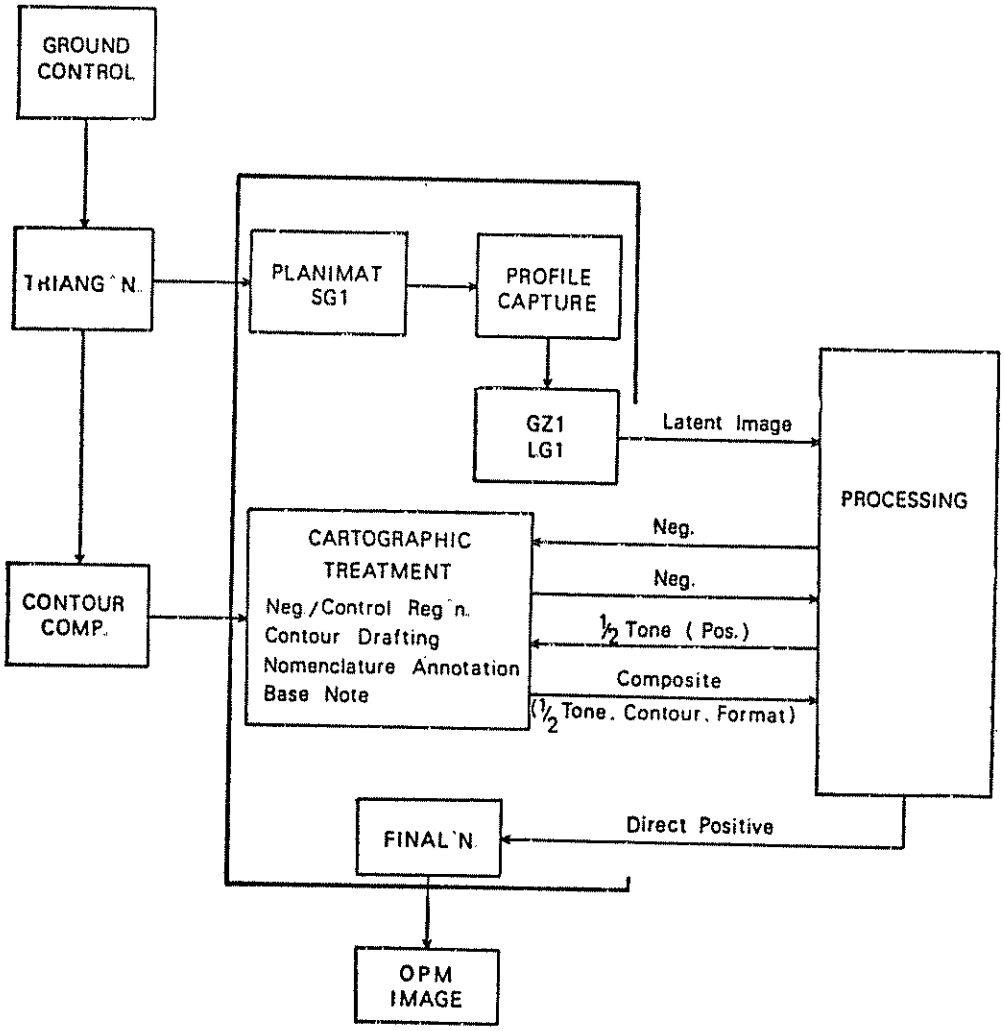


Figure 34. Australia: supervision area for orthophotomap production (Department of Lands and Surveys, Western Australia)

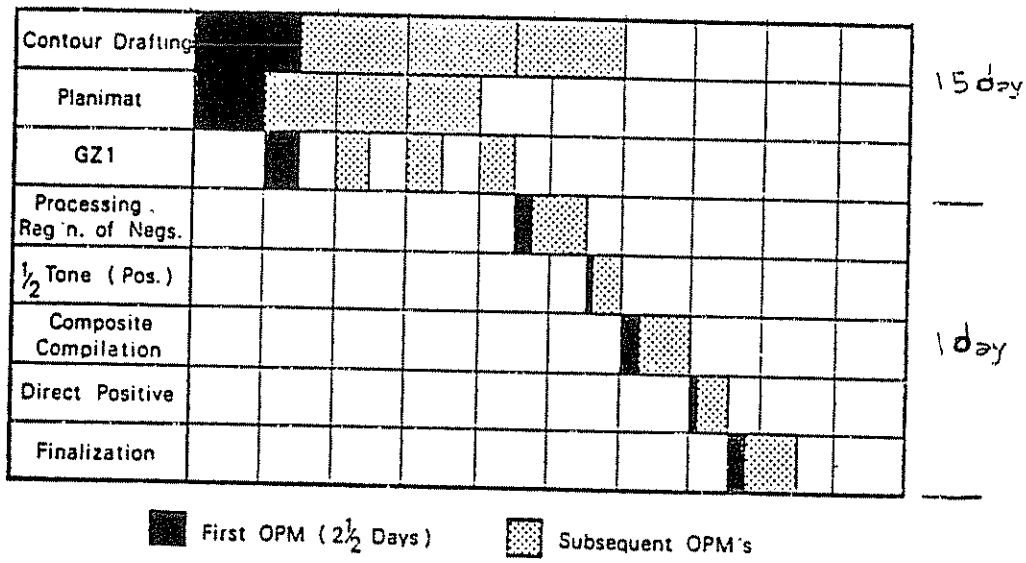
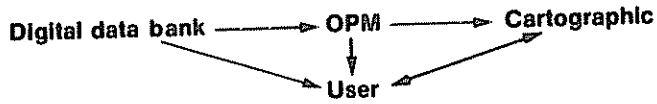


Figure 35. Australia: work flow path for orthophotomap production (Department of Lands and Surveys, Western Australia)

be accomplished by exempting the procedure from having to capture non-systematic and complex area data. If the user requires symbolization of this information the OPM image can be directed to a specialized area accompanied by a stereomate image, where this information can be extracted by "eye ball" interpretation processes.

If the data extraction system can be made to support orthophotomapping production and supply a data profile record with the possibility of a computer generated contour plot, the possible savings could reduce the expended time by some 0.36, for the production of OPM images. This saving reduces the time element from 2.5 days to around 1.7 days giving a net saving in cost of 0.12. To this cost saving, expenditures in the production of a stereomate of approximately 0.1 must be added, but again to this, the advantage of added throughput to both systems, both digital acquisition and OPM production, plus the added cartographic data extraction capabilities, present a total information concept to which the role of the OPM image is one of support to both the digital system and the cartographic process.



The above conceptual diagram shows the interaction of the total information system with the map user.

In addition to the forementioned possibilities of production savings from the derived data of a total terrain digital system, is the possibility of "picking up" camera station exposure orientation data during the aerotriangulation procedure. This will not always eventuate if the technique employed is that of flying a 90 per cent forward overlap to select a centrally located exposure to form the OPM image. In this case exposures coincident with the aerotriangulation will be infrequent.

ORTHOPHOTOMAP REVISION

Simplicity and economy are the major features of OPM revision programmes. The image rectification process is controlled by utilizing the original flight path configuration with the restitution of the new aerial photography. The original mapping control and the previously stored data profile record, are used for this purpose.

A factor of 0.7 cost saving can be effected in comparison to the original production costs using this technique. The saving is, however, dependent upon the degree of change that has occurred in the landscape such that might necessitate amendment to the profile and nomenclature records.

A total digital data bank concept could be expected to support revision programmes by procedural updates to the nomenclature file as changes occur. Amendment to the terrain relief data file, will be largely a function of the scale and the technique employed at the time of the restitution of the revision photography in a stereoplotter.

APPLICATIONS OF ORTHOPHOTOMAPS

User applications and the problems associated with the mapping of OPM images, should probably be identified in terms of value to the user and related to whether the OPM image is a more useful product than the aerial photograph.

In order to do this, one should first consider whether the user requires the amount of information that can be assessed from the aerial photograph and secondly, whether the user requires the mensuration capabilities, contour information and image annotation contained within the OPM.

The possibility of cartographic data extraction and symbolization in this context, is essentially a labour-intensive service which is of advantage to some users. It presents a capability of increased throughput in the digital acquisition and image rectification production areas, and influences the efficiency of the producers in collecting and disseminating information. Not all users require symbolized line presentations and those that do not, are able to access information from the digital data bank or from the OPM image. The ability of the OPM image to show contour information in a correct relationship to image data and the integration of the total data into an easily accessible referencing system, are major considerations that regular users of map products find advantageous.

Generally the majority of users of OPM products do not seem to require the mensuration accuracy capabilities that maps are capable of providing, except perhaps engineers, who prefer precise line presentations for design and construction projects. These are specialists who would make more use of special project OPMs rather than series presentations. This preference is supported by the activities of the New South Wales Department of Main Roads. Here, special project large-scale OPM images have been successfully used as an economic and convenient alternative product for the detail that must be plotted and annotated on road location and road design plans invoking stadia survey and photogrammetric plotting methods. It was generally agreed by DMR that the planimetric accuracy of the OPM was sufficient but that some field completion for critical terrain level values and for street-sign classifications were still required. Conclusions supported the usefulness of OPM images in rural areas, where topography cannot be adequately portrayed by line mapping.

These final remarks correlate well with studies by the United States Geological Survey suggesting the need for a subjective approach to prompting a decision to map certain areas by OPM. It was found that generally, areas of sparse image detail and low profile were more suitable than areas of dense image detail or high profile. The contour information tended to obliterate terrain data, and image complexity in dense image areas tended to confuse the reader. The problem is seen to be essentially one of scale and contour interval, where densely populated areas lend themselves to orthophoto mapping at larger scales, and areas of steep terrain to mapping by conventional methods. Some of the problems in the study referring to image quality and planimetric accuracy have to some degree been overcome by later developments in technology.

In contrast to mapping requirements for engineering purposes in which engineers deal with specific measured data, town planners are less concerned with precise measured data and more concerned with feelings and relationships between the spatial properties of the landscape, and they have emerged to be the major customers

for OPM products. They are interested in the ease of access to map information which can be extracted from an integrated referencing system. This system will enable the joining of images, to cover a region, without any loss of accuracy between the spatial relationships of broad, complex area and point data. Planners in Australia find the 1:5,000 (2m V.I.) orthophotomap invaluable at the conceptual stage of planning. They also find them most suitable for cost-benefit analysis of the impact of planning concepts on the physical and cultural landscape. This final point is illustrated in a present attempt by Governmental sewerage planning engineers to use OPMs for preliminary planning and cost-benefit analysis of a main sewerage outlet line. This particular line extends across a generally rural landscape to the coast, in Western Australia.

CONCLUSION

This paper has endeavoured to present orthophotomapping in the context of an information system as a support to digital mapping procedures. For this concept to be effective, producers must first seek to understand the needs of the users and accept the challenge of new technology and methods to expedite the dissemination of information. The users for their part must support the change by the acceptance of new forms of map products.

The cost of the technology is high, but a cost-benefit trade-off against the greater volume of information that can be processed to a usable form, is a decided advantage to the user in the decision-making processes. These users have the right to demand integrity, quality and timeliness in the data and it is to these ends that a mapping organization has cause to operate in an atmosphere of organized co-operation, between the various stages of map production.

Quality and presentation of OPM images are major problems generally requiring subjective controls until an organization has progressed in expertise and in the purchase of modern equipment upon which objective controls can be introduced.

Working Group IV-5 of the International Society of Photogrammetry has the responsible task of tracing the differing methods of production and presentation of orthophotomaps and photomaps, and the results will be presented to the 1980 Congress of the Society.

REFERENCES

Blachut, T. J., and M. C. Van Wijk, (1976), "Results of the orthophoto experiment 1972-76". (Photogrammetric.)

Ducher, Guy (1977), "Survey of the characteristics and production of stereo-orthophotos and stereo-orthophotographic instruments".

Hill, A. R. (1975), "Photogrammetric engineering and remote sensing, Dec. 1976", P.P1483-149 report. (An evaluation of orthophotomaps.)

Lo, C. P. (1976), *Geographical Applications of Aerial Photography* (New York, Crane Russak and Co.)

Sandwith, P. G. (1974), "Experience with orthophotography for DMR in New South Wales", Proceedings of the Australian Cartographic Conference, Sydney.

Southard, R. B. (1975), "Practical applications of orthophotographs", paper No. E3, Commonwealth Survey Officers' Conference.



Figure 36. Australia: standard series 1:5,000 orthophotomap (Department of Lands and Surveys, Western Australia)

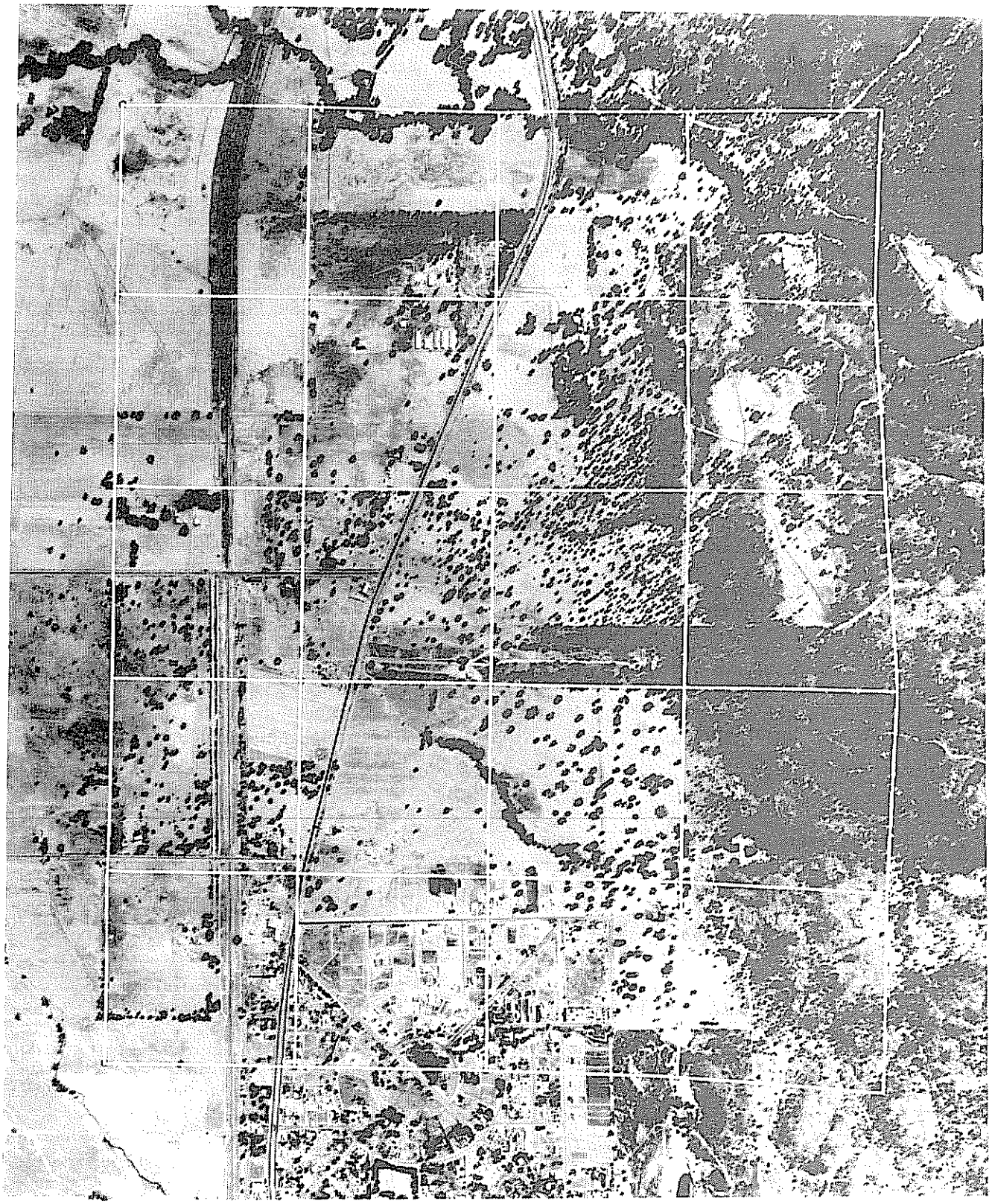


Figure 37. Australia: aerial exposure from which orthophotomap (figure 36) was constructed, showing the AMG grid distortion in the original source image

AUTOMATION IN COMPUTER-ASSISTED CARTOGRAPHY*

Paper presented by Australia

Le système AUTOMAP, qu'a adopté le Royal Australian Survey Corps en 1976, est un système de cartographie numérique conçu pour effectuer certaines des opérations cartographiques à forte intensité de travail et augmenter ainsi la production de cartes sans faire appel à du personnel supplémentaire. Ce système permet en outre de disposer d'une banque de données numériques utilisables pour établir des cartes dérivées. (Voir carte 1 hors-texte.)

Le système AUTOMAP se compose de cinq sous-systèmes :

1. *Le sous-système de saisie des données* dont l'objet est la collecte et la préparation des données au moyen d'appareils de restitution stéréoscopique B8 et de convertisseurs numériques Gradieon;

2. *Le sous-système constitué par un lecteur optique à balayage* qui convertit automatiquement en numérique les données à reproduire;

3. *Le sous-système de vérification du tracé* qui permet d'obtenir des tracés de vérification pour des données converties en numérique;

4. *Le sous-système polyvalent* qui permet la constitution et la tenue à jour d'une banque de données, le traitement des données et la préparation de bandes pour la production graphique finale;

5. *Le sous-système de sortie* qui permet les réalisations graphiques finales.

Chacun de ces sous-systèmes est autonome. De ce fait, on peut installer les sous-systèmes en des endroits différents. Les composants de ces sous-systèmes ont été choisis de telle sorte qu'en cas de défaillance d'un composant on dispose aisément de matériel de secours.

Ce système qui est la première étape d'un système d'ensemble est pour l'essentiel semi-automatique, la saisie et la préparation des données et le contrôle des programmes s'effectuant manuellement. Il donne de bons résultats et présente les avantages suivants :

a) Economie de main-d'œuvre du fait de la suppression de la compilation manuelle et des tâches de transcription;

b) Mise en place d'une base de données topographiques numériques;

c) Formation de personnel aux divers aspects de la cartographie numérique;

d) Acquisition de compétences en matière de gestion informatisée;

e) Possibilité d'utiliser les données numériques ainsi disponibles pour des applications et des recherches.

Compte tenu de ces bons résultats, on prévoit d'accroître la capacité du système et d'y ajouter de nouveaux dispositifs automatiques grâce à :

a) La conversion du mode analogique au mode numérique de la majorité des appareils de restitution stéréoscopique qui seront cependant laissés à commande manuelle;

b) L'augmentation de la capacité du sous-système de vérification des tracés et du sous-système polyvalent;

c) L'installation de terminaux interactifs à écran de visualisation reliés aux convertisseurs numériques afin d'améliorer la préparation des données;

d) La mise en place d'un système à balayage Raster doté de son propre ordinateur spécialisé afin de convertir en numérique les cartes analogiques n'ayant pas encore fait l'objet d'un tel traitement ainsi que de nouvelles cartes analogiques d'origines diverses.

Les données numériques seront intégrées à la banque de données topographiques numériques de l'armée australienne et l'on pourra, de manière sélective, y avoir accès et les manipuler aux fins :

a) De la production de cartes topographiques au 1/63 350 et de cartes à des échelles allant du 1/25 000 au 1/2 000 000 selon tous les modes de projection;

b) De l'établissement de cartes thématiques à partir de certaines seulement des données contenues dans la banque de données topographiques;

c) De la confection de bandes destinées au matériel d'orthophotocartographie;

d) Du rassemblement de données topographiques numériques destinées à d'autres utilisateurs.

La banque de données topographiques numériques contient à présent 1 435 unités numérisées se décomposant comme suit :

Origine des unités numériques au 1/25 000 :

a) Stéréo-photographie 1,184

b) Données existantes (relief uniquement) 251

AUTOMAP, introduced into the Royal Australian Survey Corps in 1976, is a digital cartographic facility designed to replace some of the labour intensive activities in map making, and so increase map production without an increase in personnel. A by-product of the process is a digital data bank from which derivative mapping can be produced. (See map 1 in pocket.)

The AUTOMAP system is divided into five subsystems:

1. *The input subsystem*: provides data collection and editing from B8 stereoplotters and Gradieon table digitizers.

2. *Optical line following subsystem*: performs automatic digitization of existing reproduction material.

3. *Plot verification subsystem*: produces verification plots of digitized material.

4. *General purpose subsystem*: performs data bank formation and maintenance, data processing, and production of plot tapes for final graphic output.

5. *Output subsystem*: produces the final output from AUTOMAP.

*The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.72/L.49.

Each of the subsystems is off-line to the other subsystems. This off-line principle reduces component dependence, and allows subsystems to be remotely located from each other. Components of the subsystems have been selected to provide considerable equipment back-up in the event of component failure.

The system is the first stage of a comprehensive system, and is essentially semi-automatic, requiring manual data acquisition, editing and software control. It has proved successful, with the following benefits:

(*a*) Manpower savings from obviating manual compilation and scribing procedures;

(*b*) Initiation of a digital topographic data base;

(*c*) Training of personnel in various aspects of digital mapping;

(*d*) Acquisition of computer management expertise;

(*e*) Supply of digital data for application and research.

Following this success, it is planned to increase the capacity of the process and introduce further automatic features by:

(*a*) Converting the majority of stereoplotters from analog to digital output, but remaining manually driven;

(*b*) Increase the capacity of the plot verification and general purpose subsystems;

(*c*) Introduce interactive visual display units in conjunction with digitizing tables to improve the editing procedures;

(*d*) Add a Raster Scanning System with its own dedicated computer to digitize the existing backlog of analog maps as well as new analog maps from various sources.

Digital data will be incorporated into the Army digital topographic data bank, to be selectively accessed and manipulated for:

(*a*) The production of standard topographic maps and charts at scales from 1:25,000 to 1:2,000,000 on any required projection;

(*b*) Thematic maps requiring only selected information from the topographic data bank;

(*c*) Drive tapes for orthophotomap equipment;

(*d*) Digital topographic data for other users.

The digital topographic data bank at this time contains 1,435 digital units made up of digital units at 1:25,000 from:

(*a*) Stereo-photography 1,184

(*b*) Existing material (relief only) 251

AN INTRODUCTION TO THE ADJUSTMENT OF THE ASTRO-GEODETIC NET OF CHINA*

Paper presented by China

RÉSUMÉ

La compensation du réseau national astro-géodésique de la Chine commencera à la fin de 1981. On fera la compensation d'ensemble par la méthode des moindres carrés. Les points de différents niveaux de triangulation et de cheminement utilisés pour la compensation sont environ 50 000, et le nombre total d'observations de 300 000.

Afin de vérifier, comparer et étudier la stabilité des résultats de la compensation du réseau géodésique total par la méthode des moindres carrés, deux méthodes seront utilisées. La première est celle de Helmert-Wolf bien connue. Dans la seconde méthode, le réseau sera divisé en plusieurs blocs, chaque bloc sera compensé par la méthode des paramètres. Ces blocs seront ensuite connectés par des conditions d'identité. Cette méthode peut être généralement équivalente à la méthode de compensation des observations corrélatives avec des conditions en utilisant les différences de coordonnées entre les points adjacents situés sur les lignes de séparation comme ensemble d'observations corrélatives.

La variance et covariance des observations corrélatives seront obtenues par la compensation de chaque bloc.

La solution des équations normales est calculée par la méthode de transformation de coefficients.

Afin de résoudre la singularité des équations normales dans les blocs, nous suggérons comme méthode de traitement d'ajouter des constantes aux éléments principaux des coefficients des équations normales. Cette méthode de traitement est simple, efficiente et souple.

CONFIGURATION OF THE CHINESE ASTRO-GEODETIC NET

The establishment of the national astro-geodetic net was carried out over about 20 years, from the early 1950s to the end of the 1960s. The principle followed was from the higher class to the lower one, the latter being controlled by the former. To begin with, primary triangulation chains were established over almost the whole country along meridians and parallels, the interval between adjacent chains being about 250 km. Each primary chain loop was filled with a continued secondary triangulation net, except in individual loops where

*The original text of this paper, prepared by Gu Dansheng, appeared as document E/CONF.72/L.80.

secondary nets were superseded by tertiary ones. In difficult districts, such as Qinghaixizang plateau, instead of a primary triangulation chain, a precise electronic distance measuring (EDM) traverse net was established. Thus, the Chinese astro-geodetic net is a continuous net, combined by triangulation and traverse. Initial sides were provided, either by base extension or geodimeter measurement, at both ends of each chain segment and the centre of each chain loop. Astronomical observations of latitude, longitude and azimuth were made at both ends of each initial side and traverse legs, 250 km apart. These initial sides, and Laplace azimuths derived from astronomical observations, provide the astro-geodetic net with scale and azimuth controls.

The national primary triangulation net consists of nearly 5,000 stations with a total length of about 80,000 km forming 120-odd loops. The precise EDM traverse net consists of more than 500 stations with a total length of approximately 10,000 km. The number of triangulation and traverse stations of primary, secondary and tertiary classes entering for adjustment as a whole will be about 50,000 with a total number of observations of nearly 300,000. It is a gigantic task to adjust such a large astro-geodetic net as a whole by the method of least squares. This work is scheduled to be carried out in 1980.

Problems involved in astro-geodetic net adjustment

Reference spheroid

Regarding the dimension of the reference spheroid, the following values recommended by the XVI General Assembly of the International Union for Geodesy and Geophysics (IUGG) will be adopted in the 1980 adjustment:

$$a = 6{,}378{,}140 \text{ m}$$
$$d = 1{:}298{,}257$$

Regarding the orientation of the reference spheroid, two systems are adopted: one is suitable for locality while the other is related to the centre-of-earth mass. The former is defined by the condition that the sum of the squares of height anomalies over the whole country are minimum; it applies to national defence and economic construction. The latter takes the centre-of-earth mass as that of the reference spheroid and applies chiefly to space technique.

Astronomical observations

In the computation of astronomical observations, the following systems and constant are adopted:

Co-ordinates of pole: JYD 1968.0 fixed mean pole of China;

Time: Combined time 1978 of China;

Star position: FK4;

Aberration constant: 20″. 496.

During the period from 1953 to 1960, observations were made to connect 10 fundamental longitude stations, of which three were reobserved in 1975/76. The new observations possess higher accuracy and will be adopted in the 1980 adjustment.

Length standard

Prior to 1961, the length standard was introduced from the USSR. Since then the wave length of the red spectrum line of cadmium was adopted as standard. This standard was superseded in 1964 by the wavelength of the orange spectrum line of Krypton-86. According to related data, the scale of the astro-geodetic net is substantially in conformity with the national length standard and hence with the international length system.

Deflection of vertical and height anomaly

In computing the deflection of vertical, we distinguish two kinds of district according to the availability of gravity data. In a district where 5′ × 5′ mean free-air anomalies are available, the gravimetric deflections of vertical for all stations are computed by the gravimetric method, and then converted to astro-geodetic deflections of vertical by making use of nearby astronomical stations. In a district where no gravity data are available, topographic deflections of vertical are computed according to surrounding topography and on the basis of hypothesis of isostasy: and likewise to get astro-geodetic deflections of vertical. The accuracy obtainable with these two methods is about ± 3″ - ± 4″.

In the computation of height anomaly, we likewise distinguish two kinds of district. In the district where gravity data are available, astro-gravimetric levelling is adopted. If no data are available, astronomical levelling and topographic methods are adopted. This procedure consists in laying out a number of astronomical levelling loops, the interval between adjacent astronomical points being 20-30 km, then interpolating height anomalies within each loop by the topographic method.

Unified adjustment

The national astro-geodetic net had been locally adjusted on the principle of controlling the lower class by the higher one; that is, at first, the net of higher class was adjusted and then held fixed in the adjustment of the net of lower class. As a result of this procedure, it was found that at the junctions of the primary chain and secondary net, the corrections in many directions of the secondary net were more than two or three times larger than the mean square error of observation. With a view to obviating the effect of such errors, an alternative was proposed: some of the secondary stations, located immediately on both sides of the primary chains and within them, were suitably incorporated in the adjustment of primary chains; in the adjustment of secondary nets, the adjusted primary chains and some secondary stations located within them were held fixed. Owing to the rapid development of electronic computing techniques, a high-speed large-capacity computer has had extensive use. In the 1980 adjustment, the principle of controlling the lower class by the higher one will no longer be followed. A unified adjustment of triangulation and traverse of all classes as a whole will be carried out.

Adjustment on the spheroid

In the past, the adjustment of the geodetic net was carried out on the plane of Gauss-Krüger projection. Related experiments have indicated that this procedure always brings about an error of 0.2 m in the adjusted coordinate as a result of approximation of error equations in the overlap of projection zones of Gauss-Krüger. In order to avoid this effect, the 1980 adjustment will be carried out on the spheroid.

The treatment of Laplace azimuth

There are many mountain ranges in the vast territory of China. Some primary triangulation chains, each several hundred kilometres long, have been laid out along areas of similar topographic conditions, for example, along one side of a mountain range. The observations of horizontal angles within such chains are likely to be affected by systematic errors. Furthermore, the primary chains chiefly extend along meridians and parallels; therefore they are liable to be affected by the so-called "lateral refraction of the earth". In order to prevent or reduce these two kinds of effect which may occur, the Laplace azimuths will be held fixed in the 1980 adjustment.

METHOD OF ADJUSTMENT

The national astro-geodetic net will be adjusted by two methods. In the first method, the net is divided into several blocks, each block being adjusted by methods of indirect observation. These blocks are then connected into an entirety by conditions of identity. The second method is that of indirect observation in co-ordinate. The results obtained by both methods are compared with each other.

Adjustment by dividing into blocks connected by conditions of identity

Figure 38 serves as an example for describing the basic principle of this method and its application to the 1980 adjustment.

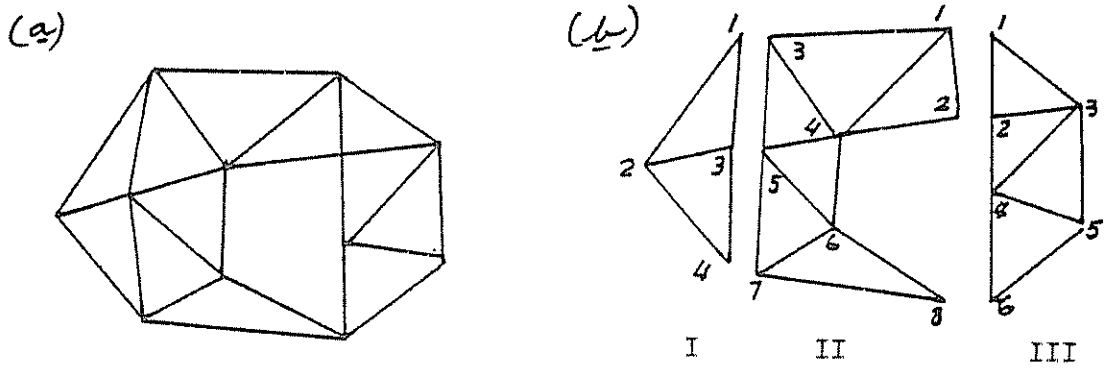


Figure 38. China: adjustment of the national astro-geodetic network by dividing into blocks

The triangulation net of figure 38 is divided into three blocks, I, II and III. Within each block, triangulation points are numbered independently, as shown in (*b*) above. Unknowns to be adjusted and observations located at junction points are divided along the dividing line into corresponding groups. Let error equations formed for a block be:

$$B_i X_i + L_i = V_i \quad (i = \text{I. II. III.}) \qquad (1)$$

where: B_i = coefficients of error equations (matrix)
X_i = unknowns to be adjusted (column vector)
L_i = constant terms (column vector)
V_i = corrections to observations (column vector)

Blocks are then connected as follows: select a group of suitable "connecting elements" on the dividing line and set up conditions of identity for corresponding connecting elements of adjacent blocks as shown in expressions (2) below. Subsequently, normal equations (4) are formed by making use of adjustment of indirect observations with conditions (2); the X_i of each block can be obtained as a result of solving (4).

In the selection of connecting elements, attention should be paid to the following principles: first, in order to simplify the computation, the selected connecting elements should bear simple functional relations with co-ordinates and the orientation angles of junction points. For example, the co-ordinate and orientation angle of the junction point, as well as co-ordinate difference, distance, and azimuth between adjacent junction points are selected as connecting elements. Second, normal equations should possess better property; for example, if the co-ordinate differences between adjacent junction points are taken as connecting elements, we get superior equations (7); on the other hand, if the co-ordinates of junction points are selected as connecting elements, the property of equations (7) will become inferior, especially in a large free net. In the practical example shown in figure 38(*b*) the orientation angle of the junction point, the co-ordinate difference between adjacent junction points and the co-ordinates at one end of each dividing line are selected as connecting elements. The corresponding conditions of identity are:

$$
\left.\begin{aligned}
&Z_1^{\mathrm{I}} = Z_3^{\mathrm{II}} && (2)_1\\
&X_1^{\mathrm{I}} - X_3^{\mathrm{I}} = X_3^{\mathrm{II}} - X_5^{\mathrm{II}}\\
&Y_1^{\mathrm{I}} - Y_3^{\mathrm{I}} = Y_3^{\mathrm{II}} - Y_5^{\mathrm{II}}\\
&Z_3^{\mathrm{I}} = Z_5^{\mathrm{II}} && (2)_1\\
&X_3^{\mathrm{I}} - X_4^{\mathrm{I}} = X_5^{\mathrm{II}} - X_7^{\mathrm{II}}\\
&Y_3^{\mathrm{I}} - Y_4^{\mathrm{I}} = Y_5^{\mathrm{II}} - Y_7^{\mathrm{II}}\\
&Z_4^{\mathrm{I}} = Z_7^{\mathrm{II}} && (2)_1\\
&X_4^{\mathrm{I}} = X_7^{\mathrm{II}} && (2)_2\\
&Y_4^{\mathrm{I}} = Y_7^{\mathrm{II}}\\
&Z_1^{\mathrm{II}} = Z_1^{\mathrm{III}} && (2)_1\\
&X_1^{\mathrm{II}} - X_2^{\mathrm{II}} = X_1^{\mathrm{III}} - X_2^{\mathrm{III}}\\
&Y_1^{\mathrm{II}} - Y_2^{\mathrm{II}} = Y_1^{\mathrm{III}} - Y_2^{\mathrm{III}}\\
&Z_2^{\mathrm{II}} = Z_2^{\mathrm{III}} && (2)_1\\
&X_2^{\mathrm{II}} - X_8^{\mathrm{II}} = X_2^{\mathrm{III}} - X_6^{\mathrm{III}}\\
&Y_2^{\mathrm{II}} - Y_8^{\mathrm{II}} = Y_2^{\mathrm{III}} - Y_6^{\mathrm{III}}\\
&Z_8^{\mathrm{II}} = Z_6^{\mathrm{III}} && (2)_1\\
&X_8^{\mathrm{II}} = X_6^{\mathrm{III}} && (2)_2\\
&Y_8^{\mathrm{II}} = Y_6^{\mathrm{III}}
\end{aligned}\right\} (2)
$$

It is obvious that if the adjustment is carried out with angle, the above expressions (2) will be absent, and that if the adjustment is carried out on a plane, such connecting elements as the co-ordinates at one end of each dividing line may be unnecessary; thereby the above expressions $(2)_2$ will disappear.

By writing (2) in the form of a matrix, we get

$$Z_{\mathrm{I}}^T X_{\mathrm{I}} + Z_{\mathrm{II}}^T X_{\mathrm{II}} + Z_{\mathrm{III}}^T X_{\mathrm{III}} = 0$$

or

$$\sum_{i=1}^{\mathrm{III}} Z_i^T X_i = 0 \qquad (3)$$

Here and in what follows, T is a notation of transposed matrix.

Normal equations corresponding to (1) and (3) will be

$$
\left.\begin{aligned}
&A_i X_i + Z_i K + W_i = 0 \quad (i = \mathrm{I}, \mathrm{II}, \mathrm{III}) && (4)_1\\
&\sum_{i=1}^{\mathrm{III}} Z_i^T X_i = 0 && (4)_2
\end{aligned}\right\} (4)
$$

where: K - correlates corresponding to conditions (3) (column vector)

$$
\left.\begin{aligned}
&A_i = B_i^T B_i\\
&W_i = B_i^T L_i
\end{aligned}\right\} \quad (i = \mathrm{I}, \mathrm{II}, \mathrm{III}) \qquad (5)
$$

If in the setting up of (1), different blocks adopt different values for the approximate values of unknowns at junction points, expressions (2), (3) and $(4)_2$ should, in addition, contain constant terms.

The arrangement of the coefficients of normal equations (4) corresponding to figure 38(*b*) is shown in figure 40.

Solution of normal equations

In the 1980 adjustment, the direct method (multi-resolution method) will be adopted for solving (4); the reduced equations of $(4)_2$ will be computed by passing through transformation coefficients Z^0.

Let Z_i^0 be transformation coefficients (column vector) corresponding to (4); their values can be determined as follows:

$$A_i Z_i^0 = 0 \qquad (i = \mathrm{I}, \mathrm{II}, \mathrm{III}) \qquad (6)$$

Multiplying $(4)_1$ by $(Z_i^0)^T$, then adding all of them to $(4)_2$, we get

$$\sum_{i=1}^{\mathrm{III}} \{(Z_i^0)^T A_i + Z_i^T\} X_i + \{\sum_{i=1}^{\mathrm{III}} (Z_i^0)^T Z_i\} K + \sum_{i=1}^{\mathrm{III}} (Z_i^0)^T W_i = 0$$

taking into consideration (6), the above expressions can be written as

$$\{\sum_{i=1}^{\mathrm{III}} (Z_i^0)^T Z_i\} K + \sum_{i=1}^{\mathrm{III}} (Z_i^0)^T W_i = 0 \qquad (7)$$

which are the reduced equation of $(4)_2$. The values of K can be obtained by solving (7); substituting these values into $(4)_1$ we get X_i of all blocks.

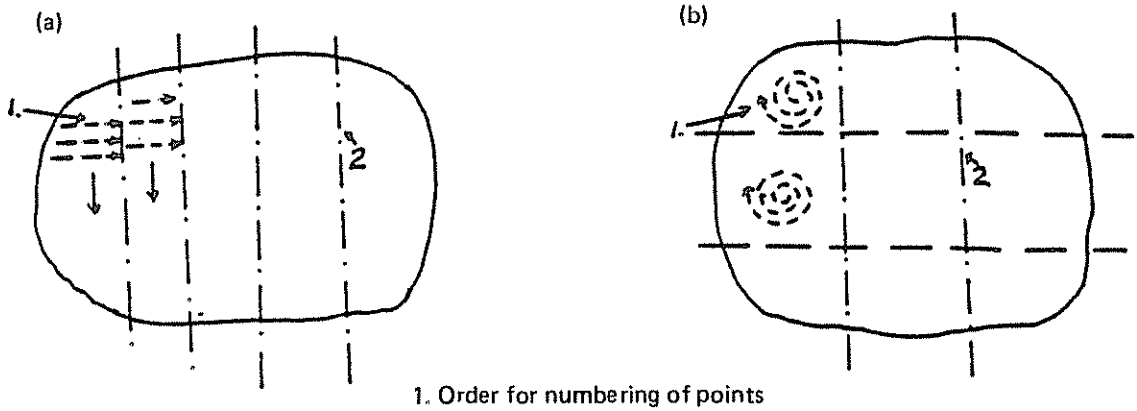
The reduced equations (7) of $(4)_2$ are computed by passing through transformation coefficients Z_i^0. This method has the advantage that in the process of solving Z_i^0, depending on the capacity of the computer, we divide Z_i into some groups according to column, and solve separately. Furthermore, as is generally the case, the distribution of non-zero elements in Z_i is quite sparse. If the elements of a certain row in Z_i are all zero, then the elements of a corresponding row in Z_i^0 have no effect on the computation of (7), as can be seen from (7); thus, we need not store these elements, or we do not compute them at all. However, it is clear from figure 40 that the non-zero elements in Z_i are either $+1$ or -1. Their positions depend only on the numbers of junction points in a block. Therefore, it is entirely possible for us to produce values of Z_i automatically in the computer, according to the number of junction points and their positions on the left and right dividing lines. If we employ these three peculiarities to the full, the computer capacity required in the solution will be reduced to a great extent.

Owing to the fact that Z_i can be divided according to column into groups and solved separately, the distribution of non-zero elements in Z_i is little related to the storage capacity of the computer required in the process of solution. This facilitates, to a certain extent, the division of the net into blocks and the numbering of points. For example, in the 1980 adjustment, the method for dividing blocks and numbering points shown in figure 39(*a*) will be adopted, instead of that shown in figure 39(*b*).

Some problems peculiar to the method of adjustment by dividing into blocks connected with conditions of identity

On account of the fact that in this method, the numbering of points and the setting up of equations (1) and (6) within each block are fully independent, in certain cases of dividing blocks, equations (6), set up from (1), may happen to be indeterminate. For example, if a block (triangulation net) contains neither fixed point nor side length and azimuth, it is impossible to deter-

mine the position, size, and orientation of this net, thereby leading to an indeterminate solution of these equations. The procedure is then as follows: select at least one or two points on the dividing line of this block; if there is neither fixed point nor side length and azimuth, at least two points should be selected; if there is only a fixed point without side length and azimuth, or the opposite is the case, at least one point should be selected; to the main elements (coefficients on main diagonal, one each in abscissa and ordinate) of equations $(4)_1$ and (6) corresponding to these selected points, a constant C (positive or negative) should be added. Meanwhile from the main elements (one each in abscissa and ordinate) of equations $(4)_1$ and (6) in the adjacent block corresponding to these selected points, the same constant C should be subtracted. After the above treatment, equations (6) will generally become a system of equations having determinate solutions.



1. Order for numbering of points
2. Dividing line

Figure 39. China: order for the numbering of points

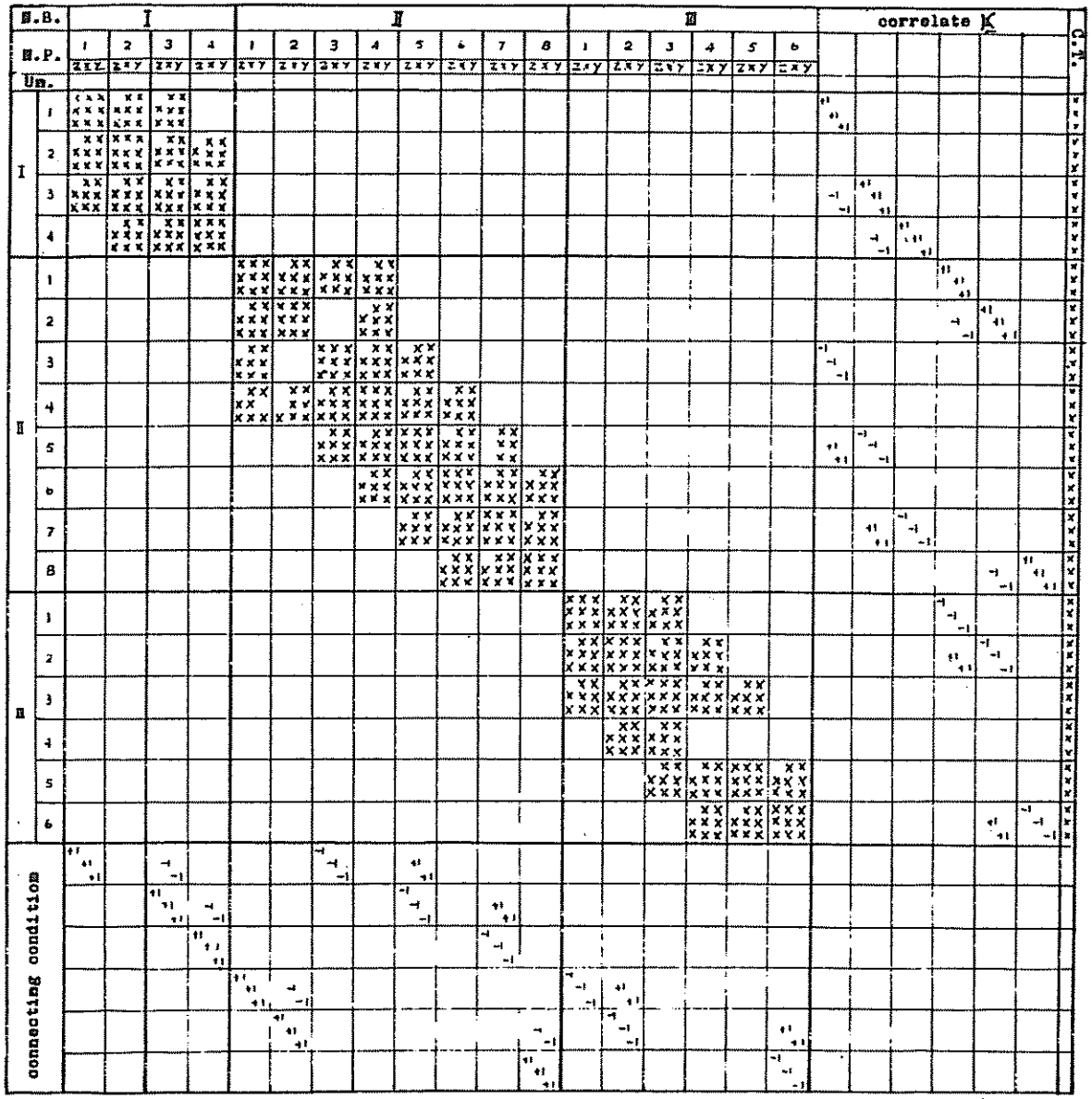
The above treatment changes only the values of K in equation (4), but does not affect X_i in them. The effect of this treatment on equations (4), (6) or (7) is substantially changing their property. Thus we can make use of this treatment for properly controlling and regulating the property of these equations without affecting the required solution of X_i in equations (4). This is an important peculiarity of this method. Preliminary testing indicates that in the above treatment, the property of equations (4), (6), and (7) and the accuracy in forming the coefficients of (7) are sensitive to the changes in the number, position, and distribution of junction points and the value of constant C. This is a problem of considerable interest on which our researches hitherto are rather insufficient.

A medium value should be selected for constant C. Neither a too large value nor a too small one is suitable. In the 1980 adjustment, a value of 0.5 will be taken for constant C. The number of junction points subject to this treatment in each block is limited to 1-2.

In this method of adjustment, the numbering of points within each block and the setting up of equations (1) and (2) are carried out independently. This fact greatly facilitates the joint adjustment of networks of different organizations or countries, especially when the networks participating in the joint adjustment have undergone local adjustment respectively. Their intermediate results, obtained from the previous adjustments (error equations and normal equations etc.), can be introduced to the joint adjustment directly. It doesn't matter much whether the common points in the junction of two networks form a single row or several rows.

In the absence of a fixed point in a block, we can proceed as follows: if the adjustment of the net is carried out on a plane, any point on the dividing line can be selected as a fixed point. This will generally have no effect on the result of the adjustment; on the other hand, if the adjustment is carried out on a spheroid, this may result in some effect, but not a significant one, especially for free and attached networks of small extent.

Finally, it is worthy of note that if the network is adjusted with direction, the observed directions on the dividing line are used once more in the adjacent block. Thus in the setting up of equations (5) from (1) within each block, the weights of these directions should be taken as half of their originals.



Key

N.B. Number of blocks
N.P. Number of points
Un. Unknown
z Unknown of orientation angle, which will be absent when the adjustment is carried out with angle
x,y Unknown of longitude and latitude (or abscissa and ordinate)
C.T. Constant term

Figure 40. China: arrangement of the coefficients of normal equations

PHOTOGRAMMETRY IN CHINA*

Paper presented by China

RÉSUMÉ

L'auteur commence par un résumé de l'évolution de la photogrammétrie en Chine pendant la période de 1930 à 1970. A la fin des années 60, déjà, toute la Chine était couverte de cartes topographiques aux échelles du 1/100 000 et 1/50 000, produites exclusivement à l'aide des méthodes et des appareils photogrammétriques (multiplex, stéréoscope à miroirs, stéréomètre, redresseur). Depuis le début de 1960, des ordinateurs électroniques ont été utilisés pour la triangulation analytique sur bandes de clichés.

En 1970, on a commencé l'établissement d'une carte de base au 1/10 000 en utilisant des photographies aériennes au 1/30 000 et des stéréocartographies précises. Le traitement analytique s'exécute surtout à l'aide de la compensation par blocs des bandes, mais il existe aussi des programmes de calcul pour compensation par faisceau et par modèle indépendant. A présent, la production massive des orthophotos est encore en phase expérimentale.

La recherche photogrammétrique comprend la compensation par blocs, la photogrammétrie automatique, l'établissement et l'application des modèles numériques de terrain, ainsi que des problèmes géométriques de la télédétection.

In early 1930, China began to import photogrammetric instruments, and at that time German and Swiss instructors were invited to organize some photogrammetric courses. Thus the first group of photogrammetric technical personnel was trained and a photogrammetric party organized. But it is only since 1949, when the New China was founded, that under the leadership of the Chinese Communist party photogrammetric mapping of large areas in accordance with definite specifications was started. Since that time the number of Chinese photogrammetric technicians has increased, and in many of the departments of the Chinese national economic construction, such as the ministries of forestry, geology, railway, water conservancy, mining, metallurgy and various organs of city planning, photogrammetric production groups have been set up. The Chinese National Bureau of Surveying and Mapping was established in 1956 to co-ordinate the mapping projects of these different organizations as well as for the guidance of the provincial survey bureaus in carrying out the survey works for the Chinese standard-scale maps.

Before the beginning of the 1970s, surveying for maps on the standard scales 1:100,000 and 1:50,000 of the whole Chinese territory except a few very difficult regions had been accomplished. The surveying methods used had been all aero-photogrammetric. At that time wide-angle or super-wide-angle aerial cameras were used, with the frame format of 18 × 18 cm. The technique in photogrammetry during the 1950s and 1960s in China was as follows.

One method of photogrammetric map compilation adopted at that time was to plot the contour lines with a plane-table in the field, on photoplans or on single photographs. Of course in the latter case, field plotting on single photographs had to be rectified by the use of an optical projector. Another method was to sketch the contour lines on aerial photographs indoors with the help of a stereometer. The sketched contours, as well as the field-interpreted details on the photographs, again had to be rectified with an optical plotter, usually in different zones. For the mountainous regions, however, multiplex was exclusively used for the plotting. For the plotting of the map at 1:100,000 scale, use has also been made of the method of contour sketching on the photographs, free-hand with the help of a mirror stereoscope based upon the so-called "peg points", i.e. points with known heights. As to the densification of the minor control points, graphical radial triangulation was primarily used for the planimetric positions in the flat and undulating areas, while multiplex, with a set of multiprojectors, was used for the simultaneous determination of the planimetric position as well as the height of points in the mountainous regions. For the densification of the heights control alone, a semi-analytic method of the so-called "non-distorted model" was sometimes used.

The plotting instruments used in the above-mentioned methods were at first imported from foreign countries, then gradually substituted by those of Chinese domestic manufacture. Among the home-made instruments the most widely used was the stereometer, by which the contour lines are sketched on one of the photographs. The home-produced stereometer type X-2 was additionally equipped with a planimetric correction device, so that the correct position of the contours and also the planimetric details could be plotted all at the same operation. For certain mapping projects, particularly those of the agencies of our national economic construction, precision universal-type plotting instruments were also used, such as the stereoplanigraph C5 from Germany, the Autograph A7 and A8 from Switzerland and the stereograph Drobyschev СД and the stereoprojector Romanofsky СПР-2 from the USSR. A Chinese home-manufactured plotting instrument of this type was the so-called stereoplotter HCT-1.

From the beginning of the 1960s, electronic computers were used for analytical aerial triangulation of individual strips. The field control points used for each strip were 5 or 6 in number, generally spanning over two map sheets. The electronic computer used at that time was mostly of home manufacture, type 103, which is a small

*The original text of this paper, prepared by Wang Zhizhuo, Wuhan College of Geodesy, Photogrammetry and Cartography, appeared as document E/CONF.72/L.81

fixed-point computer with a very small storage capacity of only 1,024 or 2,048 words and a computer speed of 2,000 operations per second. Its use was rather limited; nevertheless the use of the electronic computer at that time in aerial triangulation had great advantages and soon acquired widespread adoption in Chinese surveying institutions.

As to the researches on photogrammetric mapping at that time, many of them had aimed at studying the theory of plotting with a fine distorted pencil of projecting bundles. This was a problem of restitution work on stereo-plotters at that time, where the principal distance of the picture-taking camera was sometimes not compatible with that of the projectors on the analog plotting machines. In the field of aerial triangulation, topics for research were comparatively abundant, as for example the effect of some measures (such as the choice of orientation points by the analytical relative orientation, or the form of polynomials used by the non-linear transformation of the strips) on the accuracy of aerotriangulation; the propagation of accidental errors and systematic errors of the triangulation strips; and the use of physically determined absolute orientation of the aerial camera during flight (such as use of the records of a statoscope, a radio-altimeter and radar-position fixing devices). Since the beginning of the 1970s, the mapping project conducted by the Chinese National Bureau of Surveying and Mapping has gradually changed from mapping of the base map at scales 1:100,000 and 1:50,000 and, partly, 1:25,000, to mapping of the base map at scale 1:10,000. This latter scale is the main one at which work is now done by the Chinese National Bureau of Surveying and Mapping. In order to enhance mapping efficiency as well as cope with international development, the picture size 23 x 23 cm is now used instead of 18 x 18 cm. For the map scale of 1:10,000 a photo scale on the order of 1:30,000 is now adopted; the ones formerly used were 1:12,000 to 1:14,000. As to the plotting, stereo-plotting instruments of greater precision are used. Since the manufacture of precision photogrammetric analog instruments in China lags far behind the needs for map production work, quite a number of foreign plotting instruments have been imported, such as Planimat D2 from Zeiss Opton, Topocart B, Stereometrograph F from Zeiss-Jema, and Autograph A10 and Aviograph B8 from Wild. Many of the Chinese engineering agencies utilize these kinds of instruments also for large-scale mapping at scales 1:2,000 and 1:5,000, while the photo scales in these cases are three to six times smaller.

In the field of analytical aerotriangulation, change at this time has been made from the aerotriangulation of single strips to that of blocks. For the block adjustment, the method of simultaneous adjustment of all the included strips is primarily used: it is called block adjustment by strips. On the other hand, block adjustment by independent models has been adopted in some photogrammetric institutions also. It is thought that block adjustment by strips is possibly not greatly inferior in the present case to block adjustment by independent models, since the former method might be more profitable in the elimination of systematic error influences. As to block adjustment by bundles (i.e. the method based on the principle of colinear condition), computer programs are also available, and in the realm of research attention is also drawn to use of the method of "self-calibration", that is, the use of additional parameters during the adjustment.

The digital computers now used in the photogrammetric production bureaus are all domestically produced, like the so-called type X-2 and DJS-121. The core-storage of these computers is 8K (word length of 42 bits) and their computing speeds are respectively 25,000 and 30,000 operations per second. The other larger computers are of the type 441B-II, 441B-III, DJS-6 and TQ-16, the core storage of which varies from 8K to 32K with a computing speed of from 25,000 to 120,000 operations per second. The computer programs are generally written in machine code, with a few exceptions where the programming language ALGOL 60 is used. For research purposes, however, programming language is used exclusively, and still larger computers have to be used. The use of peripherals connecting to a certain computer centre, which is a very common practice in Europe, as was observed on this trip, is not yet available in the Chinese surveying institutions.

As to the accuracy of block triangulation, China has not attained the advanced world level, particularly in planimetric point determination. The reasons for this might be, first, that the signal marks for field controls have not been widely used; secondly, few have used the special point-pricking instruments for the transfer of conjugate image points. Besides, the stereocomparators used are mostly the home-manufactured ones of type 18 × 18 instead of the more precise instruments such as type PSK.

However, for convenience in arranging map production works, excessive large blocks of aerial triangulation are not generally adopted. Therefore the observed accuracy of the image points, though not very high, still fulfils the requirements of map production work. For a mapping project on scale 1:10,000, a small block consisting of 4 x 4 = 16 map sheets may be taken as typical. Planimetric field-control points are placed each on the corners of the block (a total of 4); or two extra points may sometimes be placed with one on each side of the block along the cross-flight direction (a total of 6). As for the height field-control points, one point is to be placed on every lateral overlap of the strips along both sides of the block in the cross-flight direction, and several points in between are arranged. For research purposes, very large aerotriangulation blocks have been adopted. Simulated image data materials, carrying with them fictitious random, as well as systematic, errors, will be computed for this purpose. The establishment of a test field is also being planned.

As to the other problems arising during the development of modern photogrammetry, such as the production of orthophotomaps, automation and digitalization in photogrammetry, as well as close-range photogrammetry, research work is now being carried out in different photogrammetric institutions in China. In the following brief description of this, some personal prejudices in the expressed viewpoints cannot be avoided.

In Chinese engineering enterprises, opinions are unanimous in welcoming the use of orthophotomaps. But ways to produce such maps are still in the experimental stage. Nowadays photomaps of the scale of 1:10,000 and larger have been made by some of the provincial survey bureaus, but they are all made for flat areas by rectifiers. The orthophoto projecting equipment now existing in China consists of a few sets

of the Orthophoto B attachment of Topocart B of Zeiss-Jena, and one set of Ortho-3 projector of Zeiss Oberkohen. A set of PPO8 from Wild has been set up only recently. Until now no satisfactory result in orthophotomap production has been published in China.

By the orthophoto production works in the hilly topography, the consistency of the image details between the adjacent slit scanning strips has to be specially emphasized. The Chinese photogrammetrists are now paying more attention to the arrangement taken by the Wild Avioplan OR-1, where the consistency between the adjacent strips is assured through the use of the corresponding image co-ordinates. During a visit to Zeiss Opton, it was learned that a new model of ortho-projector equipment G2, which will be used in conjunction with the Planicomp C/100, will be manufactured very soon. It is really a good idea of Zeiss Opton to find the necessary image co-ordinates analytically with the help of the Planicomp, as compared with that done digitally by the Wild Avioplan OR-1. At the Congress of the International Society of Photogrammetry (ISP) in 1976 in Helsinki, several new types of analytical plotters were exhibited. Since that time, the prospects of the analytical plotter tend to be more promising as compared with those of the conventional mechanical stereoplotters. But for the plotting of conventional photography in which China is slowly being engaged, the advantages in the use of an analytical plotter are still not realized, in so far as it has not yet been automated by the use of image scanning and correlation devices. However, we are watching with interest the recent hardware and software developments of the analytical plotters in other countries, and some Chinese photogrammetrists have started to design and make one type of analytical plotter of their own.

Some of the Chinese photogrammetrists are of the opinion that the most promising way to automate photogrammetry should be by way of image digitilization, that is, to sample and quantitize the entire overlapping area of the picture images into pixels by the use of a scanning densitometer and to store the digitized information in magnetic tapes. The stored digital information will then be used for carrying out the digital correlation and for calculating automatically the picture orientations by means of a digital computer system, with the aim of forming a digital terrain model (DTM) together with the respective density values of all the selected pixels. Thus it is not difficult, finally, to pick up the contours from the highly densified DTM through the computer system software and at the same time to print the orthophoto map by reversed process on the same scanning densitometer. In this respect, the thesis written in 1975 by W. Kreiling of the Federal Republic of Germany has had a great influence in China. In fact, the American Digital Automatic Compilation System (DAMC) and the recently revised model DMS have already set successful examples in this respect. Naturally, difficulties in carrying out such a project nowadays should not be underestimated. These difficulties might include the requirements in the hardware and software aspects of the computer system due to the tremendous amount of data storage and data transfer and the preprocessing of the image as well as the complicated problems of the man-machine interface involved. Some Chinese photogrammetrists are engaged in other forms of photogrammetric automation or semi-automation which might be easier to realize than that mentioned above, such as automation by putting an automatic correlation device on an analytical plotter; and semi-automation by means of a stereocomparator. In the latter case, a stereocomparator and computer are used to establish the digital terrain model by observing on the comparator quite a large amount of conjugate image points, and hence to interpolate and draw the contour lines automatically.

The use of the digital terrain model in engineering surveying projects is now beginning to be introduced to the engineering design agencies by Chinese photogrammetrists. This kind of research work in railway engineering is already under way. The use by some metallurgical agencies of the idea of DTM for making topographic correction of gravitational measurement has been shown to be very effective. Our photogrammetrists have also paid attention to the application of close-range photogrammetry in the medical and other special fields.

Remote sensing is a recent important application of photogrammetry; or perhaps photogrammetry may be taken as a branch of the remote sensing technique. Knowledge of data acquisition, data processing and pattern recognition of the remote sensing technique is having a serious influence on the development of photogrammetry, particularly that of photogrammetric automation and digitilization. Knowledge of remote sensing is now beginning to be introduced into the curricula of Chinese photogrammetric educational institutions and will be taught to photogrammetrists in furtherance of their studies. Some photogrammetrists are already engaged in analysing geometric distortions of various remote sensing images; or they are participating in actual remote sensing work in different departments of Chinese national economic construction.

SURVEY OF SUGAR LANDS, FIJI*

Paper presented by Australia

RÉSUMÉ

En 1973, le Gouvernement fidjien a acheté à la société CSR environ 28 000 hectares de terres qui appartenaient à celle-ci en pleine propriété ou qu'elle tenait à bail de la Couronne, et il a demandé au Gouvernement australien de l'aider à établir les levés cadastraux des propriétés individuelles afin de pouvoir délivrer des titres dûment enregistrés aux exploitants.

Le document décrit succinctement les événements qui ont abouti à la mise en vente des terres de la société CSR, ainsi que les méthodes de travail employées et les dispositions administratives prises pour établir les levés.

THE COLONIAL SUGAR REFINING COMPANY

The Colonial Sugar Refining Company of Sydney, N.S.W., which was renamed CSR Ltd in 1973, commenced operations in Fiji in 1880 by establishing its first mill at Nausori in the Rewa valley. From the 1890s, it began leasing plantation areas to Europeans, many of them former field-staff of the company.

Problems between the growers and millers led to the appointment of several commissions of inquiry, and finally CSR ceased milling operations in Fiji at the end of March 1973. The Government of Fiji bought 70,000 acres of CSR's freehold and Crown leasehold land and placed four sugar mills and associated equipment under the control of the newly formed Fiji Sugar Corporation Ltd, a statutory company established to control sugar production.

PARTICIPATION BY AUSTRALIA IN THE PROJECT

The Government of Fiji was unable to offer the tenants a registrable lease without extensive surveys being carried out; therefore it asked Australia to provide a team of surveyors and a draftsman under the South Pacific Aid Programme, to carry out surveys within the existing cadastral system and legislature for registration of the land as occupied by the tenants.

This project, as a foreign aid programme, is administered and funded by the Australian Development Assistance Bureau of the Department of Foreign Affairs.

The team leader and supervising draftsman arrived in Fiji in September 1974, four months in advance of the rest of the project staff.

The aid agreement

After acceptance of the recommendations of a feasibility study team, an agreement was prepared whereby Australia was to provide a team of registered surveyors, a draftsman, vehicles, survey equipment and funds for housing and office accommodation for project staff and their Fiji assistants.

The Fiji Government undertook to:

(*a*) Provide the following technical and field staff, and secretarial assistance throughout the project:

10 technical assistants (surveyors in training),
5 trainee draftsmen,
20 chainmen,

Clerical officers and typists as required;

(*b*) Provide building sites, arrange for construction of residential and office accommodation, supply and maintain utility services and meet all costs of day-to-day running and internal travel.

(*c*) Arbitrate in any boundary dispute between tenants.

Staff

The Australian team consists of seven surveyors (one of whom is team leader) and a draftsman.

The Fiji authorities are providing up to 45 personnel on a permanent basis, and additional staff have been loaned on short term from the Department of Lands and Survey.

THE FIELD SURVEY

Boundary surveys are not commenced until after a public meeting has been held in each area and adjoining tenants have reached agreement on common boundaries, rights of access, location of public roads, drains and other areas allocated for public purposes.

Progress at 30 June 1979

Survey field operations and drafting commenced in February 1975 and the following figures tabulate progress at the end of June 1979:

FIELD OPERATIONS

Location	*Original estimate of area*	*1979 estimate of actual area*	*Area completed*	*Percentage completed*
	(acres)			
Cuvu	4 735	5 846	5 846	100
Nadi/Lautoka	6 490	7 269	6 104	84
Ba	6 985	7 615	6 774	89
Rakiraki	5 355	6 426	5 320	83
Raviravi	2 673	3 207	—	Nil
Tavua	8 456	11 161	709	6
Labasa	4 789	5 400	4 831	89
TOTAL	39 483	46 924	29 584	63

A total of 209 plans have been lodged with the Department of Lands and Surveys, comprising 3,084 lots. Registered leases issued to tenants total 154.

*The original text of this paper, prepared by the Australian Survey Office, appeared as document E/CONF.72/L.26.

TRAINING

One of the most important aspects of the project is the training of Fiji staff, to assist them in qualifying for eventual registration as land surveyors or survey draftsmen.

Study awards are available to Fiji personnel, and already one technical assistant and five draftsmen have been granted project training awards with the Australian Survey Office, Department of Administrative Services, Canberra. The length of training in Australia varies between 6 and 9 months.

CONCLUSION

The survey of former CSR sugar lands in Fiji under the Australian South Pacific Aid Programme will assist in the establishment of an improved system under which the tenants will benefit by registration of their leases, giving them security of tenure which was not previously available.

Better land management and greater productivity should be secondary benefits.

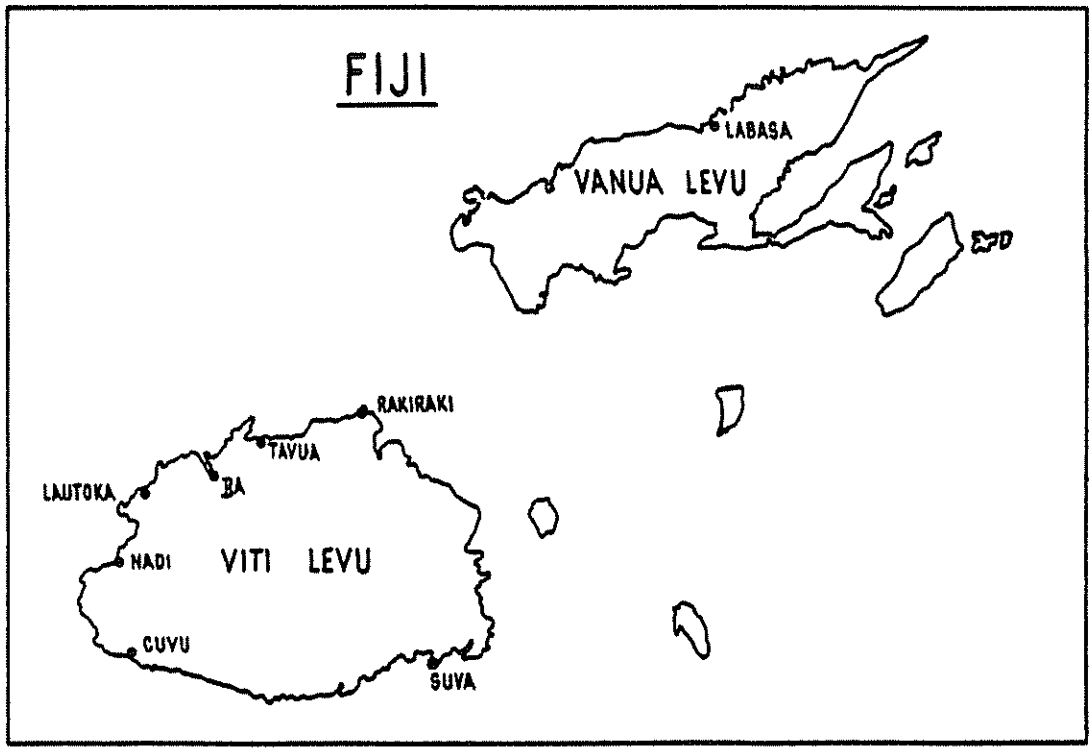


Figure 41. Australia: location of field operations

ORTHOPHOTOMAPPING FOR DRAINING OF AGRICULTURAL LANDS IN FIJI*

Paper presented by Australia

RÉSUMÉ

En 1976, le Gouvernement de Fidji a obtenu de la Banque mondiale un prêt pour l'étude et la construction d'un système de drainage et de digues de protection dans les principales zones de plantations de canne à sucre et de rizières de Fidji. L'octroi du prêt bancaire était subordonné à la condition que des cartes appropriées soient établies avant que l'étude technique du projet ne commence.

Fin 1976, le Gouvernement de Fidji a pris contact avec le Gouvernement australien afin d'obtenir son concours pour l'établissement de ces cartes dans le cadre du programme australien d'aide dans le Pacifique Sud qui est administré par le Ministère des affaires étrangères par l'intermédiaire du Bureau australien d'assistance au développement. Le Service topographique australien a été engagé en tant que maître d'œuvre du projet. Il a été convenu que le Gouvernement de Fidji financerait la réalisation du canevas planimétrique et que l'Australie se chargerait de la photographie aérienne et de la réalisation des cartes.

In 1976 the Fiji Government obtained approval for a loan from the World Bank to design and construct drainage and sea wall protection in the major sugar cane and rice growing areas of Fiji. A condition of the Bank loan was that satisfactory maps be available before engineering design work commenced. Existing maps were too small in scale and out of date. Aerial mapping was considered the only way that suitable scale topographic maps could be produced in a short time.

Late in 1976 the Government of Fiji approached the Government of Australia to assist in the mapping as part of Australia's South Pacific Aid Programme, which is administered by the Department of Foreign Affairs through the Australian Development Assistance Bureau (ADAB). The Australian Survey Office was engaged as the ADAB agent for the project. It was agreed that the Fiji Government would provide resources for establishment of ground control while Australia would provide air photography and carry out the map production.

The Australian Survey Office also provided a project co-ordinator whose duties included advice to the Senior Surveyor, Drainage and Irrigation Division of the Fiji Ministry of Agriculture and Fisheries, on the execution of the control surveys, drawing up specifications and procedures and ensuring that the specifications were met so that the map production phases in Australia would proceed smoothly.

The project co-ordinator was in Fiji for two six-month terms; 11 July to 15 January 1978 and 24 May to 6 December 1978.

MAPPING

It was decided to produce orthophotomaps at 1:5,000 scale showing spot heights in the low-lying flat plains, 2-metre contours up to 20 metres elevation and 20-metre contours above that level. Almost 350,000 acres required mapping with 2-metre contours and/or spot levels for the engineering drainage design. The most economical map sheet layout required 140 map sheets for a total area of 415,000 acres.

AERIAL PHOTOGRAPHY

The aerial photography extended about 10 per cent outside the area to be mapped. It was flown at low level with monochrome film for the contouring and spot heights and, with transferred control, at high level with colour film for the orthophoto projections.

Details were:

1. High Level
   Flying height: 17,500 feet above sea level
   Scale: 1:32,000 approximately
   Film: colour negative
   Forward overlap: 80% ± 5%
   Lateral overlap: 25% ± 5%
   Purpose: *Orthophoto production*
2. Low Level
   Flying height: 9,000 feet above sea level
   Scale: 1:16,000 approximately
   Film: Black and white negative
   Forward overlap: 60% ± 5%
   Lateral overlap: 25% ± 5%
   Purpose: *2-metre contours and spot levels*

Colour film was chosen for the high-level photography for purposes of vegetation identification. Although the extra cost of using colour film was minimal, there was some disadvantage in that black-and-white diapositives produced from colour film are not as distinct as those produced from black-and-white film.

Two examples of colour stereo pairs of photographs and one 4-times enlargement were ordered and financed by ADAB to show the Fiji authorities the potential uses of colour photographs. All films for the project were given to the Air Survey Section, Department of Lands and Surveys, Suva, on the completion of the mapping, and black-and-white prints can be ordered through that Department. The set of black-and-white proof prints used by the field parties were given to the Drainage and Irrigation Division.

The final payment amounted to almost $A 74,000 which included the supply of prints and diapositives.

CONTROL SURVEYS

The existing primary triangulations of Viti Levu and Vanua Levu were surveyed and computed by British

*The original text of this paper, prepared by the Australian Survey Office, appeared as document E/CONF.72/L.50.

Army surveyors, led by Captain G. T. McCaw, between 1910 and 1918. In some cases marks and/or beacons had been destroyed or moved and the following policy was adopted for each district. The co-ordinates of a prominent trig station, preferably a McCaw trig, were adopted as co-ordinate datum for that district. The bearing to another trig, preferably McCaw, was calculated and adopted as azimuth for that control survey network. All photo control points and convenient other existing control stations were then connected to the datum stations in a closed network. This will enable a simple shift and re-orientation of the maps to be made in the event of any future resurvey of the primary network.

The projection adopted by McCaw for Viti Levu was the Cassini. Vanua Levu and adjacent islands were treated as a separate group by McCaw, who computed the primary triangulation on a slightly modified projection known as Cassini Hyperbolic.

The ground control was undertaken by three consultant firms from Suva (65 per cent); survey personnel of the Drainage and Irrigation Division from Lautoka, Suva and Labasa (15 per cent); and an Australian Survey Office team of two (20 per cent).

All calculations were undertaken or supervised by the Australian Project Supervisor or the Senior Surveyor, Drainage and Irrigation Division.

The two-man Australian Survey Office field team brought their own survey equipment from Canberra but relied on the Drainage and Irrigation Division for assistants and vehicles. Two senior technical assistants were assigned to the team for four months. The training they received improved their surveying understanding and performance considerably.

ORTHOPHOTOMAP PRODUCTION

As well as showing photographic detail and level information the maps showed the Cassini grid, geographic graticule, geographic place names, locality sketch, geographic data, origins of control survey and photography details.

The production costs were about $A 2,000 for each sheet.

The final product was a transparent half-tone composite positive orthophotomap. Three copies of each map were produced.

PROJECT COSTS

The Australian Government costs were about $A 550,000. The Fiji Government costs for field survey, mainly by consultants, were estimated to be about $A 250,000.

A section of map at correct scale and a scale reduced copy of a complete map are attached (figures 42, 43).

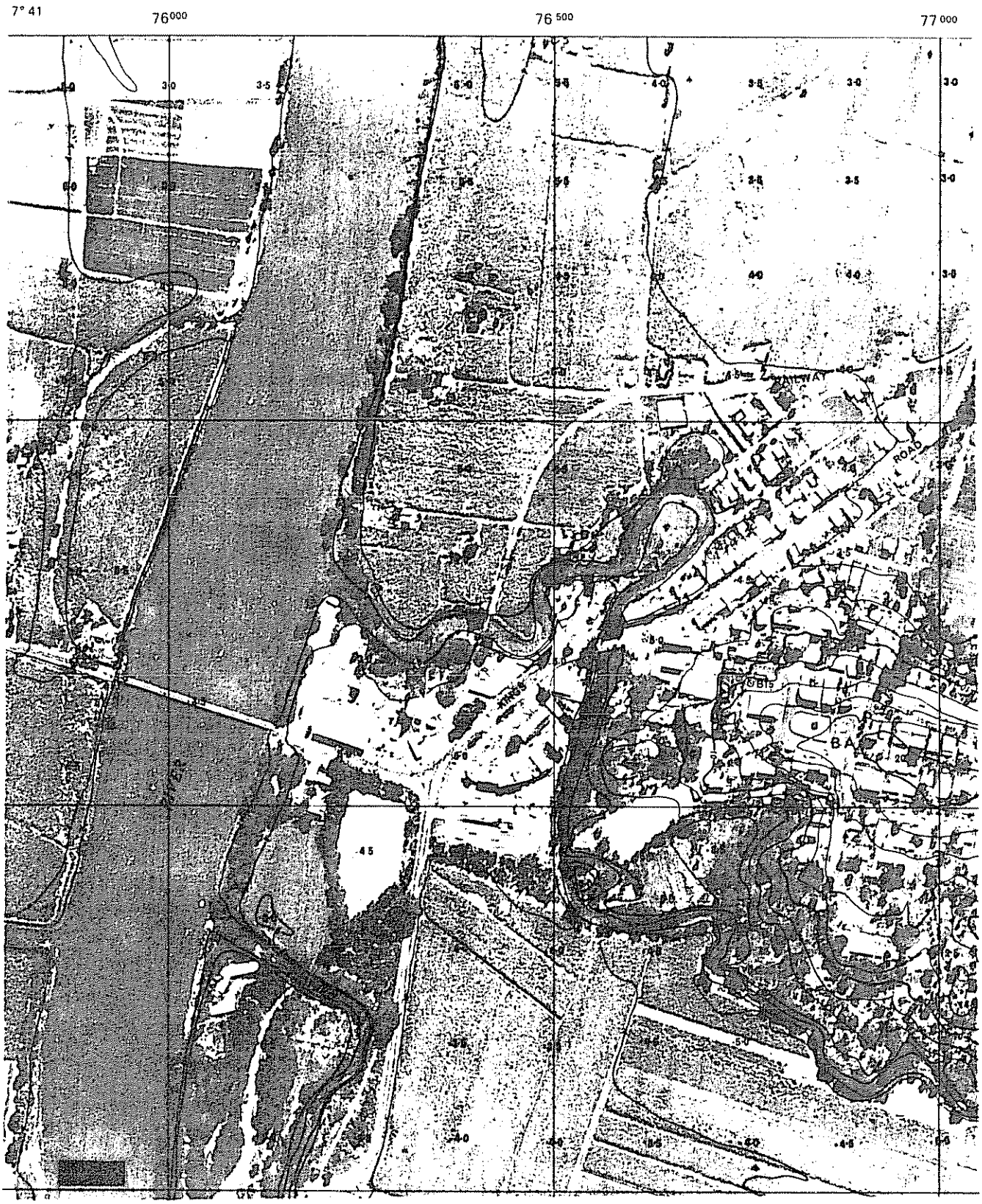


Figure 42. Australia: section of orthophotomap

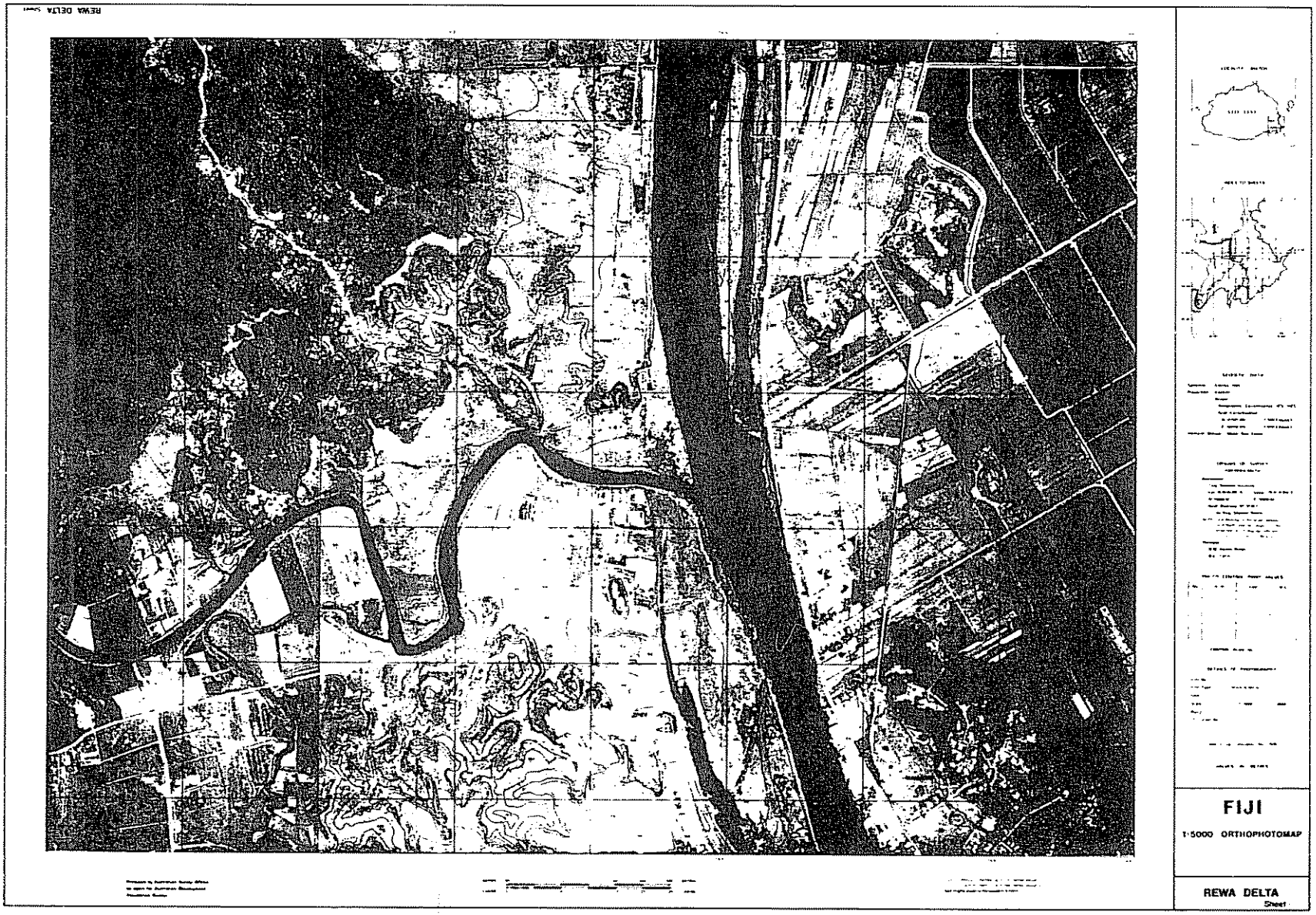


Figure 43. Australia: section of orthophotomap at reduced scale

QUESTIONS TECHNIQUES RELATIVES À LA CARTOGRAPHIE GÉODÉSIQUE DE BASE UTILISANT LA MÉTHODE DOPPLER SUR SATELLITE*

Document présenté par la France

SUMMARY

The most spectacular evolution in geodetic techniques in recent decades has been the development of spaceborne resources. Among these, the United States TRANSIT satellites, launched at first for military reasons, have been increasingly used for other purposes since 1967. Measurements of the Doppler-Fizeau effect on the various waves continuously emitted by these satellites, followed by appropriate computations, make it possible to obtain accuracies of the order of 3 to 5 m for isolated points (observed with one receiver) and about 1 metre in relative position for points in a block observed simultaneously using several receivers. The resulting network can be increased in density by using non-spatial methods.

During recent years the Institut géographique national (IGN) of France, has participated in various joint projects described in this report.

*Le texte original de ce rapport, préparé par Catherine Le Cocq, Institut géographique national, a paru sous la cote E/CONF.72/L.57. Le texte complet est publié dans *Deuxième Conférence cartographique régionale des Nations Unies pour l'Amérique, Mexico, 3 à 14 septembre 1979*, vol. II : *Communications techniques* (publication des Nations Unies, numéro de vente : E/F/S. 82.I.14), sous le titre « Examen des techniques de pointe et des faits nouveaux : géodésie et stéréopréparation, notamment par satellite ».

SPOT: THE FRENCH EARTH OBSERVATION PROGRAMME AND THE SPOT A MISSION*

Paper presented by France

RÉSUMÉ

Le satellite français SPOT A (Système probatoire d'observation de la Terre), réalisé en association avec la Belgique et la Suède en vue d'un lancement au premier semestre 1984, est conçu pour fournir des images de la surface terrestre avec une haute résolution afin de répondre au mieux aux besoins de la gestion de l'environnement et de la cartographie de base et thématique à l'échelle de l'ordre du 1/100 000.

SPOT A comprend une plate-forme standard multimission supportant deux instruments d'observation identiques couvrant chacun un champ de 60 km de large. Les images ont un pas d'échantillonnage de 10 m en mode panchromatique et de 20 m en mode multispectral (trois canaux spectraux entre 0,5 et 0,9 micron). Le pointage des instruments de prise de vue doit permettre de tester les possibilités d'observations dans des intervalles de temps rapprochés de zones particulières (temps d'accès moyen à une zone donnée 2,5 jours en moyenne à 45° de latitude), d'une part, et la pratique d'observations stéréoscopiques depuis l'espace, d'autre part.

Les données seront soit transmises en temps réel vers des stations de réception directe, soit enregistrées à bord s'il n'existe pas de stations de réception dans la région observée. Dans ce dernier cas, elles seront retransmises vers la station de réception française de Toulouse-Aussaguel. Les moyens au sol de contrôle, de réception et de traitements en cours d'établissement au Centre spatial de Toulouse permettront d'archiver, de prétraiter et de diffuser les données du satellite SPOT A aux utilisateurs.

En l'absence de réglementation internationale, la France prévoit de diffuser librement les images au pas d'échantillonnage de 20 m, et les images au pas d'échantillonnage de 10 m si leur protection n'est pas demandée par les pays observés.

The objective of earth observation is to provide, qualitatively and quantitatively, detailed information on the terrestrial environment; achievement of this objective may be considered a major step towards the better management of our planet's natural resources. Thus, without replacing conventional methods of statistical inventory and ground data collection, remote sensing from space offers an opportunity to provide valuable regional information for mapping purposes.

*The original text of this paper, prepared by C. Veillas, Centre national d'études spatiales, appeared as document E/CONF.72/L.58.

On the basis of such considerations, in September 1977 the Government of France decided to develop its own earth observation programme entitled "Système probatoire d'observation de la terre", the so-called SPOT programme. The purpose of this paper is to describe the present status of the programme and also to give information on SPOT A mission objectives; the organization of the system; ground facilities for receiving, archiving, pre-processing and processing space remote sensed imagery; planned specification of distributed data to the users; the European programme; and the situation of ground facilities with respect to other ground facilities already in operation for LANDSAT 1-3.

SPOT A: Main objectives

The main objectives of the first mission are:

(*a*) To contribute to the development of remote sensing as a tool for exploitation and management of earth's natural resources;

(*b*) To acquire high-resolution imagery of the earth's surface needed for topographic and thematic mapping at scale 1:100,000.

(*c*) To test capability for providing repeated observations of particular areas, using the depointing capability of both optical instruments (HRV, high resolution in the visible);

(*d*) To test the capability for providing stereoscopic observations from space;

(*e*) To equip a multimission platform.

General architecture of the system

The basic concept behind the SPOT system is modularity. The satellite is mainly composed of (see figure 44 (*a*)-(*c*)):

(*a*) A standard multimission platform fitted for numerous different earth observation missions for helio-synchroneous circular orbits (see figure 46);

(*b*) A specific payload designed for the mission (optical instruments and on-board recording and facilities). For SPOT A, for example (figure 44), the mission payload is composed of two identical optical instruments with electronic scanners (charge coupled detectors), on-board recorders and telecommand and telemetry facilities.

For the first mission, SPOT A, the two identical optical instruments allow:

(*a*) Taking of vertical views, each instrument scanning simultaneously the points of a 60-km line-width. Overlapping on the ground for the two instruments is 3 km; thus the total nadir viewing swath is 117 km;

(*b*) By means of a pointable mirror for each independent instrument, acquisition of side-looking imagery at more or less 27° angle to the vertical axis of the satellite to the ground. This capability leads to access to any 60-km swath within a 950-km swath and provides highly repetitive observation of given areas (the mean access time to any given area at 45° latitude is 2.5 days). (Figure 44 (*b*) and (*c*)).

Each identical instrument can work independently on two modes:

(*a*) The panchromatic mode at a 10-m sampling step;

(*b*) The multispectral mode (two channels in the visible range and one channel in the near infra-red range) at a 20-m sampling step.

Spectral bands were chosen for observation of vegetation.

Ground facilities in France

Figure 45 shows a broad view of the ground segment structure.

The SPOT system is mainly composed of (*a*) the satellite; and (*b*) the Mission Centre at Toulouse, France, which includes the satellite Control Centre, the receiving station and the image archiving and pre-processing facilities. Furthermore, a promotion and an image data unit for SPOT imageries is under development. This unit is responsible for interfacing between the Mission Centre and the users (through User Services).

Planned general specification of products delivered to users

Taking into account users' needs, users will have the choice of purchasing three types of products corresponding to three different levels of SPOT imagery:

Level 1: radiometrically rectified standard image data, mass production;

Level 2: geometrically rectified image data of cartographic quality;

Level 3: same as level 2 but from side-looking acquired image data.

This choice is given to users in order to adapt their purchases to the intended application (for example, topographic or thematic cartography, stereoscopic restitution for mine prospecting etc.)

In the absence of international regulations on access to high-resolution image data from space, Centre national d'études spatiales proposed to the Government to plan to distribute freely 20-m sampling step imagery (trichromatic mode), and 10-m sampling step imagery; except, if protection was required by observed countries, this protection would be guaranteed by the French Government.

Development calendar since 1976

At present, the SPOT A development calendar is the following:

Phase A	
Conceptual and feasibility studies	1976-77
Decision by the French Government to develop the system	September 1977
Phase B	
Detailed definitions and studies, including plans for ground facilities with participation of Institut géographique national (IGN)	1978-1979
Contracts with Sweden and Belgium	October 1978 (Sweden) June 1979 (Belgium)
Development plan	Started January 1980

(continued on page 147)

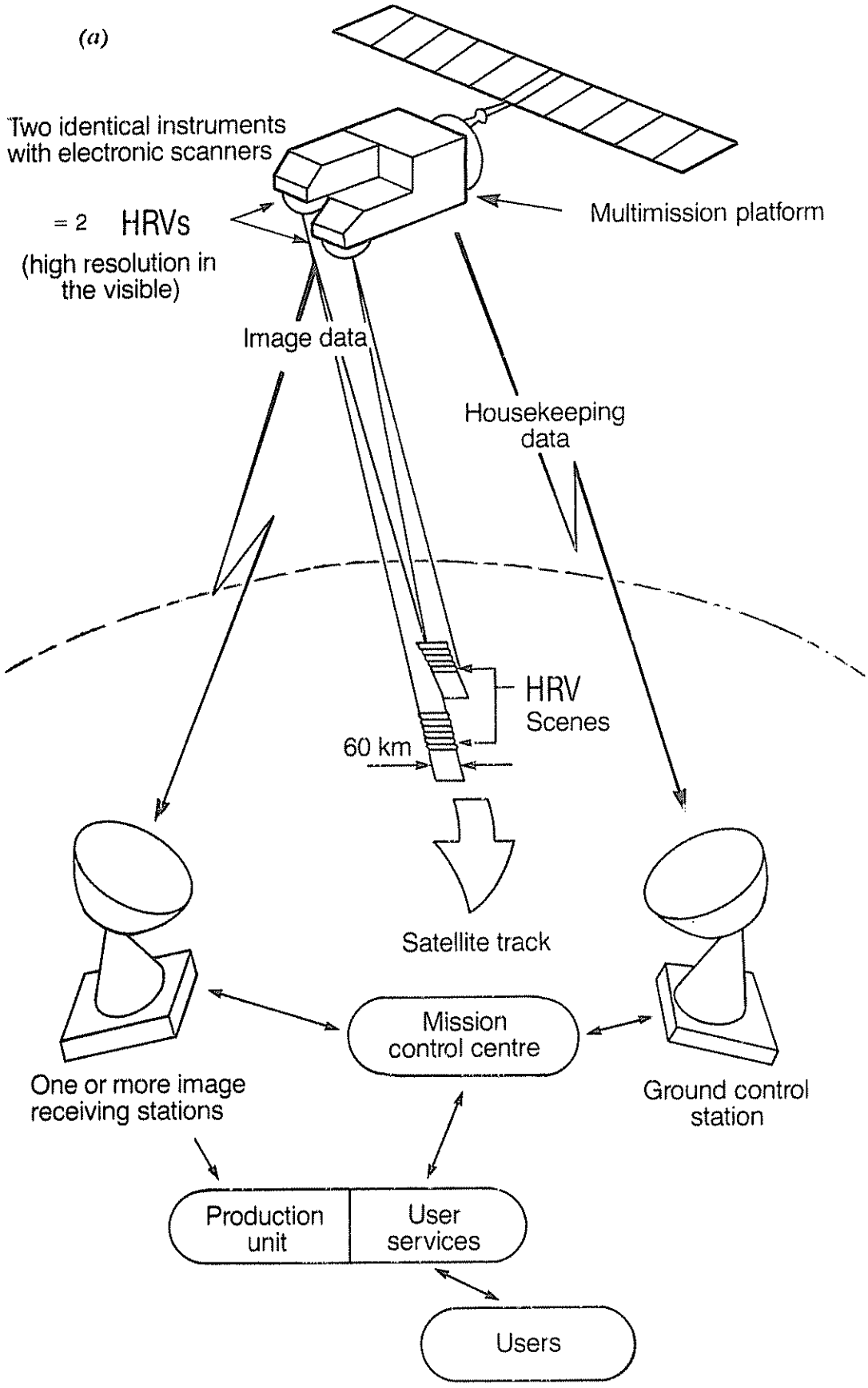


Figure 44. France: general architecture of the SPOT system; first mission, SPOT A

(b)

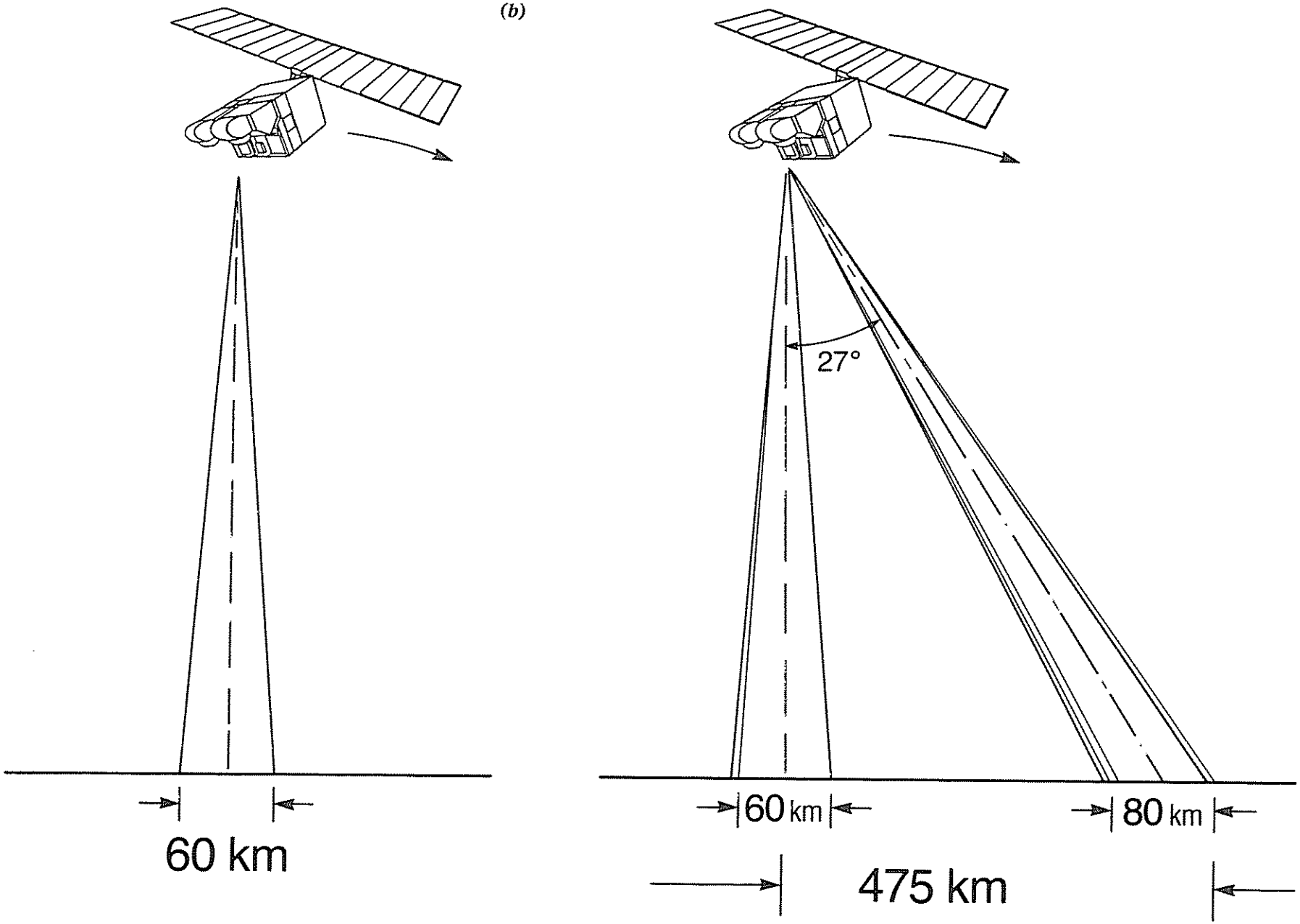
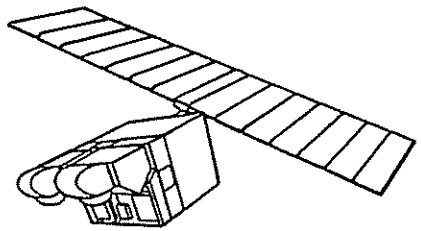


Figure 44 (continued)



(c)

A given area can be observed 12 times during a 26-day cycle (mid-latitudes)

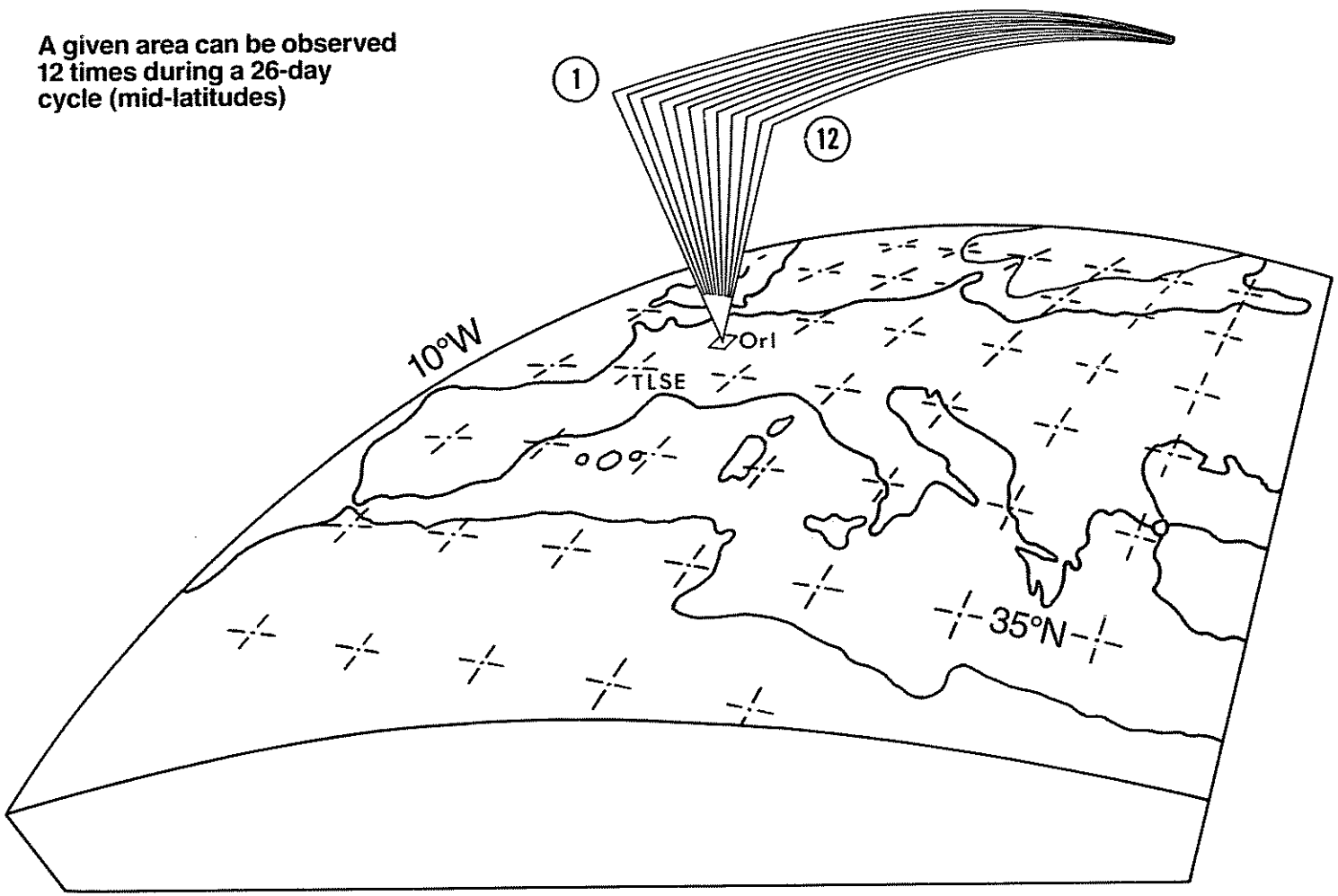


Figure 44 (continued)

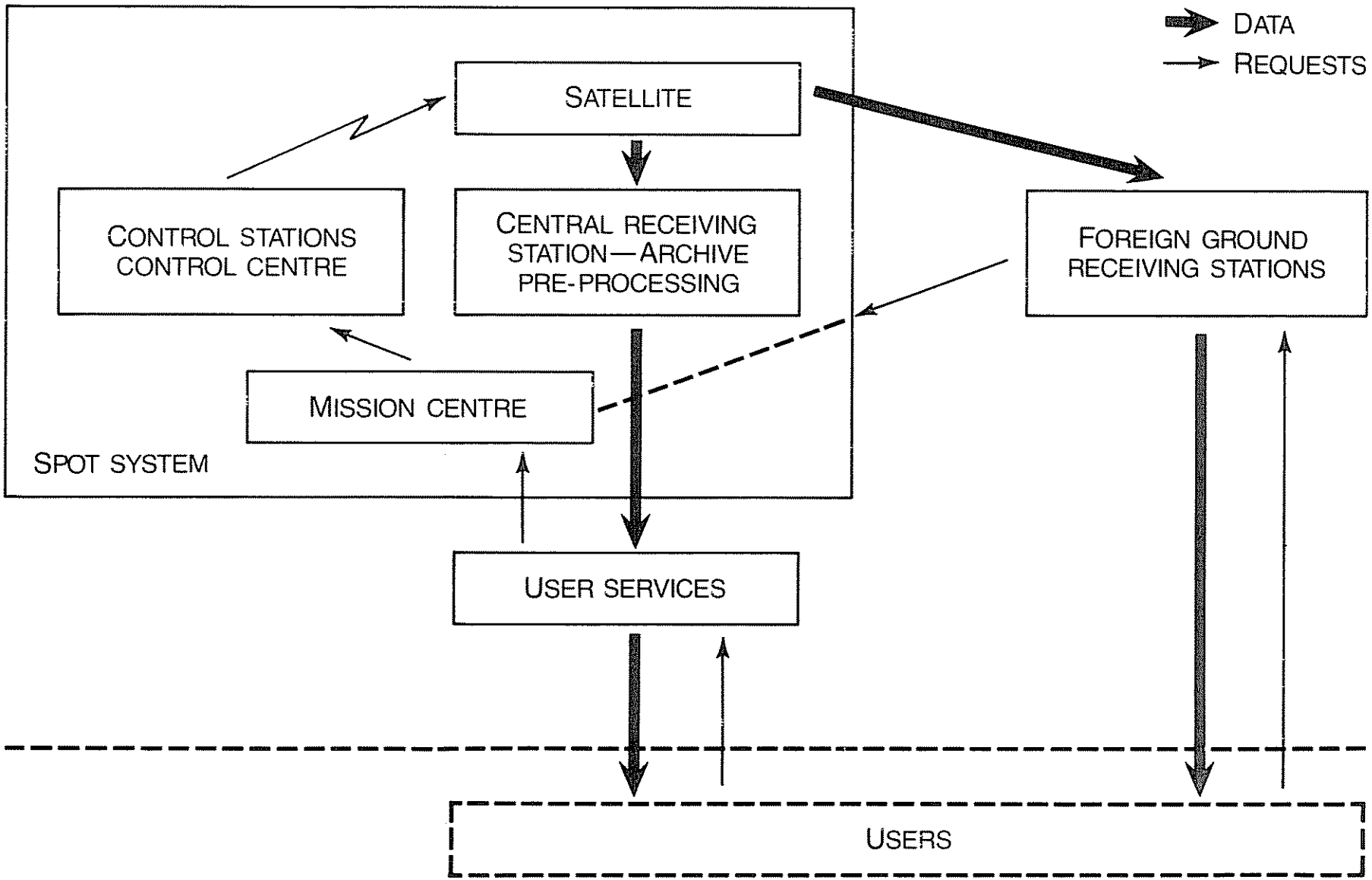


Figure 45. France: ground segment structure and data flow

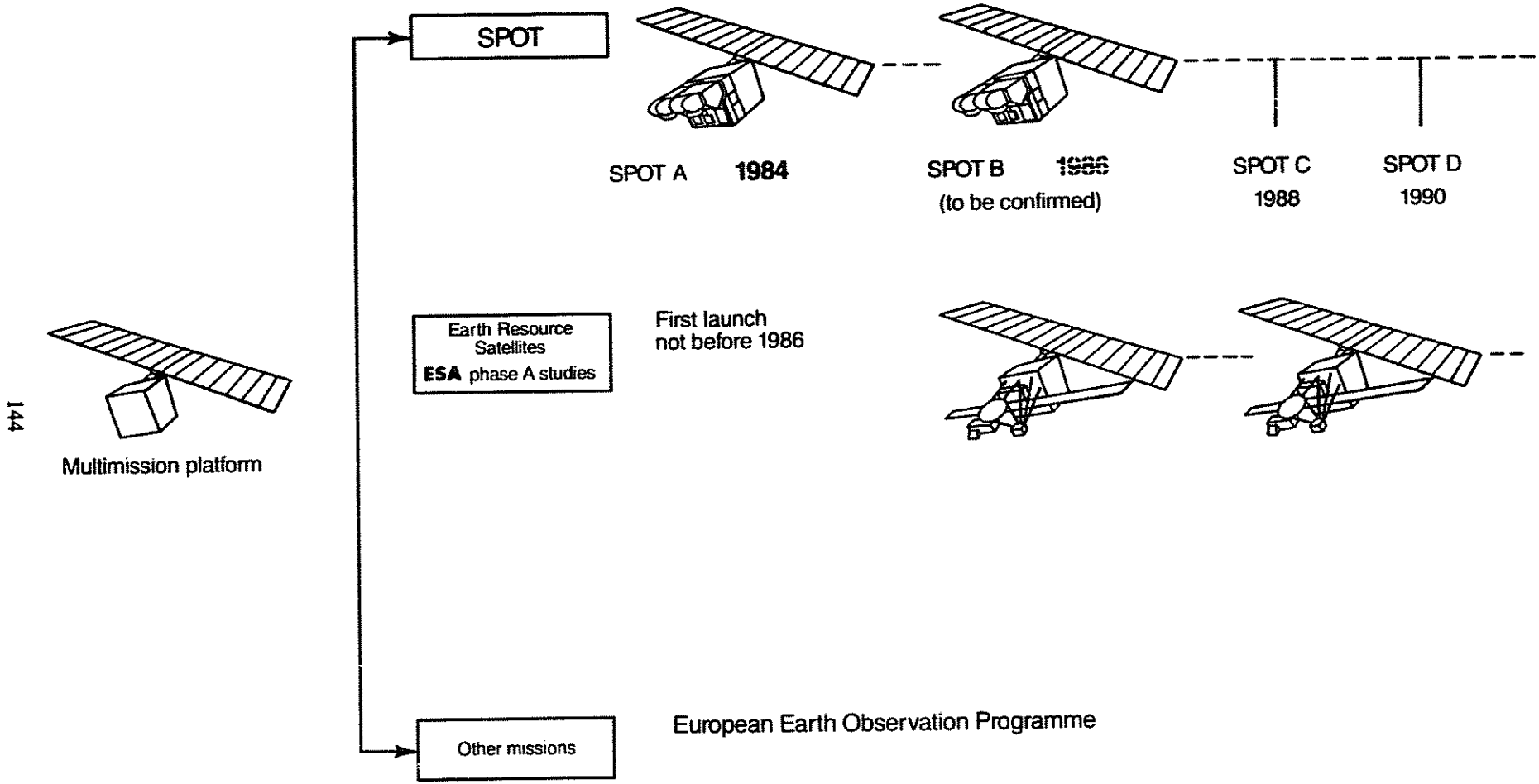
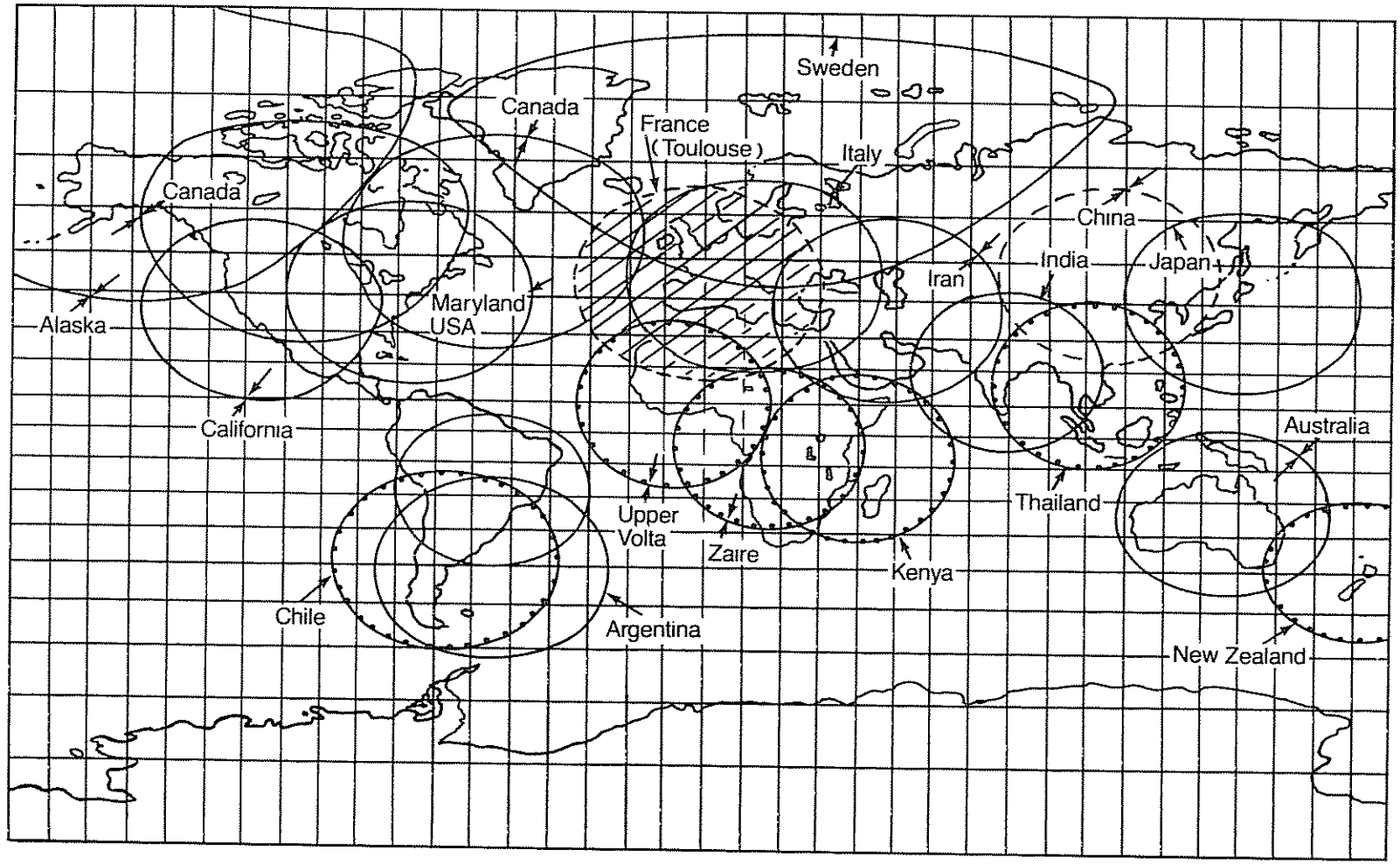


Figure 46. France: SPOT programme: standard platform—mission-specific payloads



X-band station

SPOT A main ground receiving station with LANDSAT D reception capability, 1982

S-band stations

In operation

Under development

Under planning

Figure 47. France: SPOT A and LANDSAT ground receiving stations in the world

Toulouse ground facilities	
Acquisition of subsystem delivery (on time for LANDSAT D acquisition)	March 1982
Archiving subsystem delivery	November 1982
Pre-processing subsystem delivery	March 1983 (Level 1) June 1984 (Level 2,3)
Satellite SPOT A launching	First half of 1984
Satellite SPOT B launching (to be confirmed)	1986
Satellites SPOT C and D launching (to be confirmed)	1988-1990

EUROPEAN PROGRAMME SITUATION

Figure 46 shows the situation of the European Earth Observation Programme. Definitions are in progress with respect to the SPOT programme.

COMPARATIVE GROUND FACILITIES IN VARIOUS COUNTRIES

Figure 47 shows the geographical distribution of ground receiving stations in the world, either in operation, under development or planned, for S-Band reception (LANDSAT 1-3 series). It is supposed that these stations will wish to equip themselves for receiving X-Band image data from the LANDSAT D thematic mapper: a launching is planned for 1981. All these X-Band ground receiving stations will have the opportunity to acquire SPOT A imagery at minimal supplementary cost. Any user who does not have a receiving station at his disposal in the required area, and who is willing to purchase SPOT A image data, may purchase them from the main station at Toulouse where recorded image data will be acquired and distributed to interested users, provided that their purchases are consistent with the current image data dissemination policy.

CONCLUSION

It seems clear that the SPOT programme is a major contribution of France to the observation of Earth from space for such important purposes as basic and thematic cartography to the scale of 1:100,000. The time before the first satellite is launched should be used for the preparation of ground receiving facilities and, more important, for the organization of imagery use.

UTILISATION DU LASER POUR L'ENREGISTREMENT AÉRIEN DES PROFILS*

Document présenté par la France

SUMMARY

In 1979 the Institut géographique national (IGN) perfected a new system for airborne recording of field profiles, with a view to establishing the vertical control of small-scale photogrammetric surveys in desert areas. This system is intended to replace the APR-radar previously utilized at IGN, which is less precise and which cannot be embarked on board a pressurized aircraft such as Mystère 20 or Beechcraft Super King Air.

The APR-laser system ties up around a CILAS TAY 130 laser rangefinder and a Schlumberger H 51 hypsometer, the data of which are recorded and processed on an HP 9825 computer and plotted on a printer on board the aircraft. The localization of profiles is obtained with a 35-mm camera; it can be completed by 24 x 24-cm stereoscopic aerial photography in the case of areas particularly lacking in topographic details.

This system is now implemented for establishing cartography at 1:100,000 and permits precision measurement of about 1 mètre.

Les travaux d'établissement du canevas de restitution photogrammétrique se heurtent à des difficultés sérieuses dans le cas de levés à petite échelle (1/100 000, 1/200 000) de zones désertiques. Ces régions sont en général étendues, pauvres en moyens logistiques, d'accès difficile et dépourvues d'équipement géodésique et de nivellement. Le canevas de restitution doit donc être fourni par une méthode se satisfaisant d'une infrastructure d'appui très peu dense afin de limiter les travaux au sol au strict minimum. En particulier, le canevas altimétrique peut être obtenu par exploitation en aérotriangulation analytique de profils du terrain enregistrés à bord d'un avion et rattachés au réseau de nivellement par des travaux au sol : c'est la méthode des profils aéroportés dite APR (airborne profile recorder). A l'Institut géographique national (IGN), cette méthode est mise en œuvre depuis une vingtaine d'années, en utilisant un télémètre radar monté sur avion HD 34 ou B.17. Mais ce télémètre ne peut être monté sur avion pressurisé moderne, tel que Mystère 20 ou Beechcraft Super King Air; d'autre part, ses performances étaient limitées : angle d'ouverture du faisceau radar important (2°) ne convenant pas en région accidentée, précision de mesure de l'ordre de 3 m.

L'IGN s'est orienté en 1978 vers un nouveau système embarquable sur avion pressurisé et utilisant un télémètre laser.

ORGANISATION DU SYSTÈME APR-LASER DE L'IGN

Le but de ce système est l'enregistrement à bord d'un avion d'un profil de terrain, c'est-à-dire l'intersection

*Le texte original de ce rapport, préparé par M. R. Brossier, Institut géographique national, a paru sous la cote E/CONF.72/L.60.

du terrain avec le surface générée par le faisceau laser au cours du déplacement de l'avion. Ce profil est obtenu à partir de deux ensembles de mesures.

La mesure selon une certaine fréquence de la distance avion-sol est effectuée à l'aide du télémètre laser. Ces mesures seraient directement exploitables si la route de l'avion était parfaitement horizontale. Ce n'est généralement pas le cas, et il est nécessaire de tenir compte des variations d'altitude de l'avion.

Ces variations sont mesurées à l'aide d'un baromètre différentiel ou hypsomètre, l'avion étant maintenu sur une ligne isobare à l'aide de l'altimètre de bord.

Les données fournies par le télémètre et l'hypsomètre sont enregistrées sur cassette, sur calculateur Hewlett-Packard 9825 de 8 kilomots qui calcule ensuite et enregistre les données du télémètre corrigées des variations d'altitude de l'avion.

En sortie du calculateur une imprimante permet de restituer sur listage les variations d'altitude de l'avion par rapport à la surface isobare et le profil du terrain corrigé de ces variations.

Le profil ainsi enregistré doit pouvoir être localisé avec précision sur le terrain. C'est le rôle d'une caméra 35 mm, dite caméra auxiliaire, solidaire du télémètre, qui travaille au coup par coup, selon une cadence préalablement choisie. Son axe de prise de vues est réglé pour être parallèle au faisceau laser : le point d'impact au sol est enregistré sous forme d'une croisée de réticule venant sur le cliché 35 mm. La position de cette croisée peut être repérée par rapport au centre du cliché.

La prise de vues par caméra 35 mm est complétée par une prise de vues stéréoscopiques normale avec chambre Wild RC 10, format 24 x 24 cm, installée sur la seconde trappe de l'avion, si le terrain présente peu de détails topographiques (cas des régions désertiques par exemple). La chambre RC 10 est montée sur une suspension Wild PAV 10, télécommandable par le navigateur qui maintient l'axe de prise de vues 24 × 24 cm en position verticale. La cadence de cette prise de vues est réglée pour obtenir le recouvrement stéréoscopique (au moins 60 p. 100).

Les tops de la caméra 35 mm sont déclenchés simultanément à ceux de la prise de vues 24 × 24 cm; toutefois il est possible d'augmenter la cadence des clichés 35 mm afin de suivre en détail l'incidence des variations en roulis de l'avion. Cependant, la meilleure solution pour tenir compte du roulis serait de le mesurer par système gyroscopique, de l'enregistrer et d'effectuer la correction correspondante sur la distance avion-sol, sur le calculateur HP 9825; cette solution sera mise en œuvre en 1980.

Chaque top de prise de vues 35 mm est repéré par un astérisque et le numéro du cliché correspondant sur le listage donnant le profil aéroporté.

Exploitation des profils aéroportés

Le profil du terrain ainsi obtenu est référencé à une surface isobare. Or les couches atmosphériques, aux altitudes utilisées (de 2 000 à 6 000 m), ne sont ni parfaitement régulières, ni absolument stables.

Ainsi pour un profil isolé, il serait nécessaire de coter chacune de ses extrémités afin de tenir compte de la pente moyenne de la surface isobare (mais en négligeant ses déformations intermédiaires). En fait, on établit un réseau de profils APR orthogonaux dont on assure l'homogénéité interne avant rattachement au nivellement. Cette méthode permet de tenir compte des variations dans le temps d'une surface isobare donnée. En effet au point d'intersection de deux profils orthogonaux correspond évidemment une altitude terrain unique.

Les mesures APR permettent alors en ces points de coter les surfaces isobares de référence les unes par rapport aux autres et d'effectuer une compensation interne globale du réseau. Le rattachement au nivellement est réalisé aux endroits où un profil APR coupe une maille de nivellement (ou en tout autre endroit d'altitude connue : mer par exemple). L'introduction de points d'altitude connue permet de faire une deuxième compensation du réseau et de déterminer l'altitude de l'origine commune à tous les profils du réseau et par conséquent de déterminer ensuite l'altitude de n'importe quel point situé sur un profil.

Le système APR-laser est actuellement utilisé pour l'établissement de la cartographie du désert du Rub Al Khali en Arabie saoudite. Il s'agit d'un chantier très important, couvrant 500 000 km² environ. L'APR est réalisé sous forme d'un réseau de profils nord-sud et est-ouest, selon un maillage imposé (30' en longitude pour 1°30' en latitude), à une altitude de 5 400 m au-dessus du sol. La longueur cumulée des profils est de l'ordre de 15 000 km. Les profils APR, rattachés à des traverses de nivellement effectuées au sol, sont destinés à l'équipement altimétrique d'une couverture aérienne systématique à 1/100 000 qui sera exploitée pour la production d'orthophotographies à 1/100 000 et de cartes au trait dérivées à 1/250 000.

Le télémètre à laser TAY 130 du système IGN

Ce télémètre est construit par la CILAS (Compagnie industrielle des lasers). Il est conçu pour être monté sur aéronef et se trouve alimenté par le réseau 28 V continu de bord.

Le principe de la télémétrie laser consiste à chronométrer le temps écoulé entre l'émission d'une impulsion lumineuse et son retour après réflexion sur le sol. L'impulsion se déplaçant à la vitesse de la lumière, il est facile d'obtenir la distance laser-point d'impact par la relation :

$$D = C \frac{t}{2}$$

D Distance en mètres;
C Vitesse de la lumière en mètre par seconde ($c = 299{,}71 \cdot 10^6$ m/s);
t Temps en secondes mis par l'impulsion pour faire le trajet aller et retour.

Caractéristiques

Distance maximale de mesure :	15 km
Fréquence de mesures :	20 hz (soit une impulsion toutes les 50 millisecondes)
Emetteur laser YAG (grenat d'yttrium aluminium) dopé au néodyme	
Longueur d'onde d'émission	1,06 μm
Energie maximale par impulsion	40 mJ
Durée de l'impulsion	18 ns

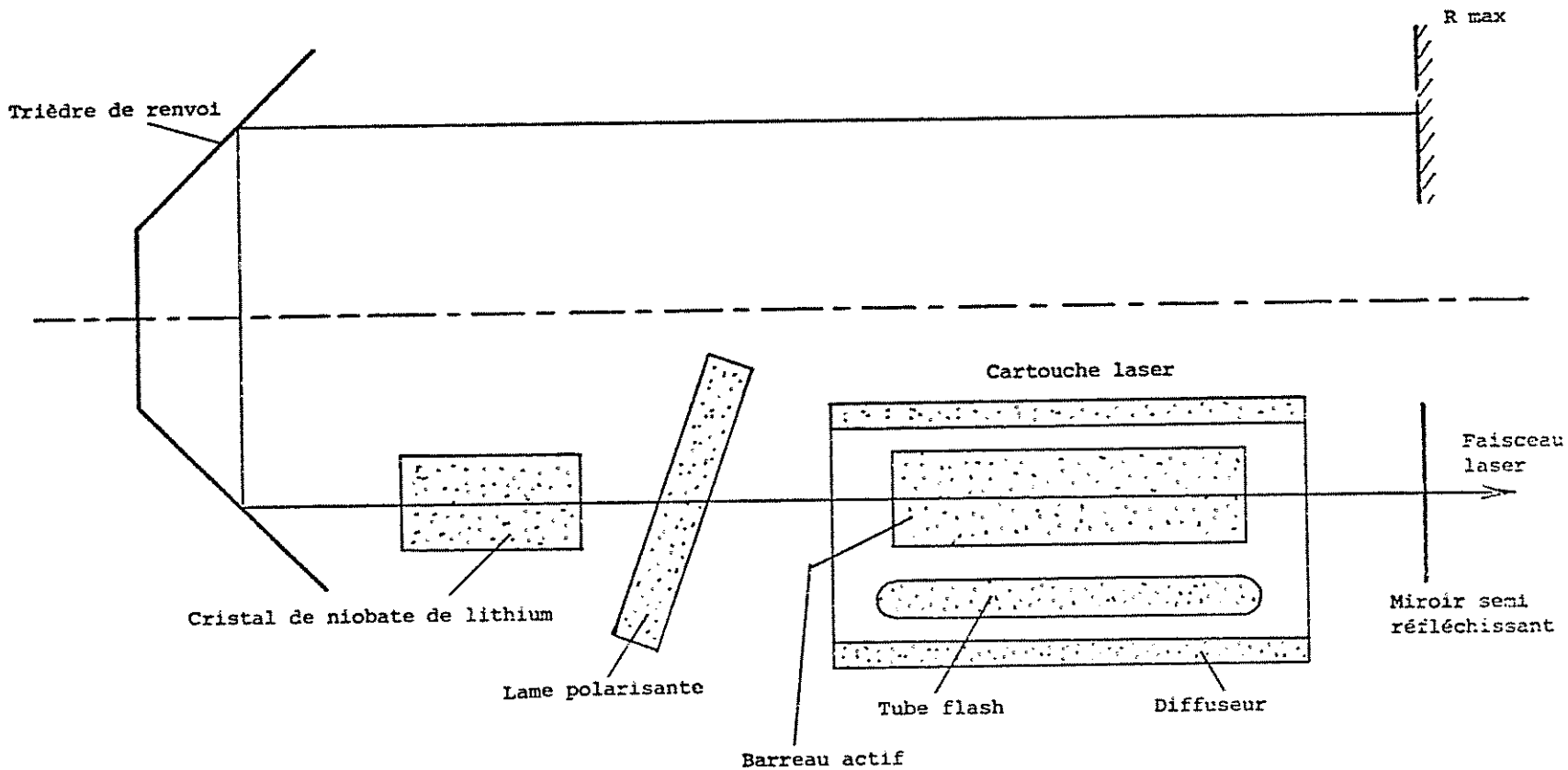


Figure 48. France : télémètre CILAS TAY 130; cavité laser

Divergence d'émission (angle au sommet du cône contenant 86 p. 100 de l'énergie totale émise)	0,5 m rad
Champ géométrique de réception de l'onde retour	8 m rad
Précision de mesure	± 0,50 m
Erreur d'alignement entre les axes du réticule et de l'émission laser	0,25 m rad
Diamètre de la pupille de réception	70 mm
Température de fonctionnement	0 à 40°C
Dimensions	30x35x85 cm
Poids	25 kg environ

Fonctionnement

Le télémètre laser TAY 130 comporte les éléments suivants :

— Un générateur d'impulsion comprenant une cavité laser et son électronique d'alimentation et de commande de tir;

— Un circuit de réception de l'impulsion retour;

— Les optiques d'émission, de réception et de visée;

— Un dispositif de chronométrie pour la mesure du temps séparant les impulsions de départ et de retour après réflexion sur la cible.

La cavité est terminée par deux miroirs, l'un ayant un coefficient de réflexion maximal (Rmax), l'autre un coefficient de réflexion de l'ordre de 30 p. 100 : c'est par cette lame que sort le faisceau. L'ensemble comprenant le barreau, le tube flash et le diffuseur constitue une cartouche, dans laquelle circule un liquide de refroidissement.

L'émission de l'impulsion laser est réalisée par déblocage de la cavité optique. Le barreau actif de la cartouche laser est mis en état d'excitation (pompage optique) par l'allumage d'un tube flash obtenu par la décharge d'un condensateur; la lumière de ce tube flash est répartie autour du barreau actif par un diffuseur. Le déblocage de la cavité est assuré par l'ouverture d'un obturateur électro-optique déclenché au moment où la fluorescence du milieu actif est voisine de son maximum. Les miroirs délimitant la cavité entretiennent un mouvement d'aller et retour des photons induits : il en résulte une oscillation, l'amplification à chaque passage étant supérieure aux pertes de la cavité.

L'impulsion de départ du comptage de la distance est obtenue par la détection d'une faible partie de la puissance émise. La puissance réfléchie constitue l'impulsion écho; elle est détectée par une photodiode, les circuits de réception assurant l'amplification et la mise en forme de ces impulsions.

L'HYPSOMÈTRE SCHLUMBERGER H 51

Cet appareil permet de mesurer des variations de pression par rapport à une valeur de référence. Les étendues de mesures réalisables par le constructeur variant de ± 2 m bar à ± 10 m bar. L'IGN a retenu l'échelle ± 5 m bar, correspondant par exemple à des écarts en altitude de ± 50 m, à 3 000 m d'altitude.

L'élément sensible de l'hypsomètre est une membrane dont les déformations sont fonction des variations de la pression statique de l'avion par rapport à une valeur de référence donnée par un réservoir témoin et réglée avant l'exécution de l'enregistrement.

Ces déformations sont transmises au noyau d'un transformateur différentiel. Les déplacements de ce noyau engendrent des variations de tension du secondaire mesurées par un circuit électronique et converties en un signal de sortie qu'on peut enregistrer sur cassette du calculateur HP 9825. L'hypsomètre et son auxiliaire électronique sont alimentés à l'aide du courant 28 V continu de bord. La précision des mesures de variation d'altitude de l'avion est de l'ordre du mètre.

CONCLUSION

Le système APR-laser embarquable sur avion moderne devrait redonner un nouvel élan à la technique APR pour les levés photogrammétriques à petite échelle. La précision des mesures (télémètre et hypsomètre) est maintenant de l'ordre du mètre; seule subsiste l'imprécision de la référence isobarique elle-même qui est fonction de la maille choisie pour le réseau des profils orthogonaux et de la densité des points rattachés au nivellement. La finesse du faisceau laser permet par ailleurs d'envisager des enregistrements en zone montagneuse, surtout dans la mesure où l'on pourra introduire dans les calculs les variations en roulis de l'avion.

Indépendamment des utilisations à but photogrammétrique, on peut aussi concevoir des applications de l'APR-laser dans d'autres domaines, par exemple pour l'étude préliminaire et le choix d'itinéraires routiers, ferroviaires, de tracés de lignes électriques, etc.

MÉTROLOGIE*

Document présenté par la France

SUMMARY

This paper describes the methods of geodetic metrology (determination of a few dozen points with accuracy of one millimetre) and photogrammetric metrology (determination of several hundred points with accuracy of one centimetre). In outlines the application of geodetic metrology to the study of the stability of dams and

*Le texte original de ce rapport, préparé par Jean Bucloux, Institut géographique national, a paru sous la cote E/CONF.72/L.64.

the monitoring of other engineering construction. It also shows the application of photogrammetric metrology to civil engineering, industry and physical planning studies, as well as to surveys of historical monuments.

Déterminer avec une précision de l'ordre du millimètre quelques dizaines de points par des mesures d'angles et de distances : c'est la métrologie géodésique, mise en œuvre lors de la construction du pont suspendu de Brotonne.

Mais s'il faut déterminer, au centimètre près, la position de plusieurs centaines de points, on utilisera la métrologie photogrammétrique comme c'est le cas pour l'autoroute d'accès au tunnel de Fréjus.

LA MÉTROLOGIE GÉODÉSIQUE

Les méthodes mises en œuvre sont celles de la géodésie : mesures d'angles, de distances, de dénivelées, calculs rigoureux par ordinateur; mais elles en diffèrent sur les points suivants :

Utilisation d'équipements particuliers à la fois précis et stables (voir le centrage d'un théodolite sur un repère ancré dans le sol).

Soin minutieux apporté par des spécialistes à des mesures qui, souvent, atteignent la résolution du dixième de millimètre.

L'étude de la stabilité d'un barrage exige de nombreuses mesures effectuées à partir de piliers ancrés en des endroits stables. La complexité du schéma est une garantie de la qualité des résultats.

La métrologie géodésique permet la surveillance d'un ouvrage en cours de construction ou l'étude de la stabilité d'un ouvrage ou de ses déformations sous l'effet de contraintes connues. La précision obtenue est de quelques millimètres ou dixièmes de millimètres selon la dimension de l'ouvrage.

Certaines applications atteignent les limites de ce qu'il est possible de faire en métrologie, telle la mise en place et le réglage des éléments de l'accélérateur de particules et de l'anneau de collision d'Orsay.

LA MÉTROLOGIE PHOTOGRAMMÉTRIQUE

Le relevé d'un objet fixe ou en mouvement peut être fait à partir de plusieurs photographies prises et exploitées dans des conditions bien précises (étude de la surface d'un canal au passage d'une péniche).

L'exploitation des clichés sur un appareil analytique récent tel que le Matra-Traster permet d'effectuer en temps réel des mesures au micron et des calculs sophistiqués sur l'ordinateur inclus dans l'appareil, ainsi que tout tracé cartographique.

GÉNIE CIVIL ET INDUSTRIE

Que ce soit pour déterminer la forme d'un objet ou pour connaître ses déformations, la photogrammétrie sera la technique à choisir si le nombre de points à déterminer est très grand ou bien si la stabilité de l'objet lui-même ou de la zone environnante est précaire.

L'obtention d'une grande précision (de l'ordre du millimètre ou de quelques millimètres selon la dimension de l'objet) dans le domaine du génie civil ou de l'industrie exige que les points soient matérialisés au mieux comme c'est le cas pour une antenne radar ou des pales de turbine.

ÉTUDES D'AMÉNAGEMENT

Les perspectives représentent l'inclusion d'un bâtiment en projet dans un quartier ancien. Elles ont été réalisées par tracé automatique à partir de photographies aériennes et des documents du projet. L'utilisation de fichiers ainsi constitués permet toutes sortes de calculs et de représentations.

Une méthode plus élémentaire pour représenter l'impact d'un projet consiste à en tracer une perspective rigoureuse sur une photographie prise à partir d'un certain point de vue; c'est ce qui a été fait dans la simulation effectuée pour la société la Hénin.

L'ARCHÉOLOGIE ET LES MONUMENTS HISTORIQUES

Les techniques de relevé photogrammétrique permettent d'enregistrer sans tarder l'état présent des monuments quelle que soit la complexité de l'architecture ou du décor. Ces archives répondent parfaitement aux exigences de la Convention de La Haye sur la protection des biens culturels. Elles sont une base essentielle des opérations d'inventaire et des travaux de recherche.

MODÈLES NUMÉRIQUES DE TERRAIN: ÉTABLISSEMENT ET APPLICATION À LA CARTOGRAPHIE DE L'AMÉNAGEMENT*

Document présenté par la France

SUMMARY

For some 10 years, the Institut géographique national (IGN) has studied and perfected processes of measurement, computation and utilization of "field digital models", i.e. altimetric data describing the shape of the topographic area and recorded on a data processing base utilizable on a computer.

Unlike field "cartographic" models, i.e. maps, which were the only ones available until now (heights, hachures, contour lines), the field "digital" models lend

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themselves to any variant of presentation and utilization that makes it easier and more efficient to take relief into account in studies or projects related to the topographic area.

On the one hand, digital knowledge of the relief allows the automatic rectification of aerial photographs, and even space images, permitting "photomaps" to be established quickly and at a lower cost. This is particularly useful for developers or searchers. On the other hand, field digital models constitute, for the engineer with computer equipment at his disposal, a kind of digital map, which represents a more flexible tool than the traditional paper document, the only representation variants of which are obtained by reproduction/photographic combination.

Depuis près d'une dizaine d'années, l'Institut géographique national a étudié et mis au point des processus de mesure, de calcul et d'exploitation de « modèles numériques de terrain », c'est-à-dire de données altimétriques décrivant la forme de la surface topographique, et enregistrées sur un support informatique exploitable en ordinateur.

A la différence des modèles « cartographiques » de terrain, c'est-à-dire des cartes, qui jusqu'à présent étaient les seuls disponibles (cotes, hachures, courbes de niveau), les modèles « numériques » de terrain se prêtent à toutes sortes de variantes de présentation et d'exploitation, qui tendent à rendre plus commode et plus efficace la prise en compte du relief dans les études ou projets liés à la surface topographique.

D'une part, en effet, la connaissance numérique du relief permet de redresser automatiquement les photographies aériennes, voire les images spatiales, ce qui permet d'établir rapidement et à moindre coût des « photocartes » régulières, particulièrement utiles pour des aménageurs ou des chercheurs. D'autre part, les modèles numériques de terrain constituent, pour l'ingénieur disposant de matériel informatique, une sorte de « carte numérique », qui représente un outil beaucoup plus souple que le document-papier traditionnel, dont les seuls variantes de présentation sont obtenues par reproduction/combinaison photographique.

A notre époque de plus en plus marquée par les opérations d'aménagement, mais aussi de plus en plus circonspecte à l'égard de leur impact sur l'environnement, l'informatisation de la topographie vient à point nommé pour faciliter la détermination des facteurs liés à la forme du terrain (altitude, pente, forme, orientation, éclairement, intervisibilité, etc. ...) et d'en automatiser la représentation sur autant de cartes spécialisées. Il ne s'agit pas ici de créer de l'information *ex nihilo*, mais seulement d'extraire de la description numérique du relief toutes les informations implicites qui y sont incluses et que le cartographe classique ne pouvait matériellement représenter sur la carte (surtout s'agissant d'une carte de base, devant servir au plus grand nombre) : ainsi la représentation par hachures donne bien une valeur de la pente, mais non directement l'altitude, tandis que la représentation par courbes de niveau donne bien l'altitude en certains points (ainsi que la forme du terrain), mais non directement la pente, et ces deux représentations sont bien entendu exclusives l'une de l'autre et ne peuvent coexister sur le même support.

L'automatisation, au contraire, permet, à partir d'un modèle numérique de base, de « sortir » telle ou telle représentation la mieux adaptée aux besoins de l'utilisateur : carte de pente pour une évaluation de risques naturels, perspective automatique pour une étude d'impact (insertion dans un site) ou carte des éclairements pour le choix d'une implantation, ou encore carte des intervisibilités pour l'étude de la vulnérabilité d'un paysage.

Dans ce dernier cas, en plus de l'information « terrain nu », il serait extrêmement précieux de disposer de l'information « sur-sol », c'est-à-dire des éléments faisant saillie au dessus du sol. Mais la composition très variée de ces éléments (végétation, bâti) et variable dans le temps (à la différence du relief, en général beaucoup plus pérenne) en rend la constitution et la mise à jour plus difficile. Ces problèmes sont actuellement étudiés par un groupe de travail conduit par le Service d'études techniques des routes et autoroutes, auquel participe l'IGN et les principaux organismes concernés.

Partie prenante d'une telle évolution, qui rejaillit évidemment sur ses techniques propres de levé et de révision cartographiques, l'IGN a été conduit à développer, d'une part la numérisation de l'ensemble du relief français, d'autre part des processus de calcul et d'exploitation des modèles numériques de terrain qu'on peut obtenir à partir de cette numérisation. Aussi le présent rapport est-il divisé en différentes sections, qui s'articulent ainsi :

a) Exposé sur les numérisations en cours et bref survol des techniques utilisées;

b) Les différentes formes de modèles numériques de terrain calculés et archivés à l'IGN;

c) Les différentes techniques de traitement et de sortie graphique tracé automatique);

d) Figures (49 et 50) illustrant la dernière section.

LES NUMÉRISATIONS EN COURS

Les considérations précédentes sur la nécessité d'une carte topographique numérique pour diversifier les documents fournis aux utilisateurs, jointes aux besoins internes à l'IGN d'une banque de données géographiques, ont conduit à développer des programmes systématiques de numérisation d'informations topographiques, grâce à la maîtrise des techniques d'acquisition et de conversion des données correspondantes. Ces numérisations en cours sont présentées ci-dessous selon un classement lié aux techniques utilisées (qui sont brièvement décrites au passage) :

Numérisation du relief de la France à l'échelle de base 1/25 000

Rappelons que le 1/25 000 est la plus grande échelle pour laquelle l'altimétrie du territoire est entièrement décrite par des courbes de niveau. La numérisation de cette altimétrie, entreprise au cours de l'année 1977, se

poursuit actuellement au rythme de 23 cartes/jour, et est prévue pour couvrir la totalité du territoire.

Ce processus repose entièrement sur l'existence des cartes donnant la description du relief sous forme de points cotés et de courbes de niveau. Les talus et autres arrachements verticaux figurant sur ces cartes ne sont pas pris en compte en tant que tels lors de la numérisation. Il s'agit donc de numériser ces cartes par lecture des données, conversion numérique et enregistrement sur bande magnétique. Deux types de techniques sont utilisées :

La lecture manuelle, par un opérateur, à l'aide d'un numériseur ou coordinatographe à enregistreur magnétique : chaque pointé de l'opérateur entraîne la mesure de l'enregistrement automatique des coordonnées correspondantes, précédé d'un code d'identification défini par l'opérateur. Cette méthode s'applique particulièrement à des données ponctuelles (points cotés), mais aussi à des données linéaires (une courbe de niveau étant considérée comme une ligne brisée joignant un nombre fini de points en séquence). En tout cas, c'est la seule méthode possible lorsque la lecture de la carte requiert une interprétation (sélection des détails, reconnaissance de leur nature ou de leur valeur) de la part de l'opérateur.

La lecture automatique, par un capteur à balayage muni d'une tête de lecture (barrette de photo-diodes) capable d'analyser intégralement le document et de reconnaître l'ensemble des points élémentaires « noirs » qui constituent l'information représentée (ensemble des lignes cartographiques). Ces points numérisés matriciellement (c'est-à-dire par profils) sont ensuite filtrés, triés et chaînés pour décrire de façon vectorielle les lignes cartographiques originales. On aboutit ainsi à un résultat semblable (au codage d'identification près) à ce qu'on aurait obtenu si l'on avait numérisé le même document par lecture manuelle. Bien entendu cette méthode présente les avantages et les inconvénients des méthodes automatiques, en particulier : une très grande rapidité (grâce au capteur puis à l'ordinateur), mais limitation actuelle à des données graphiques dont la topologie obéit à des lois à la fois simples et aussi rigoureuses que possible, comme c'est le cas des courbes de niveau, lorsqu'elles sont disponibles sur un document séparé.

Les équipements actuellement utilisés à l'IGN pour ces deux types de lecture sont des numérisateurs (coordinatographes) manuels à haute résolution (0,01 mm) et à viseur libre (loupe liée par un seul fil d'alimentation), tandis que le système de lecture automatique est constitué d'une table de traceur, dont le chariot supporte le capteur, et munie d'un éclairage en lumière cohérente (laser) qui est focalisé en permanence sur la partie du document exploré par le capteur. A titre indicatif, il faut un peu moins d'une heure pour analyser une planche complète 50 x 60 cm, quelle que soit la résolution (taille du point élémentaire) choisie au moment de la numérisation (50 ou 100 microns).

La numérisation de courbes de niveau à grande échelle par photogrammétrie numérique

L'automatisation des processus d'établissement des cartes à grande échelle (1/5 000, 1/2 000), c'est-à-dire de cartes topographiques nouvelles, a conduit, pour d'autres motifs que précédemment, à numériser également l'information topographique, et notamment les courbes de niveau, mais cette fois directement en sortie des appareils de restitution photogrammétrique, autrement dit simultanément aux levés stéréophotogrammétrique eux-mêmes.

Le processus est, dans son principe, analogue à celui de la lecture manuelle décrite précédemment, à ceci près que cette lecture porte sur une image à trois dimensions, l'image stéréoscopique formée et analysée par le restituteur. Des codeurs permettent de mesurer les coordonnées dans les trois dimensions, et une électronique de commande assure à la fois le codage d'identification des éléments numérisés et l'enregistrement de toutes les informations, codes et coordonnées, sur bande magnétique.

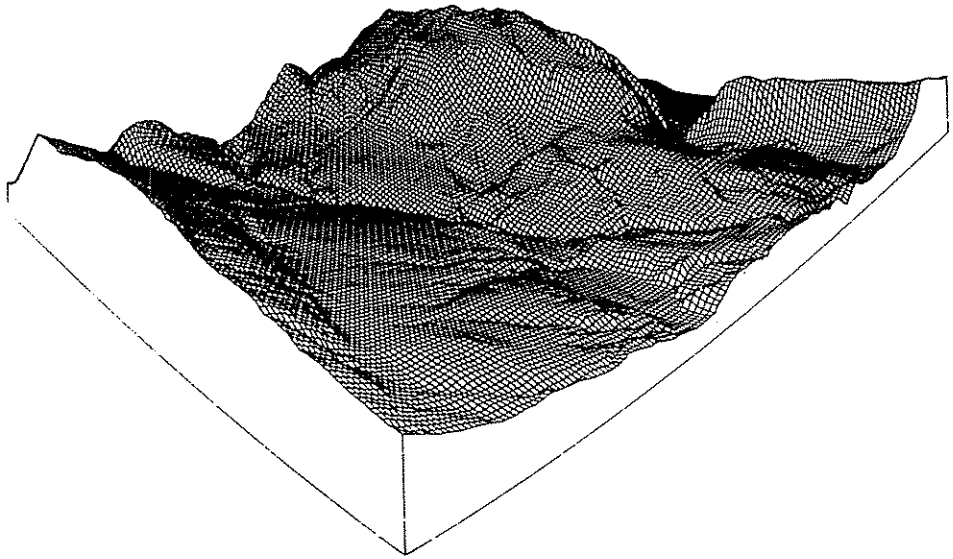
Sans détailler davantage les principes de la restitution photogrammétrique, rappelons qu'elle est la technique de base utilisée actuellement pour la cartographie topographique. On peut noter d'ailleurs que la numérisation systématique des cartes à 1/25 000 évoquée précédemment n'est en fait que la numérisation *a posteriori* de données d'origine photogrammétrique qui sont à la source des cartes actuelles. On conçoit que le fait de numériser directement les données pendant la restitution des cartes actuellement en cours de fabrication représente à la fois un gain de temps et un gain de précision par rapport à la numérisation de cartes existantes.

Numérisation de profils altimétriques et de semis de points

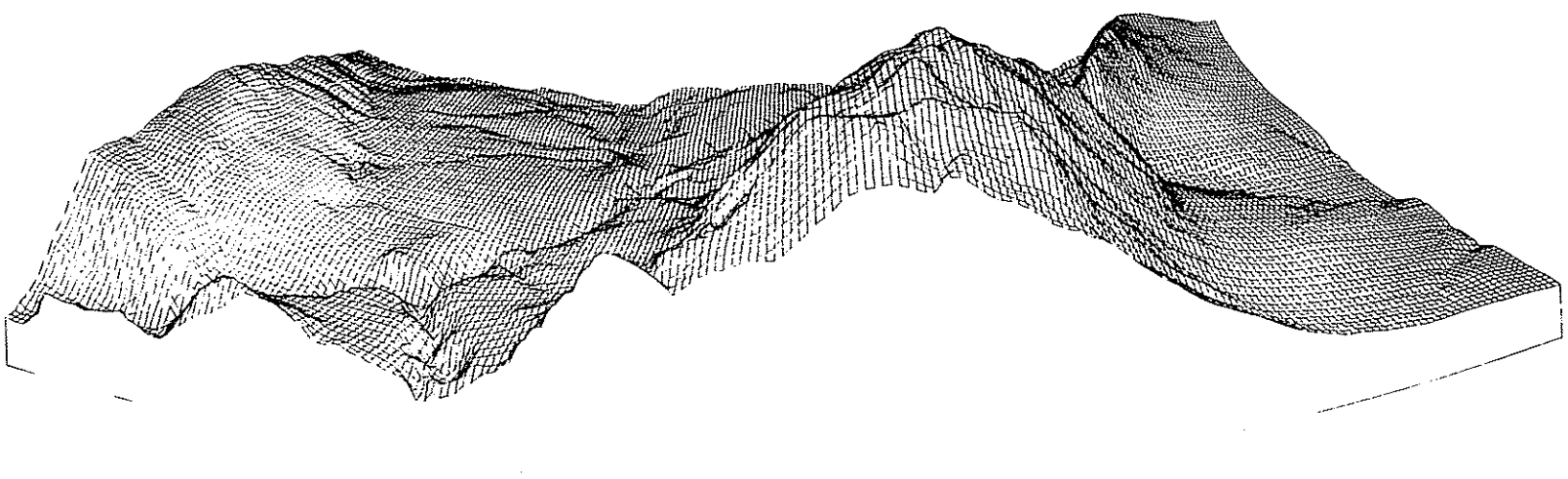
Les deux types de numérisation systématique mis en œuvre actuellement par l'IGN (numérisation de la carte de base à 1/25 000 par lecture manuelle et automatique, numérisation de cartes à grande échelle par photogrammétrie numérique type 1/14 500), et qui viennent d'être décrits, doivent être complétés par la description d'autres types d'acquisition de données sur le relief, applicables dans certains cas.

La numérisation de cartes existantes, quelle que soit leur échelle ou leur présentation, est toujours possible par lecture manuelle, mais ne passe pas nécessairement par le suivi des courbes de niveau. Dans les régions très plates, un semis de points cotés donne une description aussi bonne (sinon meilleure) et plus économique que des courbes de niveau quasi-informes. Il peut s'agir là d'une description du terrain moins exhaustive que celle des courbes de niveau, dans la mesure où, dans les zones montagneuses par exemple, le nombre de courbes de niveau peut devenir énorme (proportionnel à la dénivelée) et surabondant, voire gênant, vis-à-vis de l'utilisation qui en est faite; les profils à espacement constant donnent au contraire une description du terrain moins lourde et suffisante pour la plupart des applications.

Les semis de points caractéristiques et les profils permettent, tout comme les courbes de niveau, de calculer par interpolation des modèles numériques de terrain sous forme de réseaux réguliers (généralement orthogonaux) de points cotés. C'est généralement à partir de ces modèles numériques de terrain qu'on peut obtenir une représentation cartographique convenable, telle que courbes de niveau, blocs-diagrammes, cartes de pente, etc. (voir la dernière section). C'est également à partir d'eux qu'on peut effectuer des calculs (dérivation, intégration, etc.) donnant des surfaces des cubatures (volume en eau d'une retenue de barrage, volume de déblais d'un chantier), des pourcentages de visibilité, d'éclairement, etc. Enfin, c'est à partir d'eux (mais aussi

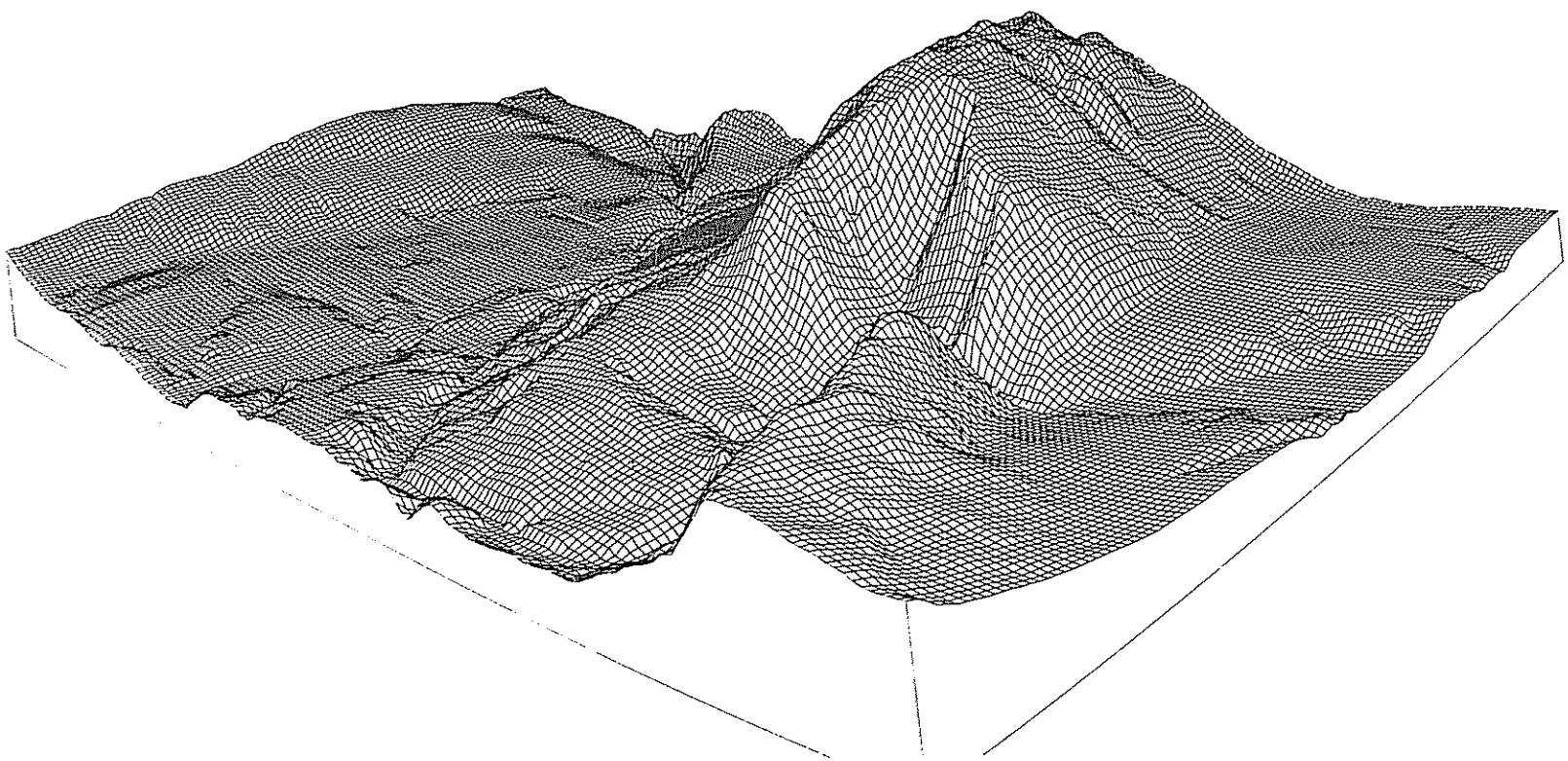


a) Point de vue 3000 m sud-ouest



b) Point de vue 3000 m nord

Figure 49. France : trois modèles numériques de terrain; blocs-diagrammes du relief de Saint-Julien-en-Genevois



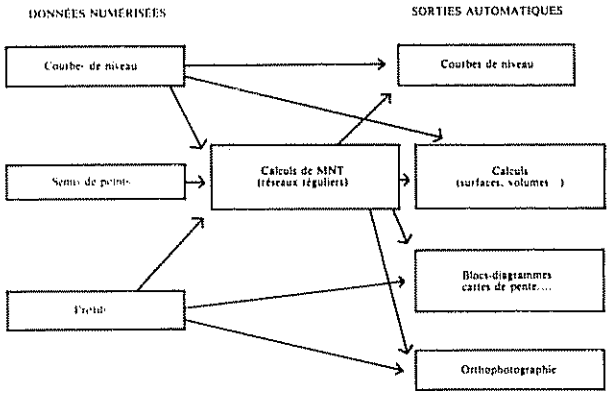
c) Point de vue 3000 m sud-est

Figure 49 (suite)

directement des profils) qu'on peut obtenir automatiquement l'orthophotographie.

Orthophotographie : photo redressée différentiellement et remise en projection orthogonale sur un plan, par « orthoprojection » selon un modèle de déformation (le relief) qui élimine toutes les parallaxes et redonne une échelle constante à l'ensemble de la photo. Une photo aérienne ainsi orthoprojetée devient superposable à la carte de même échelle.

Au total, on peut dresser un tableau des différentes données de départ suivant leur nature, et indiquer les différentes options de traitement, avec les sorties possibles :



La section suivante donne quelques indications sur les formes sous lesquelles les numérisations du relief sont archivées et exploitées à l'IGN, ainsi que les types d'application qui en sont faits.

Les différentes formes de modèles numériques de terrain actuellement utilisées à l'IGN

Le signe MNT utilisé dans la suite pour « modèle numérique de terrain » désigne ici toute description numérique du terrain enregistrée sur support informatique. Il ne se limite donc pas aux réseaux réguliers de points cotés (généralement rectangulaires) mais distingue trois formes :

a) MNT sous forme de courbes de niveau;

b) MNT sous forme de points cotés, semis de points;

c) MNT sous forme de grille rectangulaire.

Pour chacune de ces trois formes, les applications sont brièvement décrites, en même temps que les spécifications propres à chacune de ces applications (et qui induisent des contraintes pour la définition des MNT).

MNT sous forme de courbes de niveau numérisées

Ces fichiers ont été constitués soit par photogrammétrie numérique à grande échelle (1/500 par exemple), soit par numérisation de la carte topographique de base à 1/25 000 ou à 1/50 000. Les applications peuvent être classées comme suit :

Dessin de planches de courbes de niveau à différentes échelles. — Les spécifications caractéristiques de ce type de modèle sont les suivantes : adéquation des raccords entre coupures à 1/25 000 ou entre couples stéréoscopiques restitués photogrammétriquement; nécessité d'un codage des courbes fermées; limitation du nombre d'interruptions; régularité de la répartition des points numérisés sur la courbe en fonction de la courbure (la ligne brisée joignant ces points ne doit pas s'écarter de plus de 0,2 ou 0,3 mm de la courbe originale. Cela est important quand on doit dessiner les courbes à plus grande échelle. Dans le cas de traceurs utilisant des interpolations polynômiales pour le tracé de courbes, des programmes spécialisés calculent préalablement des points intermédiaires pour obtenir un tracé fidèle à la courbe désirée.

Calculs de profils de terrain. — Pour cette application, les courbes de niveau doivent être interrompues le moins possible, et seulement si la pente est régulière et que les courbes de haut de pente et de bas de pente y figurent (même dans ce cas, les interruptions peuvent être gênantes en cas de profil sinueux); d'autre part, il faut évidemment que la dénivellation entre points hauts et points bas du profil soit égale à plusieurs équidistances.

Calculs de MNT rectangulaires. — Deux types de traitement peuvent être appliqués :

Un programme d'interpolation linéaire à deux dimensions, par calcul d'intersection de courbes avec le maillage puis interpolation entre ces points, programme pour lequel les interruptions des courbes sont gênantes (comme pour les tracés de profil). Il est à noter d'autre part que l'équidistance des courbes est un paramètre du calcul (prise en compte notamment pour calculer les sommets et les thalwegs).

Un programme d'interpolation par fonction spline, selon lequel les paramètres de pente et de courbure extrêmes peuvent être ajustés suivant la morphologie du terrain, et selon lequel les points d'appui appartenant aux courbes de niveau numérisées interviennent suivant leur proximité.

Accessoirement : calculs de volumes. — Le simple calcul de la surface des courbes d'une zone inondable permet d'obtenir les volumes d'eau en fonction du niveau de l'eau (application aux prévisions de volume en eau de barrages à construire).

MNT sous forme de points cotés, semis de points

Dans les zones très plates ou ne disposant d'aucune cartographie, et où il est difficile de filer les courbes, le terrain peut être décrit par un ensemble de points cotés. Les applications sont les suivantes :

Calcul de volume. — Dans le cas de la dépression de Qattara en Egypte, un MNT rectangulaire a été calculé à partir d'un semis de points calcules par aérotriangulation analytique.

Calcul de courbes de niveau, afin de représenter cartographiquement le relief, même imparfaitement, à toutes fins utiles.

MNT sous forme de grille rectangulaire

C'est sous cette forme que les données sont le plus facile à exploiter pour de nombreuses applications. Ces applications peuvent être particulièrement « sensibles » à certains spécifications des modèles (pas, extrema, etc.).

Cartes de pente. — Le calcul est une dérivation de la fonction $z = f(x,y)$. Cela nécessite une bonne continuité des altitudes du MNT (absence de marches d'escalier, même si l'amplitude n'en est pas significative). D'autre part, pour que la carte reflète convenablement la morphologie du terrain, il faut un maillage fin (40 à 60 m).

Cartes d'ensoleillement. — Les calculs prennent en compte la pente (voir plus haut) ainsi que les ombres

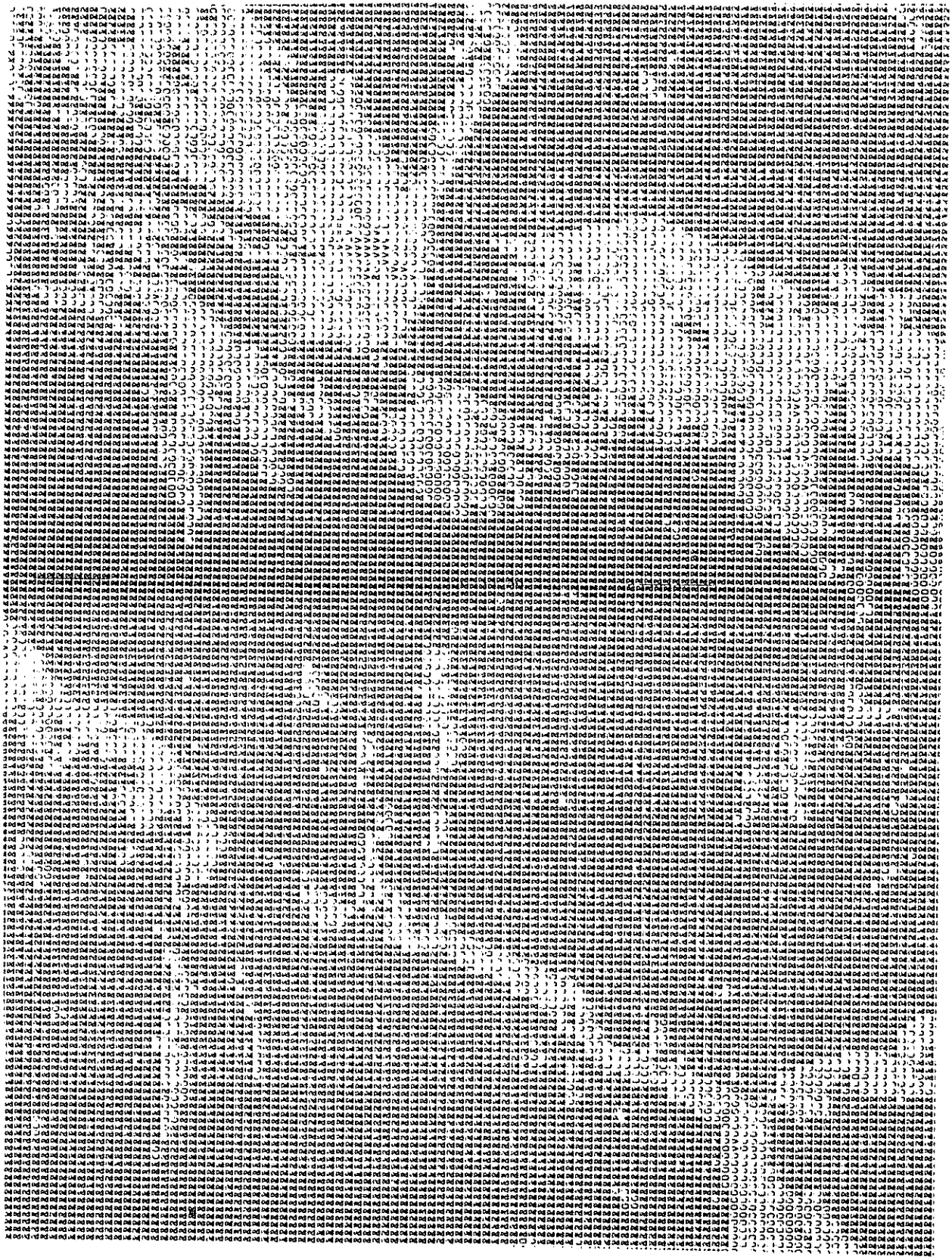


Figure 50. France : deux modèles numériques de terrain; orientation des pentes, Saint-Julien-en-Genevois

Figure 50 (suite)

portées par le relief environnant. Ce deuxième facteur demande de prendre en compte un débordement important du MNT surtout à l'est et à l'ouest (seuls les points hauts étant d'ailleurs importants), une erreur d'altitude (positive) pouvant avoir une influence même loin de sa position.

Orthophotographie automatique (redressement différentiel de clichés aériens). — Il s'agit de générer une bande magnétique comportant le MNT rectangulaire ainsi que les x,y correspondants et en coordonnées-cliché (cela dans un certain format). Il faut noter que les erreurs d'altitudes sont d'autant plus graves qu'on se trouve loin du centre du cliché (une erreur de 5 m à une demi-focale du centre entraîne une erreur planimétrique sur l'orthophoto de 2,5).

Autres applications (dessins de blocs-diagrammes, calculs de cubatures, intervisibilité, etc.).

Dessin de courbes de niveau interpolées. — Ce problème est assez bien résolu, mais des défauts subsistent, en particulier dans les fonds de thalweg.

Spécifications géométriques

Repérage. — Tous les MNT constitués à l'IGN sont repérés en coordonnées Lambert (I, II, III, ou IV).

Découpage. — Pour les MNT sous forme de courbe de niveau et sous forme de points cotés, le découpage des zones numérisées correspond soit à un couple restitué (SCGE[1]) soit à un découpage géographique en grades correspondant aux coupures au 1/25 000. Les MNT rectangulaires sont définis par les coordonnées de leur coin sud-ouest, les dimensions en X et en Y, le pas en X et en Y, et éventuellement l'inclinaison par rapport au système Lambert.

LES DIFFÉRENTES TECHNIQUES DE TRAITEMENT ET DE SORTIE GRAPHIQUE

Traitements d'image (orthoprojection) et sorties photographiques

Traitée sur un système mixte optico-mécanique à commande numérique, l'orthoprojection permet de redresser différentiellement des images photographiques, compte tenu d'un modèle de déformation : pour des photographies aériennes, ce modèle dépend essentiellement du relief.

Le traitement consiste à diviser virtuellement le terrain en mailles rectangulaires, à calculer pour chacune d'elle son altitude à partir du MNT et à calculer sa position sur le cliché : l'image de cette maille pourra ainsi être transformée optiquement (rotation + changement d'échelle) et projetée en sortie sur un film à l'emplacement théorique (rectangulaire) qu'elle doit occuper sur l'orthophotographie, image de la projection cylindrique orthogonale du terrain sur un plan horizontal, et donc superposable à la carte de même échelle.

Un tel traitement, rapide et peu onéreux, est couramment appliqué aux photographies aériennes, et est également applicable aux images spatiales (images LANDSAT), bien que, pour ces dernières, le relief ne soit pas le facteur principal de déformation.

Pour les satellites futurs, en revanche, et notamment ceux dotés d'un système programmable de visée oblique (satellite français SPOT par exemple), les modites numériques de terrain jouerons un rôle majeur pour le redressement et l'exploitation des images spatiales obliques : seule la disposition MNT permettra de réaliser la superposition d'images successives du même terrain qui n'auraient pas été prises sous le même angle.

Enfin les MNT permettent, simultanément, de générer des images obliques du terrain là où l'on ne dispose que d'images verticales : d'où une simultation de la stéréoscopie (« stéréo-orthophotographie ») extrêmement souple et adaptable aux problèmes posés.

Cartes de pente

Techniques de traitement

La pente du terrain est la tangente de l'angle que fait la normale au terrain avec la verticale. Pour chaque maille du MNT, quatre valeurs peuvent être calculées (on peut aussi prendre la moyenne des quatre valeurs). La carte maillée obtenue comporte donc quatre fois plus de mailles.

La valeur des classes de pente peut évidemment être choisie par l'utilisateur.

Techniques de sortie graphique

Ces techniques sont liées aux matériels utilisés :

Imprimante d'ordinateur. — Cette facture est en voie d'abandon à cause de son manque de souplesse (la dimension de la maille est fixe et est exprimée en fraction de pouce, ce qui nécessite la plupart du temps un assemblage puis une réduction photographique pour mise à l'échelle).

Traceur automatique, utilisé en tracé sur couche. — Cette technique permet d'obtenir directement à l'échelle un masque par classe de pente. A chacune sera attribuée un trame photographique plus ou moins dense, combinée avec le masque correspondant. La combinaison photographique de toutes les classes conduit à un document du type n° 1.

Restitueur d'image (Vizir traceur matriciel). — Il s'agit d'une technique particulièrement performante et appelée à un grand développement, et qui permet d'obtenir des documents de type n° 1 mais tramés directement, et combinés en même temps sur le même film, donc avec un délai très court.

Traceur rapide en couleurs (Benson à rouleau). — Cette sortie, très facile à obtenir comme la précédente, intéresse beaucoup d'utilisateurs qui l'utilisent comme document de travail, par exemple pour le report de zonages sur d'autres documents. Son défaut sémiologique (un phénomène quantitatif étant représenté sous forme qualitative de couleurs non ordonnées) peut donc être toléré, dans la mesure où il est compensé par un très net avantage sur le plan de la lisibilité.

Cartes d'ensoleillement

Techniques de traitement

L'indice de rayonnement direct théorique représenté ici par un caractère pour chaque maille de terrain (dimension 64 x 80 m) est proportionnel à l'énergie solaire reçue par unité de surface, cumulée sur l'ensemble d'une journée supposée sans nébulosité.

L'indice 100 correspond à l'énergie reçue par un élément de terrain constamment exposé au soleil au cours de la journée, et dont la normale est orientée vers le soleil à midi (heure locale).

[1]SCGE : Service des cartes à grande échelle à l'IGN dont la production est assurée notamment par photogrammétrie numérique et cartographie automatique

L'indice 0 correspond à un élément de terrain constamment à l'ombre.

Le calcul tient compte de la position du soleil au cours de la journée (huit positions calculées) et des zones situées à l'ombre pour ces huit positions.

En conclusion il faut noter que :

1. Seul le rayonnement solaire direct est pris en compte (et non le rayonnement diffus);

2. L'atmosphère est supposée « sans nébulosité »;

3. La valeur représentée est proportionnelle à l'énergie reçue par une surface de 1 m^2 ayant l'orientation et la pente du terrain.

Techniques de sortie graphique

Voir cartes de pente.

Blocs-diagrammes

Techniques de traitement

Le problème est de déterminer les parties cachées. On considère le MNT profil par profil et on compare chacun au précédent pour déterminer les parties cachées (s'il y a un point caché, on remplace son ordonnée par celle du point qui le cache). Cette détermination est affinée par une méthode plus complexe.

Techniques de sortie graphique

Il s'agit d'une sortie classique sur traceur automatique.

Cartes d'intervisibilité

Généralisation de la notion de bloc-diagramme et de perspective, la carte d'intervisibilité traduit la « sensibilité visuelle » des différentes parties du terrain à l'égard d'un ou plusieurs points de vue, et permet ainsi d'évaluer l'impact d'un aménagement en termes de paysage.

Différentes définitions peuvent être données de ce type de carte, ainsi que différentes représentations : des essais sont en cours en liaison avec le Service d'études techniques de routes et des autoroutes (SETRA).

Cartes d'exposition

La carte d'exposition ou « d'orientation du terrain » complète la carte de pente, qui ne représente que la valeur absolue de la pente de chaque maille du terrain, sans tenir compte de son orientation. Celle-ci peut être classée en secteurs 6 ou 8 par exemple, l'orientation indéterminée du terrain plat pouvant être donnée arbitrairement dans le secteur sud.

DOPPLER ACTIVITIES AND EXPERIENCES IN POINT POSITIONING AT THE INSTITUT FÜR ANGEWANDTE GEODÄSIE*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

En raison de la haute précision et de la fiabilité qu'on peut aujourd'hui atteindre dans la détermination des positions par la méthode Doppler, en utilisant le système de satellites de navigation de la marine des Etats-Unis d'Amérique, un certain nombre d'activités ont été enterprises en Europe occidentale au cours de ces dernières années.

Dans le document sont examinés un certain nombre de projets mis en œuvre depuis 1975 sous la seule responsabilité, ou sous l'égide, de l'Institut für Angewandte Geodäsie/SFB-78 (Institut de géodésie appliquée). Ces projets vont d'expérimentations locales à la détermination des coordonnés de stations sur de grandes étendues, telles que l'Europe.

Les calculs ont été effectués à l'aide d'éphémérides opérationnelles et d'éphémérides précises, en utilisant la technique de la localisation à partir d'un seul point, ainsi que la méthode des semi-arcs courts. L'accent est mis sur la comparaison des résultats des différentes campagnes et, en fonction de cette comparaison, sur l'estimation de la précision obtenue dans la détermination des positions au moyen du système de satellites de navigation.

In view of the high accuracy and reliability which is now attainable by Doppler point positioning, using the United States Navy Navigation Satellite System (NNSS), a number of activities have taken place in western Europe during the last years.

This paper reviews some projects conducted since 1975 under the sole responsibility, or co-ordinating leadership, of the Institut für Angewandte Geodäsie/SFB-788. The investigations cover local experiments as well as determination of the co-ordinates of stations over large areas, such as Europe.

The computations were carried out with broadcast and precise ephemeris, using the single-point positioning technique as well as semi-short-arc methods. Emphasis is placed on a comparison of the results of various campaigns and—based on this comparison—an estimation of the accuracy of point positioning using the NNS System.

*The original text of this paper, prepared by W. Schlüter, Institut für Angewandte Geodäsie, Frankfurt am Main, member of the Sonderforschungsbereich-Satellitengeodäsie, Technical University, Munich, appeared as document E/CONF.72/L.66.

THE DOPPLER CAMPAIGNS

Since 1975 permanent Doppler observations have been carried out at the Wettzell satellite tracking sta-

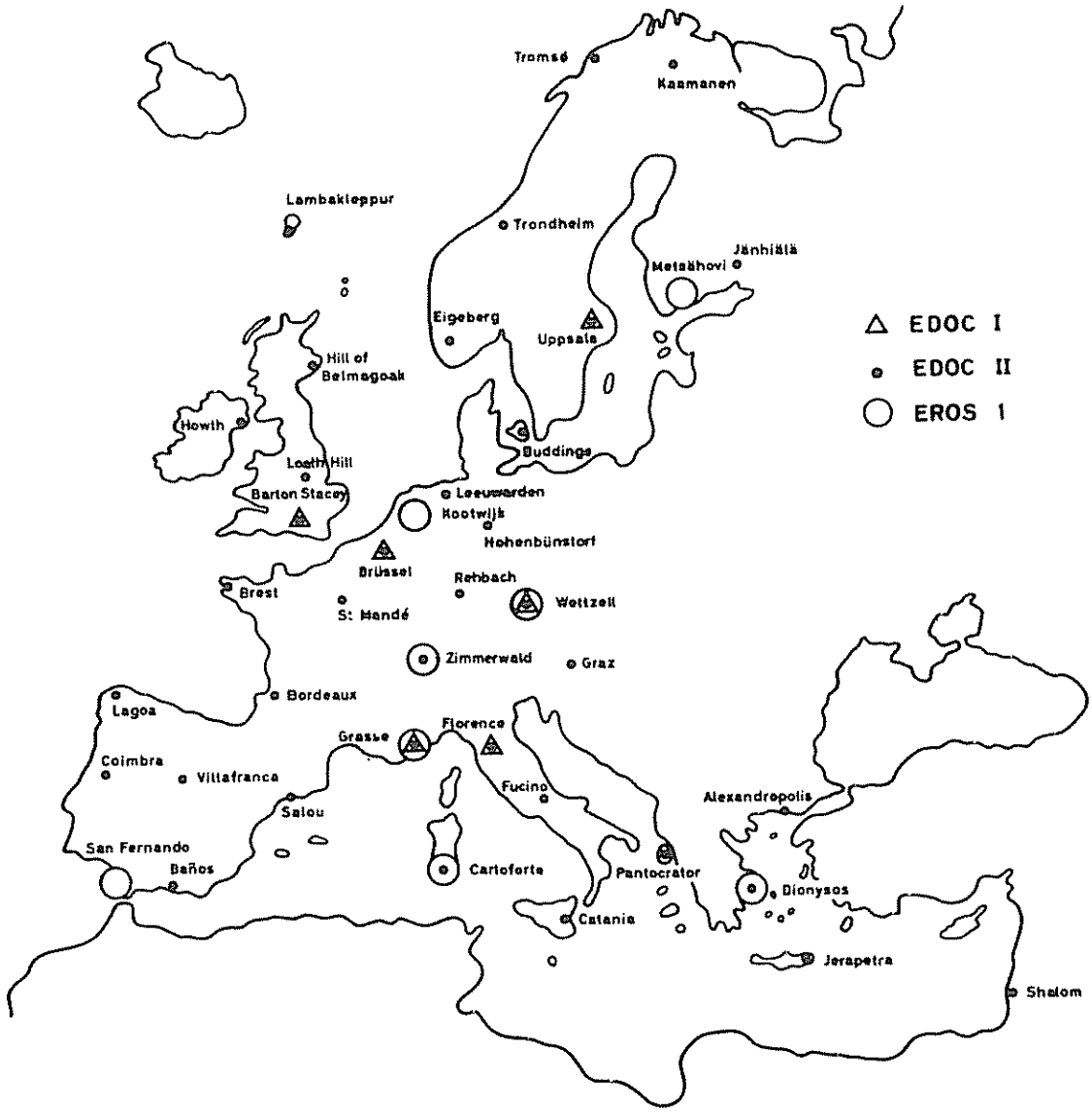


Figure 51. Federal Republic of Germany: European Doppler observation campaigns; EDOC-1, EDOC-2 and EROS stations

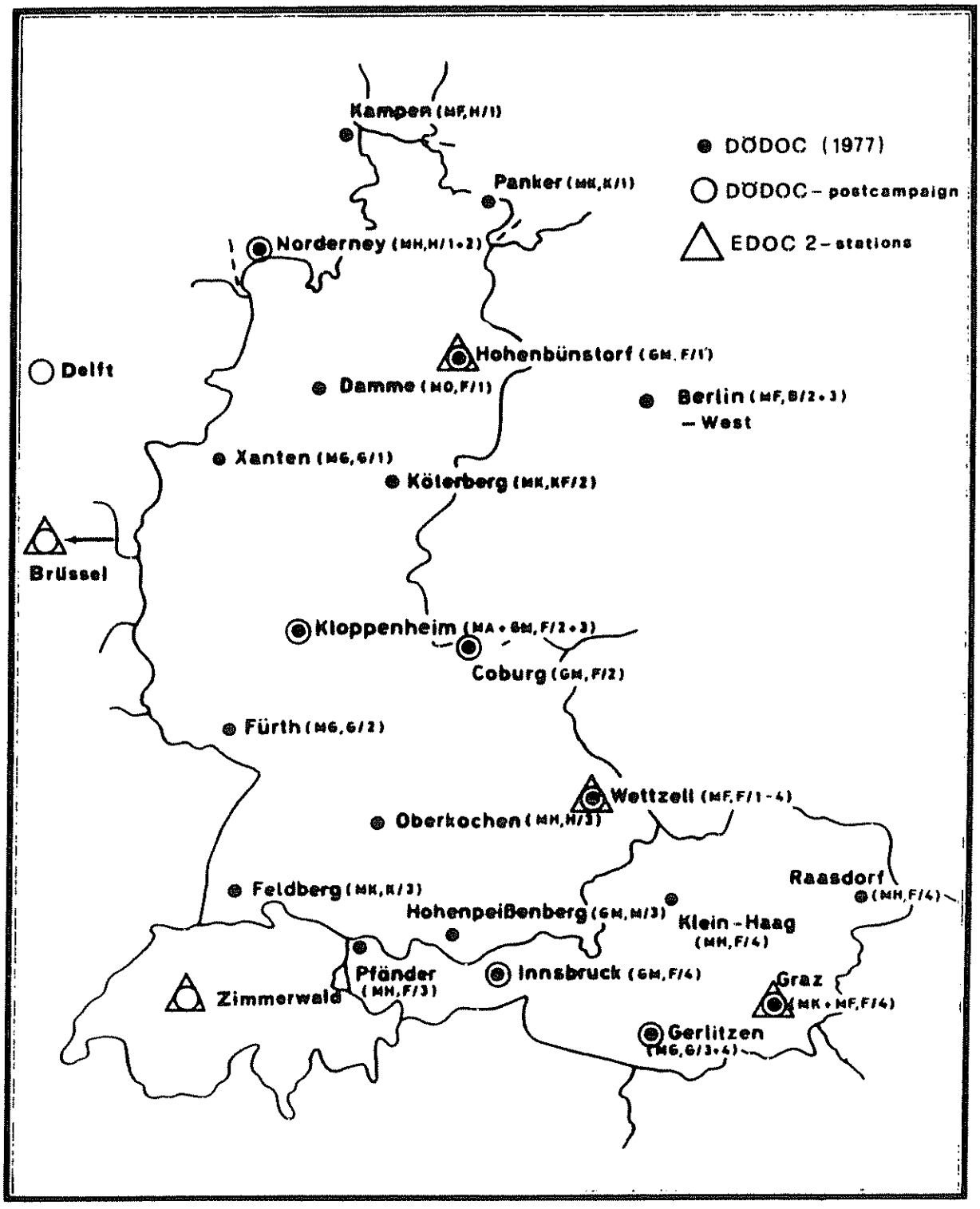


Figure 52. Federal Republic of Germany: German-Austrian Doppler Observation Campaign (DÖDOC); network of stations

tion, and the results have been published (Schlüter, 1978). Besides these permanent Doppler observations at Wettzell, simultaneous Doppler measurements at other stations in Europe were carried out for various special projects (Seeger *et al.*, 1978a,b). The co-ordinate differences of these tracking stations can be determined with high accuracy using translocation or semi-short-arc techniques. Only a short description of the various Doppler campaigns can be given here; more detailed information, including the final results, has been published in separate papers. In addition, some local experiments such as antenna calibration tests have been performed, controlling the Doppler results by terrestrial measurements (Schlüter *et al.*, 1979).

EDOC-2

The Second European Doppler Observation Campaign (EDOC-2) was organized by the Working Party on Geodynamics of the Council of Europe to establish a zero-order network of reference points for western Europe and to determine the transformation parameters between the Doppler networks and the (terrestrial) European datum ED-50 or ED-79, respectively. A final data set was supplied by 37 stations covering western Europe (figure 51) from observations conducted simultaneously in the period from 23 April to 7 May 1977. The final computations were performed at the Institut Géographique National (Paris), at the Observatoire Royal de Belgique (Brussels) and the Institut für Angewandte Geodäsie (Frankfurt) with different software. The final results are published in Boucher *et al.* (1979); they indicate global distortions in the terrestrial ED-50 system of a magnitude of about 10 metres.

DÖDOC

The German-Austrian Doppler Observation Campaign was planned by the Institut für Angewandte Geodäsie (IfAG), at Frankfurt, acting within and on behalf of the SFB-78 of the Technical University of Munich and the Institut für Weltraumforschung of the Austrian Academy of Sciences at Graz. The objectives are the computation of geocentric NWL-9D co-ordinates for all stations of the primary triangulation network of the Federal Republic of Germany and of Austria, the computation of precise transformation parameters for these networks to European datum ED-50 or ED-79 respectively and the controlling of scale and orientation of the primary triangulation networks (Seeger *et al.*, 1979). The Doppler observations were carried out at 21 well-distributed stations of the primary triangulation networks (figure 52) in four sub-campaigns from May to July 1977 using up to 9 Doppler receivers simultaneously. The final computations will be carried out at the Institut für Weltraumforschung at Graz, and at the Institut für Angewandte Geodäsie at Frankfurt. Preliminary computations led to the conclusion that a post-campaign was desirable due to the malfunctioning of one instrument; this DÖDOC post-campaign was carried out in July/August 1979.

EROS-DOC

With the intention of providing support to the European Range Observations to Satellites (EROS) campaign in the form of a set of co-ordinates of the Laser ranging stations in Europe derived from Doppler measurements, a special observation campaign was planned during the first EROS Conference. Doppler data were supplied by eight stations (figure 51) from observations conducted simultaneously during 14 days in December 1977; the co-ordinates of the Doppler antennae were published in Schlüter *et al.* (1978).

SURGE North Sea experiment (SEATOC, NORSDOC)

Within the framework of the SEASAT Users Research Group of Europe (SURGE), a validation project for altimetry was planned using the North Sea as a test area. For the comparison of an astro-gravimetric geoid of the North Sea area with an altimetric geoid derived from SEASAT-1 altimeter data, the co-ordinates of the SEASAT-1 tracking stations, as well as of several transformation points around the North Sea, have to be computed in one co-ordinate system (Lelgemann *et al.*, 1979). The determination of the co-ordinates will be done within two campaigns. The co-ordinates of the 13 European tracking stations will be computed from the data of the SEASAT Tracking Station Observation Campaign (SEATOC), which was carried out in June/July 1978. For the inclusion of the 11 transformation stations around the North Sea (figure 53) in this tracking network, the North Sea Doppler Observation Campaign (NORSDOC) was carried out in April 1979. The computation of the co-ordinates of the tracking as well as the transformation stations has already commenced.

Point positioning for time-keeping laboratories

In satellite geodesy and navigation, time has become more and more important. For one-way time-transfers in the submicro-domain via satellites it is necessary to have precise co-ordinates in a uniform reference system. The IfAG plans, in co-operation with the Physikalisch Technische Bundesanstalt (PTB) and the European Space Agency (ESA/ESOC), to carry out a time-transfer via Meteosat. As IfAG has to determine the co-ordinates of the participating stations by Doppler observations, it was suggested to extend that campaign to time laboratories and institutions which need precise time (Laser and VLBI stations). More than 20 stations distributed over western Europe have participated in the simultaneous observations in November 1979.

COMPARISON OF VARIOUS RESULTS

Some remarks on the computational procedure

All computations of IfAG have been carried out with the program GEODOP, which was developed by J. Kouba (Kouba and Boal, 1975). Moreover, sub-routines for the generation of satellite orbits based on numerical integration of the equations of motion for the Hill orbital variables have recently been included in GEODOP by J. Kouba and H. Hauck. Therefore, a complete short-arc program is now available.

The main problem in Doppler point positioning is the elimination of systematic errors due to errors in the ephemeris and other causes. Within limited areas the systematic influence of some errors may be nearly constant. Therefore, point positioning relative to other stations in a limited area can be done with better accuracy than in the global frame. Using translocation or short-arc techniques the effect of systematic errors in the orbit can be nearly eliminated. Simultaneous observations

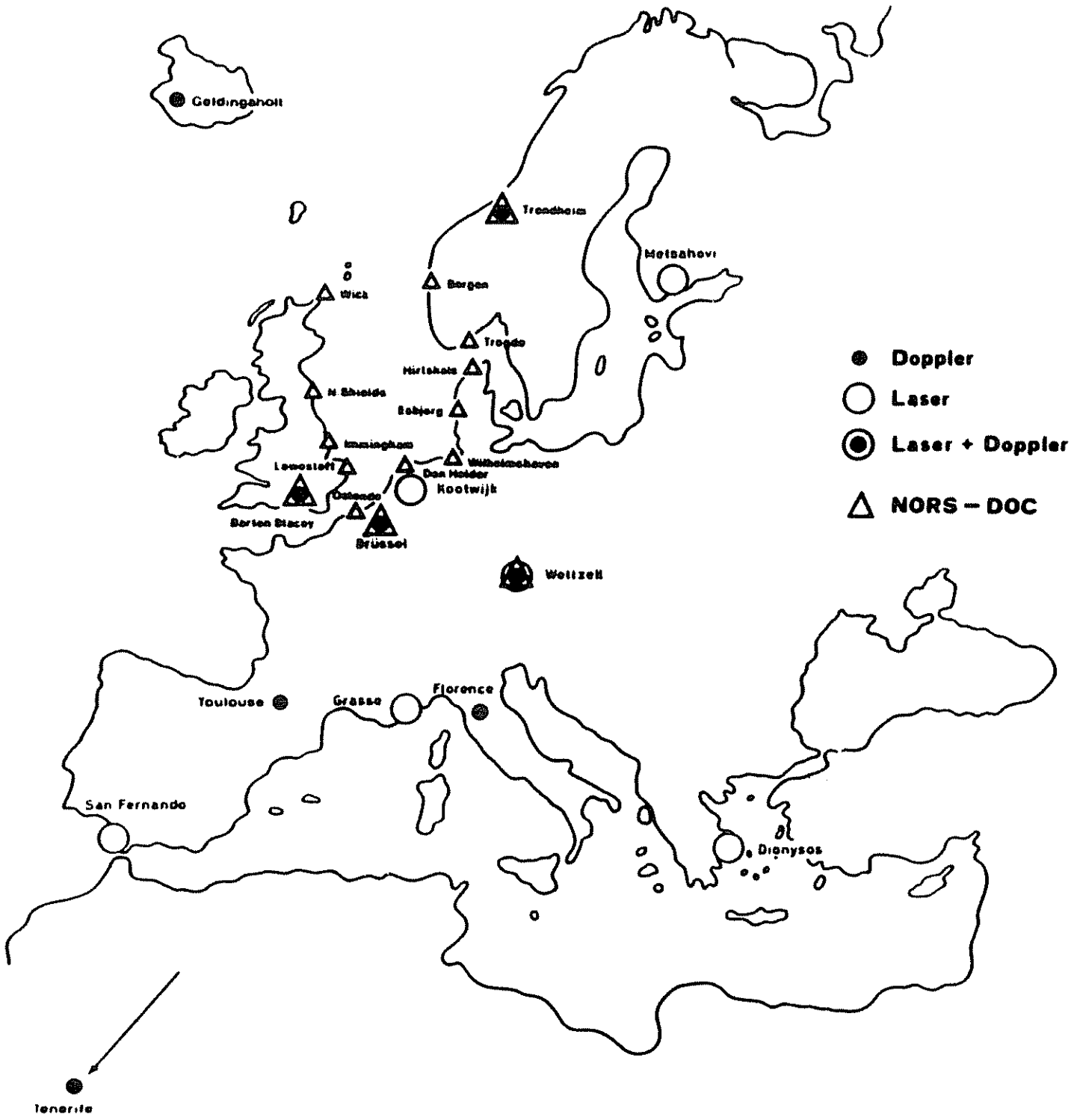


Figure 53. Federal Republic of Germany: SEASAT Users Research Group of Europe (SURGE) experiment; tracking stations

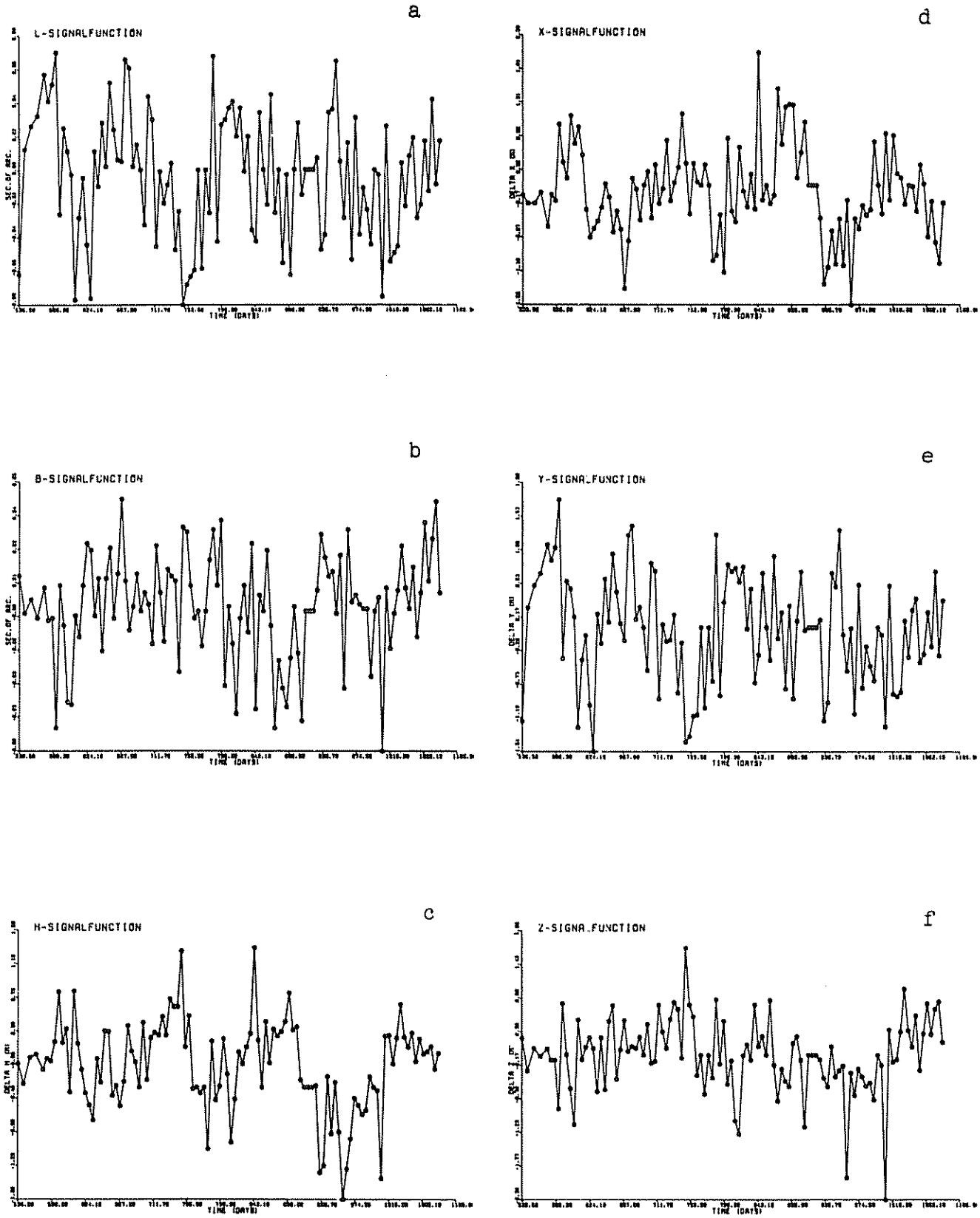


Figure 54. Federal Republic of Germany: Doppler observations at Wettzell; co-ordinates of the station evaluated in periods of five days

and semi-short-arc computation techniques were used within the data evaluation of the various campaigns as listed in the previous section.

The following information will give an overview of the accuracy of the Doppler point positioning from results obtained at IfAG. In the present state of experience it seems best to compare different results for the same quantity without using statistical tests. However, with better knowledge about the size and, moreover, the correlation of the errors, statistical tests must be applied when the results of different campaigns of different measurement techniques are compared.

Single-point positioning

Since the Wettzell station took part in all campaigns described above, a comparison of the results obtained is possible. Table 1 summarizes the results of the determination of the position of the Wettzell station, computed with GEODOP in single-point mode. Most of the computations were done using precise ephemeris as well as broadcast ephemeris. The reproducibility of station co-ordinates, using data from a period of about 10 days and broadcast ephemeris (~150 passes), was estimated to be

$$m_x = m_y = m_z = 2.0\ m$$

The reproducibility of station co-ordinates, using data from a period of about 10 days and precise ephemeris (~80 passes) was estimated to be

$$m_x = m_y = m_z = 0.5\ m$$

These results may be checked by analysing the permanent Doppler observations at Wettzell. Using Doppler data from 5-day periods of observations of the NN-Satellite 19 (10-20 passes), station co-ordinates have been computed with the aid of precise ephemeris. An estimation of the accuracy of the co-ordinates was derived from a simple arithmetic mean as

$$m_x = m_y = m_z = +0.4\ m$$

Figure 54 shows the results of the co-ordinate computation in ellipsoidal co-ordinates (longitude L; latitude B; heights H) as well as in Cartesian co-ordinates X,Y,Z. From a spectral analysis of the set of co-ordinates of the Wettzell station, systematic effects with a magnitude of about 0.5 m and frequencies of about four months were suspected.

TABLE 1. DOPPLER CO-ORDINATES OF WETTZELL OBSERVED DURING SEVERAL EXPERIMENTS

Campaign	*Precise ephemeris*			*Broadcast ephemeris*		
	x (m)	*y (m)*	*z (m)*	*x (m)*	*y (m)*	*z (m)*
	4075	931	4801	4075	931	4801 .....
1. Permanent observations/mean (May 1975-November 1976)	531.36	805.17	606.76	—	—	—
2. EDOC 1 (May 1975)	541.10	805.31	606.84	540.80[a]	809.17[a]	607.56[a]
3. EDOC 2 (April-May 1977)	540.81	804.98	607.89	538.47	804.45	612.10
4. DÖDOC 1977						
17-26 May	540.14	805.29	606.07	537.77	803.95	610.20
1-10 June	540.49	806.13	606.87	535.75	805.11	612.05
14-23 June	541.09	806.06	607.00	536.12	804.99	612.51
26 June-6 July	541.44	806.15	607.05	536.36	804.62	613.97
5. EDOC post-campaign (July 1977)	542.03	805.39	606.54	—	—	—
6. Calibration Exp. I (1977)						
23 August-16 September	541.36	805.40	607.27	537.91	803.70	610.76
7-18 October	540.97	805.10	606.88	538.92	803.03	608.86
18-28 October	541.01	805.40	607.03	542.52	803.03	608.19
28 October-8 November	541.32	805.32	606.84	540.92	803.28	608.86
8-18 November	541.30	805.76	607.32	541.95	803.93	608.35
7. EROS-DOC (December 1977)	541.80	805.11	606.87	543.92	805.29	607.43
8. SEATOC (23 June-5 July 1978) ..	541.04	806.26	606.71	—	—	—
9. Calibration Exp. II (1978)						
14-30 July	540.32	806.97	608.03	—	—	—
31 July-15 August	541.35	805.91	607.33	—	—	—
17-28 August	540.85	804.54	606.38	—	—	—
29 August-9 September	540.46	804.55	606.58	—	—	—
Mean	540.07	805.52	606.96	539.28	804.55	610.07
Standard deviation	± 0.48	± 0.61	± 0.47	± 2.70	± 1.65	± 2.18
$\sqrt{m_x^2 + m_y^2 + m_z^2}$	± 0.91				± 3.84	

[a] Only Satellite 19.

Point positioning using (quasi) simultaneous observations at several stations

By carrying out simultaneous Doppler observations at several stations, systematic errors such as orbital errors may have the same influence on all station positions. Therefore, a higher accuracy for the differences of the co-ordinates of the stations (relative point positioning) involved may be achieved by translocation or short-arc techniques.

In an antenna calibration experiment at the station in Wettzell, two Doppler equipments were used with two antennae at a distance of about 52 m. It was assumed in this experiment that the influence of orbital errors as well as of meteorological conditions is the same for both locations. Always after 10 days of observations one antenna was moved to another site, occupying in this way five positions.

The results of the antenna calibration experiment are summarized in table 2, where the differences between

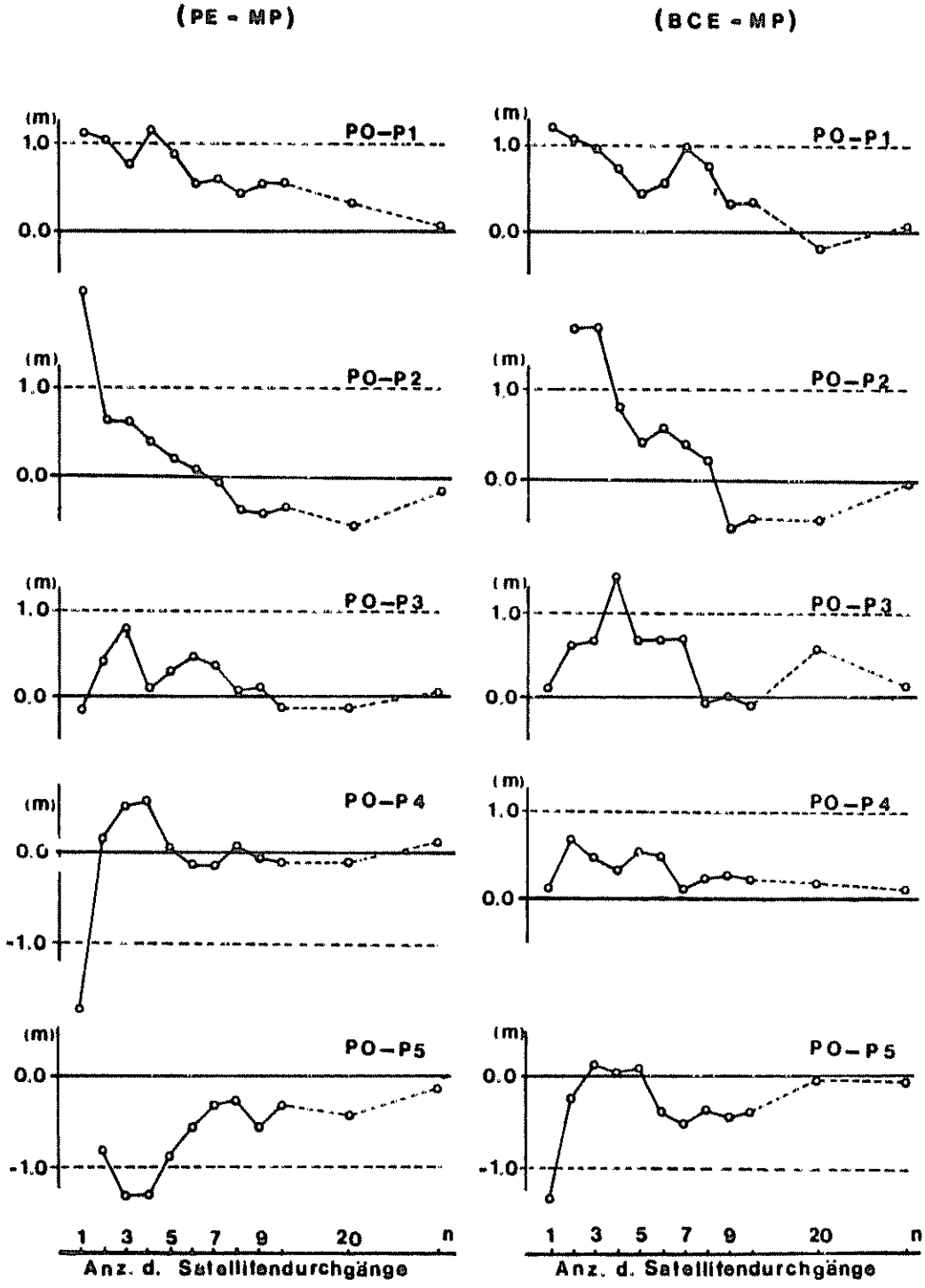


Figure 55. Federal Republic of Germany: differences between Doppler-derived ranges after evaluating 1, 2....10 passes and terrestrial measured ranges

the observed distance and the distance derived by the Doppler positioning results are listed. The co-ordinates are computed using broadcast (*BCE*) and precise (*PE*) ephemeris, both in single point (*SP*) and in multipoint (*MP*/translocation) mode. The differences are *less than 15 cm*, with one exception: evaluating broadcast ephemeris in *SP* mode showed significantly larger differences of up to 2.5 m. Figure 55 shows the difference between the terrestrial observed distance and the distance derived from Doppler observations after evaluating 1, 2....up to 10 passes. Even after introducing only very few passes, the differences for the (*BCE-MP*) and also for the (*PE-MP*) solutions are less than 1 m (Schlüter *et al.*, 1979).

TABLE 2. RESULTS OF A POSITIONING TEST WITH TWO RECEIVERS AT TWO STATIONS AT A DISTANCE OF ABOUT 50 M
(10 days simultaneous observations at each position)

Simultaneous observations (From-To)	*Terrestrial measured range (r) (m)*	*Range differences (terrestrial-Doppler)*			
		PE-SP (m)	*PE-MP (m)*	*BCE-SP (m)*	*BCE-MP (m)*
P0-P1	52.39	− 0.13	− 0.05	1.39	− 0.02
P0-P2	52.31	+ 0.13	+ 0.21	− 0.12	+ 0.12
P0-P3	52.35	+ 0.12	+ 0.03	− 0.43	− 0.12
P0-P4	54.60	− 0.15	− 0.11	− 1.38	− 0.10
P0-P5	50.48	+ 0.07	+ 0.12	− 2.52	+ 0.09
Mean		+ 0.03	+ 0.04	− 0.61	− 0.01
St. dev		± 0.11	± 0.13	± 1.46	± 0.11

The set of stations involved in DÖDOC covers an area of about 1,000 x 1,000 km. Since in this area an excellent terrestrial network is available too, it permits the possibility of checking the results of DÖDOC using completely independent data.

A first test, however, is based on the fact that DÖDOC was subdivided into four sub-campaigns: the first covers the northern part of the Federal Republic of Germany; the second the central part; the third the southern part; and the fourth, Austria. Always two stations were selected as overlapping points for the mutual connection of the sub-campaigns. As a permanent station, Wettzell was chosen, together with Norderney, Kloppenheim and Gerlitzen as overlapping points between the sub-campaigns.

Considering the three chord-lengths, table 3 allows a comparison of the terrestrial results with several Doppler solutions, computed at IfAG for several sub-campaigns, phase 1 to phase 4. Since the $BCE_{12.13.14}$-*MP* solution was computed using only the observations to those three satellites for which no precise ephemerides were available, the *PE* and *BCE* solutions are independent, in view of the observations as well as the orbital data.

As a second and more extended test, a five-parameter Helmert transformation of the German part of DÖDOC into ED 77 was performed. Figure 56 shows the residuals in north-south and east-west components, whereas figure 57 shows the residuals in height components for the independent solutions *PE-MP* and $BCE_{12.13.14}$-*MP*. The simple quadratic means of the residuals for the precise ephemeris solution are

$$m_N = \pm 0.25\ m\ ,\ m_E = \pm 0.16\ m\ ,\ m_H = \pm 0.38\ m$$

and the corresponding values for the broadcast ephemeris solution using the NN-Satellites numbers 12, 13 and 14 only are

$$m_N = \pm 0.27\ m\ ,\ m_E = \pm 0.24\ m\ ,\ m_H = \pm 0.46\ m$$

TABLE 3. COMPARISON OF CHORD-LENGTHS OBSERVED TWICE DURING THE DÖDOC CAMPAIGNS

Chord length From-To	*1 ED 50 (ED 77) (m)*	*2 Solution*	*3 Phase a (m)*	*4 Phase b (m)*	*5 1-3 (m)*	*6 1-4 (m)*	*7 3-4 (m)*
WTZ-NDY	641 411.91						
a = phase 1	(... 412.23)	*PE-MP* 7	412.99	412.65	− 1.08	− 0.74	+ 0.34
b = phase 2		*PE-SP*	411.94	411.99	− 0.03	− 0.08	− 0.05
		$BCE_{12.13.14}$-*MP7*	411.87	411.54	+ 0.04	+ 0.37	+ 0.33
WTZ-KLP	322 323.73						
a = phase 2	(... 323.53)	*PE-MP* 7	324.13	323.94	− 0.40	− 0.21	0.19
b = phase 3		*PE-SP*	323.72	323.45	+ 0.01	+ 0.28	0.27
		$BCE_{12.13.14}$-*MP7*	323.61	323.73	+ 0.12	0.00	− 0.12
WTZ-GLZ	283 264.27						
a = phase 3	(... 264.37)	*PE-MP* 7	264.21	263.68	+ 0.06	+ 0.59	+ 0.53
b = phase 4		*PE-SP*	263.83	263.61	+ 0.44	+ 0.66	+ 0.22
		$BCE_{12.13.14}$-*MP7*	264.64	264.53	− 0.37	− 0.26	+ 0.11

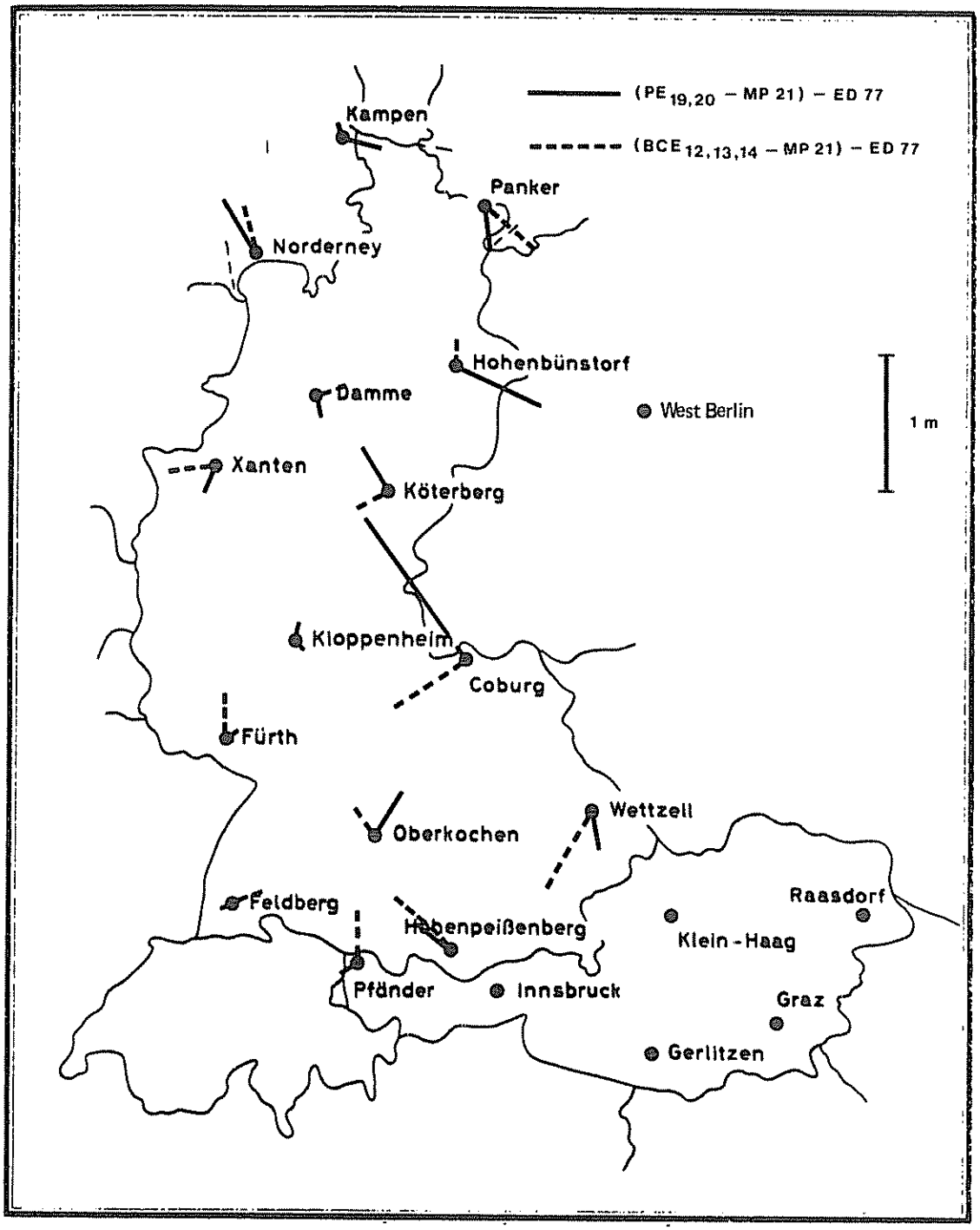


Figure 56. Federal Republic of Germany: residuals in northings and eastings from the transformation of ED77 to the (PE-MP21)—and the ($BCE_{12,13,14}$-*MP21*)*—solution/German part*

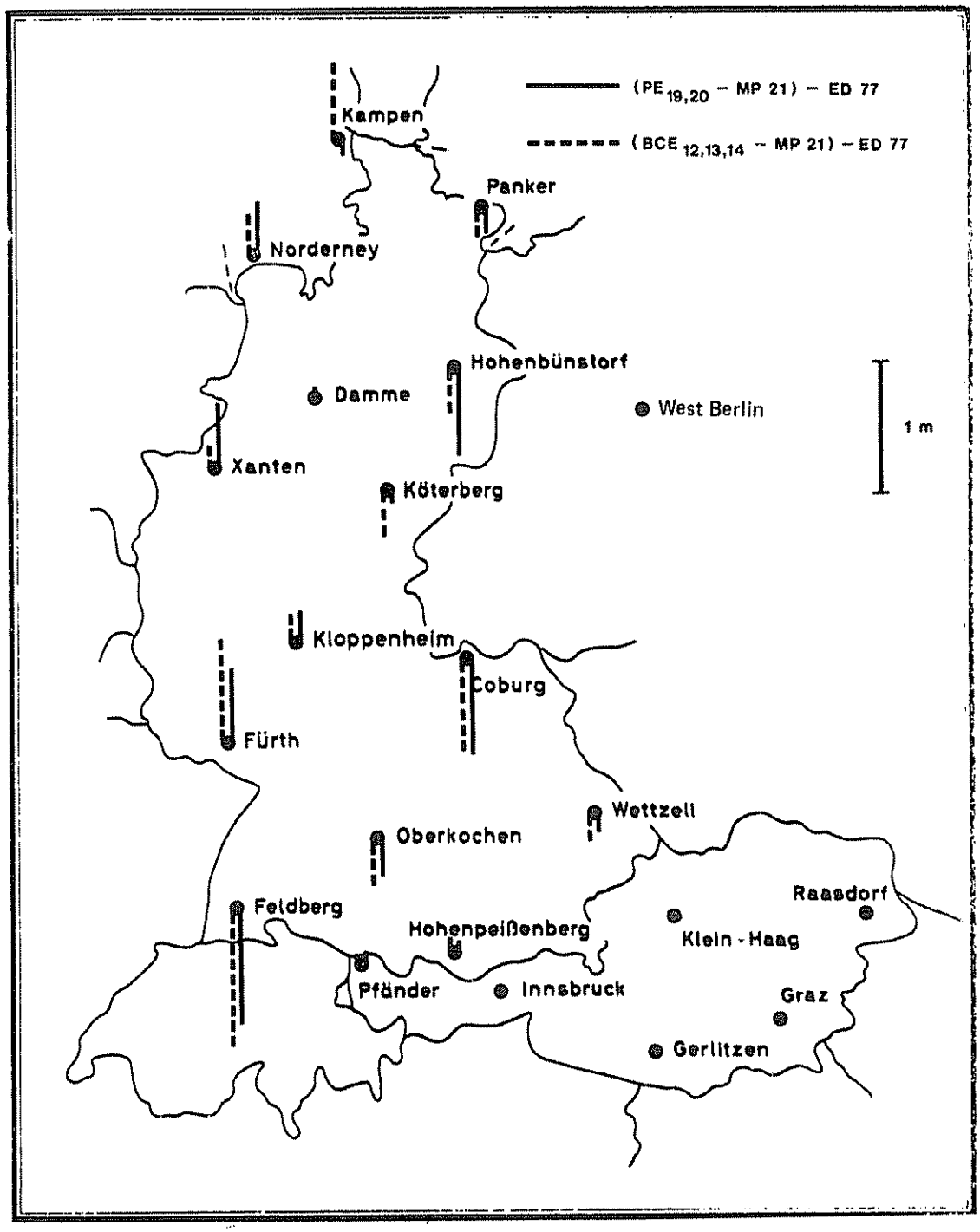


Figure 57. Federal Republic of Germany: residuals in height from the transformation of ED77 to the (PE-MP21)—and the ($BCE_{12,13,14}$-*MP21*)*—solution/German part*

The Doppler co-ordinates of the stations Hohenbünstorf and Coburg have not been introduced into the transformation procedure owing to malfunctioning of the receiver; the same receiver was used at both of these stations. At Coburg only 39 passes of the two satellites 19 and 20, and at Hohenbünstorf only 48 passes (average of the other stations: about 70 passes), have been received. The lock-on time for most of the passes on these two stations turned out to be from 2 to 6 minutes too late, so that the number of Doppler-counts is much smaller here than from undisturbed observations. The residuals of the different solutions are of the order of a few decimetres; so far the overall conformity between the Doppler and the terrestrial networks turned out to be much higher than has been expected.

The differences in height are somewhat larger than those in northings and eastings (see figures 56 and 57). We may recognize systematic differences in the southern area of the Federal Republic of Germany. The origin of these larger differences results probably from the less accurate geoid existing for this area. Such a conclusion was confirmed by a comparison of the presently used astro-geodetic geoid (Heitz, 1969, 1970) with a gravimetric geoid computed by Lelgemann (Lelgemann, 1974, 1978a).

For a comparison of the Doppler results of EROS-DOC and EDOC 2 a homogeneous terrestrial network is not available. However, the small differences of the results for the stations Wettzell, Zimmerwald and Dionysos, as obtained in both campaigns, show the uniformity of Doppler co-ordinates in larger networks. Table 4 shows the differences of the co-ordinates as obtained in EDOC 2 and EROS-DOC for these three stations and for *PE-MP*, *PE-SP* and *BCE-SP* solutions.

Table 5 shows the chord lengths between these stations and the differences between EDOC-2 and EROS-DOC. It should be pointed out that even lines up to 1,600 km could be reproduced with an accuracy of better than 10^{-6}.

As a result of these comparisons it could be stated that the computational modes, such as PE-SP, PE-MP and BCE-MP, are of the same quality. This leads to the conclusion that the precise ephemerides are of high quality and the improvements due to translocation or semi-short-arc methods are very small.

The results, as obtained at IfAG and summarized above, are confirmed by the results given in Hothem *et al.*, 1978, where Doppler results are compared especially with VLBI (very long baseline and interferometry) results. That paper includes a comparison of chord distances of length up to 4,000 km; the differences are all less than one metre.

Conclusions

From the large number of activities and computations which have been described in paragraphs 2 and 3 the following conclusions may be drawn:

1. The reproducibility of NNSS Doppler co-ordinates, computed from the broadcast ephemerides in the single point mode, is of the order of 5 m; the equivalent value based on the precise ephemerides is 1-2 m (the remaining differences result from uncertainties in the orbit determination, from refraction errors and from using different computing models).

Table 4. Comparison of EDOC-2 results with EROS-DOC

Station	Doppler-solution		Co-ordinates x	y	z	Differences (2-1) Δx (m)	Δy (m)	Δz (m)
WTZ	*PE-MP*	1 +	4 075 541.3	931 806.4	4 801 607.6			
		2	540.3	804.9	605.9	− 1.0	− 1.5	− 1.7
	PE-SP	1	541.8	805.1	606.9			
		2	540.4	805.1	607.4	− 1.4	0	+ 0.5
	BCE-SP	1	543.9	805.3	607.4			
		2	538.5	804.5	612.1	− 5.4	− 0.8	+ 4.7
ZMW	*PE-MP*	1	4 331 297.2	567 531.6	4 633 133.6			
		2	296.7	531.5	134.5	− 0.5	− 0.1	+ 0.9
	PE-SP	1	297.6	530.6	133.2			
		2	296.5	530.8	133.7	− 1.1	+ 0.2	+ 0.5
	BCE-SP	1	299.8	531.3	133.7			
		2	293.0	529.4	138.8	− 6.8	− 2.9	+ 5.1
DNS	*PE-MP*	1	4 595 234.1	2 039 436.9	3 912 616.0			
		2	237.4	436.3	615.6	+ 3.3	− 0.6	− 0.4
	PE-SP	1	234.7	436.1	615.2			
		2	233.7	435.9	616.8	− 1.0	− 0.2	+ 1.6
	BCE-SP	1	235.7	436.8	616.2			
		2	230.5	433.9	621.0	− 5.2	− 2.9	+ 4.8
	Mean differences (2-1)			*PE-MP*		+ 0.6	− 0.7	− 0.4
						± 2.4	± 0.7	± 1.3
				PE-SP		− 1.2	0.0	0.8
						± 0.2	± 0.2	± 0.6
				BCE-SP		− 5.8	− 2.2	+ 4.9
						± 0.8	± 1.2	± 0.2

1 = EROS-DOC
2 = EDOC-2 (*PE-MP*, *BCE-SP*: IfAG-solution; *PE-SP*/EDOC-Austin)

TABLE 5. COMPARISON OF THE CHORD-LENGTHS COMPUTED FROM EDOC-2 AND EROS-DOC RESULTS

From-To	Solution	EROS-DOC	EDOC-2	Difference (m)	ppm
WTZ-ZMW	*PE-MP*[a]	475 910.3	908.7	− 1.6	3.4
	PE-SP	910.0	910.0	0	0
	BCE-SP[a]	909.5	909.6	+ 0.1	0.2
WTZ-DNS	*PE-MP*[a]	1 512 359.7	361.1	+ 1.4	0.9
	PE-SP	360.2	359.6	− 0.6	0.4
	BCE-SP[a]	359.9	358.4	− 1.5	1.0
ZMW-DNS	*PE-MP*[a]	1 659 913.7	914.4	+ 0.7	0.4
	PE-SP	914.1	913.3	− 0.8	0.5
	BCE-SP[a]	913.7	913.2	− 0.5	0.3

[a] IFAG results for EDOC-2.

2. Much higher precision in the vicinity of a few decimetres (0.2 to 0.4 m) is attainable as soon as we make use of multi-point positioning methods within networks up to 1,000 x 1,000 km and—more important—with station-to-station distances not larger than 200-400 km (short-arc, semi-short-arc or translocation techniques). These methods are even applicable to more extended networks if the distance between the stations does not exceed the 200- to 400-km limit (if necessary by subdividing the network into different blocks). Most important is that here results are obtained of a really high relative accuracy, making use of both the precise and the broadcast ephemerides.

This application promises and guarantees optimal results, e.g. in connection with basic networks to be densified by photogrammetric aerial triangulation and traversing with conventional or inertial techniques. Using this mode, NNSS Doppler positioning is even then of important assistance if we have to control and improve large continental networks, e.g. the European triangulation or the North American network.

3. From the experiences of the three EDOC-2 computing centres we have learned that from using different models in computing large Doppler networks, differences of the order of approximately 0.5-1 m in each coordinate may occur due to the modelling, whereby there appears to be a strong correlation between the level of accuracy achieved and the quality of the data collected or the observing conditions experienced.

To obtain highest accuracy around 0.1-0.2 m, further studies to define the optimal data processing model are strongly recommended. For very precise applications of Doppler some improvements seem to be necessary and will be realized with the launching of the two Nova-Satellites for NNSS, as follows:

(*a*) Improvement of the orbit determination, especially the influence of surface forces (drag-free satellites);

(*b*) Improvement of time and frequency control.

Further possible improvements include:

(*a*) Clear definition of the phase centre of the antenna as well as the stabilization of the phase centre;

(*b*) Refinement of mathematical model, e.g. the refraction model.

It may then be possible that the use of the NNSS system will provide results, providing valuable information to questions arising in geodynamical investigations.

REFERENCES

Boucher, C., P. Paquet and P. Wilson, "The Second European Doppler Observation Campaign (EDOC-2): results and conclusions obtained by EDOC-2 computing centres", paper presented at the Second International Geodetic Symposium on Satellite Doppler Positioning, Austin, Texas, 22-26 January 1979.

Heitz, S. "Eine astronomisch-geodätische Geoidbestimmung für Westdeutschland", Deutsche Geodätische Kommission series B, No. 167 (Frankfurt am Main, 1969).

_____, "Auf das Bessel-Ellipsoid bezogene astrogeodätische Geoide für die Bundesrepublik Deutschland" NAKAVERM series I, No. 48 (Frankfurt am Main, 1970).

Hothem, L. D., D. S. Robertson and W. E. Strange, "Orientation and scale of satellite Doppler results based on combination and comparison with other space systems", Second Symposium on Problems Related to the Redefinition of the North American Network, Arlington, Virginia, United States, 24-28 April 1978.

Kouba, J., and J. D. Boal, "Program GEODOP Documentation" (Ottawa, Geodetic Survey of Canada, 1975).

Lelgemann, D., "Zur gravimetrischen Berechnung des Geoids der Bundesrepublik Deutschland", Deutsche Geodätische Kommission series A, No. 77 (Frankfurt am Main, 1974).

_____, "The astro-gravimetric computation of the geoid in the Federal Republic of Germany", paper submitted to the International Symposium on the Geoid in the Europe and Mediterranean Area, Ancona, Italy, 25-29 September 1978.

_____, "Projection, theoretical studies and proposed execution of the SEASAT-A altimetry validation experiment of SURGE", Proceedings of the Second International Symposium on the Use of Artificial Satellites for Geodesy and Geodynamics, Athens, 1978.

Schlüter, W. "A spectral analysis of the Doppler data NNSS of the satellite observation station at Wettzell", paper presented at the Second International Symposium on the Use of Artificial Satellites for Geodesy and Geodynamics, Athens, 1978.

_____, and H. Seeger, "Comparison of the results from the German-Austrian (German part) and the EROS Doppler observation campaigns with ED50 and ED77", RETrig-Symposium, Madrid, 7-12 May 1979.

_____, and F. Kramer, "Ein Experiment zur Untersuchung der Leistungsfähigkeit von Dopplermessungen SFB 78", Jahresbericht 1978, publication of the Bayerischen Kommission für die Internationale Erdmessung: Astronomisch-Geodätische Arbeiten (in press 1979).

Seeger, H., D. Lelgemann and P. Wilson, "On Doppler activities in western Europe", paper submitted to the Intercosmos Symposium on Geodetic Uses of Artificial Satellites and Upper Atmosphere Research, Olsztyn, Poland, 12-16 September 1978.

_____, and P. Wilson, "Doppler activities 1974-78 at the Institut für Angewandte Geodäsie (IfAG)", paper prepared for the Meeting for Discussion on Satellite Doppler Tracking and Geodetic Applications, Royal Society, London, 10-11 October 1978.

_____, W. Schlüter, K. Herzberger, F. Krämer and G. Soltau, "The German-Austrian (German part) and the EROS Doppler observation campaigns (DÖDOC and EROS-DOC)", paper submitted to the Second International Symposium on Satellite Doppler Positioning, Austin, Texas, 22-26 January 1979.

THE EUROPEAN REMOTE SENSING MISSION ON SPACELAB-1*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

Il importe d'exécuter d'urgence, dans le monde entier, des cartes conçues pour la mise en valeur des ressources et le développement social. Les techniques cartographiques actuelles n'ont permis d'établir les cartes requises que dans les régions développées ou à forte densité de population. Ainsi, de nombreuses régions du monde ne sont pas encore couvertes par de telles cartes, même à petite échelle. Les techniques se sont considérablement perfectionnées, mais elles ne permettent pas encore de couvrir les besoins des décennies à venir.

Les chambres photogrammétriques embarquées à bord de satellites offrent une solution intéressante, à condition que certaines exigences en matière de résolution et de précision géométrique soient respectées.

Les cartes existantes doivent être constamment révisées. Les images obtenues par satellite pourraient accélérer considérablement les travaux nécessaires.

Aussi a-t-on placé à bord du Spacelab 1 une chambre de prise de vues cartographiques afin de déterminer l'intérêt que présente l'établissement de cartes à partir de photographies spatiales.

Si cette expérience est concluante, on prévoit pour le milieu des années 80 la mise au point d'un satellite opérationnel ayant à son bord une chambre de prise de vues cartographiques. Celle-ci devrait être équipée d'un magasin contenant suffisamment de pellicule pour prendre plusieurs milliers de photographies couvrant la quasi-totalité des terres émergées en quelques mois, les prises de vues étant déclenchées selon les données fournies par des satellites météorologiques. Selon des estimations précises, cette méthode devrait être plus économique et plus rapide que la couverture par photographies aériennes.

PAST SPACE IMAGERY MISSIONS

Since the first manned earth orbiting space missions, space photography has been utilized in the United States of America as well as in the Union of Soviet Socialist Republics. Cameras used in these missions were mainly non-photogrammetric, resulting in image scales generally smaller than 1:1,000,000. These images served general interpretation purposes. The United States National Aeronautics and Space Administration (NASA) made their images of missions Gemini 4-7 (1965), Gemini 10-12 (1966), Apollo 7 (1968) and Apollo 9 (1969) available for international use.

These images demonstrated what later automatic image acquisition systems with scanners, such as LANDSAT 1, 2 and 3, were able to achieve from 1972 on. The LANDSAT programme has made the countries of the world aware of the potential of space imagery for the purposes of thematic mapping of geological features, vegetation cover, hydrological information and land use. It was soon realized, however, that the spacial resolution of LANDSAT 1 and 2 of 79-m pixel size (and of LANDSAT 3 of 30-m pixel size) is much too coarse for reliable mapping with the standard of a topographic map.

Both the United States and the USSR have demonstrated with improved camera systems in the missions Skylab (1973) and Sojuz (since 1976) that photographic resolutions between 25 to 40 m (corresponding to pixel sizes of about 10 to 15 m) could be reached. These cameras were photogrammetrically calibrated and they possessed image motion compensation. The drawback of these space-photography missions was that the missions were of relatively short duration, covering only isolated parts of the globe. On the other hand the formats of the images were not usable in standard photogrammetric plotting equipment. For that reason the capabilities of space photography could not be fully demonstrated to the mapping community throughout the world.

FUTURE RESOURCE SATELLITE MISSIONS

Various attempts are being made internationally to reach higher spatial resolutions with future automatic earth resources satellites.

The success of the LANDSAT programme lay in its capability to provide world-wide coverage every 18 days if not inhibited by cloud cover or by transmission and reception conditions.

Several countries or country groups, such as members of the European Space Agency have entered into agreements with NASA to receive LANDSAT data using their own receiving stations. Most countries used these images in analog form for photogrammetric interpretation of geographical, geological, hydrological, biological or agricultural regional phenomena.

Much better interpretation results were used in multispectral classification of terrain features utilizing the four spectral channels of LANDSAT-data in digital form. While digital treatment of LANDSAT data was demonstrated to be superior in every respect to analog interpretation, it was realized at the same time that digital processing of LANDSAT data is time-consuming and costly. For that reason not all received LANDSAT-images can be digitally processed to give optimal inter-

*The original text of this paper, prepared by Gottfried Konecny, Institute for Photogrammetry, University of Hanover, appeared as document E/CONF.72/L.82.

pretation results. At the same time, the detectability of an object is limited to about 2.5 times the pixel size. Therefore LANDSAT 1 and 2 images are able to resolve objects with sufficient contrast with certainty only if they are at least 200 m in size.

Since many thematic, and especially topographic, requirements call for detection of objects of only a few metres in size, future earth resources satellites are trying to achieve smaller pixel sizes. In the United States LANDSAT D is being designed for a pixel size of 30 m. France, likewise, has decided on a pixel size of 30 m for the SPOT-satellite.

The proposals in the United States for the Stereosat-satellite (15 m), of the European Space Agency (COMS; 30 m) and in Japan, call for higher resolution than LANDSAT 1 and 2.

One of the limiting factors to achieving the desired resolution suitable for topographic mapping is the data transmission rate. In a LANDSAT image 3,200 image elements are digitized every 50 m along the scan (yielding an equivalent pixel size of 79 m) with 8-bit grey level information for each of the 4 spectral channels. With one scan every 79 m, with a velocity of 7.7 km/sec, 97 scans must be made per second. To transmit these, a data rate of 10 M bit/sec is required.

For LANDSAT D a data rate of 85 M bit/sec will be necessary. The present technological limit is 200 M bit/sec, disregarding cost considerations. To reach the potential of current photography achievable with photogrammetric cameras, however, a data rate of 900 M bit/sec would be required. During the next decade it does not appear to be feasible to reach this rate economically.

Space photography therefore surpasses the capabilities of automatic sensors to provide data to solve cartographic problems at medium and small scales.

Planned and suggested space photography missions

Surveys of mapping progress in the world, published in "World Cartography" No. XIV, indicate that current mapping methods utilizing aerial photography yield too slow a progress. The progress is not only a function of the area to be mapped but also in relation to the number of photographs to be utilized for mapping. Systematic photographic coverage from space leads to utilization of far fewer photographs and far fewer control requirements and should therefore lead to faster progress in mapping.

The requirements for space photography are :

(*a*) That a sufficient resolution is achieved to detect all objects of interest;

(*b*) That a specified positional accuracy can be achieved commensurate with mapping standards;

(*c*) That a specified elevation accuracy can be achieved commensurate with mapping standards.

These requirements vary for the different mapping scales and for different types of terrain.

Based on these specific requirements a suitable space mapping system utilizing photographic cameras can be designed. The Institute for Photogrammetry at the University of Hanover, in collaboration with the space agency of The Federal Republic of Germany (DFVLR), has been engaged in a study of a suitable space photographic system in the so-called "Atlas" programme. The technical realization of the project is being studied by the ERNO Company.

The Atlas programme is composed of three phases:

Phase A: Utilization of a standard mapping camera in space to acquire photographic imagery from a low orbit out of a pressurized manned cabin;

Phase B: Use of an improved camera (optics and image motion compensation) from a pressurized unmanned container;

Phase C: Use of the container in a free-flying retrievable unmanned satellite.

While phases B and C are at the proposal stage, phase A will be realized as an experiment during the first European Spacelab mission.

Spacelab-1 metric camera experiment

The Government of the Federal Republic of Germany has placed at the disposal of the European Space Agency a Carl Zeiss, Oberkochen, RMK 30/23 photogrammetric mapping camera, which has been modified to meet space requirements, as a European space facility. While the experiment is funded by that Government, the DFVLR is responsible for procurement and engineering carried out by Zeiss, ERNO and Kaiser Trethe to operate the camera electronically by ground commands and to accommodate it in the Spacelab module. The European Space Agency sets up experimentation in countries interested and has issued a call for experiment proposals. The response has been overwhelming. Over 100 institutions in all continents have expressed interest in experimenting with imagery. Based on these proposals a timeline for areas to be photographed was drawn up, permitting photography subject to cloud cover conditions.

Altogether 3 film magazines with a total of 1,650 photographs can be exposed. In order to select the most suitable film types, joint co-operative tests were carried out in 1978 and 1979, utilizing high altitude photography involving aircraft of the Institut géographique national (IGN) of France and the DFVLR. In the evaluation, the French agencies Centre national d'études spatiales (CNES) and IGN, the German Agencies DFVLR and the Institut für Angewandte Geodäsie, as well as the universities of Milan and Hanover, were involved. The tests continued in 1980. They indicate that a photographic resolution of about 20 m (corresponding to a pixel size of 8 m) can be reached from Spacelab-1 utilizing black and white film. Infrared false colour films yield slightly lower, but still acceptable resolution, while the colour films available cannot be recommended.

The photographs will be taken with 80 per cent or with 60 per cent overlap. The proposals indicated that the images will be subject to a wide range of investigations and methods ranging from topographic to thematic mapping in various disciplines such as geography, geology, forestry, land use planning, agriculture, hydrology, coastal engineering and oceanography. Concerning the methods to be used, all known mapping techniques are included: aerial triangulation, analog mapping, the use of analog plotters, rectification, orthophotomapping and standard photointerpretation.

The experiments should give a clear indication, over a wide area of the world, whether the further steps of

the Atlas programme should be pursued and how energetically.

SPACELAB-1 MICROWAVE REMOTE SENSING EXPERIMENT

The second remote sensing experiment on Spacelab-1 consists of a microwave system, conceived by the DFVLR, funded by the Federal Republic of Germany, and built by Dornier. Like the camera experiment it has been placed at the disposal of the European Space Agency as a facility, and the Agency has also issued a call for experiment proposals.

The microwave sensor can be operated in 3 modes:

(*a*) As a microwave scatterometer for point-by-point determinations of sea-state;

(*b*) As a passing thermal microwave radiometer in point mode;

(*c*) As a sidelooking imaging radar in the X-band, which is designed to render a 9-km wide image strip with a pulse width of 25 m (pixel size).

Because of the very limited swath, this experiment is of lesser interest to the mapping community.

CONCLUSION

There is a documented urgent need for mapping on a world-wide basis for resource and social development. Present mapping techniques have been able to provide the required maps only in developed or in densely populated regions. A large part of the world still lacks maps even at small scales. Although present mapping techniques have been vastly improved, they are still not capable of providing the required maps within the next decades.

Satellite imagery from photogrammetric cameras offers a promising alternative, if resolution and geometric accuracy requirements can be met.

Even where maps already exist, there is a constant need to revise them. Here also satellite imagery may considerably speed up the work of updating.

For that reason a mapping camera was placed into orbit on Spacelab-1, in order to demonstrate the possible advantages of mapping from space photography. If the experiment is successful, further development of a free-flying, serviceable satellite, carrying a mapping camera, is foreseen for the mid-1980s. This camera should contain a magazine carrying film for several thousand photographs, able to cover almost the total land area of the earth in a few months time under the control of weather satellite information. Careful estimates indicate that operations should be more economical and less time-consuming than mapping by aerial photography.

REFERENCES

F. J. Doyle, "A large format camera for shuttle" *Photogrammetric Engineering* No. 1; 1979.

H. Kautzleben and others, "First results of the experiment Raduga for photographic remote sensing", Proceedings of the European Space Agency, SP-134: Earth Observation from Space and Management of Planetary Resources, Toulouse 1978.

G. Konecny and M. Schroeder, "Einsatz einer Reihemesskammer im Weltraumlaboratorium Spacelab" *Allgemeine Vermessungsnachrichten*, No. 10, 1977.

———, "Einsatz von photographischen Messkammern im Weltraum" *Allgemeine Vermessungsnachrichten*, No. 7, 1979.

M. Schroeder and G. Konecny, "Use of a metric camera in Spacelab" Proceedings of the European Space Agency, SP-134, Toulouse, 1978.

RESULTS OF ANALYSES OF DATA COLLECTED WITH ADVANCED LASER-RANGING INSTRUMENTATION INSTALLED AT WETTZELL AND THE IMPLICATIONS FOR SOUTH-EAST ASIA AND THE PACIFIC*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

Le document présente tout d'abord les résultats d'analyses détaillées de données obtenues à l'aide des instruments de mesure de distances au laser installés à Wettzell. L'auteur expose ensuite l'intérêt que présentent ces techniques pour des travaux scientifiques portant sur la région du Pacifique, dans le contexte du Programme mondial de recherches sur la géodynamique. Il évoque pour terminer les possibilités de participation des scientifiques et des organismes spécialisés à des programmes communs de recherches théoriques et appliquées.

Laser ranging to satellites is being performed on an international scale as part of an overall interest in geodynamics involving laser-ranging and very long baseline interferometry (VLBI) as two complementary, space-oriented geodetic measuring techniques. This paper covers the contribution of the Federal Republic of Germany towards the world-wide geodynamics programme in the area of satellite-ranging and attempts to bring these efforts into perspective for the South-East Asia and Pacific region.

*The original text of this paper, prepared by P. Wilson, Institut für Angewandte Geodäsie, Frankfurt am Main, appeared as document E/CONF.72/L.68.

The Institut für Angewandte Geodäsie (Abteilung II of the Deutschen Geodätischen Forschungsinstituts) and the Sonderforschungsbereich 78, Satellitengeodäsie of the Technical University of Munich, have been working together over the last ten years to evolve a concept (1)[1] for active engagement in geodynamical research complementary to the United States National Aeronautics and Space Administration (NASA) programme (2). The overall objectives of these and similar international programmes are to improve understanding of the gravity field and the dynamics of the solid earth through the application of space technology and the multidisciplinary, multinational pooling of information. Such programmes may be broken down into global, regional and local components. Whereas spaceborne techniques will be used to obtain optimal coverage for all three components, laser-ranging will most probably be confined to the global and regional aspects of the problem. By mid-1980 a network of fixed and mobile laser-ranging systems will be deployed and the observational phase of an ongoing programme will be under way by 1981. The area of primary interest will be concentrated initially on the Pacific ring, around which high population densities occur in conjunction with areas of maximal anticipated crustal motion, accompanied in some areas by severe earthquakes. However, global tracking networks are required for optimal modelling of the space-observed parameters and reference stations are required in tectonically stable areas in order to facilitate the separation of crustal changes from other effects, such as earth rotation (3).

It is against this background that the work in progress at Wettzell is to be considered and in the light of which the interest of the developing countries in the regions confronted by the problems arising from changes of a tectonic origin must be aroused, and the necessary support found for their active involvement in programmes of this kind.

Introducing the laser-ranging system installed in Wettzell

The laser-ranging equipment installed at the satellite observation station in Wettzell has been operational since April 1978. Since that time it has performed without major disturbance, and satellite passes have been observed to all low geodetic satellites equipped with retro-reflectors, as well as to Lageos.

The stationary laser is mounted in a climatically controlled environment under the control of the operator seated at the computer interface unit (figure 58). The laser beam is directed into the Coudé channel traversing the two rotational axes of the mount and emerges finally from the transmitting telescope, which has been directed, under the control of the computer, towards the momentary position of the target being tracked.

The return signal is picked up by the 60-cm Cassegrain optics of the receiver telescope, which focus it via a variable attenuator and narrowband filter onto the static crossed-field photomultiplier. The range-time is generated by a computing counter, which is triggered by a signal from the outgoing laser pulse and stopped by the amplified return pulse.

Range, epoch and system status data are recorded by the computer on magnetic tape for each outgoing pulse. This data includes the momentary reading of the shaft encoders at the time of laser firing and the measured power output.

The computer is also used to pre-calculate look angles and predicted ranges, which are written onto disk in preparation for the future mission. Besides general mode control, other functions controlled by the operator from the computer interface unit and the computer include the adjustment of the effective divergence of the transmitted laser beam, the attenuation and the field of view of the receiver, the start/stop signal thresholds, as well as system calibration and encoder diagnostics.

The laser comprises an oscillator, regenerative amplifier and three amplifiers. The output beam is frequency doubled to give 0.25 joules at 532 nanometres with a pulse-width (at half-energy) of 200 picoseconds. The repetition rate of the laser is 4 hertz.

A detailed description of the system is given in (4).

Status of satellite ranging

The satellite ranging system (SRS) has now been in operation for just over a year. Table 1 gives a summary of the results achieved from June 1978 to June 1979. In all, some 234 passes were observed to the low flying satellites, for an average of about 400 returns per pass. The 66 passes observed to Lageos yielded an average of about 1,100 returns per pass.

Figures 59-62 show some typical pre-processed passes for the principle satellites. To obtain these results the mean orbital elements were used to compute a fit of the observations to the predicted orbit. The residuals were then considered to identify the condition of positive measurement (bottom diagram, figures 64-67). In the event that ranging was confirmed, a quality assessment of the observations commenced with a short arc fit to the observations, holding fixed a set of assumed co-ordinates for the observing station and adjusting the 6 orbital parameters. The residuals to this fit were then matched to a (maximally 8th order) polynomial to obtain the final residuals as plotted here in the upper diagrams of figures 64-67, filtering out noisy measurements (middle diagram). It can be seen from the results shown in the figures 59-61 that the SRS at Wettzell produces low noise ranges of a high quality, but an inspection of figure 62 suggests that a deterioration in the quality of the observations occurred over the first week of June 1979. Other ranging results from that time confirm this speculation. The reason for this was that no effective preventive maintenance had been performed during the first two months of the 3-month EROS-III campaign, which ran from 1 April to 30 June of this year. This factor is not conducive to the production of outstanding results over protracted periods of observation, such as can now be anticipated. On the other hand, this experience gives an indication of the overall stability which has been achieved with this advanced system.

The results presented here in figures 59-61 may be considered typical, no attempt having been made to select data samples, but further improvements can still be made to compensate remaining systematic biases, e.g. due to variations in return pulse amplitude.

Evaluation of results

Besides pre-processing, the Institut für Angewandte Geodäsie, in co-operation with the Department of Aero-

[1] Numbers in parentheses are keyed to the reference list.

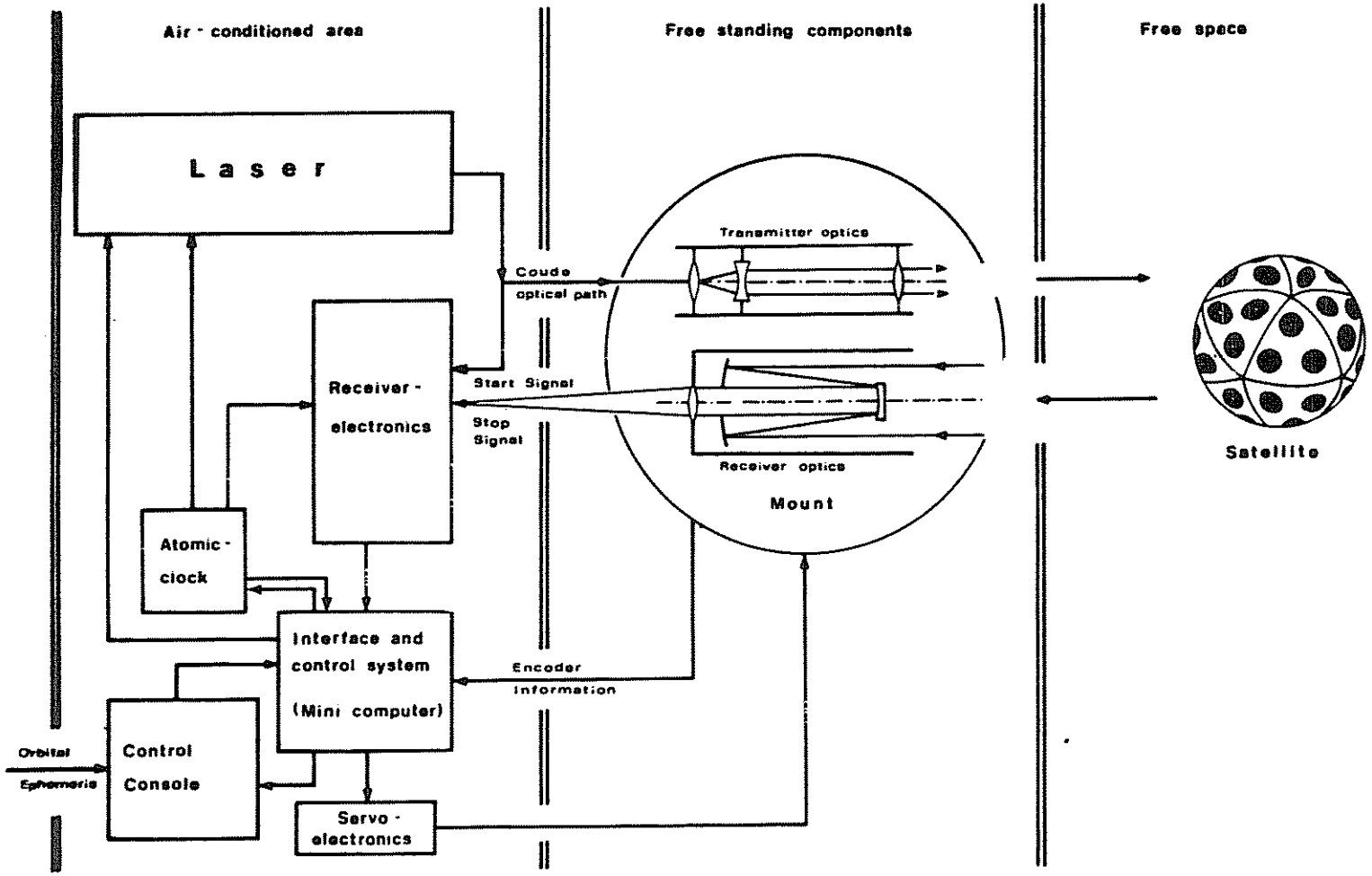


Figure 58. Federal Republic of Germany: block diagram of the SRS (satellite ranging system)

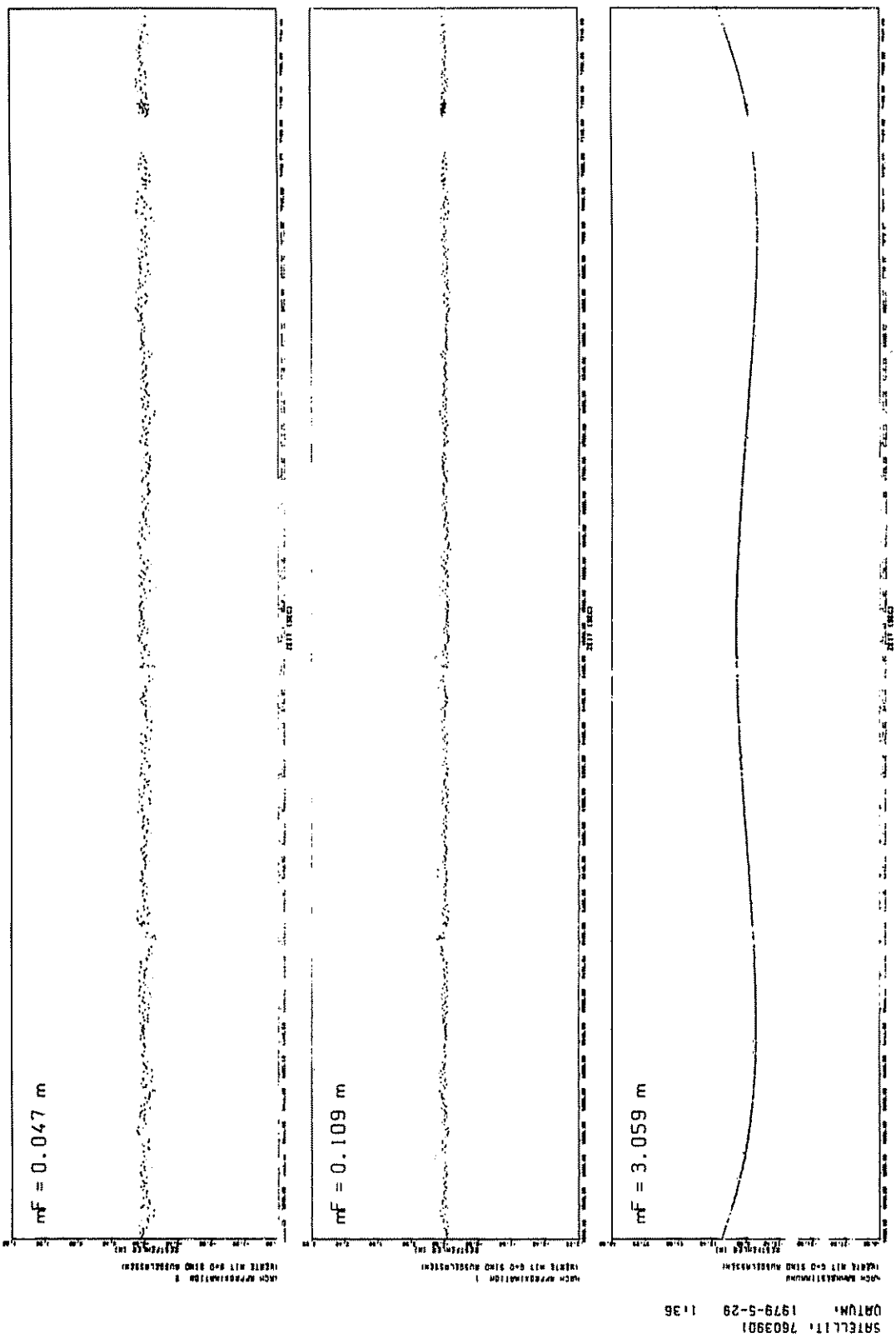


Figure 59. Federal Republic of Germany: laser ranging to satellites; a typical Lageos pass

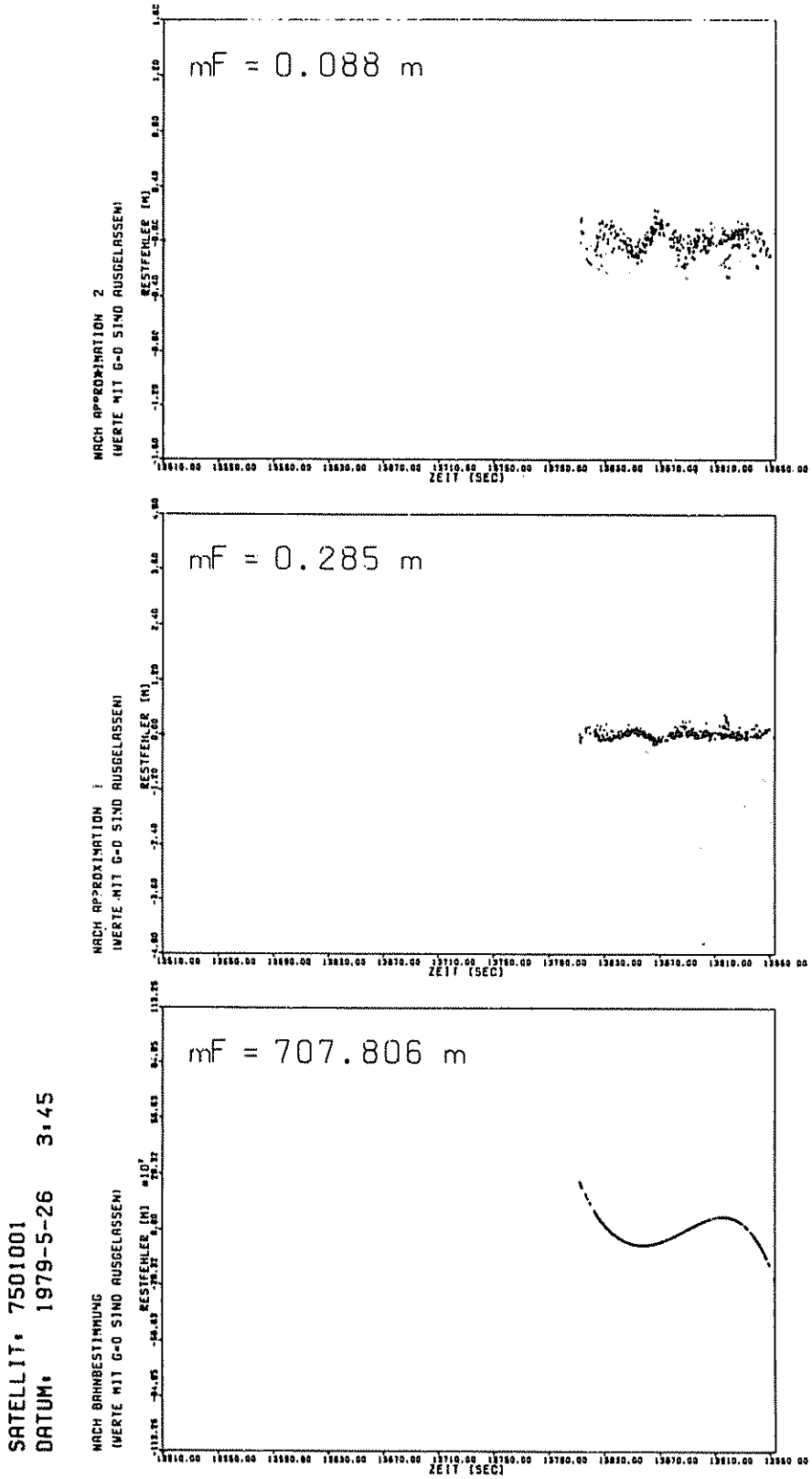


Figure 60. Federal Republic of Germany: laser ranging to satellites; a typical Starlette pass

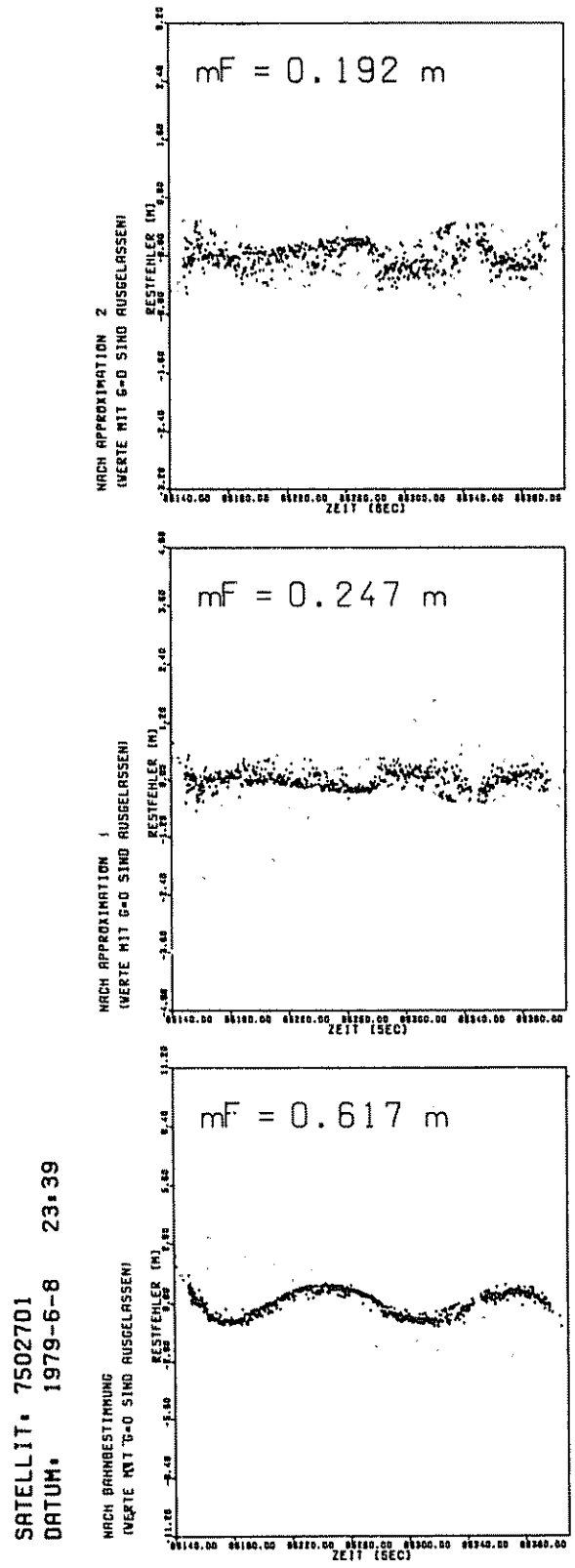


Figure 61. Federal Republic of Germany: laser ranging to satellites; a typical GEOS-3 pass

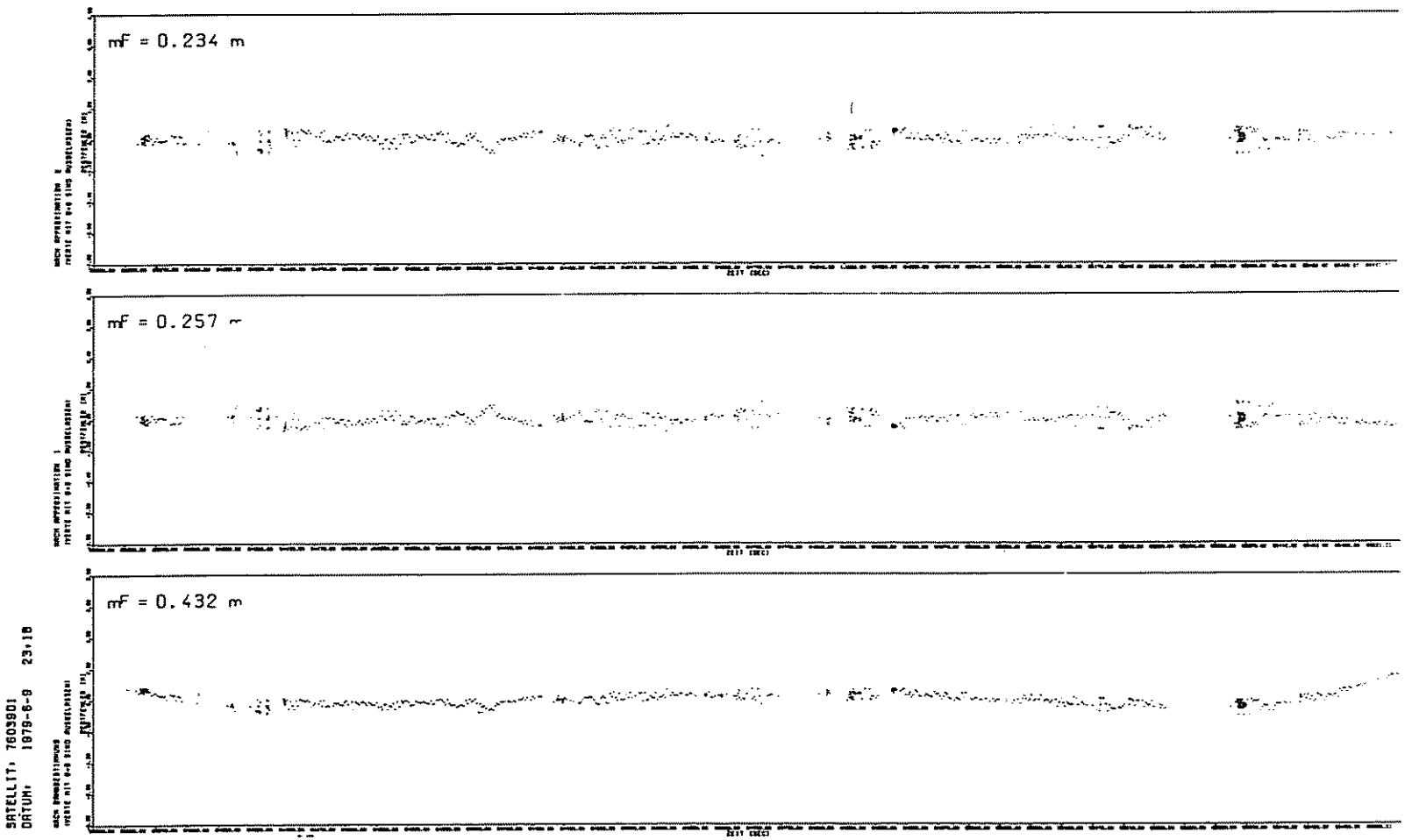


Figure 62. Federal Republic of Germany: a Lageos pass showing degenerated ranging quality

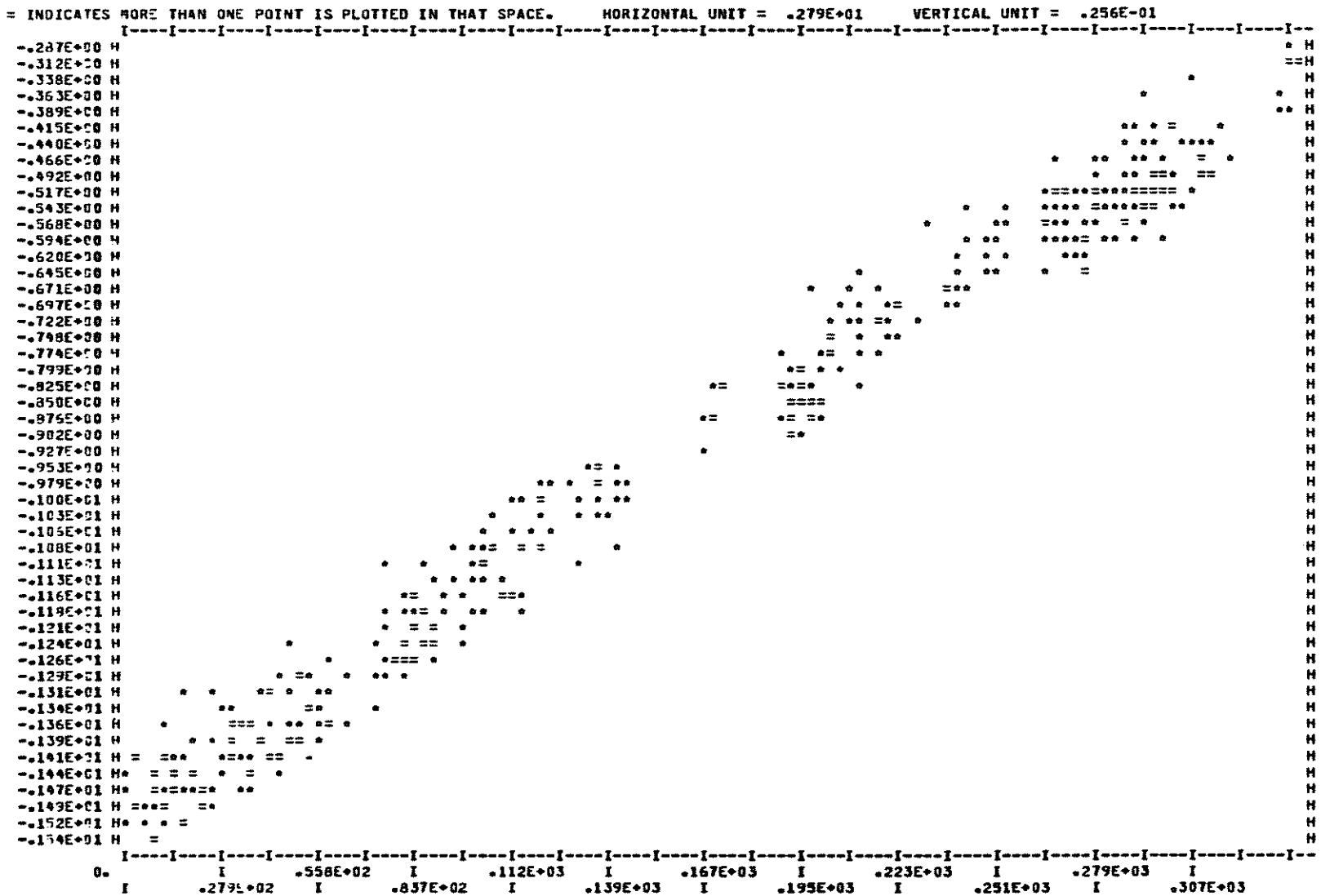


Figure 63. Federal Republic of Germany: a comparison of ranges observed in Wettzell to the extrapolated orbit

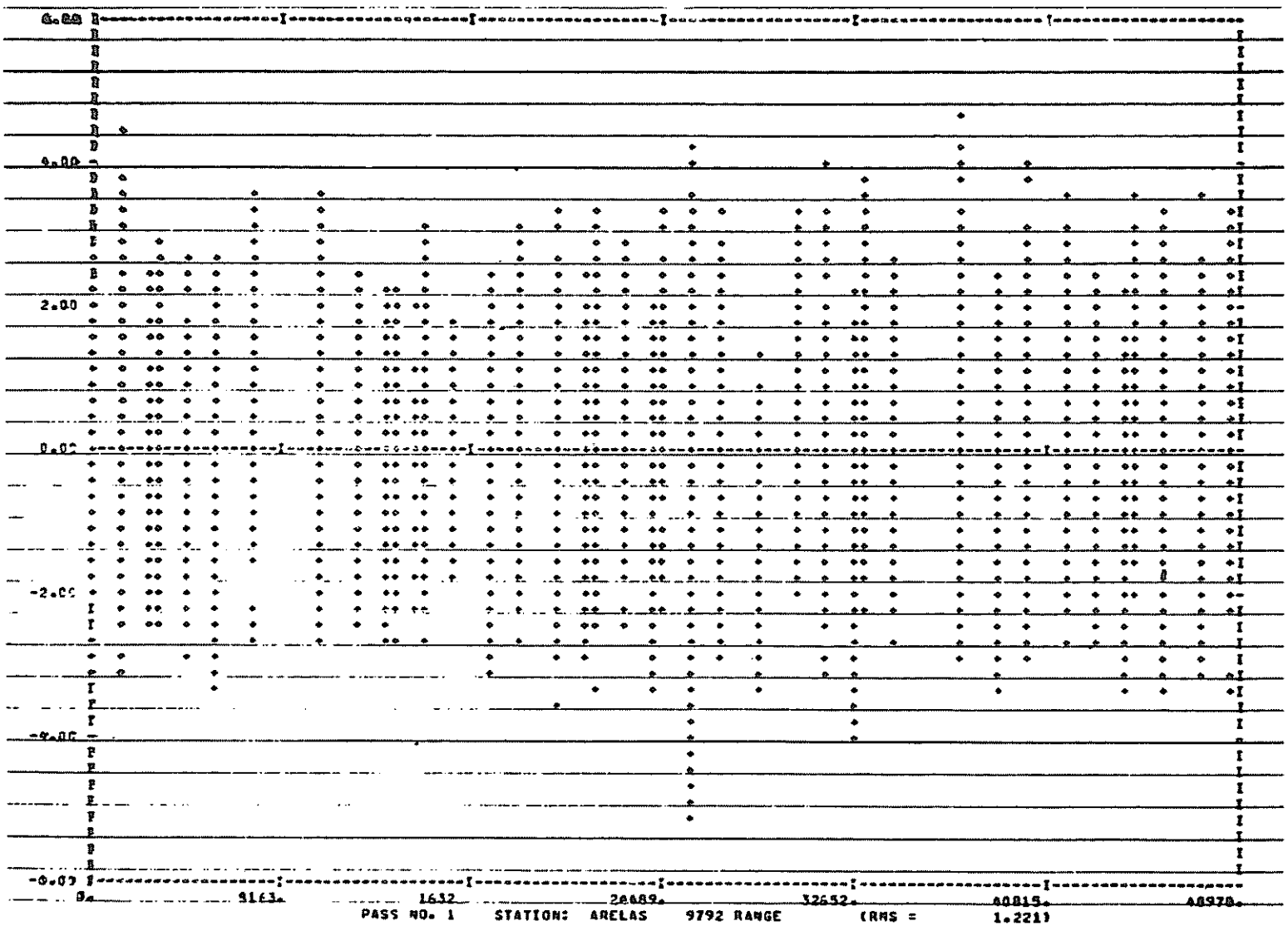


Figure 64. Federal Republic of Germany: passes from Arequipa used in the 35-day solution

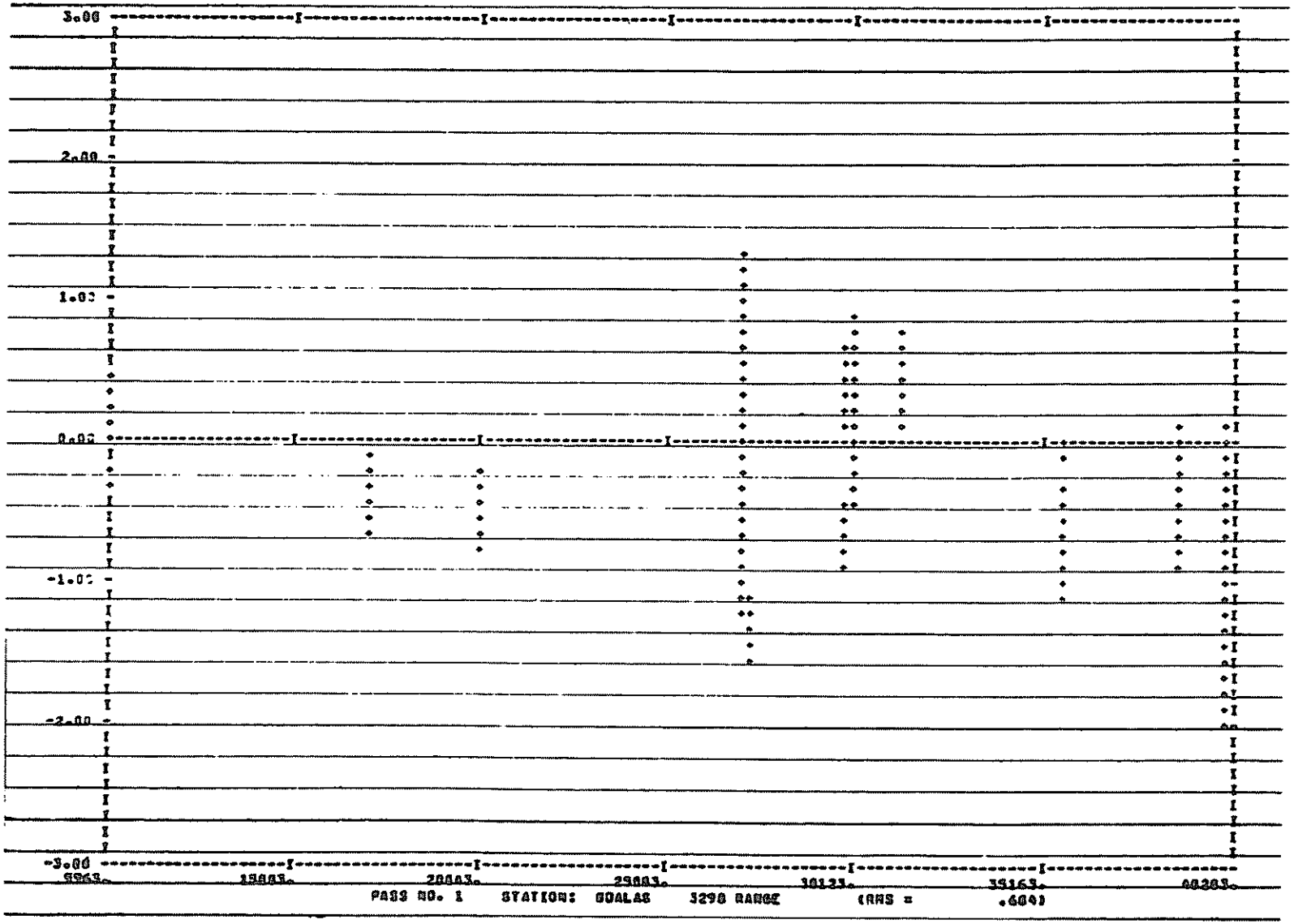


Figure 65. Federal Republic of Germany: passes from Bermuda used in the 35-day solution

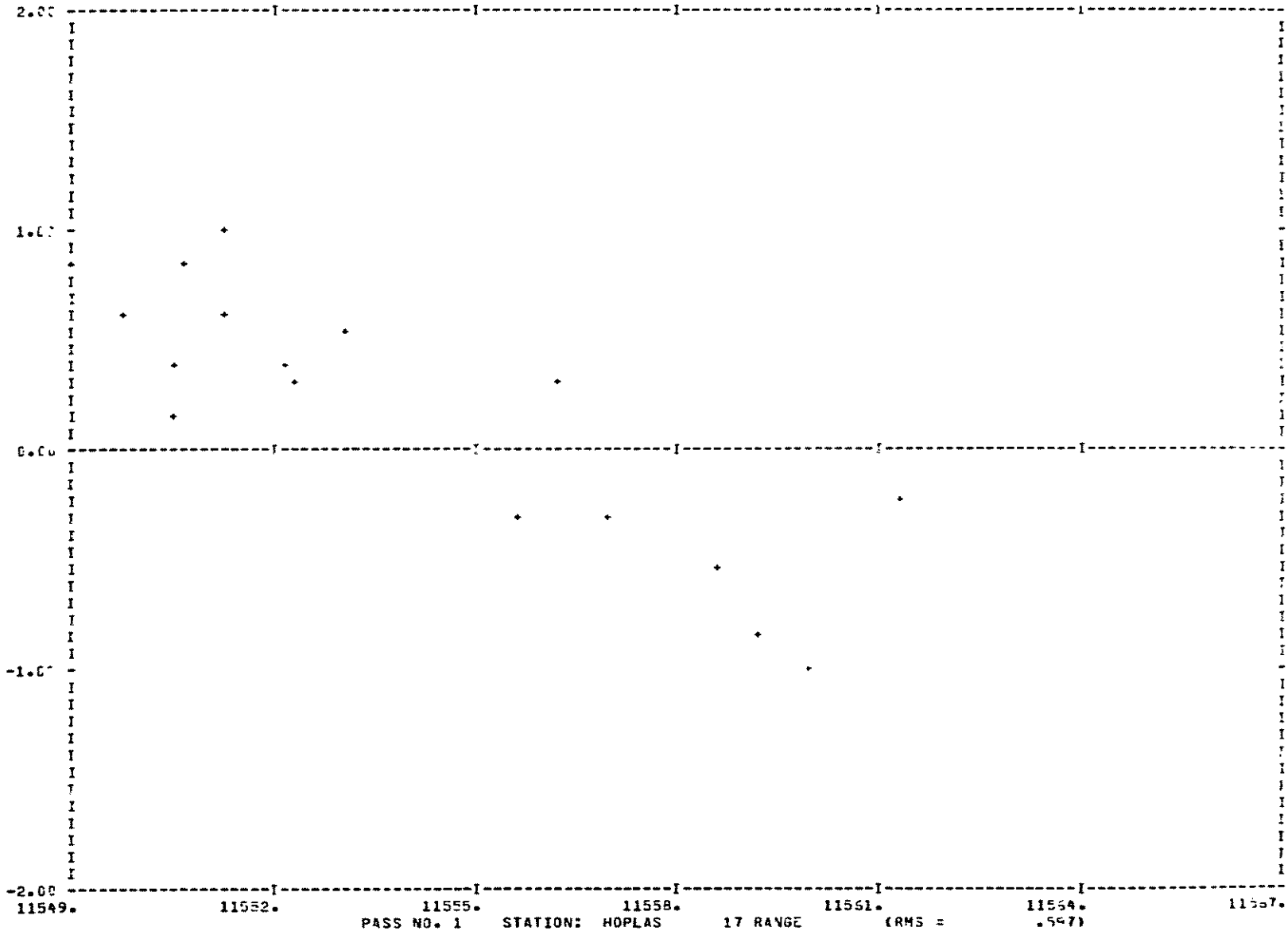


Figure 66. Federal Republic of Germany: passes from Mt. Hopkins used in the 35-day solution

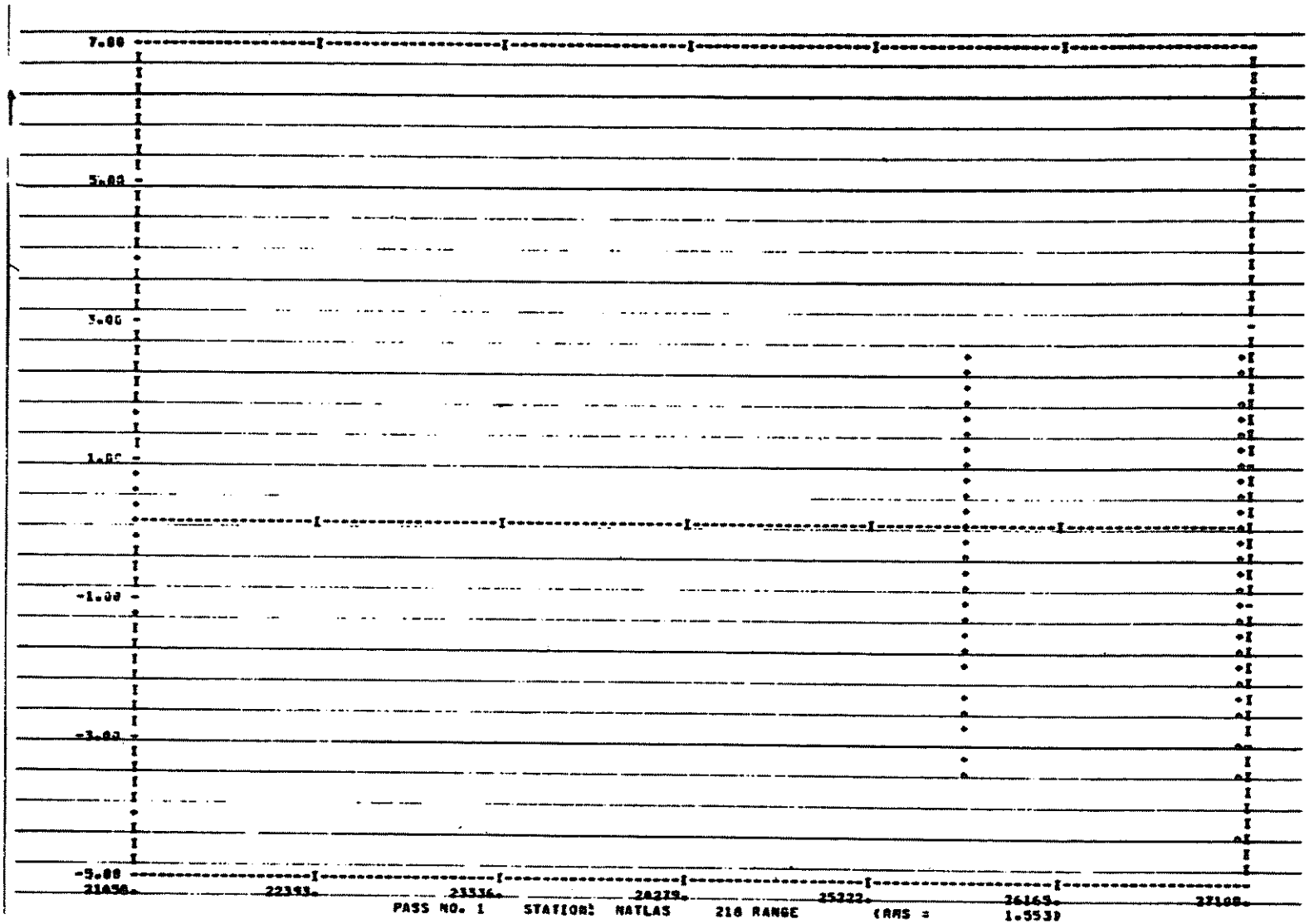


Figure 67. Federal Republic of Germany: passes from Natal used in the 35-day solution

TABLE 1. SUMMARY OF OBSERVATION RECORDS FOR WETTZELL, JUNE 1978 – JUNE 1979

Satellite	Month												Total passes	Average returns per pass
	J	J	A	S	O	N	D	J	F	M	A	M	J		
BE-C		4			3				1					8	420
GEOS-1	2	7		2	26	2			5					44	650
GEOS-3		8	12	3	14				5	1	5	15	11	74	465
SEASAT-1		2	5	1	1									9	225
Starlette	1		18	3					4	11	8	22	32	99	300
Lageos		2	16	2	10				4	2	1	14	15	66	1 125

space Engineering at the University of Texas, makes use of the program UTOPIA for the evaluation of data collected in Wettzell. Figure 63 confirms the noise level of the system under normal operation. To obtain this result, a single 135-day long arc fit was performed to the Wettzell observations to the orbit extrapolated from an epoch in February 1979. A more detailed, "absolute" analysis of the 1979 data obtained at Wettzell will be possible only after data have been collected from the global network, but preliminary indications confirm that good data are being taken; that the Lageos orbit has the required stability for geodynamic investigations and that the orbit is being determined with better than 1-m accuracy by the models currently being used in UTOPIA (5).

The remaining figures show results of a 1978 35-day arc computed for a station co-ordinate determination for Wettzell, using supporting ranging data from Arequipa, Bermuda, Mount Hopkins, Natal, Orroral Valley, San Fernando and Stalas (figures 64-71). Despite the varying noise levels of the data used, the results are extremely good, confirming yet again both the high precision of the Wettzell data and the quality of the Lageos ephemeris. Figure 72 gives a summary of the characteristic values obtained in the solution and figure 73 summarizes the data input. In the figures 64-71, each line of points represents a single pass of data, for which the length of the line is an indication of the spread of the residuals, and each point represents more than one observation.

CONCLUSIONS

The described results demonstrate the capabilities of state-of-the-art satellite ranging. There is every reason to believe that the results to be obtained over the next years will have a significant impact on our knowledge of the driving forces behind crustal motion and thus to our understanding of earthquake phenomena, perhaps even enabling us to make predictions of critical events. To achieve this it is necessary to propagate the best understanding of the objectives of these programmes—a task only possible with good will, joint effort and mutual trust—and to make use of information available from multinational, multidisciplinary sources. The task of modelling the problems being encountered is a challenging one and large enough for the scientists of all nations to play a significant role. The interest of the countries represented at this meeting should be directed to these problems and assistance should be given to those requesting it in the form of technical exchange. The instrumentation being used for these activities is expensive and should be used effectively. In all phases of these operations, the assistance, co-operation and involvement of local officials, know-how and labour will be required. This is a challenge for those organizing such efforts. It is a challenge also to become involved to the full extent of the available resources—local, national and international.

REFERENCES

1. "SFB 78: Konzeptpapier zur zukunftigen Forschungsrichtung des Sonderforschungsbereiches 78", *Satellitengeodäsie* (Munich), 1979.
2. National Aeronautics and Space Administration, "Application of space technology to crustal dynamics and earthquake research", NASA technical paper No. 1464 (Washington D.C., 1979).
3. D. Leigemann, J. Szameitat and P. Wilson, "On the design and error characteristics of a fundamental global geodetic network", report to the Committee on Recent Crustal Movements of the XVII General Assembly of the International Union for Geodesy and Geophysics, Sydney, 1979.
4. P. Wilson, "A short-pulse satellite ranging system", Proceedings of the Electro-Optics/Laser 77 Conference, Anaheim, California, 1977.
5. R. E. Schutz, private communication.

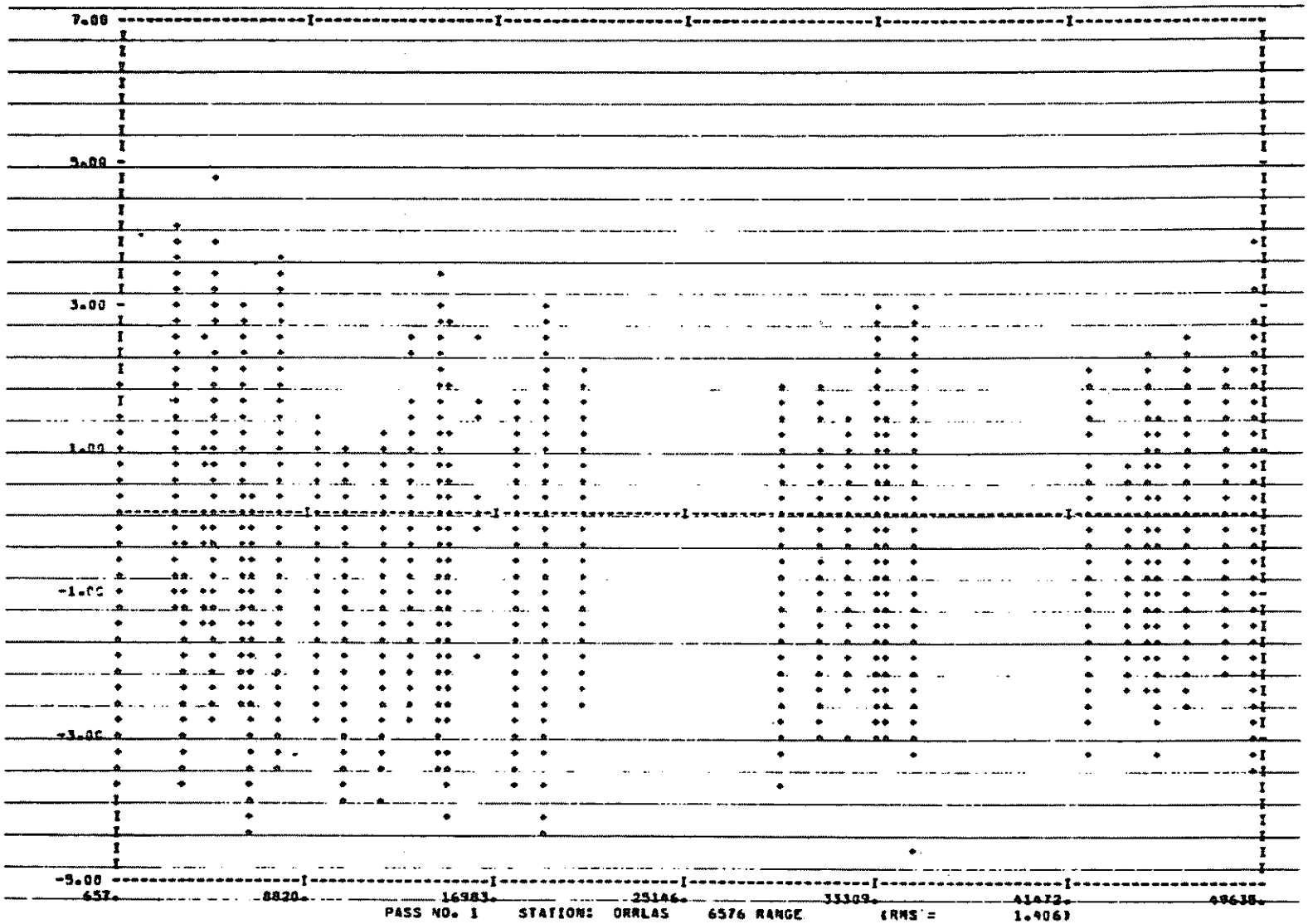


Figure 68. Federal Republic of Germany: passes for Orroral Valley used in the 35-day solution

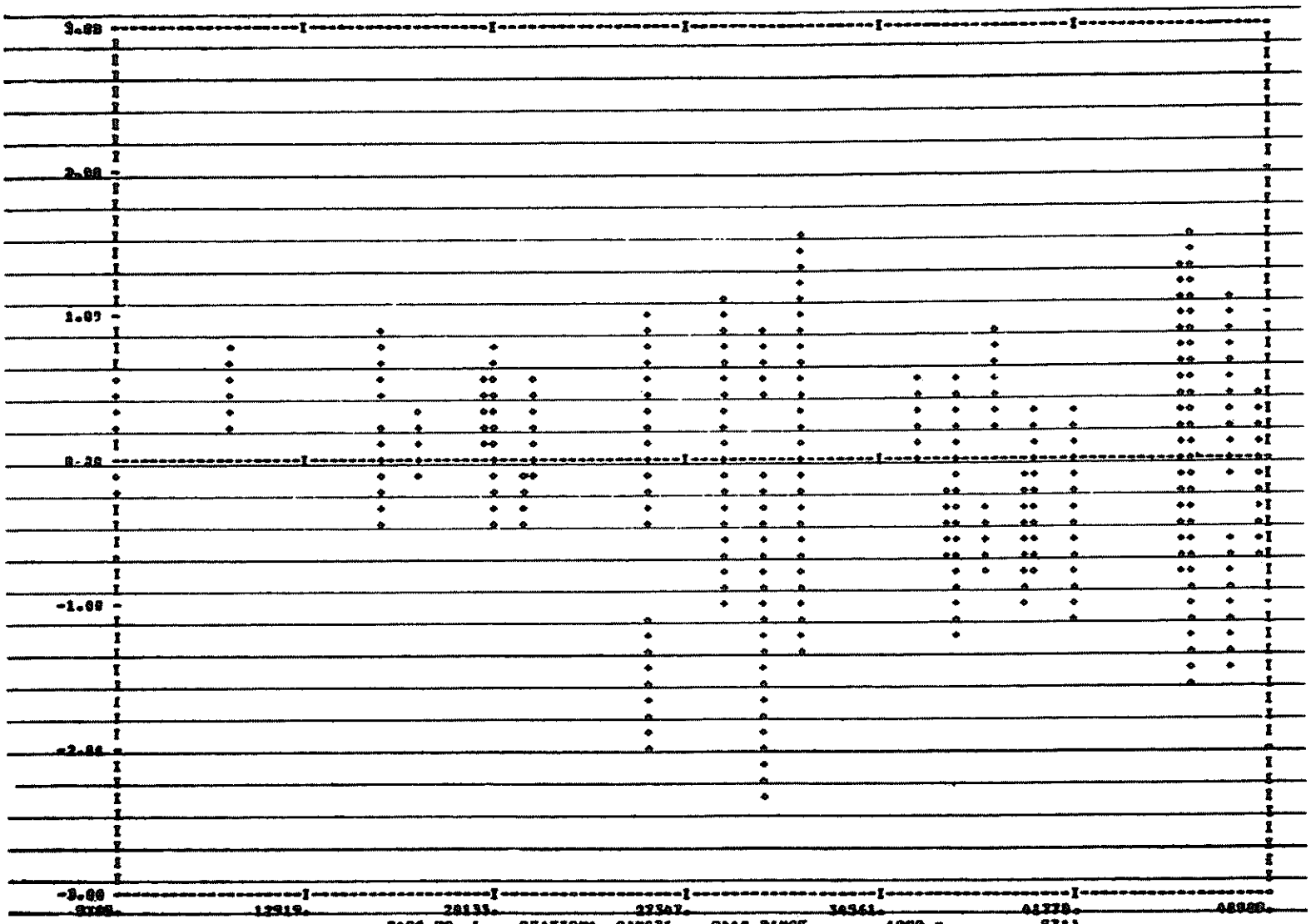


Figure 69. Federal Republic of Germany: passes from San Fernando used in the 35-day solution

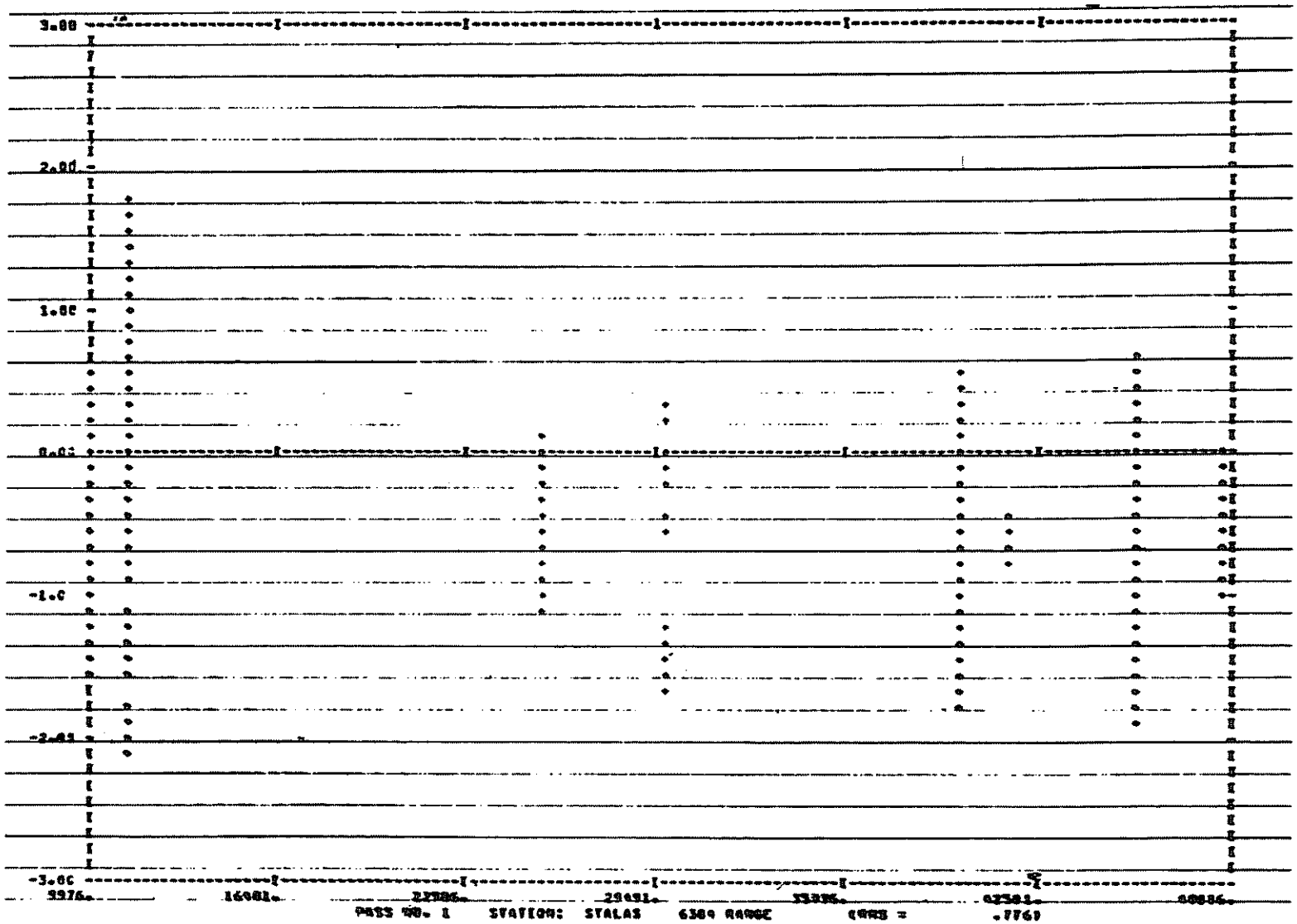


Figure 70. Federal Republic of Germany: passes from Stalas used in the 35-day solution

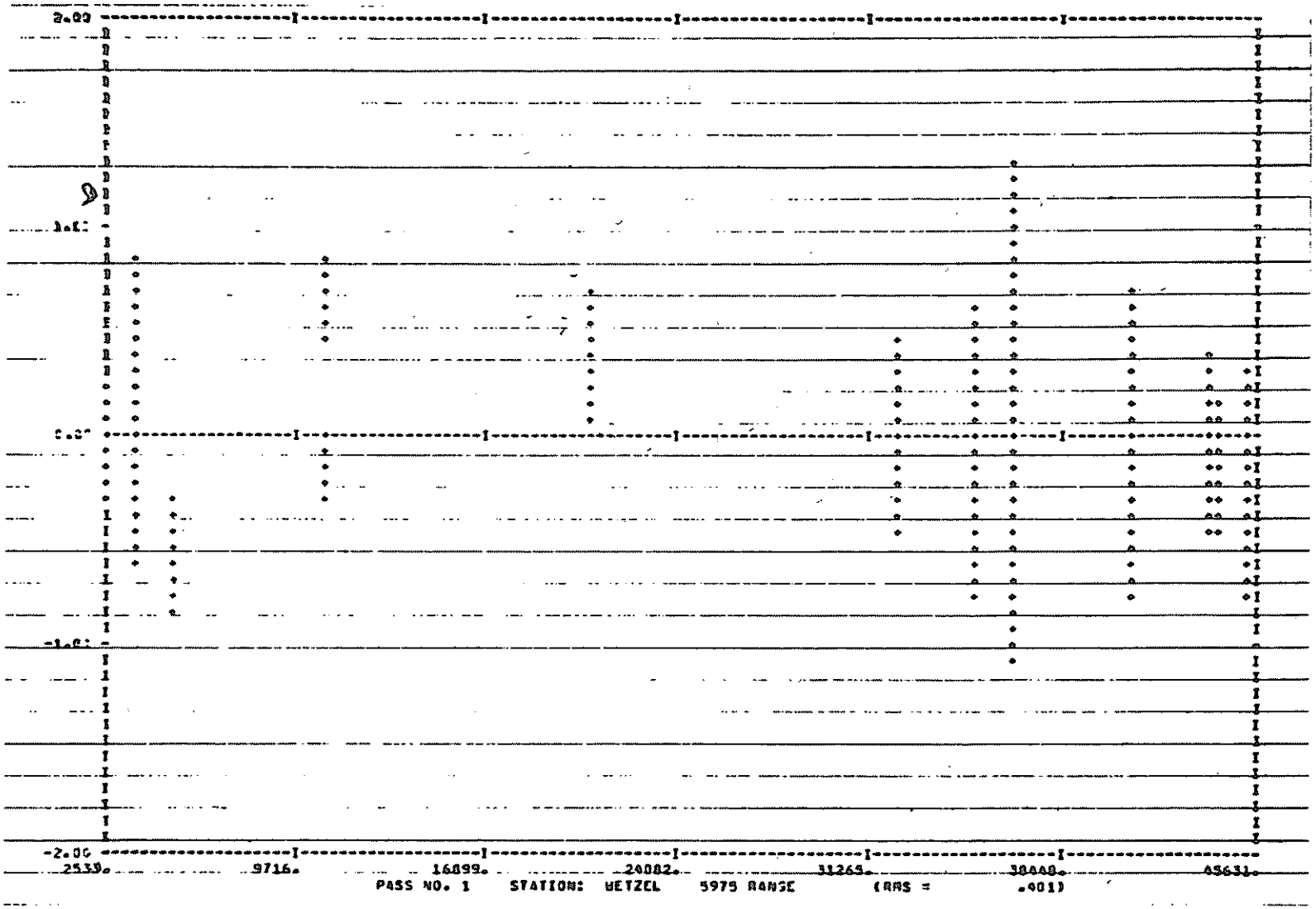
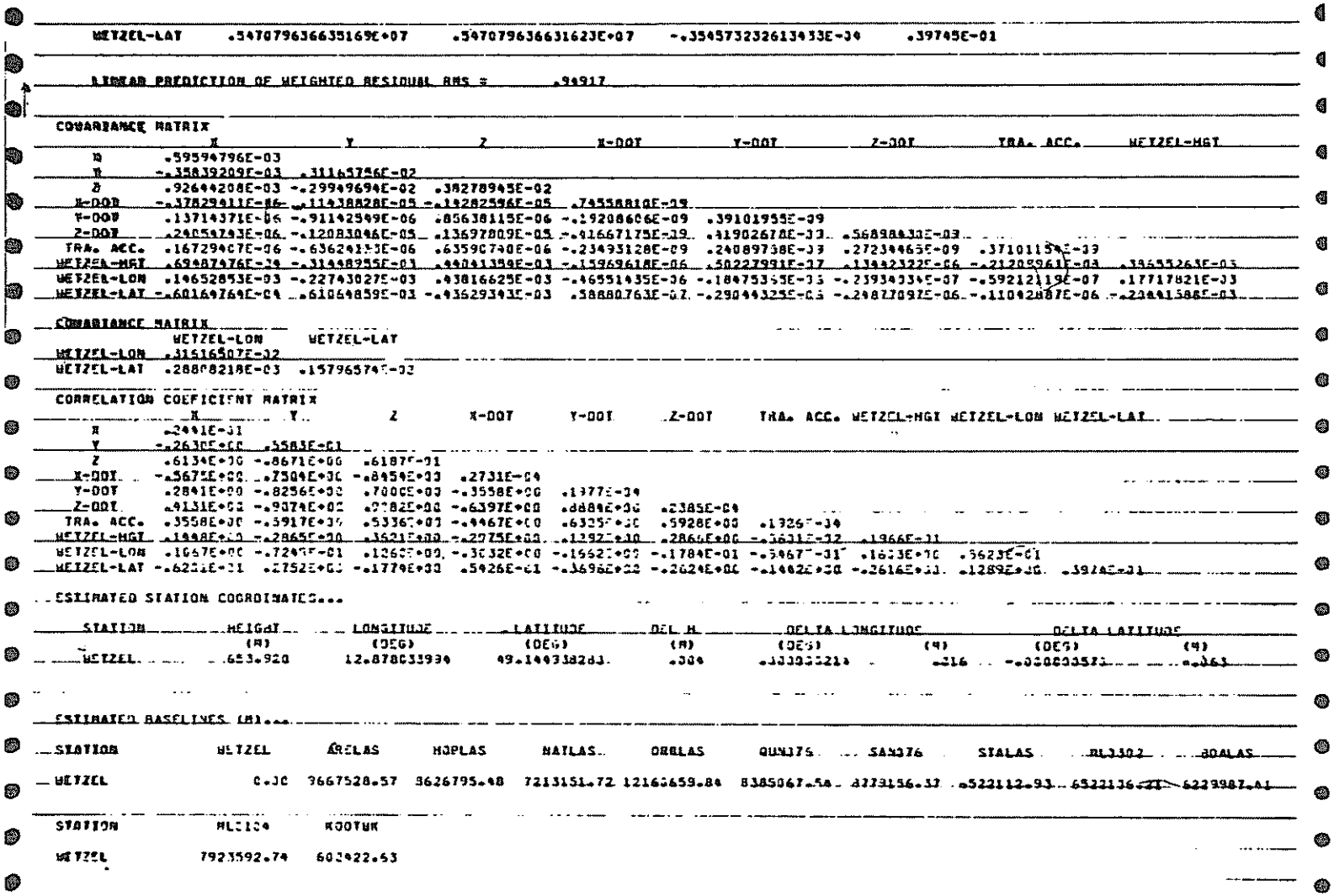


Figure 71. Federal Republic of Germany: passes from Wettzell used in the 35-day solution



```
WETZEL-LAT     .547079636635169E+07     .547079636631623E+07     -.354573232613433E-04     .39745E-01

LINEAR PREDICTION OF WEIGHTED RESIDUAL RMS =        .94917

COVARIANCE MATRIX
                X              Y              Z              X-DOT          Y-DOT          Z-DOT          TRA. ACC.      WETZEL-HGT
   X        .59594796E-03
   Y       -.35839209E-03  .31165756E-02
   Z        .92644208E-03 -.29949694E-02  .38278945E-02
 X-DOT     -.37829411E-06 -.11438828E-05 -.14282596E-05  .74558810E-09
 Y-DOT      .13714371E-06 -.91142549E-06  .85638115E-06 -.19208606E-09  .39101955E-09
 Z-DOT      .24054743E-06 -.12083046E-05  .13697809E-05 -.41667175E-09  .41902678E-09  .56898430E-09
 TRA. ACC.  .16729407E-06 -.63624133E-06  .63590740E-06 -.23493128E-09  .24089738E-09  .27234465E-09  .37101154E-09
WETZEL-HGT  .69487476E-04 -.31448955E-03  .44041359E-03 -.15969618E-06  .50227991E-07  .13442322E-06 -.21209961E-04  .39655263E-03
WETZEL-LON  .14652853E-03 -.22743027E-03  .43816625E-03 -.46551435E-06 -.18475365E-06 -.23934334E-07 -.59212119E-07  .17717821E-03
WETZEL-LAT -.60164764E-04  .61064859E-03 -.43629343E-03  .58880763E-07 -.29044325E-06 -.24877097E-06 -.11042887E-06 -.23441586E-03

COVARIANCE MATRIX
              WETZEL-LON      WETZEL-LAT
WETZEL-LON  .31516507E-02
WETZEL-LAT  .28808218E-03  .15796574E-02

CORRELATION COEFICIENT MATRIX
                X              Y              Z              X-DOT          Y-DOT          Z-DOT          TRA. ACC.  WETZEL-HGT  WETZEL-LON  WETZEL-LAT
   X        .2441E-01
   Y       -.2630E+00  .5583E-01
   Z        .6134E+00 -.8671E+00  .6187E-01
 X-DOT     -.5675E+00  .7504E+00 -.8454E+00  .2731E-04
 Y-DOT      .2841E+00 -.8256E+00  .7000E+00 -.3558E+00  .1377E-04
 Z-DOT      .4131E+00 -.9074E+00  .9782E+00 -.6397E+00  .8884E+00  .2385E-04
 TRA. ACC.  .3558E+00 -.5917E+00  .5336E+00 -.4467E+00  .6325E+00  .5928E+00  .1926E-04
WETZEL-HGT  .1448E+00 -.2865E+00  .3621E+00 -.2975E+00  .1292E+00  .2866E+00 -.3631E-02  .1966E-01
WETZEL-LON  .1067E+00 -.7245E-01  .1260E+00 -.3032E+00 -.1662E+00 -.1784E-01 -.5467E-01  .1603E+00  .5623E-01
WETZEL-LAT -.6201E-01  .2752E+00 -.1779E+00  .5426E-01 -.3696E+00 -.2624E+00 -.1442E+00 -.2616E+00  .1289E+00  .3974E-01

ESTIMATED STATION COORDINATES...

STATION        HEIGHT        LONGITUDE        LATITUDE        DEL H        DELTA LONGITUDE        DELTA LATITUDE
                (M)           (DEG)            (DEG)           (M)          (DEG)          (M)          (DEG)          (M)
WETZEL         653.920      12.878033934     49.144938283      .004      .000000214      .016     -.000000573      -.063

ESTIMATED BASELINES (M)...

STATION        WETZEL       ARELAS       HOPLAS       NATLAS       ORBLAS       QUN076       SAN076       STALAS       RL0302       BOALAS
WETZEL            0.00   9667528.57   8626795.48   7213151.72  12160659.84   8385067.54   8779156.37   6522112.93   6522136.21   6229987.41

STATION        RL0104       KOOTWK
WETZEL        7923592.74    602422.63
```

Figure 72. Federal Republic of Germany: characteristic values of the 35-day solution

UTOPIA OBSERVATION REPORT (MODE 4)

PASS NO. 1 PASS START (UTC) 7/21/1978 5:28:22.429351 ELAPSED TIME 2977897.400507 SEC

STATION SUMMARY:

	PASS NO	TOT NO. OBS/PASS	RANGE OBS	RMS
WETZEL				
	1	5975	5975	.401
	PASS TOTALS	5975	5975	.401
ARELAS				
	1	9792	9792	1.221
	PASS TOTALS	9792	9792	1.221
HOPLAS				
	1	17	17	.997
	PASS TOTALS	17	17	.997
HATLAS				
	1	218	218	1.553
	PASS TOTALS	218	218	1.553
ORRLAS				
	1	6576	6576	1.496
	PASS TOTALS	6576	6576	1.496
QUN076				
	1	3	3	0.300
	PASS TOTALS	3	3	0.300
SAN076				
	1	9442	9442	.571
	PASS TOTALS	9442	9442	.571
STALAS				
	1	6384	6384	.776
	PASS TOTALS	6384	6384	.776
RLO302				
	1	0	0	0.300
	PASS TOTALS	0	0	0.300
BOALAS				
	1	3298	3298	.698
	PASS TOTALS	3298	3298	.698
RLO134				
	1	0	0	0.000
	PASS TOTALS	0	0	0.000
KOOTWK				
	1	0	0	0.300
	PASS TOTALS	0	0	0.000
STA-PASS TOTALS		41702	41702	.949

Figure 73. Federal Republic of Germany: summary of the data input for the 35-day solution, together with the computed standard errors

MAPPING FOR WATER SUPPLY SCHEMES IN TANJUNGKARANG TELUKBETUNG AND KOTA BUMI, SUMATRA*

Paper presented by Australia

RÉSUMÉ

Dans le cadre de son programme d'aide internationale, le Gouvernement australien s'est engagé à fournir une assistance technique pour l'étude de faisabilité et la conception de systèmes d'approvisionnement en eau pour les villes jumelles de Tanjungkarang-Telekbetung et le centre régional de Kota Bumi dans la province de Lampung à Sumatra, villes de 400 000 et 30 000 habitants respectivement.

Ce programme est administré par le Bureau australien d'assistance au développement du Ministère des affaires étrangères. Le Ministère du logement et de la construction s'est engagé, au nom du Bureau, à fournir une assistance technique et a prié le Service topographique australien de réaliser les levés et les cartes pour le projet.

As part of its overseas aid programme, the Government of Australia has undertaken to provide technical assistance for feasibility study and design of water supply systems for the twin cities of Tanjungkarang-Telukbetung and the regional centre of Kota Bumi in the Province of Lampung, Sumatra, cities of 400,000 and 30,000 respectively.

The programme is administered by the Australian Development Assistance Bureau (ADAB), Department of Foreign Affairs. The Department of Housing and Construction undertook, on behalf of ADAB, to supply expert assistance and requested the Australian Survey Office to carry out the survey and mapping for the project.

MAPPING REQUIREMENT

The mapping requirement was for 57 orthophotomaps (OPM) in the Tanjungkarang-Telukbetung region and 9 OPMs in the Kota Bumi area. Maps were to be at the scale of 1:2,500 each covering an area of a 2 x 1.5 km with 2-metre contours. The comparative costs of producing a 1:2,500 scale contoured map sheet for a flat urban area are approximately:

Orthophotomaps	$2,900
Line maps	$5,600

These are Australian costs for complete production from flying through to field checking. The photographic image of the OPM portrays most of the detail present at the time of photography. For engineering purposes, for which the map was required, this type of presentation was preferred to a line map which shows only selected detail symbolically represented.

AERIAL PHOTOGRAPHY AND CONTROL

Monochrome photography at 1:15,000 scale was flown north-south or east-west through the centres of the proposed map sheets (see figures 74 and 75). Forward overlap of 80 per cent was used to ensure that each OPM would be wholly covered by a single photograph.

Photo control points were selected so that the aerial triangulated block would cover all the map sheets required and also possible future requirements which could then be produced at a later date without recourse to further field-work.

A total of 56 control points were required in the Tanjungkarang-Telukbetung area—42 with horizontal co-ordinates and elevation and 14 with elevation only; and 12 points in the Kota Bumi area. Universal Transverse Mercator (UTM) co-ordinates based on the GRS67 Padang datum were used for the photo control in both areas.

PRELIMINARY MAPS

Department of Housing and Construction engineers selecting reservoir sites and pipe-line routes, and also doing land-use surveys to assess water requirements, needed maps urgently—before any mapping control could be started. These were provided in the form of half-tone film positives of the air photographs enlarged to approximately 1:2,500 scale and covering the area of each proposed map sheet. These were adequate for the purpose and any number of copies could be made cheaply and quickly.

COSTS

The total time spent by survey parties on photo control for the mapping was 52 party weeks. The remainder of the field-time on the project was spent on engineering surveys of the pipe-line routes, reservoir sites, treatment plant sites etc. associated with the project.

Indonesian counterpart staff, labourers and drivers were provided by the Indonesian Government through the project office in Tanjungkarang.

The total cost (in United States dollars) of the map production part of the project was:

Aerial photography		
Area covered	approx. 470 sq km	
Flight distance	approx. 300 km	
Photo scale	1:15,000	
Forward overlap	80%	
Cost of flying and supply of:		
4 complete sets of prints (total 2,036 sheets)		$55,000
Enlargements to 1:2,500 scale (approx 1 x .8 m)		
Total for 66 map sheets, 66 x $240		$15,840

*The original text of this paper, prepared by the Australian Survey Office, appeared as document E/CONF.72/L.44.

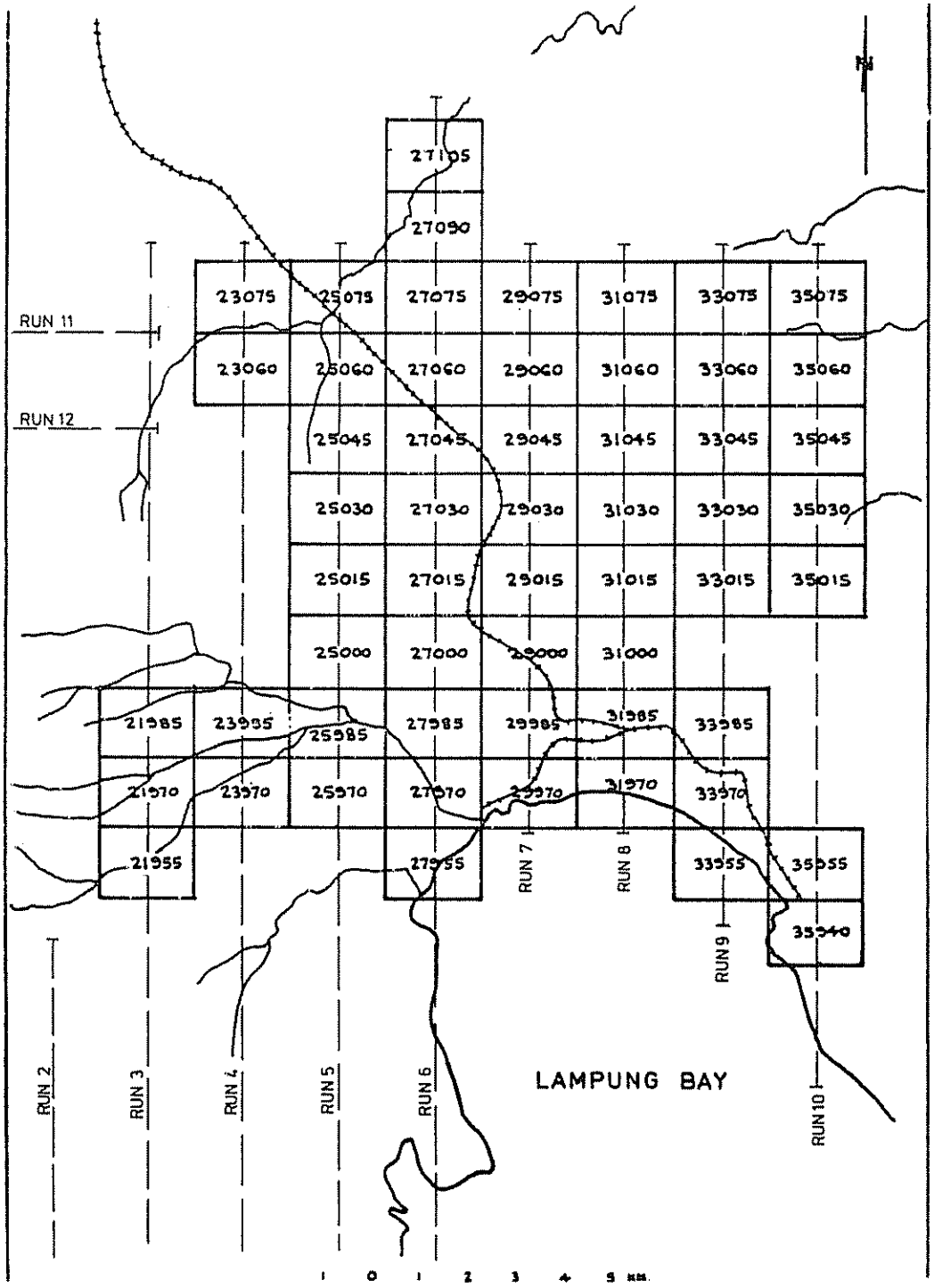


Figure 74. Australian plan of 1:2,500 scale mapping, Tanjungkarang-Telukbetung, Sumatra

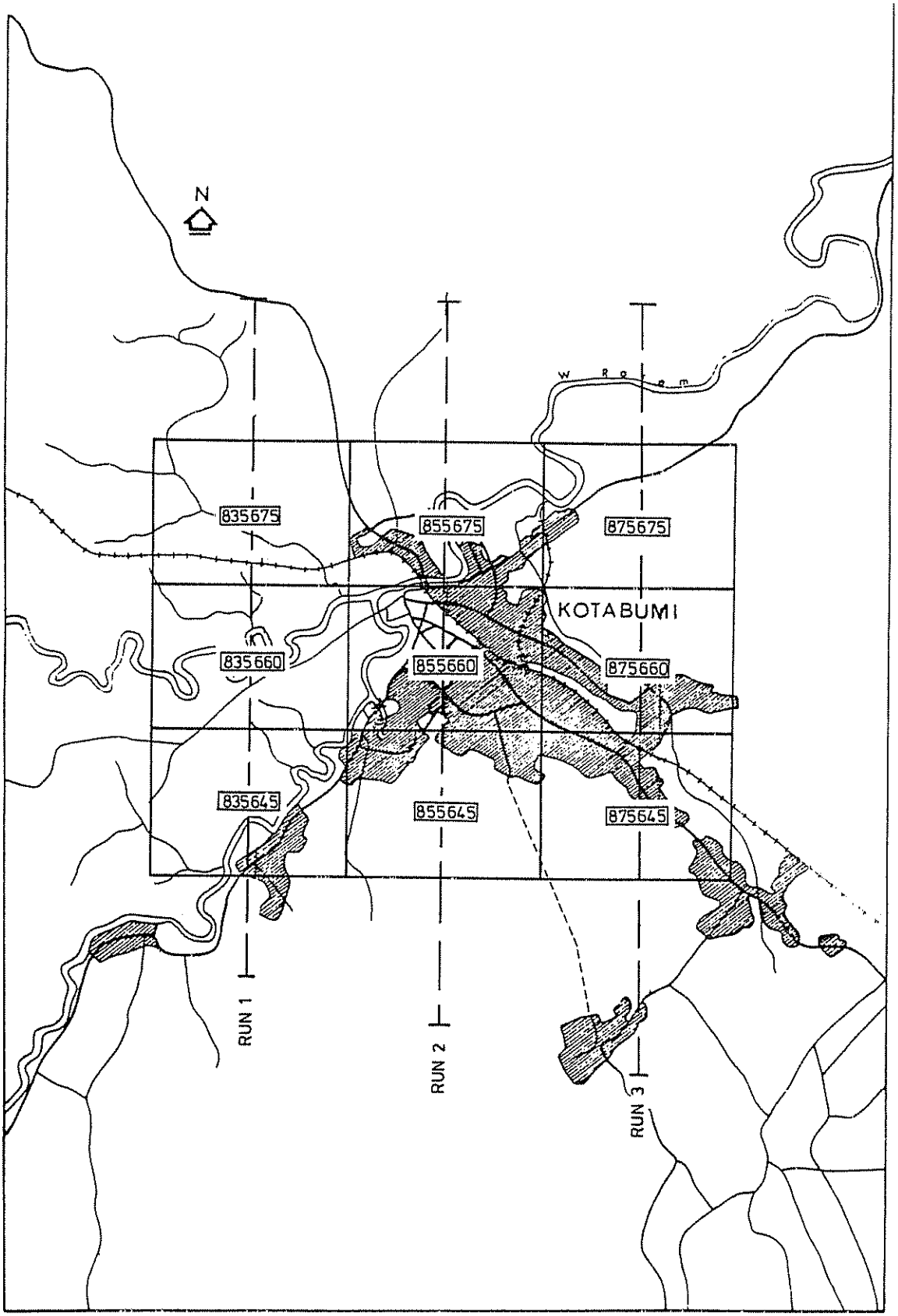


Figure 75. Australia: map sheet lay-out and flight diagram of Kota Bumi area, Sumatra

Orthophotomaps (as quoted, maps not finalized)	
Tanjungkarang-Telukbetung area, 57 map sheets with contour overlay	
Kota Bumi Area, 9 map sheets with contour overlay	$98,000
Field survey (approximate figures)	
Salaries and allowances	$42,000
Other incidental costs	$ 9,000
Office costs	$19,000
Total for production of OPMs and photo enlargements	$240,000

(Costs of purchasing of equipment which forms part of the Government-to-Government Aid grant have not been included. The Indonesian Government's contribution of counterparts, labourers, drivers and administrative assistance has also not been included.)

THE ESTABLISHMENT OF A BASIC NATIONAL GEODETIC SYSTEM*

Paper presented by Sweden

RÉSUMÉ

Les réseaux géodésiques de base existant en Suède font actuellement l'objet d'une nouvelle série de mesures.

La première triangulation géodésique du pays a été entreprise au début du siècle et achevée en 1951, et elle a abouti à une série de mailles relativement espacées. Ces mailles ont été complétées par une triangulation au niveau inférieur dont la qualité était variable. Une étude du réseau effectuée dans les années 60 a mis en évidence des défauts assez graves et l'on a entrepris un programme de nouvelles mesures et d'augmentation de la densité. Le document décrit les techniques de mesure employées (la trilatération au moyen de signaux portatifs construits spécialement et d'instruments de mesure électronique les distances à laser), ainsi que la méthode de calcul qui a été adoptée afin d'assurer que les coordonnées puissent être obtenues aussi rapidement que possible, de manière à faciliter les liaisons entre tous les levés et le réseau national.

La troisième modification du réseau suédois de nivellement de précision a été entrepris en 1979. Comme cela avait été le cas pour le réseau de triangulation, de nouvelles techniques ont été mises au point. Le nivellement motorisé sera la principale technique de mesure employée. Les méthodes qui ont été mises au point et les instruments sont décrits dans le document.

Les résultats obtenus jusqu'à présent ont été de haute qualité, le rendement a été considérablement amélioré et les coûts par kilomètre de nivellement sont inférieurs à ceux qui sont entraînés par les méthodes classiques.

By western European standards, Sweden, with a total area of 449,000 km² and a population of 8.24 million is sparsely populated. Large areas of the country are mountainous or forest-covered, with a population density of less than 10 persons per km²; between 60 and 70 per cent of the population live in urban areas.

As late as the 1930s the country was still, basically, an agrarian society. Since the middle 1940s the rate of economic development has been very high; and at the present time Sweden is one of the most highly industrialized countries in the world. Progress in the field of surveying and mapping had, however, prior to the middle 1960s, in no way kept pace with the country's general rate of development, and the need for basic geodetic control was becoming acute.

THE TRIANGULATION NETWORK

The first systematic geodetic triangulation of Sweden dates back to the first decades of the nineteenth century. By the turn of the century a coarse-meshed system of chains of first-order triangulation had been established extending from the connection to the Danish triangulation in the south to the Russian-Swedish triangulation north of the Polar Circle and from the Baltic coastal islands in the east to three connections to the Norwegian triangulation in the west. Within the chains a limited amount of second- and lower-order triangulation was carried out although the geographical distribution of triangulation stations was very irregular. Large areas of the country were without triangulation.

The purpose of this first triangulation was twofold: first to serve as a framework for the national mapping programme and secondly to provide the basis for scientific geodetic studies. Demands for an increased and more diversified mapping programme, the lack in many areas of an adequate triangulation network to which newly completed town and city triangulations could be connected and developments within international geodesy resulted in 1905 in a decision to modernize and extend the national triangulation network. A re-observation programme was prepared with the aim of establishing a first-order framework of the best achievable accuracy which included the measurement of base lines and the observation of Laplace stations. Observation of the network, which comprises thirteen closed loops made up of single or double chains of triangles, was begun during the first decade of the present century and completed in 1951. In addition to the angular observations 29 Laplace stations were observed and 11 baselines were measured.

*The original text of this paper, prepared by Ian Brook and Jean-Marie Becker, National Land Survey of Sweden, appeared as document E/CONF.72/L.70.

The demands of the national mapping programme were a major factor in instigating the re-triangulation, and to keep pace with those demands the computation of the network could not be delayed until all 13 loops had been observed. Computation of the separate loops was therefore carried out as the angular observations were completed and, thereafter, the separate loops were connected to each other. The computational problems involved in this procedure were accentuated by the fact that observation of Laplace stations and the measurement of base-lines did not keep pace with the angular observations. By 1938 five base-lines and seven Laplace stations had been completed and with the help of these the five southernmost, earlier-computed loops were subjected to a re-scaling and re-orientation. Thereafter, continuing northwards the loops were computed in nine separate stages.

External pressures had, necessarily, overridden purely geodetic considerations and good quality observational data was subjected to less satisfactory adjustment procedures, which led inevitably to deformations and scale errors in the adjusted network. The adjustment did not fulfil scientific requirements but, as has been the case in many other countries, it was considered that a distinction should be made between co-ordinates intended for mapping purposes and co-ordinates for scientific purposes and that, initially, the mapping requirements should be given priority. Second- and third-order triangulation was later carried out to fill out the areas within the first-order loops.

This is a state of affairs which is by no means uncommon in many countries in the third world where, prior to independence, colonial survey organizations established primary triangulation networks which were to serve as the basis for a large-scale mapping programme. Characteristic for networks of this type are relatively inaccessible triangulation stations and long side-lengths which make breakdown triangulation both difficult and expensive.

In the mid 1960s a plan for a remeasurement and densification of the Swedish national network was presented and granted Government approval. At this time, the Land Survey was in no way equipped to carry out a large scale programme of this type. In many ways this was an advantage: new ideas could be discussed, new techniques introduced and new instrumentation employed.

THE REMEASUREMENT PROGRAMME: FIELD METHODS

A proposal of fundamental significance presented by the working group responsible for formulating the directives for the reobservation programme, was to give electronic distance-measuring (EDM) methods a prominent position. The group proposed that classical triangulation techniques should be replaced by trilateration methods. In some areas of the country EDM traversing was suggested as the most economically viable technique.

Instrumentation

In the mid 1960s, unlike today, the available range of EDM instruments was limited: laser EDM equipment was, for example, still at the prototype stage. Microwave equipment with a range and accuracy which satisfied the specifications for the new network had, however, been in use in a large number of countries since the late 1950s. The choice lay between the tellurometer MRA 101 and the distomat DI 50. From a performance point of view both instruments were fully acceptable, and from a service point of view the DI 50 offered significant advantages. The factor which finally weighted the scale in favour of the tellurometer was its better portability in difficult terrain where back-packing is often necessary. During the first three field seasons all distances were measured with tellurometer. Since the early 1970s the tellurometers have gradually been phased out and have been replaced by Aga model 8 laser geodimeters. The better inherent accuracy of the geodimeter and its lower sensibility for, for example, water vapour pressure enabled significantly rationalized observation routines to be introduced. The introduction of the laser geodimeter resulted in decreased costs and better accuracy.

Reliable and accurate distance measuring equipment is a basic requirement for a large-scale trilateration programme. Of almost equal importance is the choice of ancillary equipment. The availability of observing towers is not infrequently a factor which determines network configuration and rate of progress in the field.

In Sweden, with the exception of the most southerly parts of the country and the high mountains, geodetic observations cannot be made without towers due to the character of the terrain and the height of the forest cover. Average tree heights vary from 10-12 m in the north-central areas to 25-30 m in the south-central areas of the country. Prior to 1967 distance and angular measurements were carried out from wooden towers or from steel Bilby towers. Tower building is time-consuming and costly: without timber costs the average cost per metre for building a double wooden tower was 500 Swedish kronor in 1979. A tower-building party comprising one foreman and two labourers requires three working days to build a 20 m wooden tower. The maximum practical height to which wooden towers can be built is approximately 25 m. Bilby towers can be erected more quickly, but in forested areas without roads and tracks transport of material to the station site is both expensive and difficult.

When the remeasurement programme began it was considered that an average of 110 towers would be required per field season. Due to a considerable increase both in the number of connections to existing triangulations and the amount of contract work the number of towers built per season has been two or three times larger than this figure.

The classical type of observing tower is unsuitable for trilateration of an area network from an economic and practical point of view. In the mid-1960s a modified wooden tower in which the instrument tower and observer platform were of a unitary construction was developed for tellurometer observations. This tower type although not suitable for angular observations was sufficiently rigid and stable for microwave measurements. A logical development of this distance-measuring tower concept was a portable tower which could be easily transported and quickly erected and which, at the same time, was rugged and stable. In co-operation with a local firm a prototype duralumin tower was constructed and field tested towards the end of the 1967 field season. From this prototype construction the G-tower was developed. The basic tower in its present form is, in principle, telescopic, with a triangular cross-section. A standard 25 m tower comprises six separate

sections which are a lattice construction of duralumin tubes bonded with epoxy adhesive. The tower platform is made up from three separate units. A tower complete with platform, guys and ancillary equipment weighs between 200-300 kgs and can, in collapsed form, be transported on small standard-type car trailers.

Tower height can be varied from 12 to 18 to 25 metres and, with an extension unit, up to a maximum height of 30 m. A 25-m tower can be built and centred over the station mark by a trained tower party in under four hours. In difficult country the separate sections, due to their low weight, can be back-packed to the triangulation station.

The specifications for the original design were based on the use of MRA 101 tellurometers with a beam width between the half-power points of 6° – 8°. A high degree of positional stability was demanded, whereas the requirements for torsional stability due to the tellurometer's radiation pattern were less rigorous. Lateral displacement of the tower, complete with instrument, observer and booker, is less than 10 mm with a wind velocity of 10 m/sec. Movement around the vertical axis is of the order of 1° – 2°.

Field tests with prototype laser geodimeters in 1967 clearly indicated the high potential of this instrument. However, the rational use of laser equipment in the reobservation programme was not possible using standard G-towers due to their relatively poor torsional stability.

During the winter of 1969-1970 experiments to increase the torsional stability of the towers were therefore carried out. A prototype stabilizer was subjected to field tests and the results indicated that it was possible to decrease the movement around the vertical axis to a sufficiently low level as to permit geodimeter measurements.

The stabilized instrument platform as produced in its commercial form was constructed by the constructor of the G-tower. The platform makes it possible to carry out laser geodimeter measurements of distances up to 50 km in wind speeds of up to 6-7 m/sec. The stability of the stabilizer is good: the tip component is of the order of 1:10,000 and the twist less than 1:5,000. The stabilizer is a singularly simple construction which can be mounted on standard, unmodified G-towers. Building time is approximately one hour. The stabilizer can be transported inside the G-tower package and weighs approximately 60 kg.

Ten stabilizers are now in use in the trilateration programme and its presentation has radically affected the organization of the field-work.

The speed with which the tower can be erected, and its height increased or decreased, means that reconnaissance errors can easily be remedied by changing the tower height. For breakdown traversing along, for example, roads, very simple and very economical reconnaissance techniques, based on barometric heights, can be employed.

The tower stands on a pointed base unit and can be built over the station mark. The instrument mounting plate can be rapidly plumbed over the ground mark.

In standard G-towers the mounting plate is movable ± 5 cm and can be positioned over the station mark with the help of an optical plummet. The stabilizer can also be centred over the station mark using an optical plummet. For this purpose, a special target has been constructed. The target, which is mounted around the top of the stabilizer tube under the instrument mounting point, consists of a circular plate on which are engraved two concentric circles towards the edge of the plate and radii at 22°5′ intervals. Centring is carried out either by adjusting the guywire tensioners until the circular base of the stabilizer tube is placed concentrically within the target circles or, more commonly, by adjusting the position of the stabilizer until the "spokes" on the target coincide and remain in coincidence with the cross-hairs of the optical plummet when observations are made in at least three positions.

In addition to the G-towers, telescopic prism masts which can be raised to 30 m and light-weight G-masts which can be used for mounting prisms are also in use.

Field measurements

A very limited number of horizontal directions have been observed in the new network to supplement the older first-order observations. EDM observations are carried out following well-defined routines.

Geodimeter measurements

Crystal warm-up times have been determined for all instruments.

Meteorological observations comprise dry-bulb and wet-bulb temperatures and pressure values. Meteorological observations are started ten minutes before the geodimeter observations are begun and are, thereafter, made at five-minute intervals. The final meteorological observation is taken ten minutes after the final phase reading. The psychrometers are shaded from direct and reflected radiation and pointed against the wind to ensure adequate ventilation. At ground stations temperatures are recorded at least two metres above the ground surface. Standard long delay-line geodimeter measuring procedures are used. The three frequencies are computed in the field. The permitted spread between the three values after applying frequency corrections is 30 mm.

Meteorological observations are made at both the instrument and prism stations. Prisms are always carefully levelled, using tribrachs.

All lines over 10 km are measured twice on the same day, with a time interval of at least three hours between the measurements. The degree of correlation between these measurements is the subject of a separate report. The difference between two measurements after correction for refractive index should not exceed 2.0 cm + 2 ppm of the distance. Distances of 10 km or less are measured only once.

Studies have been made of the diurnal variation of measured distances. Ideally, each distance should be measured at least once at night and once in daylight. Economics and other practical considerations preclude, however, night observations. All distance measurements are, therefore, carried out in daylight.

Tellurometer measurements

Warm-up times have been determined for each instrument. Meteorological observations are carried out, using the same equipment and procedures as for geodimeter measurements.

A complete single determination of a distance comprises fine measurements on 13 cavity positions with

both instruments and two coarse readings, one at the lower and one at the upper end of the cavity scale. Distances of over 10 km are measured three times on separate days, whereas distances of 10 km or less are measured only twice on separate days. The permitted spread between outer values for the measurements expressed as a proportion of the distance is 1:200,000.

All tellurometer measurements are made in daylight.

Heighting

The Achilles heel of a trilateration programme is heighting. Station heights are either determined by measuring vertical angles, by levelling or by a combination of both methods. Considerable savings can be achieved by observing vertical angles to prisms illuminated using the light source in the EDM instrument.

Levelling is carried out both for direct determination of station's heights and in connection with height traversing. Lines of levels are run in both directions with a maximum permitted difference between the forward and reverse height differences of 15 $\sqrt{D}$ mm, where D is the distance in km.

Height traversing is carried out where, due to difficult terrain conditions, direct levelling is not possible. Maximum permitted traverse length is of the order of 3,000 m. Normal procedure is to run levels as near as possible to the triangulation station and to make the final connection by traversing. Two separate determinations of the height difference are made from two independent instrument set-ups. The maximum permitted difference between the two height traverse determinations is 50 mm. The model 700 geodimeter is particularly suitable for height traversing. A minimum of two sets of vertical angles are observed together with a single determination of the distance.

Calibration procedures

The quality of the field measurements is as much dependent on the careful application of fixed observing routines as on regular calibration of the instruments used.

EDM INSTRUMENTS

Zero constants are determined for the geodimeters before and after the field season; for the tellurometers a mid-season calibration is also carried out in addition to the pre- and post-field season calibrations.

Geodimeters and tellurometers

The laser geodimeters are calibrated on a high precision invar base. For calibration purposes two pillars have been built at the base terminals and an additional station has been established on line approximately half way between the pillars. A complete calibration consists of a measurement of the whole base and the two sections using high precision methods. The prisms are mounted on a special bar on which they can be moved in steps of 300 mm from − 600 mm to + 600 mm from the centre of the pillar along the direction of the baseline. A complete determination of each distance thus comprises 5 separate measurements each of which is made on three frequencies.

The line of sight has a maximum height over the ground of 10 m. Temperatures are recorded at a height of approximately 2 m and pressures at the height of the instrument.

For calibration of the model 6 geodimeters, a 50-m baseline has been established in the basement of the Land Survey Office, using invar wires. Delay-line tables are made up before and after each field season. The instrument constants are also checked at the same time using short delay-line methods.

Tellurometers are calibrated on outdoor 180-m baselines. Measurements are made at intervals of $1/8\ \lambda$ between 180.0 and 188.75 m, using the same cavity settings as are used for the field measurements. Attempts have been made to compute "critical" heights. Corrections are derived by well-known methods.

Modulation frequencies in all EDM instruments have been checked at monthly intervals with a portable frequency counter.

THE COMPUTATIONS

As was the case with the first triangulation of Sweden, the new triangulation is being carried out to meet the needs of two types of consumers: geodetic scientists and land surveyors. It was clearly stated at the project study stage that, whilst a geodetic scientist may be willing to wait until the whole of a network has been observed and adjusted as an entity, land surveyors will, for practical reasons, want the new co-ordinates as soon as possible after the field observations have been completed.

To meet the requirements of both user categories as far as possible, the country has been broken down into twelve regions. Regional boundaries mainly follow the old chains of first-order triangulation. This "cage" of triangulation gives each region a stability in orientation which has been further strengthened by the inclusion of all older first-order azimuths supplemented by new azimuth measurements.

As soon as field-work is completed in a region, regional co-ordinates are computed and made available for use. All new observations, together with the old first-order angular measurements and azimuths, are included in these regional adjustments which are based on only one fixed station. To avoid problems at regional boundaries, generous overlaps are provided. In these overlap zones transformation coefficients are computed.

At the time of writing, eleven of the twelve regions have been observed and computed and subregion 12E, which was observed during 1979, will be computed during the present winter. Co-ordinates are available for 3,250 stations. As was stated above, each region has been computed separately, based on a single fixed station. In the first nine computed regions, the co-ordinates for the fixed station were either in the old national system (2.5^g W 1938) or in the "map co-ordinate" system. The "map co-ordinate" system was a recomputation of the old primary network as a single block and is, therefore, an updated 2:5^g W 1938 system. In the last two regions to be computed, the fixed stations have been chosen in the overlap zone whereby co-ordinates obtained in the new adjustment have been used.

Before the final adjustment is made, a series of smaller adjustments of the new measurements are run to finally clean the data. Normally, the region is broken down into blocks of between 15 and 20 stations which are then adjusted with one fixed station and a fictitious azimuth across the block. After error search and correction, two or more of the blocks are put together and a

new adjustment is made. The error-search procedure is repeated until the block size reaches a value close to the maximum programme capacity which is permitted without applying Helmbert principles.

To maintain the strength of the outer edges of the regions one or two rows of stations outside the boundary are included in the adjustment. The co-ordinates for these stations are, however, excluded from the lists of final co-ordinates. This procedure ensures that the outermost stations in a region are not computed using a "lop-sided" distribution of measurements.

THE LEVELLING NETWORK

The third relevelling of the Swedish national network was begun in 1979. As also was the case with the reobservation of the national triangulation network, classical measuring techniques have been replaced by newly developed methods, in this case motorized levelling methods. Motorized levelling was first put into large-scale operation in the German Democratic Republic. The Swedish methods are based on that system, but they have been successively modified and improved.

Equipment and personnel

A motorized levelling group consists of two surveyors and two assistants, an instrument-vehicle and two vehicles on which the levelling staves are mounted.

The instrument vehicle

A standard "pick-up" has been modified as follows: A hole was cut in the rear floor through which one leg of the tripod can pass without any contact whatsoever with the vehicle. The other two legs are placed outside the vehicle on the driver's side during the measuring procedure. A protective tubular framework was mounted on the floor, to protect the tripod from accidental knocks during the observing procedure.

A jack, to raise the tripod off the ground when moving between stations and to lower it for the measuring procedure, was welded on to the rear of the vehicle.

An internal radio-system was constructed to allow contact between the observer and the booker.

The passenger seat has been replaced by a table on which an electric calculator with memory storage units is mounted. The calculator is used both to record, store and calculate checks and height differences. All data are written on a paper tape. Experiments are at present in progress using programmed electronic data storage units. If they are successful such units will replace the calculators.

An electronic precision trip-meter was mounted above the dashboard as an aid for the accurate determination of the length of fore-sights and back-sights. To protect the instrument and tripod from wind, sun and rain, a special wind-shield, which can be erected over the vehicle platform as required, was constructed.

As a standard tripod is too low to be used for motorized levelling, a specially lengthened tripod was made. The instrument is not mounted directly on the tripod. Instead, a special type of mounting plate which permits rapid rough adjustment of the instrument is used.

Warning signs have been mounted on the front and rear of the vehicle according to the requirements of the Road Safety Authority.

The staff cars

These vehicles are standard. The only major modification carried out has involved the construction of a special door for the driver's side.

A staff car is fitted with the following special equipment:

(*a*) A tubular cage-like staff support which is mounted on the roof of the car using standard roof-rack brackets;

(*b*) A specially constructed mechanical arrangement which permits rapid mounting and demounting of the staff on the support;

(*c*) A lever mechanism for placing the staff in a vertical position from the driver's seat;

(*d*) An electronic precision trip meter;

(*e*) A heavy cast-iron base plate on which the staff is placed when observations are being made;

(*f*) A mounting arrangement on the driver's door on which the base plate is hung during transport;

(*g*) In the first motorized unit, vehicles with automatic gear-boxes were used. In the later units, vehicles with standard gear-boxes have been used;

(*h*) The equipment can be tailored to fit any type of vehicle from saloon cars to Land Rovers.

Instruments and staves

The Zeiss Jena Ni 002 high precision, self aligning level is the "heart" of the system. This instrument has been specially constructed to meet the requirements of motorized levelling.

The use of an elbow-joint eye-piece makes it possible to point the instrument and to observe both fore- and back-sights from one observing position. This is a fundamental requirement for motorized levelling. For ease of operation, the instrument is also fitted with symmetrically placed locking and slow-motion screws.

A significant development in this instrument is the use of a reversible compensator which permits readings in two positions (FL and FR), thereby minimizing the effect of collimation errors.

Wooden staves with an invar band and two graduated scales have been used. The temperature of the invar band is measured with the help of a thermistor attachment.

OBSERVING METHODS

Except when making connections to bench-marks which are located away from the road, all observations can be carried out without the surveyors or assistants having to leave the vehicles.

During the initial test period a problem which was frequently encountered was that of positioning the vehicles to obtain clear lines of sight of equal length. The following routine is now followed. After the rear staff vehicle has been parked and the staff placed on the opening bench-mark, the instrument vehicle driver chooses a suitable set-up, parks and stops the engine. The driver of the forward staff vehicle zeroes the tripmeter when passing the rear staff vehicle, reads off the distance when passing the instrument vehicle and continuing an equal distance beyond the latter, parks, turns off the engine and places the staff in position on the base plate. The base plate is tapped a few times with a specially con-

structed hammer to ensure a stable positioning before the staff is placed on it.

Whilst the forward staff vehicle is moving into position, the instrument tripod is lowered to the ground, the instrument is levelled and observations to the rear staff are begun. By the time the forward staff is in position, the first set of observations to the rear staff have been completed.

The observing routine is: compensator in position 1: rear staff, left scale, forward staff, left scale; compensator in position 2: forward staff, right scale, rear staff, right scale.

The readings are transmitted to the driver/booker via the built-in communications system where they are recorded and printed on the paper tape, using the calculating machine. Consistency checks are carried out by the booker. The height difference is computed and stored in a calculator storage memory. The observed height differences are accumulated as the levelling party proceeds to the next bench-mark.

In addition to the observational data, the number of the bench-mark, the date, time and length of the sights are printed on the paper tape. The tape is cut into lengths and stored in plastic folders.

For practical reasons the forward and reverse levelling is carried out on separate days and by separate observers. It has been found that the quality of the observations tends to deteriorate after an observer has worked more than an hour. This is due both to the monotony of the observing procedure, to the relatively large number of observed quantities and to the speed of the operations. For this reason the driver/booker and the observer change places after every bench-mark.

PRACTICAL RESULTS

Work with the second first-order levelling of Sweden was completed in 1967. Since then, only secondary and tertiary levelling has been carried out as part of a densification programme. The first-order levelling was carried out using well-known classical "foot" methods, whereas the parties carrying out lower order work use small, collapsible cycles as a means of transport between set-ups. To check both the accuracy and economy of motorized levelling, tests were carried out in the field with parties using both motorized and standard "foot" and "cycle" procedures and working in the same area. The test areas were chosen in areas of Sweden which represent a cross section of the country's topography.

Daily production

The average daily production, when carrying out secondary levelling, has been 11-12 km of single levelling. Between 8 and 11 kms of high precision single levelling can be observed per day (see table 1). Relevelling of lines which had to be rejected because they did not fall within specifications has been excluded.

TABLE 1.

Levelling method	*Length levelled*			*Delays*			*Production of single levelling of approved quality per day (km)*
	Total (km)	*Approved quality (km)*	*Relevelling (per cent)*	*Weather factors*	*Mechanical problems*	*Total*	
				(percentages)			
Cycle, 2-order	10 325	9 644	6-7	4.4	2.8	7.3	6
Motorized, 2-order	4 080	4 000	2	2.1	6.1	8.2	11-12
Motorized, 1-order $2\sqrt{L}$	4 900	4 500	5-10				8-11

The average has been computed for the whole period including time lost due to stoppages caused by poor weather, illness, problems with the vehicles etc. The average rate of progress has been 2.15 km per hour with an average sight-length of 40 m (maximum 50 m). The average measuring time per set-up, including transport between set-ups, varied between 2.0 and 2.5 minutes.

These results represent an increase in the daily production of 80 per cent and 120 per cent respectively when compared with classical methods of levelling using bicycles or on foot.

Cost comparisons

The cost for one kilometre of simple levelling includes the following factors: wages, social costs, subsistence allowances, instrument and vehicle investments etc. The relatively high wage level in Sweden makes the personnel cost factor very important: approximately 90 per cent of the total costs are from this source and only 5-6 per cent for equipment.

A standard, levelling party comprises one surveyor and two assistants, whereas the equivalent motorized levelling party is made up of two surveyors and two assistants.

The cost per hour for a motorized group is about 40 per cent higher than for a standard group. The price per levelled kilometre is 20 per cent lower than for a standard "cycle" party and 30 per cent lower than for a "foot" party. First-order levelling using motorized methods is approximately 50 per cent cheaper than classical first-order levelling.

Accuracy of the measurements

In second-order levelling, instructions specify that double runnings of a line between adjacent bench-marks must agree within $4\sqrt{L}$ mm. For first-order levelling the difference may not exceed $2\sqrt{L}$ mm.

A study of the differences has been carried out and the results are shown in table 2. The percentage of relevelling is 2 per cent for motorized levelling, 6-7 per cent for "cycle" groups and 6 per cent for "foot" groups.

Advantages of the motorized levelling techniques

The principal advantages can be summarized as follows:

(*a*) The negative effects of atmosphere refraction are reduced, owing to the increase in the height of the

TABLE 2. TEST MEASUREMENTS, 1975-1976
(*Percentages*)

Levelling methods	*Difference between forward and reverse levelling = $X\sqrt{L}$ mm/km*					
	0·1 mm	*1 - 2*	*2 - 3*	*3 - 4*	*0·4 mm*	*0·5 mm*
Cycle, 2-order	20	25	35	15	5	—
Motorized, 2-order	68	23	8	1	—	—
1-order	98	2	—	—	—	—

instrument above the ground: 2.0 m compared with an average height of 1.5 m for other techniques. According to Kukkamäki's well known formula the effect of refraction is, thereby, reduced by at least 50 per cent;

(*b*) Errors due to uneven loading which can arise when an observer moves around the instrument or when the assistant moves around the staff are reduced;

(*c*) Due to the speed of the observations, errors due to settlement or rising of the instrument and staves are reduced;

(*d*) More stable stave supports and stave base-plates facilitate more accurate readings on the staves;

(*e*) Continuous checks of the consistency of observations and closures are possible in the field;

(*f*) Better quality observations are possible due to the use of two observers working under relatively short periods;

(*g*) Rapid transport permits greater flexibility. The work is physically less tiring and, due to wind-shields etc, can be carried out under relatively poor weather conditions;

(*h*) Production is increased and costs decreased.

Disadvantages of the motorized method

A number of disadvantages are listed below:

(*a*) The size of the vehicles imposes restrictions on the location of lines along narrow roads. The road must be wide enough for the cars to pass each other;

(*b*) The location of bench-marks, which must be so placed as to minimize the amount of foot levelling, can give rise to problems;

(*c*) Traffic intensity can limit the choice of set-ups;

(*d*) Training costs are initially high;

(*e*) Refraction effects due to heat radiation from the vehicles can arise under certain conditions. This has not, however, been a significant problem up to date;

(*f*) Observing routines can give rise to errors of a systematic character;

(*g*) Initially high investment costs.

COMPUTATIONS

As was the case with the retriangulation of Sweden, and for similar reasons, the country will be divided into fourteen regions. Heights will be computed and made available as soon as possible after completion of the field-work. Computation of the fourteen regions will be based on Epoch 1970 heights, which is the currently used system, and the network will be given the best possible fit to the existing precision levelling net. This will be done for purely practical purposes. Acceptance of Epoch 1970, which replaced the 1900 system that had been in use for several decades, took considerable time, and to introduce a third system would meet with opposition from land surveyors. Therefore, the best way to take full advantage of the improved accuracy of the new measurements and to put them into use as soon as possible is to base the new heights on the existing system.

Prior to the computation an analysis of the old levelling lines will be carried to detect previously undetected errors and to correct for local crustal movements using the new measurements.

When the whole network has been levelled, a scientific adjustment will be carried out.

A total of more than 40,000 km of double levelling will be carried out using motorized levelling techniques. A limited amount of levelling, using classical methods, will be necessary to connect bench-marks along railway lines to the new lines along the roads. The programme will cost between 40,000,000 and 50,000,000 Swedish kronor.

An integrated system is being developed for field booking, computing and archive storage.

Finally computed heights together with intermediate data will be stored in data bases with rapid retrieval possibilities. The question of how to store station descriptions is still under discussion. Microfilming is one suggested solution.

When the levelling programme is completed Sweden will have both fundamental triangulation and levelling networks of high international class.

REMOTE SENSING OF THE NEW ZEALAND ENVIRONMENT*

Paper presented by New Zealand

RÉSUMÉ

La Nouvelle-Zélande utilise des données LANDSAT sur les ressources terrestres depuis 1973. Huit organismes néo-zélandais en explorent toute une gamme d'applications, notamment dans des disciplines d'importance économique comme l'agriculture, la sylviculture, les études de l'occupation des sols et les levés des zones côtières et maritimes.

La Section de télédétection du laboratoire de physique et d'ingénierie du Department of Scientific and Industrial Research (Département de la recherche scientifique et industrielle) est responsable de l'introduction et du perfectionnement des techniques nécessaires pour utiliser les données LANDSAT. Le laboratoire de traitement des images est maintenant en mesure de produire directement des diapositives couleur de haute qualité à partir des données numériques fournies par les analyseurs numériques placés à bord de satellites ou d'aéronefs. Le public néo-zélandais a accès aux copies des images LANDSAT par l'intermédiaire du Department of Lands and Survey (Département des affaires foncières et des levés).

Afin de pouvoir comparer la télédétection par satellite et par aéronef, on a construit une caméra multibande qui a été placée à bord d'un aéronef pour prendre des vues au moment du passage du satellite. On étudie de nouveaux analyseurs multibande dont l'un, équipé d'un dispositif à couplage de charge, été essayé en vol.

Toute la question de l'avenir de la télédétection est actuellement examinée par un comité patronné par l'Etat. Ce comité étudie notamment la possibilité de prévoir comme équipement national soit un analyseur aéroporté, soit une station de réception pour le système LANDSAT et les futurs satellites d'étude des ressources terrestres. Les techniques de traitement des images auront vraisemblablement une incidence dans des domaines autres que le traitement des données obtenues par satellite, tels par exemple que celui du stockage de données numériques concernant l'environnement aux fins de reproduction ultérieure sous forme de cartes ou pour utilisation en association avec les images mêmes obtenues par satellite.

LANDSAT and its associated technologies have revolutionized the science of remote sensing in recent years. The spacecraft makes a unique observation platform, providing views of the earth that differ in fundamental ways from those originating closer to the earth's surface. Ground processing techniques have had to be developed to convert the numerical data from the spacecraft scanner into recognizable pictures. New types of scanner have enabled detailed views of our terrain to be acquired, using regions of the spectrum not accessible to the human eye or the camera.

It is not perhaps so readily appreciated that these new technologies will have a profound impact on other more traditional sciences. The storage, processing and display of all forms of environmental data could, at least in principle, be handled by the computer, with high quality hard-copy output products produced on special peripheral instruments. LANDSAT and other satellite data will merely be one input to an existing data bank.

New Zealand became involved in the LANDSAT programme in 1973 with the formation of the Remote Sensing Section at the Physics and Engineering Laboratory of the Department of Scientific and Industrial Research (DSIR). Its several roles include acting as a focal point for liaison with the National Aeronautics and Space Administration (NASA) of the United States of America concerning environmental satellites, and as a co-ordinating agency within New Zealand. It is also responsible for introducing overseas technology and developing an indigenous technology for processing and analysis of these new forms of data, and for providing this service to users around the country.

The LANDSAT 2 investigation programme began in 1975 with a formal agreement between NASA, DSIR and three user groups, in the Department of Lands and Survey, the New Zealand Geological Survey and the Forest Research Institute.

Initially, the Section set up a photographic laboratory with a colour additive viewer to produce and distribute colour composite prints, made from the monochrome transparencies originating from NASA and the Eros Data Center. As the two-year investigations progressed, the major effort was directed towards analysis of the Computer Compatible Tapes (CCTs) containing the original digital (numerical) data as received from LANDSAT.

In parallel with the satellite projects, an aircraft multispectral camera was developed to provide underflight pictures of the same type as those from the LANDSAT multispectral scanner (MSS). This enabled a direct comparison to be made between aircraft and satellite imagery, and efforts were made to obtain simultaneous coverage of some of the test areas.

By the end of the LANDSAT 2 investigations, eight organizations were involved, and the final report to NASA consisted of 32 papers covering developments in the technology and applications in cartography, land-

*The original text of this paper, prepared by P. J. Ellis, Department of Scientific and Industrial Research, appeared as document E/CONF.72/L.6.

use planning, geology, forestry, agriculture, hydrology and coastal and marine studies.

During this two-year period, 50 scenes of New Zealand were acquired from LANDSAT 2. The "land of the long white cloud" frustrated many attempts to cover key areas at critical times of the year, and this has impeded the progress of some of the projects. However, sufficient experience has been gained to show that regular and timely reception of satellite pictures could benefit many of the earth sciences, and provide a cost-effective way of monitoring our environment.

In 1978, several of the groups associated with the programme assisted DSIR with the purchase of a colorwrite machine, which generates high quality colour transparencies directly from the digital data. This avoids the image degradation which is inevitable with fourth or fifth generation photographic products, and opens the way to the many forms of image processing and enhancement available via the computer.

Standard versions of these products are now generally available within New Zealand, and can be purchased through any district office of the Department of Lands and Survey.

The present work involves acquisition of imagery from LANDSAT 3 and other environmental satellites, refinement of the image processing techniques, development of an interactive analysis system, a new aircraft scanner and ground radiometric measuring equipment. Earth scientists are encouraged to use the analysis facilities, and assistance is provided to several groups of users. The whole future of remote sensing in New Zealand is under discussion, and the Section is involved in evaluating possible courses of action.

General conclusions from the LANDSAT 2 investigations

Resolution

Most land-based targets in New Zealand tend to be physically smaller than their counterparts elsewhere, for instance in Australia or the United States. Moreover, a wide diversity can occur within a small area. The field sizes in an important cropping region, such as the Canterbury Plains, vary between about 2 and 10 hectares, that is, between about 5 and 25 picture resolution elements (pixels) of the present LANDSAT MSS. Man-made structures such as roads or bridges can sometimes be detected, but details of urban areas are generally insufficient to give more than a broad idea of the urban environment.

Target classification requires an accurate measurement of spectral signature, that is, of the target radiance in several spectral bands. To avoid adjacency effects with adjoining areas, each target needs to cover at least 10 pixels for an accurate classification to be made. Our experience with the LANDSAT 2 investigations indicates that an improved spatial resolution may extend the potential applications considerably, particularly in cartography, urban studies and in mensuration of small areas such as forestry wood lots. The proposed 30-metre resolution of LANDSAT D thematic mapper could be quite significant for applications in this country.

Spectral bands

The only bands used in these investigations were those of the LANDSAT MSS (500-600 nanometres (nm), 600-700 nm, 700-800 nm and 800-1100 nm). The aircraft underflights used four bands which corresponded to these within the limitations of photographic film. The results confirmed the overseas findings that MSS bands 4, 5 and 7 were most useful for vegetation analysis and analysis of band features in general. All four bands have been successfully used in estuarine studies where the differential water penetration has helped to establish band/water interfaces and to estimate the movement of suspended sediment.

Timeliness and change detection

Intervals of up to three months or more can elapse between the time of LANDSAT data acquisition and its arrival in this country. During the LANDSAT 2 investigations this was not so much of a problem because of the experimental nature of the projects. It soon became clear that one of the greatest attributes of the satellite imagery was in its ability to detect and record change. At different seasons of the year, the patterns of growth in the major cropping regions could be clearly seen, and in many cases related to local variables such as soil moisture (Thomas *et al.*, 1978a).

Over a longer period of 2/3 years, variations in some hydro-lake levels could be monitored, as could the sediment flow in major rivers (Ellis, 1978a). It is felt that satellite data acquired over the years could provide a valuable record of long-term historical changes and shorter-term seasonal effects.

Operational use of the data will certainly require timely and regular coverage. This seems at present to be possible only with a local receiving station. The limited number of scenes of New Zealand obtained during the two-year investigation period were due not only to the high incidence of cloud cover but also to priority considerations of the on-board tape recorder. Local data reception and several satellites simultaneously in orbit could greatly improve this situation.

Applications

Although New Zealand is mainly covered with vegetation, the general topography can be clearly seen from LANDSAT, and the New Zealand Geological Survey have used the data to map numerous linear features, in some cases for the first time (Oliver, 1978). More recently, some of the South Island scenes have revealed circular features averaging about 20 km in diameter, which are believed to be associated with mineralization. A prospecting company is using the imagery to aid its investigations in one of these areas.

The New Zealand Forest Service and Research Institute have used LANDSAT scenes in projects to detect areas of disease (*dothistroma*) (McGreevy, 1978), and to assist in a general inventory of indigenous and exotic forests (Ching *et al.*, 1978). Attempts to map *dothistroma* have been unsuccessful, but there is evidence to suggest that beech scale disease can be detected in the South Island forests. The forest inventory work is continuing at the present time.

In cartography, the Department of Lands and Survey have used LANDSAT scenes in the production of hill-shaded maps, aeronautical charts and in the new metric map series (Child and Dickson, 1978). The scales vary from 1:250,000 to 1:2,000,000. Another cartographic application has involved LANDSAT scenes of off-shore regions and of the Pacific Islands (Thomas, 1979). The

large area coverage and orthogonal nature of the LANDSAT image enable the relative positions of islands and reefs to be established, while the water penetration properties of MSS band 4 reveal the details of the reef and shallow water areas.

Several regions within New Zealand have been the subject of intensive land-use studies. The Department of Lands and Survey has a continuing investigation into the applications of LANDSAT imagery in this discipline. The LANDSAT 2 studies have shown that the following types of target can generally be classified: urban areas, indigenous forest, exotic forest, scrub, pasture, crops, bare soil, water, tussock grassland, bare rock and snow. Subdivisions within these categories can often be seen, but the results are inconsistent when extrapolated over large areas.

At the beginning of the LANDSAT 2 studies, the Remote Sensing Section established an agricultural test site in mid-Canterbury to see if major crop types and the distribution of stress in crops could be detected and mapped. The project has been hampered by lack of imagery at the right time of the year, but it has been established that major crops such as cereals can be seen from imagery acquired in late spring. However, the varying soils and moisture regimes have at present prevented the analysis from being extended to regions far beyond the test sites. The general stress pattern in crops over large areas of the Canterbury Plains is clearly detectable, and has been correlated with known soil moisture measurements.

Apart from the capability to map soil moisture patterns, LANDSAT imagery has also been used in snow mapping (Thomas *et al.*, 1978b), an important feature in a country which relies heavily on hydroelectric power. This is a continuing project involving staff of the University of Canterbury.

Another group within the University of Auckland have used LANDSAT scenes to study the sediment transport patterns around our coasts and in Lake Taupo, our largest freshwater lake (Cochrane *et al.*, 1978). Similar studies by the Remote Sensing Section in a marine estuary, the Pauatahanui inlet (Thomas, 1978), have demonstrated that bathymetric information can also be derived from LANDSAT data.

Image processing and analysis

Production of colour composites from monochrome transparencies suffered from two disadvantages. The first was the degree of effort required with each scene to achieve a satisfactory registration between the three images in the colour additive viewer. The second was the lengthy and costly photographic processing required to produce even the simplest colour enhancement.

The advent of the colorwrite machine has opened the way to the generation of computer processed images in colour, with near-perfect registration. The machine is interfaced to a Varian V76 time-sharing computer, and a package of programmes has been prepared to write LANDSAT images to colour film, with a variety of optional enhancements available to the user (McDonnell, 1979).

Each LANDSAT scene received from the Eros Data Center is written to film using a histogram equalization enhancement, which stretches the colours to fill the available dynamic range of the film, and emphasizes the differences between colours of the larger targets. Another enhancement scales the colour range and grey tones to provide a better match with the response of the human eye. The resulting products are used as the standard from which duplicates are made, and large scale prints from these are then made available to the public via the district offices of the Department of Lands and Survey.

Other available enhancements include those favoured by overseas image processing laboratories, including linear stretching and principal components transformations.

As our experience with LANDSAT images increases, the need to match an image with a standard map, or to combine two images taken at different times, becomes more evident. A geometric rectification programme (McDonnell, 1978) permits each image to be fitted to any desired map projection, using a matrix of ground control points to effect the match. The known errors due to the characteristics of the MSS are first corrected, and these corrections also include an allowance for the earth's curvature and perspective distortion. A simple polynomial interpolation is then used to achieve a fit with a mean error of about 0.5 pixels.

One way of combining other information with a LANDSAT scene is to generate an artificial stereo pair, in which the stereo effect is directly related to the magnitude of the new variable. This approach was first developed by a group at the Minerals Physics Laboratories, CSIRO, Australia, to combine geomagnetic data with the LANDSAT picture. The colorwrite is now used to output these products in which the "topography" represents the strength of the local magnetic field.

The combination of LANDSAT pictures into mosaics can usefully be accomplished in the computer, particularly for images that have been acquired consecutively during a single LANDSAT overpass. In this case, the two scenes can be perfectly matched by simply ensuring the proper sequence of rows from one image to the other. Work is in hand to prepare a computer mosaic of the whole country, by rectifying each image and matching the colours as far as possible.

It is also intended to combine map data with satellite imagery in the form of line overlays. This has already been demonstrated with purely photographic methods, using the topographic compilation data provided by the Department of Lands and Survey (Thomas *et al.*, 1978b). Good registration can be obtained even with the system corrected (unrectified) LANDSAT imagery, because of the intrinsically orthogonal nature of the LANDSAT image. The next step is to digitize the map data in a raster scan form similar to that from LANDSAT, and to make the overlay using fully rectified imagery.

The in-house Varian computer is comparatively small, and is more suited to the on-line processing of an image before it is finally written to the colorwrite. The Section has access to an IBM 370/168 in Wellington, via the local terminal. The computer is operated by the Ministry of Works and Development and has terminals in major cities throughout New Zealand. A package of programmes has been written for this machine, enabling most of the more common forms of analysis to be conducted by users in different parts of the country (Thomas *et al.*, 1979). Copies of all New Zealand LANDSAT CCTs are routinely kept at the computer

centre. The greater speed and capacity of this computer permit more elaborate computations to be made than would be practicable with the in-house machine.

Much of the work is directed towards classification of targets by spectral signature, and the results can be displayed on a local lineprinter, or a tape prepared for subsequent output on the colorwrite. The LANDSAT scenes can be enhanced by an edge sharpening process, and it will soon be possible to rectify a full scene and combine images taken at different times of the year.

Every advantage is taken to compare the image processing and analysis work with similar projects overseas. Recently, an agreement has been concluded with IBM New Zealand Ltd, to use the IBM LANDSAT analysis package known as ERMAN (Earth Resources Management System). This is being installed in Sydney, Australia, and permits the user to work through a menu of programmes while observing the results of his analysis on a colour CRT screen. The New Zealand projects to be analysed on this system consist of a land-use study of the "King Country" region, west of Lake Taupo, a study of some of the North Island forests, an analysis of imagery of the mid-Canterbury agricultural test site, and a study of the harbour and estuary at Tauranga.

The advantage of the interactive analysis system is in the speed with which the results are displayed, allowing the user to try numerous options before reaching a final decision. At present, using only the colorwrite machine, it is necessary to iterate towards the desired final product, with an expensive photographic processing stage between each iteration. This process is already causing problems as more specialist products are evolving, such as thematic maps showing each classification in a different colour.

To alleviate the problem, an interactive system with CRT display is being constructed, with microprocessor control and linked to the Varian computer. Eventually, most of the options available on large overseas machines should become available in this country.

Fundamental Studies

When attempting to classify targets from remotely sensed imagery, one is besieged by extraneous variables which degrade the data and confuse the final analysis. One such variable is atmospheric transmission, affecting the radiance of the ground target as seen by the spacecraft. Another is the variation in soil moisture, which causes regional variations in spectral signatures.

A series of atmospheric extinction measurements has been made over several years in New Zealand (Ellis and Duggin, 1978), using a LANDSAT radiometer with spectral bands approximating to those of the MSS. It has been possible to derive an average extinction coefficient for each band, and these figures are used for routine correction of the LANDSAT digital data.

The radiometric instruments and scanners themselves will introduce variables due to imperfect matching of the spectral responsivity of each instrument. The effect of this has been studied (Ellis and Fowler, 1978) for instruments used in the laboratory and for the LANDSAT scanners.

A field spectrometer is being constructed, and will be used to compile a library of spectra of different targets at different seasons of the year. This should help to determine the feasibility of projects and the choice of filters to be used in, for instance, an aircraft survey.

Finally, the design is nearly completed for a miniature hand-held radiometer, with all-digital display, and capable of recording radiances simultaneously in eight spectral bands. It is planned to make several of these instruments, and to distribute them to users for field application.

Remote Sensing from Aircraft

The aircraft multispectral camera has been involved in soil type surveys, studies of tidal flow in estuaries, archaeological site detection, mapping of soil erosion, snow studies, and in several agriculture and forestry projects (McDonnell *et al.*, 1978). Recently, as part of a wildlife project, a series of colour composites have been made of the Takahe valley in the southern South Island (Mills and Fowler, 1978). The takahe (*notornis*) is a very rare flightless bird, once thought to be extinct. The New Zealand Wildlife Service are conducting surveys of the breeding pairs, and assessing the availability of their food supply (mainly tussock grass). The colour composites show the relation between the territory of each pair of birds and the tussock species. From these pictures the vegetation preferred by the birds can be identified, and has been shown to contain a better balance of trace elements than in the less favoured regions.

Most of the results of our surveys have demonstrated that the versatility of the multispectral camera offers advantages over single camera photography using, for instance, false colour infra-red film. We are now able to digitize each multispectral transparency with a laboratory scanner, which permits the data to be processed by the computer in a similar way to the LANDSAT images. However, it is not easy to relate the film density to an absolute value of target radiance, because the photographic medium is not well suited to quantitative measurements. The most successful technique so far has been the combination of the human interpreter and the photographically enhanced false colour composite.

These limitations can be overcome if an imaging scanner utilizing electronic sensors is employed. This has the advantage of a linear relationship between target radiance and sensor response. Also the sensor tends to be more stable and to have a greater dynamic range, and a fundamental difference is the ability of the scanner to extend into regions of the spectrum not available to photography.

We have therefore instituted a contract with the Department of Electrical Engineering at the University of Canterbury, to investigate the performance of Charge Coupled Devices (CCDs) as sensors for an airborne multispectral scanner, and to build a prototype system for flight trials.

A single channel system has been made, and successfully completed its first test flight in September 1979.

Conclusions

The LANDSAT programme has provided the impetus to look closely at the role and applications of remote sensing in New Zealand. One result has been the development of an image processing laboratory in this country. Another has been the improvement of aircraft remote sensing capabilities.

A government-sponsored committee is examining the need for the provision of an all-digital aircraft scanner as a national facility, and for a possible receiving station for direct reception of earth resources satellite data. Our

interests extend further than the present LANDSAT series. Already, a number of scenes of this country and its coastal regions have been acquired by the Coastal Zone Colour Scanner (CZCS), aboard the spacecraft Nimbus 7. Sensors for maritime studies, such as the CZCS, and maritime satellites, such as SEASAT, could one day be of major importance to this country, with its Extended Economic Zone (EEZ) of 4.2 million square kilometres.

Whether the future sources of data are from aircraft or satellites, or both, it seems certain that remote sensing will be cost-effective in several applications of economic significance. The applications could include cartography using, for instance, sensors now being developed such as the Metric Camera (Europe), or the Large Format Camera (United States), due to be launched by the space shuttle. It is feasible to use the new image processing technology to manipulate mapping and other environmental data within the computer, and to generate high quality display products directly from the digital data base. The future will see all these techniques being exploited to an unprecedented extent.

REFERENCES

The following papers appear in "LANDSAT II over New Zealand", P. J. Ellis, I. L. Thomas and M. J. McDonnell, eds., *DSIR Bulletin*, publication ISSN-0077-961X (Science Information Division, Department of Scientific and Industrial Research, P.O. Box 9741, Wellington, New Zealand).

I. L. Thomas, M. J. McDonnell, P. J. Ellis, A. D. Fowler, R. C. Child, C. T. Nankivell, R. S. Mason (1978*a*), "Monitoring some aspects of New Zealand's agricultural programme with LANDSAT: a preliminary report", chap. 10.

P. J. Ellis (1978*a*), "The LANDSAT II investigation programme in New Zealand", summary paper, chap. 1.

P. Oliver (1978), "Seismotectonic, structural, volcanologic and geomorphic study of New Zealand", chap. 15.

M. G. McGreevy (1978), "Indigenous forest assessment", chap. 16.

N. P. Ching, B. M. Lean, R. W. Dale, I. L. Thomas, A. J. Lewis, P. Hay, A. D. Reid, I. R. Hunter (1978), "LANDSAT imagery as applied to forest management", chap. 19.

R. C. Child, P. Dickson (1978), "Mapping, land use and environmental studies in New Zealand", chap. 14.

I. L. Thomas, A. J. Lewis, N. P. Ching (1978*b*), "Snowfield assessment from LANDSAT", chap. 11.

G. R. Cochrane, M. Bellingham, A. G. R. Male, G. H. Campbell (1978), "Auckland University LANDSAT projects", chap. 18, 18.4-18.7.

I. L. Thomas (1978), "Sediment/siltation monitoring within a tidal basin using repetitive LANDSAT MSS Computer Compatible Tape data", chap. 12.

M. J. McDonnell (1978), "Digital image rectification system for LANDSAT and aircraft imagery", chap. 8.

I. L. Thomas, R. C. Child, H. A. Jefferies, D. McScott, A. D. Fowler, S. R. L. Richards (1978*b*), "Some cartographic applications of LANDSAT data", chap. 13.

P. J. Ellis, M. J. Duggin (1978), "Atmospheric measurements", chap. 4.

P. J. Ellis, A. D. Fowler (1978), "LANDSAT radiometry", chap. 3.

M. J. McDonnell, I. L. Thomas, P. J. Ellis, A. D. Fowler, R. S. Mason, R. C. Child, C. T. Nankivell (1978), "Data acquisition and distribution", chap. 2.

Other

I. L. Thomas (1979), "Applications of LANDSAT to monitoring the Pacific Islands", Proceedings of the Pacific Islands Water Resources Symposium, Wellington, 26-28 June.

———, R. C. Barrett, V. M. Benning (1979), "Classification and textural enhancement using the DSIR LANDSAT ANalysis SYStem (LANSYS1) computer package", Proceedings of LANDSAT '79, Sydney, 22-25 May.

M. J. McDonnell (1979), "Computer image processing and production at PEL", paper presented at the 49th ANZAAS Congress, University of Auckland, New Zealand, 22-26 January.

J. A. Mills and A. D. Fowler (1978), "Use of multispectral aerial photography for assessing Takahe habitat", Proceedings of the 4th Pecora Symposium, Sioux Falls, South Dakota, United States of America, October.

SURVEY CONTROL SYSTEM*

Paper presented by New Zealand

RÉSUMÉ

Le document décrit la mise en place et l'utilisation du réseau géodésique en Nouvelle-Zélande.

Après un bref aperçu historique des premiers faits qui ont abouti à la mise en place du réseau géodésique en 1949, le Département expose les progrès réalisés par la suite qui ont permis des améliorations sensibles.

Le document fait une très large place aux fondements légaux et administratifs du réseau géodésique, placé sous le contrôle du Géomètre principal du Department of Lands and Survey (Département des affaires foncières et des levés), et décrit aussi la façon dont les levés géodésiques sont coordonnés, planifiés, exécutés et enregistrés, quel que soit leur objet. Le Département joue un rôle central très important dans l'organisation et la coordination des travaux, mais d'autres services gouvernementaux, les autorités locales et des géomètres du secteur privé apportent aussi une contribution importante, que le Département encourage.

Les spécifications touchant la conception, le travail sur le terrain, la compensation, l'enregistrement et la publication des données sont fixées par le Département mais ne sont pas exposées en détail dans le document.

*The original text of this paper, prepared by A. J. Bevin, Department of Lands and Survey, appeared as document E/CONF.72/L.7.

Les procédures administratives sont essentiellement les mêmes pour le réseau de triangulation primordial et pour les levés géodésiques secondaires ou complémentaires, pour lesquels la responsabilité est déléguée en grande partie aux géomètres en chef locaux, qui sont également responsables de tous les levés de biens fonciers et du cadastre en général.

L'altimétrie par nivellement de précision est un aspect de la construction du réseau géodésique, et les procédures administratives, de coordination et d'intégration, sont les mêmes que pour la planimétrie. Des progrès considérables, sur le plan à la fois des instruments et des méthodes, ont été accomplis en ce qui concerne l'extension du nivellement de précision, initialement réservé aux travaux scientifiques.

Le principal aspect du réseau géodésique est l'existence d'un organisme administratif coordonné et centralisé, doté de la structure et de la souplesse voulues pour répondre à toutes sortes de besoins qui évoluent sans cesse.

The paper on the integrated survey system in New Zealand, presented to the Eighth United Nations Regional Cartographic Conference, January 1977, by W. N. Hawkey, provided a broad and comprehensive description of the New Zealand survey system and its elements.

The purpose and intention of this paper is to describe in general terms those elements: the National Geodetic Survey Control Network and Subsidiary Control, its origins, development, administration, specifications and some possible future developments. Space does not permit a detailed and definitive description of the system; these have been described elsewhere, and reference to them is made in the bibliography.

In this paper the survey control system is defined as:

(*a*) *Geodetic*: first, second and third order triangulation, in which the shape of the earth and projection corrections are systematically applied and the work rigorously adjusted;

(*b*) *Subsidiary*: controlled by geodetic survey so that only arbitrary adjustment on local projections and limited application of projection corrections is required;

(*c*) *Precise levelling*: a highly accurate network of differentially levelled bench-marks from which all vertical control is derived.

Background

The first triangulation surveys in New Zealand were carried out in the 1840s, in conjunction with early European settlement, but these were piecemeal, localized, and generally of low standard, barely sufficient to meet demands of new settlers for land holdings.

The origins of the national control system can be identified as starting with the abolition of the provinces and the setting up of a central Government in 1876. The Surveyor-General of the newly created Department of Lands and Survey established 12 land districts (based on the old provinces) each with its own Chief Surveyor, and a system of 29 plane meridional circuits covering the country. Minor triangulations were then extended throughout the country, where required, for settlement surveys.

The principle of working from the whole to the part was well recognized at this stage by the Surveyor-General, and meridional circuits were devised to keep surveys in terms until a primary triangulation could be undertaken and the local circuit triangulations tied together. A report on the state of the provincial surveys in New Zealand, together with recommendations for reform and a primary triangulation, had been made by Major Palmer, R.E., in 1875, at the request of the central Government.

The primary triangulation, later called the geodetic triangulation, was commenced in 1909 with the measurement of baselines and, with interruptions of two world wars and an economic depression, was completed in 1949—thus establishing the geodetic datum, 1949. The history of this triangulation and its results are comprehensively and lucidly described in Lee, 1978.

The early survey control system (prior to the 1949 datum) was based on the plane meridional circuits, each having an origin at which the position and an azimuth were determined astronomically. Some, but not all, were also connected by the minor triangulations. The triangulations were computed as plane (i.e., no projection was used at this time) and adjustment methods were limited.

Development since 1949

Second and third order extension

Extensive second and third order networks have been established over large areas of both islands, subsequent to completion of the first order. Where first order triangulation was not provided, notably the west coast of the South Island, geodetic coverage is being extended by second and third order triangulation networks. These utilize, wherever possible, existing trig stations and have enabled many old stations to be reco-ordinated in terms of the geodetic network. A further result of this has been the recomputation and readjustment of old "plane" triangulations to fit the newer geodetic control. This work, rated as "fourth order", is upgraded as new field-work is completed, and provides interim geodetic values, mainly for mapping and cadastral survey.

Introduction of electromagnetic distance measuring

With the introduction to New Zealand of the microwave tellurometer in 1959, extensive traverses were run throughout the country, particularly in the more remote areas of the South Island, to provide mapping control, and for a while considerable reliance was placed on second and third order tellurometer traverses for most geodetic control.

More recently laser geodimeters have also been used for second and third order traverses for mapping control in remote areas; however they are used more to

strengthen first and second order triangulation networks, and for high-precision surveys.

Infra-red EDM has been used mainly on third order and subsidiary control traverses.

Doppler satellite surveys

This new technology was first introduced to New Zealand in 1966-67 with the establishment of two satellite stations, as part of the world-wide PAGEOS and TRANET geodetic networks.

In 1975 and 1977 a United States team came to New Zealand to monitor the GEOS-3 satellite, and at the same time this team with the support of the Department of Lands and Survey established 19 Doppler stations throughout the country, including 4 on the Chatham Islands, using precise empheris values. These satisfy the specifications recently set by Commission 10 (Continental Networks) of the International Association of Geodesy. In 1979 a Magnavox 1502 was made available for evaluation, and a further 3 stations were established, as well as reobservations made at Kelburn observatory, where latitude and longitudes for the New Zealand geodetic datum were observed. Seven of the satellite stations were at, or close to, existing Laplace stations.

New Zealand has now probably sufficient coverage of Doppler satellite fixes to relate the geodetic datum to the various satellite datums. The use of this equipment and newer developments is being considered for positioning of isolated islands and off-shore facilities, and for control work in the Antarctic.

Geodetic astronomy

Very little geodetic astronomy has been undertaken since the completion of astronomical observations for the geodetic datum in 1949. However the establishment of first order geodetic networks for earth deformation studies and the recent extension of geodetic control into areas not covered by first order have generated a need for additional precise and geodetic astronomical work, and a programme is being implemented to:

(*a*) Monitor any regional crustal rotation along EDS networks by observation of geodetic astronomical azimuths;

(*b*) Provide azimuth control on major geodetic control extensions;

(*c*) Measure deflections of the vertical, by Laplace observations on the EDS networks and on major geodetic control extensions.

Earth deformation surveys

The introduction of a scientific programme to monitor crustal movements in New Zealand requires the survey, to first order standards, of seven chains of combined triangulation and trilateration across the country, to include existing first order and selected second and third order stations. Although primarily for scientific purposes, these surveys have also been designed and carried out with other survey and mapping control requirements in mind, and the opportunity is taken to establish additional geodetic control, as required, for potential development. As a matter of policy these earth deformation surveys are also incorporated into the national survey records.

ADMINISTRATION OF GEODETIC CONTROL

Statutory

The Land Act, 1948 (section 33), places all trigonometrical, standard and topographical surveys and precise levelling under the authority of the Surveyor-General. This, combined with the Surveyor-General's chairmanship of the Survey Board and the Department of Lands and Survey's administration of the survey regulations governing cadastral survey, has effectively integrated the geodetic survey and the cadastral system into one national survey system.

Other functions of the Surveyor-General, as detailed in W. N. Hawkey's paper, effectively ensure that other related survey and mapping activities are referenced to the national survey system and that one system serves all government, national, local body, and public requirements. This is effected by Lands and Survey chairmanship of an interdepartmental Survey and Mapping Co-ordination Committee, which meets bimonthly and comprises the Department of Lands and Survey, the Ministry of Works and Development, the New Zealand Forest Service, the Housing Corporation and the Department of Scientific and Industrial Research. In this way the survey and mapping requirements of the various departments are rationalized, given priorities and integrated into one current programme, co-ordinated by the Department of Lands and Survey.

Policy and programming

Arising from the Department of Lands and Survey's statutory and recognized responsibility as the national survey and mapping agency, the policy is that the Department sets specifications, carries out field-work, adjusts, records and publishes all geodetic control. No alteration to any records or monumentation can be made without departmental check and approval.

With increasing and competing demands for control, it became obvious that a more systematic approach was required to optimize the limited survey and mapping resources available. To achieve this the Department has instituted a five-year survey control programme based on the forecasted requirements of various government departments (e.g. the Ministry of Works and Development, the New Zealand Forest Service and the hydrographic branch of the Royal New Zealand Navy) and local authorities, and requirements for scientific research, basic mapping, and the maintenance and extension of the survey control as indicated by district offices of Lands and Survey.

Geodetic control surveys are generally carried out either for extension of basic control framework, or for a particular purpose, such as small-, medium- or large-scale mapping, mining, navigational, engineering control, land subdivision, scientific public utility, land utilization and conservation. Notwithstanding the initial purpose, the control framework is designed and executed to meet all other anticipated survey control requirements in the particular area.

Design and specifications

Partly as a result of problems in adjustment and discrepancies due mainly to a lack of geometric strength in earlier electromagnetic traverses for geodetic control,

Lands and Survey policy for designing new and revising existing control networks is to rely on conventional triangulation design with its inherent geometric strength.

In this context the role of electromagnetic distance measuring is to provide additional strength and flexibility in design, especially in areas where it is difficult to obtain sound triangulation figures and where additional scale control is necessary. Generally EDM is used to run traverses through the triangulation network, between existing fixed points. As it happens, New Zealand topography is generally well suited to triangulation.

Trilateration has been used in earth deformation surveys, in conjunction with triangulation, to obtain maximum accuracy. These surveys will be used to analyse the relative accuracies of triangulation and trilateration, or a combination of both, and it is possible that trilateration only will be used in future to repeat these surveys.

Field-work

The reconnaissance, initial scheme design, beaconing, groundmarking, and observations are carried out by the survey staff of the local Lands and Survey district offices, under the direction of the Chief Surveyors, and according to the specifications set and the design as approved, by the head office. Where surveys extend across two land districts, staff from both offices involved work together, either as one team or in close co-ordination. For major projects selected staff may be drawn from several offices to work together as a project team. District staff carry out preliminary reductions to check for correctness of the field-work before forwarding to the head office.

Maintenance

Maintenance of ground-marks, beacons, location, and access descriptions is carried out and recorded in district offices with the head office advised of details concerning changes in ground-marks. The position of trigonometrical stations is protected by statute, and any authority, department, or organization intending works likely to endanger these marks must notify the Chief Surveyor.

The responsibility for maintenance extends also to subsidiary control and cadastral survey marks and, with the continual development and construction activity by many different agencies, has become a major problem. A serious concern is that many agencies are not even aware of the existence of survey marks when construction work is commenced. It is hoped that recent legislation, which places greater emphasis on the responsibility of the construction agency concerned to protect the marks, will greatly reduce this problem.

Contribution by other government departments

A limited amount of geodetic control is carried out by the Ministry of Works and Development and New Zealand Forest Service in connection with local survey control for their project activities, and by the Department of Scientific and Industrial Research in connection with Earth Deformation Studies. The bulk of geodetic and mapping control for these organizations is done by Lands and Survey, and on occasion survey staff from the various departments have worked as one team, to fully utilize the available survey resources.

Where such activities will contribute to or strengthen the geodetic network scheme, plans are submitted to the Lands and Survey head office for investigation and approval, and the work is carried out to Lands and Survey specifications. The field observations are then adjusted by the Lands and Survey computing branch and incorporated in the survey control records.

Work carried out by other agencies or private surveyors, if of the required standard and density, is similarly incorporated into the survey control records.

Adjustment and publication

The head office computing branch is responsible for the reduction of all observations related to geodetic control and the maintenance and publication of all related records.

The international spheroid has been adopted for all geodetic work in New Zealand.

Currently all adjustments are computed by variation of co-ordinates on the spheroid, in terms of the geodetic datum, and the resulting geographic co-ordinates converted to co-ordinates in terms of the appropriate map projection.

Projections used for mapping purposes in terms of imperial units are the two transverse mercator national grids, one each for the North and South Islands. Since the change to metric units in 1972 a new map projection, devised especially for New Zealand, is in use. In this case the whole of the country is mapped on the one projection.

The existing meridional circuits have been retained for cadastral and subsidiary control purposes, each now being a transverse mercator projection with the circuit initial as the origin of projection. Metrication of these was effected by converting the existing link co-ordinates to metres, the introduction of a false origin and in two cases an overall scale reduction factor has been applied.

The basic records are maintained by the computing branch on a record card system, generally a separate card or cards for each station, plus a summary of trig stations and bench-marks in terms of New Zealand Map Series map sheets.

A graphical record is also maintained, showing the order of the triangulation, the directions observed and lines measured. Copies of all records are distributed to the district offices where they are freely available, without charge, for public use.

SUBSIDIARY CONTROL

Administration

Subsidiary control is generally carried out within a framework of geodetic control, for various mapping, engineering, navigational or cadastral purposes. This system is administered and controlled at district office level by the Chief Surveyors, to general specifications and programming set by the head office. These surveys are co-ordinated on local meridional circuits, wherever possible in terms of the geodetic datum 1949, and are recorded only in the district offices.

Urban and rural control traverses

The Department of Lands and Survey has made extensive use of modern short range EDM, traversing, and levelling equipment to provide intensive and permanently monumented control traverses in urban and closely settled rural areas. The primary purpose of these

traverses is to provide control for cadastral surveys, to preserve the definition of existing title boundaries and to reference the existing old control and cadastral surveys to the geodetic datum. Accordingly, considerable emphasis is given in these traverses to connections to salient cadastral survey marks and to permanent boundary occupations.

Other purposes of the urban and rural control traverses are to control local surveys for large-scale mapping, engineering design, utility location, and to co-ordinate precise level bench-marks.

Mapping and other minor control surveys

Ground survey control requirements for modern medium- and large-scale photogrammetic mapping are generally of a standard suitable for other uses, such as cadastral, and except in very remote undeveloped areas are generally carried out as multipurpose minor control surveys.

Contribution by other agencies and the private sector

Many minor control surveys are carried out by other agencies, and more particularly by the private sector, for large-scale mapping, land development, engineering and land subdivision. These are generally all based on geodetic control or previous surveys and provide continuing further extension and densification of the survey system. Plans of cadastral surveys have, by statute, to be lodged with and approved by Chief Surveyors, and as the various survey agencies and private sector recognize the considerable advantages of an integrated and centralized survey control and record system. Plans or data of other control surveys are generally also lodged with the Chief Surveyors. This work then becomes available for other purposes.

Recording and publication

These surveys are adjusted and examined at district office level, and recorded as survey office plans lodged with the Chief Surveyor so that they become part of the public survey records.

Work carried out by other surveying agencies is generally also drawn on survey office and land transfer plans and lodged with Chief Surveyors for examination approval. In the occasional instance where the agency does not prepare a plan (whether for reasons of cost to client or otherwise) the data are usually made available to the Chief Surveyor, where a plan is compiled and recorded of the work.

PRECISE LEVELLING

Development

The history of precise levelling in New Zealand is comparatively recent, the first major precise level traverse to geodetic standards being carried out in 1938.

From 1948 several major precise level routes were established, primarily for hydroelectric power investigation, tunnelling, drainage and irrigation works. Many of these were based on local datums and work was steadily continued to connect between tide gauges. As of now most tide gauges are interconnected, but several major routes are still required to complete the national coverage and to strengthen the network.

The introduction in 1975 of an extensive programme to monitor earth deformation in New Zealand provided a major impetus to the development of rapid precise levelling techniques. The extensions required by this programme have greatly accelerated progress towards the completion of the precise level network.

Datums

Precise level datums are based on a number of tide gauges (controlled by harbour boards) at various ports. Some gauges are long established, reliable and accurate but there are a number which are of doubtful reliability or are in sites where tidal levels may be significantly modified by coastal configuration.

At present, precise level values are expressed in terms of mean sea level derived from a reliable tide gauge. From the levelling routes so far completed, a provisional relationship has been obtained for the various datums. With the projected completion of the national network it will be possible to systematically adjust all precise levelling to a common mean sea level datum, one for each island, incorporating connections to the reliable tide gauges.

Concurrently with the introduction of metrication, local datums defined in terms of mean sea level were widely adopted by local bodies and other agencies, such as drainage and catchment boards, thus effectively relating levelling in New Zealand to these mean sea level datums.

Administrative control

The Land Act of 1948 placed precise levelling under the direction of the Surveyor-General, and the programming and execution of this work is subject to similar policies and procedures already referred to for triangulation.

Major precise level networks are approved and programmed by the head office, co-ordinated with various engineering and development requirements and with the policy of completing the national network. Furthermore any precise levelling requirement originating from district offices must first be approved by the head office. Specifications, based on international standards, for first order levelling have been set by the head office for the execution of this work. A major revision of these specifications, incorporating modern techniques, is nearing completion.

Field-work

The location, construction, and levelling of bench-marks are carried out by district office staff according to the programming and specifications set out by the head office. Much of the actual construction is funded and carried out by the Ministry of Works and Development according to Lands and Survey requirements and supervision.

Precise levelling routes generally follow main roads and consist of standard bench-marks every 1 to 1.5 km, with fundamental bench-marks at approximately 30-km intervals.

With the increased emphasis and interest in earth deformation, geologists of the Department of Scientific and Industrial Research inspect and report on the sta-

bility of existing bench-marks and proposed sites, and, where necessary, recommend alternative sites.

Field books, summaries and brief details of bench-mark construction and location are forwarded to the head office for adjustment, recording and publication.

Detailed construction and maintenance records are held in district offices.

Bench-marks are co-ordinated by connection to local cadastral surveys or geodetic control. With the introduction of short-range EDM, emphasis is on the co-ordination of bench-marks as urban or rural control traverses based on geodetic trig stations. Bench-marks are thus incorporated into the horizontal control system as permanent reference marks, and also provide for more accurate derivation of trig heights.

Adjustment and record

This is the responsibility of the head office computing branch. Little has been done in the systematic adjustment of the overall levelling network although some work has been done on small local circuits. As stated previously a considerable number of loops and connections to previous work are still required before a reliable adjustment is possible. However, all levelling is reduced and, where possible, computed in terms of one of the major tide gauges.

Records are maintained on a record card which contains mark description, access notes, co-ordinates and heights. Other records in the form of lists of bench-marks showing less detail are available in terms of imperial or metric map sheets. All these records are distributed to district offices as part of the public survey record and, as with other survey information, are freely available without charge.

Subsidiary level control

Extensive second order levelling has been carried out by the Ministry of Works and Development, to second order specifications based on Lands and Survey first order specifications and connecting to Lands and Survey first order bench-marks. Details of this work are supplied to the Lands and Survey head office and incorporated into the national record, but not necessarily on N88 record cards.

Some second and third order levelling on a local basis is carried out by Lands and Survey to extend level control in urban areas, and it is often carried out in conjunction with urban control traverses. This levelling is usually adjusted by the district office in terms of first order bench-marks and recorded by the district office on a survey office plan. Similarly, local levelling control established by local authorities is recorded in district offices, usually as a list of bench-marks cross-referenced with other survey information. Thus, this work becomes part of the national survey system and available to all users.

CONCLUSION

New Zealand has been fortunate that the need for reliable survey was recognized at an early stage of the nation's development and that responsibility for this was vested in one national survey organization, the Department of Lands and Survey. The primary objective of placing all surveys on a uniform system has been maintained and developed to provide a basis for all survey and mapping work carried out by private, local authority and government agencies, whether for land title, mapping, engineering, land utilization, environmental, recreational, navigational, scientific, public utility, or other purposes.

Benefits accruing from this survey control system are many. They arise from the full and efficient utilization and availability of all survey information and resources for any purpose, and thus avoid unnecessary duplication of staff, equipment, finance and effort. Furthermore concentration of survey resources in one major and viable survey organization facilitates co-ordinated and efficient execution of surveys and enhances the capability to meet extensive and changing demands.

The future will bring new demands on the survey system. A major one is likely to be the establishment of an integrated and computerized land resources data bank. Other demands will arise from more precise scientific study and understanding of the earth's crust, from greater emphasis on conservation and managed utilization of resources, and from changing social and development patterns consequent on the need for alternative energy sources.

The survey system is well based to meet and adapt to new requirements, and to integrate new survey activities, so that, in turn, such work may help to meet requirements of the more distant future.

REFERENCES

(Routine reports of the Department of Lands and Survey, whether published or available in the Department's files, are not listed here.)

Boyes, W. S. (1968), "Shore survey control for hydrographic surveying in New Zealand", *New Zealand Surveyor*, vol. XXV, pp. 483-501.

Busby, J. R. (1979), "The development of precise levelling in New Zealand", paper presented to the New Zealand Technician Surveyors Association Conference.

Department of Lands and Survey (1946), geodetic and transverse Mercator projection tables.

_____ (1948), technical instruction for precise levelling.

_____ (1953), technical instruction for second and third order triangulation.

_____ (1972), technical circular, 1972/3; metrication of co-ordinates.

Hawkey, W. N. (1977), "The integrated survey system in New Zealand", paper presented to the Eighth United Nations Regional Cartographic Conference for Asia and the Far East, Bangkok, 17-28 January.

_____ (1977), "Earth deformation studies and the surveyor in New Zealand", *New Zealand Surveyor*, vol. XXIX, pp. 142-150.

Lee, L. P. (1952), "The geodetic datum 1949", *New Zealand Survey Draughtsmen's Journal*, vol. 1, pp. 320-329.

_____ (1952), "Mean sea level and mean high water mark", *New Zealand Survey Draughtsmen's Journal*, vol. 1, pp. 325-343.

_____ (1974), "The search for an improved co-ordinate system for New Zealand surveys and maps", *New Zealand Surveyor*, vol. XXVII, pp. 545-568.

_____ (1978), "First order geodetic triangulation of New Zealand, 1909-49 and 1973-74", Department of Lands and Survey Technical Series No. 1.

Locke, K. R. (1979), "Programme PLEV—earth deformation vertical control in the Taupo volcanic zone", *New Zealand Surveyor*, vol. XXIX, pp. 242-263.

New Zealand National Committee for Geodesy and Geophysics, Reports on geodetic operations to the General Assembly of the IUGG.

Reilly, W. I. (1973), "A conformal mapping projection with minimum scale error", *Survey Review*, vol. XXII, pp. 57-70.

_____ and Bibby, H. M. (1975), "A conformal mapping projection with minimum scale error, part 2: Scale and convergence in projection co-ordinates", *Survey Review*, vol. XXIII, pp. 79-87.

_____ (1976), "A conformal mapping projection with minimum scale error, part 3: Transformation of co-ordinates and examples of use", *Survey Review*, vol. XXIII, pp. 302-315.

AERIAL PHOTOGRAPHY IN NEW ZEALAND*

Paper presented by New Zealand

RÉSUMÉ

Le document décrit l'évolution des levés aériens en Nouvelle-Zélande, depuis leurs débuts dans les années 20 jusqu'à l'époque actuelle. Il indique sous forme de résumé détaillé les avions et les chambres de prise de vues aériennes utilisés pendant cette période, en précisant l'échelle, le format et la couverture des photographies ainsi que ceux des pellicules cinématographiques pour les dernières années.

Il évoque le rôle joué par le Department of Lands and Survey (Département des affaires foncières et des levés) : satisfaction des besoins de la Nouvelle-Zélande en matière de photographie aérienne aux fins de l'établissement de cartes topographiques nationales et de l'évaluation des ressources, coordination des demandes des différents services gouvernementaux et tenue d'une collection nationale complète et bien documentée de photographies aériennes. Il contient notamment un exemple type des diagrammes de levé qui forment la base du système d'enregistrement de la photothèque et une carte montrant le programme de photographie aérienne pour 1979-1980. Le document décrit en outre les rapports entre le Département et le principal entrepreneur contractuel de levés aériens, New Zealand Aerial Mapping Ltd, ainsi que les termes de l'accord entre cette société et la Couronne.

Il traite de l'utilisation des photocartes et fait état du recours accru à l'orthophotographie. Il indique également que des produits picturaux transmis par satellite sont disponibles.

Le document contient aussi une étude détaillée de l'importance des applications de la photographie aérienne dans les travaux des services gouvernementaux, et des considérations sur la participation de la Nouvelle-Zélande aux levés aériens dans le Pacifique Sud.

Since the first aerial photographic sortie in New Zealand was made in 1926 a great deal of ground has been covered, both metaphorically and literally. Great distances have been flown and many negatives have been generated in the interim and today it is possible to find, within the 400,000 photographs held in our national photo library, coverage of every part of New Zealand and of many South Pacific Islands.

During this period aircraft ranging in size from a DH60 Gypsy Moth to a Canberra B2 have carried large format survey cameras with many and various focal lengths, to acquire photography for such diverse purposes as the determinations of the rate of spread of grassgrub on the Takapau Plains, the magnitude of ice movement in the Franz Joseph Glacier and the size of the "solar" salt harvest at Lake Grassmere.

Early indications of the potential uses of aerial photography both for retrospective studies and for forward planning have been fully realized and today few projects requiring information on the natural or man-made features of our landscape will be pursued without first carrying out an aerial survey.

DEVELOPMENT AND CO-ORDINATION

The earliest recorded aerial survey covered the Christchurch area and was flown in February 1926 by Squadron Leader Jim Findlay who was Officer Commanding of the Royal New Zealand Air Force station at Wigram. This was the first of an increasing number of aerial surveys to be carried out by the RNZAF during the pre-war period.

In 1935, a mapping committee, set up under the Organization for National Security, investigated New Zealand's mapping needs. As a result of this committee's recommendations, the Department of Lands and Survey was authorized to undertake the preparation of a 1-mile/1-inch national map series on a national yard grid approved by the Army authorities. In February 1936 vertical aerial photographs of an area of 1,500 sq miles (approx. 4,000 km^2) in the Hawkes Bay district were taken by the RNZAF and in March 1939 the first sheet, plotted with a Barr and Stroud precise stereoscope, was published.

Plotting from aerial photographs having proved to be economic, in 1938 the Mapping Committee set a production target of 3,000 sq miles (approx. 8,000 km^2) a year, and to meet the requirements of this programme the RNZAF purchased an Oxford aircraft specially adapted for aerial photography.

During this same period other government departments and local bodies were making increasing use of aerial photography for investigations of afforestation, coal resources, river control works, erosion, geological surveys etc. The RNZAF carried out the majority of these surveys, but from 1937 this work began to be

*The original text of this paper, prepared by R. C. Barrett, Department of Lands and Survey, appeared as document E/CONF 72/L 9

shared by New Zealand Aerial Mapping, Ltd (NZAM), a private company based in Hastings.

With the outbreak of war in September 1939, mapping activities were concentrated on the "fortress" areas of Auckland, Wellington and Christchurch and on the Waiouru training area. As the RNZAF was unable to make personnel and aircraft available for the photography, the required aerial surveys were carried out by New Zealand Aerial Mapping. By 1944, that company had become responsible for the majority of aerial photography required for military and State purposes, though the RNZAF continued to carry out a number of small surveys for special purposes.

Throughout the war years major emphasis was placed on the acquisition of photography for mapping purposes but by 1944 it was considered that the primary necessity for maps for purely military purposes had diminished and national requirements had become more important.

At this stage the Mapping Committee authorized the establishment, under the direction of the Surveyor General, of a national library of aerial photographs. The Department also took over responsibility for the indexing of all RNZAF surveys and for the storage of their negatives. A mammoth task of recording was commenced, and by the end of the war over 100,000 individual photographs had been numbered.

The Department also became responsible for the placing of all orders for aerial photographs, including those from new surveys, and for ordering copies of prints, enlargements and mosaics of existing surveys, required by the general public and government bodies.

The following extract from a 1944 paper by R. G. Dick, Surveyor General, indicates the range of demand for aerial photography for mapping purposes at that time.

"*State Forest Service*:

"250,000 acres (400 sq miles) in 18 separate parcels scattered through the Dominion require to be mapped on a large scale for reafforestation purposes.

"*Scientific and Industrial Research*: (Coal resources)

"Approximately 300 sq miles of area required to be mapped on a large scale in the Westport and Kaitangata coalfields areas.

"*Housing Construction Department*:

"Numerous large scale contoured maps of areas for housing are required for engineering and house siting purposes.

"*Public Works Department*:

"Special preliminary topographical surveys required for hydro-electric development, and aerodrome services.

"*Lands and Survey Department*:

"Preliminary topographical plan required for land development purposes.

"*Organisation for National Development*:

"A proposal to carry out a regional survey of the Dominion is now under consideration. The whole basis of the data for this survey will be the topographical map."

During the post-war period, applications expanded further to include forestry inventory control of soil erosion, river protection works, hydroelectricity development, national highways, and water supply projects.

In 1956 a memo from the Surveyor General to the heads of several government departments drew attention to the fact that "the increasing and pressing demands for special surveys for engineering, land, irrigation, town planning, river control, forestry, mining and power development projects emanating from various governmental agencies is placing an emphasis on the need for a more effective co-ordination of the survey and mapping resources of the Government".

An inter-departmental conference was called at which were present representatives of the departments of Lands and Survey, Scientific and Industrial Research, Army, Navy, Air, Mines, the New Zealand Forest Service, the Ministry of Works, the Soil Conservation and Rivers Control Council and NZAM Ltd. While primarily concerned with establishing machinery for the inter-departmental co-ordination of survey and mapping work, this conference ratified certain conditions relating to aerial surveys and photography:

(*a*) Orders should be routed through the Lands and Survey Department by being submitted to the Surveyor General;

(*b*) The Lands and Survey Department should bear the cost of photography and mapping for the standard 1:25,000 (NZMS2) and 1:63,360 (NZMS1) topographical map series;

(*c*) The cost of special photography should be borne by the Department concerned.

A committee of departmental representatives was set up to maintain formal liaison on priorities of aerial survey, photogrammetric and ground survey work. This committee now meets at two-monthly intervals, and is approaching its 120th meeting.

Subsequent maintenance of the policies requiring all orders for aerial surveys for Crown use to pass through the Department of Lands and Survey, and all survey photography to be indexed in the Department's photo library, has ensured the establishment of a comprehensive set of records which are readily accessible to anyone seeking information on photographic coverage. At the same time it has provided for the most effective use of aerial survey resources by avoiding, as far as possible, the uneconomic duplication of work which can occur in the absence of a central co-ordinating body.

Aerial Survey Contractors

When the outbreak of war in 1939 forced the RNZAF to relinquish responsibility for the supply of Crown requirements for aerial photography, the firm of New Zealand Aerial Mapping Limited and its founder and present managing director, H. P. D. van Asch, were already established names in aerial survey work. Following a visit to the United Kingdom in 1936 to study aerial photographic techniques, Mr. van Asch established his organization in Hastings as an associate company of Hunting Aero Surveys Ltd, London. At this time he was operating with a twin-engined Monospar ST-25 and it is interesting to note that this aircraft, now in honourable retirement, is the last remaining operational aircraft of its make in the world today.

By 1942 the Monospar was proving to be inadequate to meet the heavy demands brought on by the war-time requirements for topographical mapping, and in 1943 the Government purchased a Beechcraft AT 11 for use by NZAM on a rental basis.

Altitude limitations on the Beechcraft restricted its ability to cover much of New Zealand's high country,

and in 1963 an Aero Commander 680F was purchased. At this time NZAM bought the Beechcraft from the Crown at its book value and continued to operate it for both Crown and private surveys. By 1977 the Beechcraft had had 35 years of service and was coming to the end of its commercial life. In May 1977 the Cabinet approved expenditure for the purchase of a Rockwell Commander 690B, which came into service in December 1978, and which is jointly owned by the Crown and NZAM.

At the time of the purchase of the Beechcraft, a formal agreement was entered into between the Government and NZAM and this has been renewed at intervals. Essentially the volume of high-altitude precision work required in New Zealand can support only one experienced well-equipped organization, and because aerial survey is a fundamental requisite to any development, or defence, strategy it is essential that such an organization exists within New Zealand. The mapping agreement between the Government and NZAM not only secures this situation but also obtains for the private and public sections the benefit of economy stemming from the scale of the operation.

The agreement requires NZAM to undertake aerial survey work required by the Crown on priorities set by the Surveyor General and in terms of a scale of charges reviewed periodically and approved by the Minister of Lands. It is interesting to note at this point that these charges are calculated on the basis of areas of usable photography supplied at various scales, and not on an aircraft + equipment + personnel cost for individual surveys. The Crown reserves the right to place orders with other operators and NZAM may use the aircraft to undertake aerial photography and other allied work for local government and private enterprise as long as the rates of charging for this are not lower than those applied to work for the Government. NZAM is also responsible for the custody and safety of all Crown negatives.

In 1944 the then Surveyor General stated that "New Zealand has been fortunate in obtaining the services of a well-trained and efficient aviator who produces work of a very high standard". This remark was made in the early days of an association between private enterprise and the Crown which may well be unique. The sentiment expressed is still applicable and in the intervening years has been extended to cover the whole staff of NZAM.

Since the 1950s several other aerial survey firms have been established. The Crown makes use of their services from time to time but most of their work is drawn from regional and local authorities, *ad hoc* bodies and the farming community. Notable amongst these have been Aerial Surveys Ltd of Nelson, and Aero Surveys Ltd of Tauranga which has now been incorporated into the Nelson company. Both of these firms have assisted in the maintenance of the comprehensive records of aerial photography held in the photo library by supplying details of the many surveys they have carried out.

Scales and Coverage

From the earliest years of aerial survey, many small areas have been covered, within the limitations of the aircraft and cameras available, at a variety of scales to suit particular needs.

Extensive surveys at standardized scales, for both mapping purposes and resource investigation, have been, in the main, the responsibility of the Department of Lands and Survey. In 1936 the 4,000 km of coverage in Hawkes Bay flown by the RNZAF was photographed at a scale of 20 chains to an inch (1:15,840). Between 1939 and 1943, NZAM's Monospar aircraft with its operating ceiling of 11,000 feet had achieved 50,000 km^2 at this scale. By 1956 the North Island (115,000 km^2) was almost entirely covered and 75 per cent of the South Island's 150,500 km^2 was completed. The notable area still remaining was the Southern Alps and surrounding high country.

The arrival, in 1944, of the Beechcraft with its higher ceiling of 17,000 feet, allowed for the introduction of a new standard scale of 30 chains to an inch (1:24,000) which was better suited to the methods then being employed for mapping. With the acquisition of more sophisticated stereoplotters during the 1950s it became possible to contemplate an even smaller scale of photography for mapping for the NZMS 1 (1:63,360) series. In 1955 the purchase of a Wild RC5A camera with an Aviogon 4 1/2" (114 mm) lens allowed for a reduction in scale of NZMS 1 mapping photography to 1:45,000, and in the following nine years 80,000 km^2 was flown at this scale. At the same time an interchangeable Aviotar 8 1/4" (210 mm) lens gave the same camera the facility to obtain 1:24,000 photographs over most of the country.

The purchase of the Aerocommander 680F again raised the ceiling, this time to 25,000 feet, and again brought a capacity for reducing the scale of standardized coverage, this time to 1:63,360. A new concept was introduced which involved the precise location of photo centres so that each image covered a specific section of a sheet of the NZMS 1 topographical map series. This photography was known as "3B" as it was originally intended that enlargements at 1:15,840, of individual photographs, would supersede the NZMS 3 photomap series. Because the photographs were numbered and filed in terms of the appropriate NZMS 1 sheet, they could be referred to quickly without having to consult a photo index map, but they proved to have other limitations which created user resistance. By 1974, 101,000 km^2 of "3B" photography had been flown but, with the establishment of the NZMS 260 (1:50,000) series to replace the NZMS 1, this type of coverage was phased out.

Pressure on the Department during the 1960s to speed up the completion of NZMS 1 coverage of the country resulted in a further step being taken to reduce the scale of mapping photography.

In 1965 a Wild RC9 super-wide-angle camera with an 88-mm lens was purchased, and extensive areas, particularly in the South Island, were flown at a scale of 1:86,000.

With the introduction of metrication in 1973, a decision was made to settle on two standard scales—1:50,000 and 1:25,000—for national mapping and resource photography. These coincided with the publication scale of the new metric NZMS 260 series and the scale of the base mapping, which is available in plan print form (NZMS 270 Topoplots). So far 105,000 km^2 at 1:50,000 and 80,000 km^2 at 1:25,000 have been flown. The areas programmed for coverage are related

to the sheets of the NZMS 260 series and the programme is reviewed annually. See figure 76.

It is government policy to update the photographic coverage on a 10-year cycle over most parts of New Zealand, with a 5-year cycle for some of the more rapidly developing areas.

In addition to the "resource" and mapping photography programmed by the Department of Lands and Survey, extensive areas of coverage at 1:10,000 are flown for the New Zealand Forest Service for interpretation purposes; the country's State Highways are covered by 1:8,000 strip photography for the National Roads Board; and the Department of Education, the New Zealand Railways and the Post Office have ongoing standard scale requirements. As well, many local and regional authorities obtain coverage of urban areas and, although these bodies are not required to channel their orders through this Department, the details of the coverage are included in the photo library records.

Films and formats

Black and white. By far the greatest proportion of photography in New Zealand is black and white from panchromatic negatives. Stable based film has been used since 1948, and negatives from prior to that date are monitored periodically. It is intended to copy these on to a modern medium to ensure the retention of this historically valuable information.

The film in most common use today by NZAM Ltd is Kodak 2402 Plus X.

Colour. The main user of colour photography is the New Zealand Forest Service where it has been found to be superior to black and white for forest interpretation purposes. One of the early applications was the study of the occurrence of dothistroma fungus disease in exotic forests. Colour surveys have since been made of the kauri stands in Northland and of a number of other forests, the largest of which is the indigenous beech area in northern Westland. A further 12,000 km^2 is currently on order in the Nelson district for use both for photogrammetric mapping and for interpretation purposes.

When colour film first became available to us in 1965, use was made of Kodak 2448 Estar base. As this is a reversal film, which gives an original positive transparency, any requirement for duplicate transparencies and prints necessitated the production of an internegative. However, subsequently it was found that the film could produce acceptable results when processed to a negative stage only, a forerunner of the aero-negative system.

Aerocolour 2445, introduced in 1974, has now become the most commonly used colour medium. A negative film, it has the advantage of allowing good-quality prints and transparencies to be acquired readily.

Infra-red false colour. Only limited use has been made of this film, Kodak Type 2443. Unexposed film must be kept under refrigeration, small surveys are expensive and the results have appeared to be only marginally better than colour on the test areas that have been photographed.

Infra-red black and white. The main application of this film, Kodak Type 2424, has been for multi-spectral surveys. In 1974 the Department of Lands and Survey purchased a Fairchild I^{2}S camera for the acquisition of airborne photography to be used in conjunction with LANDSAT imagery. At the same time the Physics and Engineering Laboratory of the Department of Scientific and Industrial Research teamed up four Hasselblad cameras for the same purpose. Two of these cameras use Type 2424 film for the infra-red bands. (The faster Type 2403 Tri-X is used in the other two cameras for the red and green bands).

Camera formats. Early photography had a variety of formats with the 9 x 7 inch (23 x 18 cm) being the most common.

In 1955, following a comprehensive independent study of the Department's mapping facilities, a decision was made to purchase a Wild camera which had an 18 x 18 cm format, and for the next 10 years this size of photograph was predominant. From 1965 there was a move towards the larger and more universal 23 x 23 cm, and since 1975 a full range of focal lengths has been available in combination with this format. For full details see annex I.

Recording and availability

Comprehensive records of the location and extent of aerial surveys and of various relevant details about the photography have been maintained since the Department of Lands and Survey first became involved in this field of activity.

With the formal establishment of NZAM Ltd as the primary contractor to the Crown, a system of survey numbering and indexing was evolved which, with some refinements, is still in use at the present time. Each survey is assigned a unique number and a name, which allows the charts to be filed either numerically or alphabetically (see figure 77). Blocks of numbers are assigned to the various aerial survey companies and they are responsible for the preparation of the charts. As the larger companies provide these for private as well as Crown surveys, an extremely informative reference source has been built up over the years.

To complement this system, the Department of Lands and Survey has built up a set of index maps which allow for the rapid identification of all existing surveys in any part of New Zealand. In the early days in which this record initiated, flight lines and photo centres were marked on the appropriate sheet of the 1:63,360 cadastral series; since January 1979, the NZMS 261 (1:50,000) cadastral maps have been used.

The Department's National Photo Library located on the lower ground floor of the Charles Fergusson Building, Bowen Street, Wellington, holds approximately 400,000 photographs, and a further 12,000 are added each year. In 1976, at the time the Department moved into these premises, three power-filing units were installed to replace the former wooden drawer cabinets for storage.

A complete set of survey charts and index maps is available for public inspection, or written inquiries may be addressed to the Surveyor General, Head Office, Department of Lands and Survey, Private Bag, Wellington. Each of the Department's 12 district offices holds records and photographs covering its district area. Orders for contact prints, enlargements and half-tone products may be placed through either the Photo Library or the district offices. These same offices provide a service for the ordering of LANDSAT products.

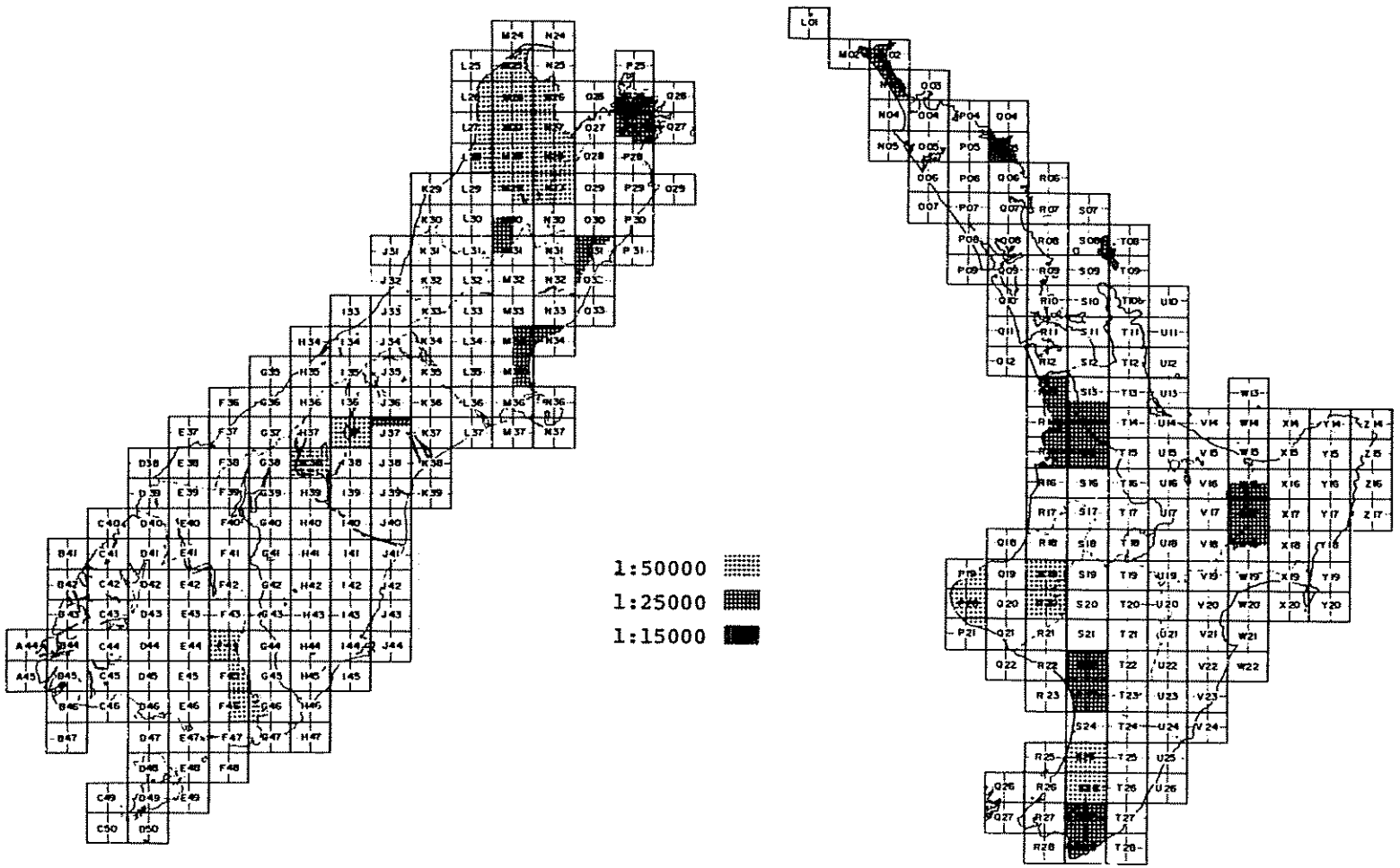


Figure 76. New Zealand: major areas of photography included in the 1979-1980 flying programme

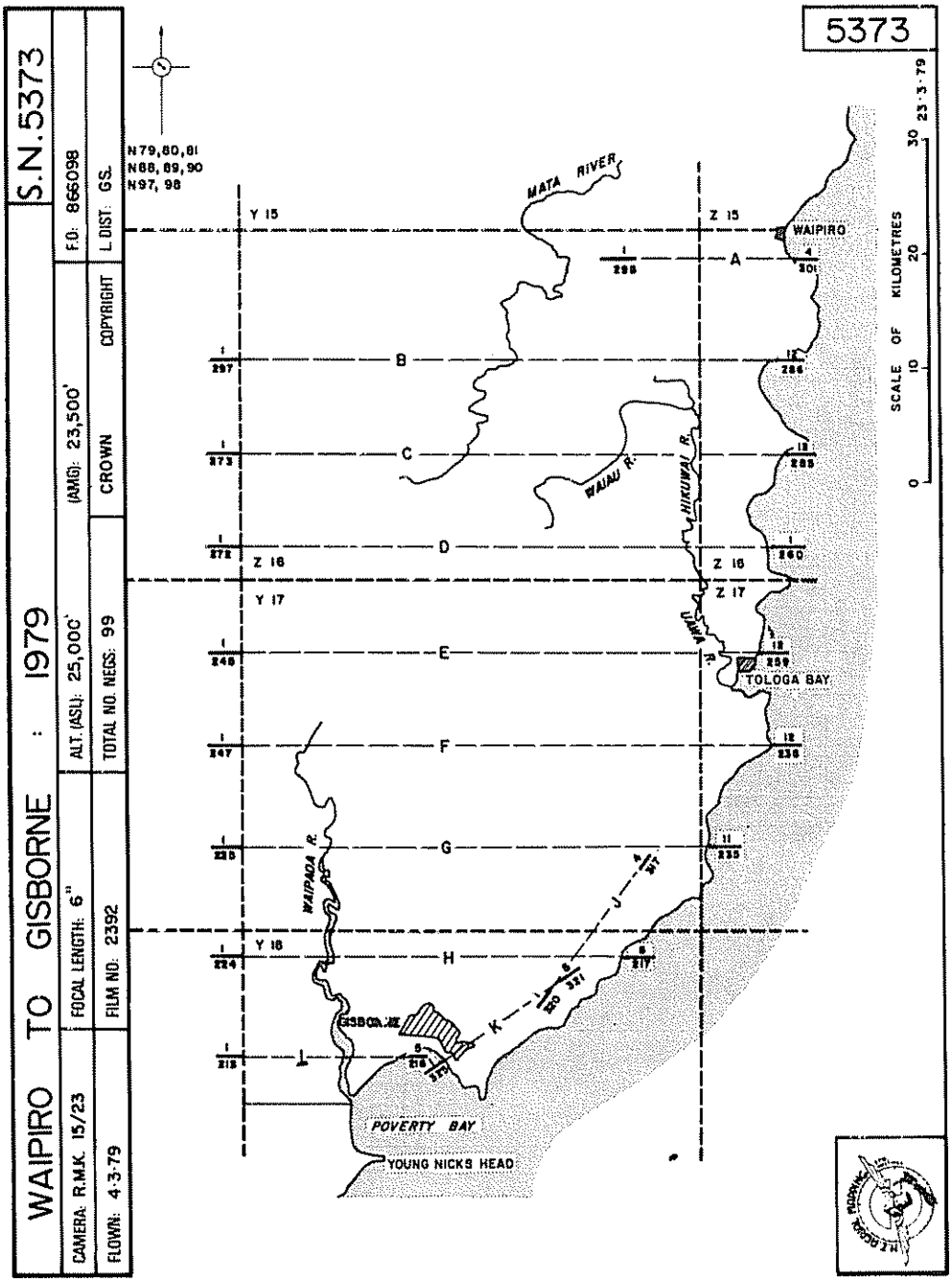


Figure 77. New Zealand: typical survey chart

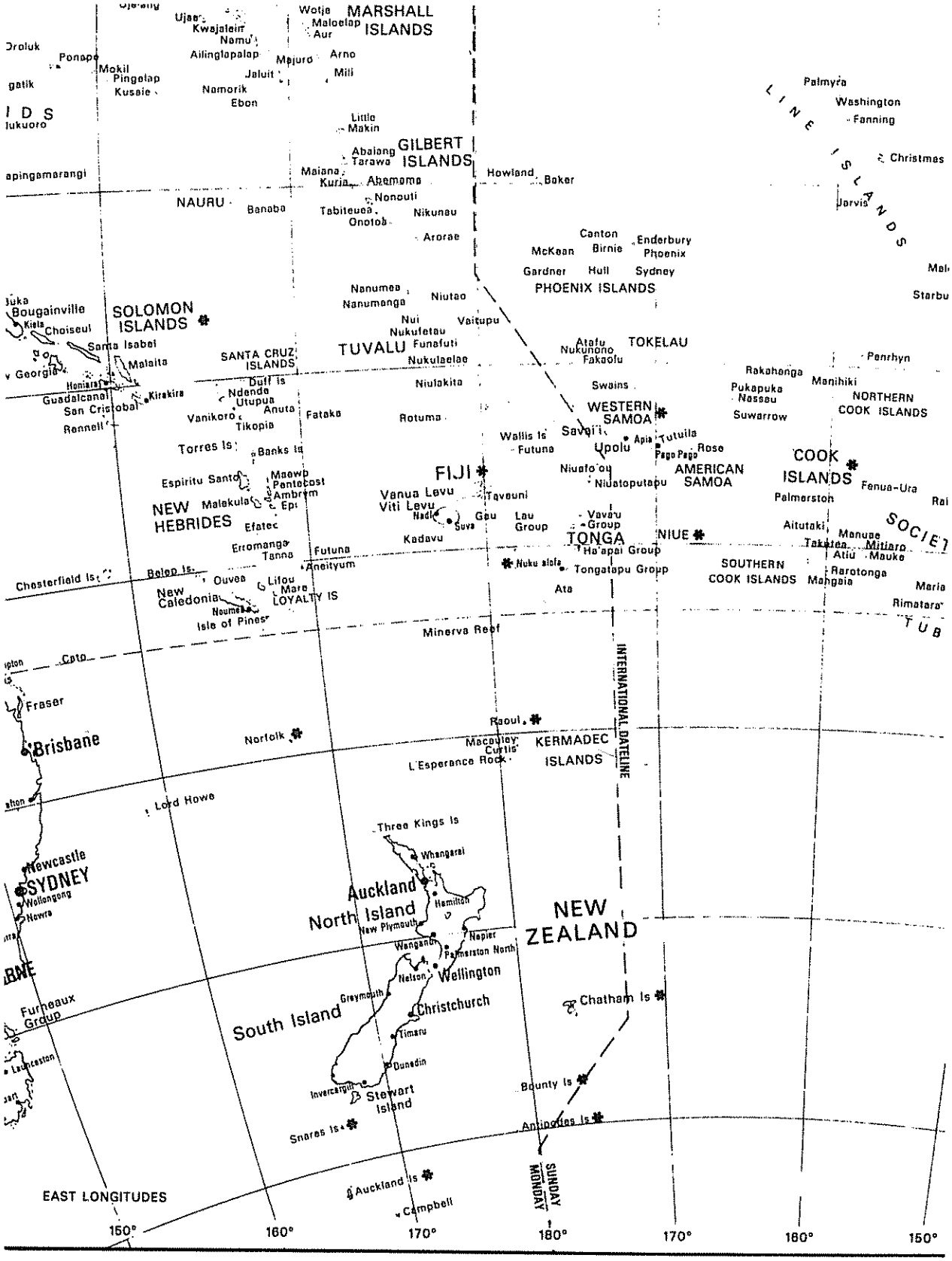


Figure 78. New Zealand: aerial surveys in the South Pacific

Satellite imagery

Although consideration of this medium is not included in a strict interpretation of this paper's title in that it is neither "aerial" nor "photography" it would be inappropriate to exclude mention of it in this review.

The computer compatible tapes (CCT) of the LANDSAT imagery, supplied by NASA, are used by the Remote Sensing Section of the Physics and Engineering Laboratory of DSIR to generate an initial 95 x 95 mm transparency. From these, 35 mm slides, duplicate transparencies or enlargements can be produced to order.

The scenes are designated in terms of the 28 standard locations which cover New Zealand, and in addition each is given a reference number by the Remote Sensing Section relating to its chronological order. At the time of writing a full set of cloud-free scenes is still to be achieved.

PHOTOMAPS

In the course of the years many photo mosaics have been assembled to satisfy a variety of requirements, but only two specific photomap series have been produced.

NZMS 3 series (1:15,840). From 1947, photomaps at a scale of 20 chains an inch (1:15,840) were produced to supplement the limited number of contoured maps available at that time. They were prepared from photography of the same scale and the sheetlines conformed to those of the NZMS 2 (1:25,000) topographical series. Over a period of 18 years, some 90 per cent of the North Island and 20 per cent (the more developed areas) of the South Island were covered. Although no new sheets have been produced since 1975, there is still a steady demand for copies.

NZMS 277 series (1:10,000). In 1974 a group of 16 sheets was produced to cover the Christchurch metropolitan area. A further 29 sheets covering the Seddonville-Inangahua area of the West Coast of the South Island were prepared at the request of the New Zealand Forest Service.

The sheetlines correspond to those of the NZMS 260—1:10,000. There are no plans to extend this series over the whole country, but it is hoped to produce coverage in orthophotograph form over urban and developing areas.

Orthophotography. Because of the nature of the terrain in New Zealand the areas over which unrectified, or even rectified, photographs may be used as map substitutes are extremely limited. Because of this, developments in orthophotography systems have been followed with interest over a number of years. In 1977 the department purchased a Wild OR1 Avioplan unit which is being used in conjunction with a Wild B8S plotter adapted for terrain scanning. Provision has also been made to provide input from two Wild A8 plotters. Three areas of large-scale contoured orthophotomaps for engineering purposes have been completed to date, two for irrigation projects and one for highway realignment. It is planned to expand the use of this equipment, in the future, into the production of 1:10,000 orthophotomaps.

APPLICATIONS OF AERIAL PHOTOGRAPHY BY GOVERNMENT DEPARTMENTS

The Department of Lands and Survey acts as a coordinator of aerial survey orders for all departments of Government. The following summary gives an indication of the range of purposes for which photography has been specifically planned. It is not, however, a comprehensive listing of the infinite variety of uses made of existing photography by departments, organizations and individuals.

Agriculture and fisheries: Agricultural pest research;

Defence: Military and naval establishments and training areas;

Education: School sites and buildings;

Electricity: Power stations, transmission lines, hydro lakeshore erosion surveys;

Energy: Coal resource evaluation, opencast mine monitoring;

Forest service: Interpretation photography for species identification, volume assessment, disease studies; cyclical coverage to record utilization and redevelopment; photography for mapping for forest management and for planning of roading and logging;

Foreign affairs: Bilateral aid projects in agriculture, forestry and power development;

Housing corporation: State housing development sites, urban renewal studies;

Justice: Prison farm sites;

Lands and survey: Resource photography to provide regular recover of urban and rural areas; special photography for land settlement, national parks and reserves; multispectral photography for land use planning; photography for topographical mapping and aeronautical charting;

Maori affairs: Land development blocks;

Post office: Cable routes, radio stations;

Railways: Station yards, workshops, ballast pits, route strip photography, mapping for tunnel location route realignments and "weatherproofing";

Scientific and industrial research: Geological, glacial, soil, geophysical, oceanographic, geothermal, botanical studies; experimental multispectral photography to complement LANDSAT imagery;

Transport: Aerodromes, aircraft approach paths, navigational aid sites; harbour and foreshore developments; road traffic engineering studies;

Works: Photography and mapping of irrigation areas, geothermal, thermal and hydro power schemes; pipeline routes; canals; dam and tunnel sites; new highway, motorway and rail routes; bridge sites; water and soil conservation areas; strip photography of state highways.

AERIAL SURVEYS IN THE SOUTH PACIFIC

New Zealand has been involved in aerial photography in the South Pacific area since 1942. Figure 78 indicates

the range of the surveys carried out by the RNZAF, the Civil Aviation Administration (now the Civil Aviation Division of the Ministry of Transport), and NZAM Ltd. Further involvement is anticipated in the future but the widely disposed locations of the islands, the lack of advance meteorological information, together with the rapid local development of cloud formation cause many flights to be abortive.

Extensive surveys of Western Samoa, Fiji and the Solomon Islands have been funded by the New Zealand Government. The photography generated by these projects has been available for use for photogrammetric mapping either by local government or by New Zealand on its behalf, for the production of enlargements and half-tone transparencies, for resource studies and for the planning of development projects.

WHAT OF THE FUTURE?

The future prospects for the ongoing application of the conventional photography of today are now being seriously challenged by developments in electronic technology. Images from visible and infra-red wave bands, captured by satellite and airborne mechanical multispectral scanners, are now familiar to us. Tomorrow, solid state scanning arrays will supply digital data to define, with superior resolution, information from wavelengths that today's films cannot record. Manned aircraft and spherical lenses will take their place in past history along with Laussedat's kite-balloon and daguerreotypes.

In just over fifty years of aerial survey, the New Zealander's perspective of his country has expanded from a "bird's-eye" view to the vista of a space traveller. Who knows what the next fifty years will bring.

ANNEX

Survey aircraft and cameras used in New Zealand

Aircraft	*Operator*	*Period*	*Operating ceiling*
Military aircraft			
Bristol F2B	NZPAF	pre-1927	15 000′
D.H.9	NZPAF	pre-1927	12 000′
D.H.50A*	NZPAF	1927-1931	12 000′
Fairey IIIF	NZPAF-RNZAF	1929-1938	15 000′
Airspeed Oxford	RNZAF	1938-1954	17 000′
Vickers Vincent	RNZAF	1941	15 000′
Hawker Hind	RNZAF	1942	20 000′
Boeing (Canada) PB2B Catalina	RNZAF	1945	20 000′
English Electric Canberra B2	RAAF	1958-1963	40 000′ +
Lockheed P-3B Orion	RNZAF	1966-	30 000′ +
Civil aircraft			
D.H. 60 Gipsy Moth	HBAC	1935	10 000′
G.A. Monospar ST25 Universal	NZAM	1937-1944	11 000′
Beech AT11	NZAM	1944-1978	17 000′
Aerocommander 680F	NZAM	1963-	25 000′
Rockwell Commander 690B	NZAM	1978-	30 000′
Percival Proctor IV	PWD	1949-1951	12 000′
Miles Gemini	PWD	1949-1951	12 000′
Douglas D.C 3	DCA	1960s	20 000′
Cessna 206	ASN	?-1978	25 000′
Cessna 185	ASN	1978-	17 000′
Cessna 172	N & ESP	1971-	12 000′

Camera type	*Focal length*	*Operator*	*Period*	*Format*
F8	8 1/2″	RNZAF	1932	9″x7″
	7″	RNZAF	1934	9″x7″
	5″	RNZAF	1936	9″x7″
F24	5″	RNZAF	1936	5″x5″
Eagle IV	10″	NZAM	1936-1955	9″x7″
	8 1/4″	NZAM	1936-1955	9″x7″
	8 1/4″	RNZAF	1939	9″x7″
	10″	RNZAF	1940	9″x7″
F24	6″	RNZAF	1940	5″x5″
Eagle IV	20″	NZAM	1940s	9″x7″
F24	5″	PWD	1949-1951	5″x5″
Wild RC5A	115mm	NZAM	1963-1976	18cmx18cm
	210	NZAM	1963-1976	18cmx18cm
Eagle IX**	6″	DCA-CAA MWD	1959?-	9″x9″
Wild RC8	115mm	NZAM	1963-1976	18cmx18cm
	210	NZAM	1963-1976	18cmx18cm
RC9	88	NZAM	1965-	23cmx23cm
Zeiss RMK	600	NZAM	1969-	23cmx23cm
Fairchild I^2S***	150	NZAM	1974-	4-90mmx90mm
Zeiss RMK	150	NZAM	1975-	23cmx23cm
	300	NZAM	1975-	23cmx23cm

Camera type	*Focal length*	*Operator*	*Period*	*Format*
Fairchild	6"	ASN	1975-	9"x9"
	12"	ASN	1975-	9"x9"
	24"	ASN	1975-	9"x9"
Zeiss RMK	210mm	NZAM	1976-	23cmx23cm

Source: Compiled by G. P. NEWTON 9/79.
Note:
NZPAF: New Zealand Permanent Air Force
RNZAF: Royal New Zealand Air Force
RAAF: Royal Australian Air Force
HBAC: Hawkes Bay Aero Club
NZAM: New Zealand Aerial Mapping Ltd
PWD: Public Works Dept
ASN: Aerial Surveys Nelson
N & ESP: N & ES Paterson Dunedin
DCA: Dept of Civil Aviation
CAA: Civil Aviation Administration
MWD: Ministry of Works and Development
*First specialized survey aircraft in N.Z.
**Water and Soil Org. MWD now have the camera pod mounted to fit to a Cessna 206.
***Multispectral camera.

AEROPHOTOGRAPHIC CAMERAS OF TES TYPE USED FOR TOPOGRAPHIC SURVEY*

Paper presented by the Union of Soviet Socialist Republics

RÉSUMÉ

Des chambres de prise de vues aériennes AFA-TES de format 18x18 cm, équipées d'objectifs à distances focales de 350, 100, 70 et 50 mm et angles de champ de 40, 103, 120 et 136,5° respectivement, ont été mises au point en Union soviétique. Elles utilisent de nouveaux objectifs permettant d'améliorer les qualités d'exactitude dimensionnelle et de définition des images, ainsi qu'un posemètre automatique et un obturateur rotatif rapide. Les erreurs photographiques peuvent être corrigées.

La qualité des images est fonction des facteurs suivants : distorsion photogrammétrique de la chambre de prise de vues aériennes, caractéristiques des obturateurs, non-planéité et déformation de la pellicule, correction du système optique, mouvement de l'image, etc.

La réduction de l'effet de distorsion est obtenue par la correction des aberrations (astigmatisme, courbure de champ et chromatisme) dans les calculs des objectifs-grands-angulaires et grâce à une amélioration des techniques de fabrication permettant une plus grande fidélité aux calculs et une correction de la courbure de champ et de l'astigmatisme. La distorsion calculée des objectifs de la nouvelle chambre de prise de vues aériennes n'est pas supérieure à 5 microns. La distorsion réelle de toutes les chambres, à l'exception du modèle TES-5, ne dépasse pas 10 microns.

Aerophoto cameras AFA-TES with focal lengths 350, 100, 70 and 50 mm and angular fields 40, 103, 120 and 136.5°, respectively, the picture shape being 18x18 cm, have been developed in the Union of Soviet Socialist Republics. They have new lenses that make it possible to improve metric and image qualities of pictures and an exposure automatic system with a rapid rotor shutter. Picture mistakes can be rectified.

The quality of pictures is influenced by the following factors: photogrammetric distortion of the aerocamera, characteristics of shutters, non-flattening of the film and its deformation, correction quality of the optical system, image motion etc.

The distortion effect decrease is achieved by reduction of the symmetrical radial and colour distortion in calculations of wide-angle camera lenses and by improving the technology of manufacture, enabling the calculated data to be reproduced more accurately and tangent and asymmetrical distortion to be lowered. The calculated distortion of the lenses of the new aerophoto cameras is up to 5 μm. The real distortion of all cameras, except TES-5, is not more than 10 μm.

In developing the new lenses special attention was paid to eliminating chromatic and monochromatic aberrations. In this respect some progress has been made: in the new cameras the chromatic difference of magnification characteristic of "colour" distortion does not exceed 0.02 mm.

The geometrical distortions connected with the operation of the shutter were eliminated by using the central shutters placed very close to the aperture diaphragm or in the plane optically conjugated with it. The image quality is strongly influenced by the image geometrical motion dependent on the image movement rate and ex-

*The original text of this paper, prepared by V. B. Il'in and V. G. Afremov, appeared as document E/CONF.72/L.86.

posure. The rapid shutters in TES-type cameras make it possible to obtain real exposure of up to 1/700 sec. The short exposures provide images essentially without effects of the geometrical image motion.

The shutters of the new cameras are principally the same; they differ only in leaf sizes dependent on the diameter of the aperture covered, its maximum size being 35 mm.

The exposure control is performed by changing the number of the electric motor turns in proportion with the variation of the integral brightness of the terrain. The proportionality coefficient is determined by the two parameters: relative aperture of a lens and the ratio of the film actinism to the filter factor.

Automatic exposure control (AEC) in cameras of TES-type is performed with the help of a photoelectric exposuremeter consisting of a unit with a photo-cell and a regulator of turns of the electric-motor shutter.

Changing the proportionality coefficient is achieved by varying the sensitivity of the photoelectric exposuremeter.

The results of the flying test showed that in the case of photography of medium contrast terrain (plain, foothills etc.) root mean square deviation of integral density of negatives is within ±7-10 per cent. During photography of the areas with considerable fluctuations of landscape brightness (mountain regions) the deviations are ±12-16 per cent.

The film flattening in cameras of TES-type is made by pressing it to the glass plate (focal lengths are 50, 70 and 100 mm) that has calibration marks, making it possible to fix residual errors due to nonflattening and deformation of the film. To increase the accuracy of film flattening a steady stretch of the film is provided before the exposure and at the time of photography by using an electromagnet friction unit with variable momentum and by pressing the film to the glass with an elastic slab.

Studies of the film flattening accuracy were carried out with an interference unit. They showed that under laboratory conditions the medium deviation of the film from the glass surface, regardless of its type and flattening method, is ±5-6 μm.

The new series consists of the following cameras: AFA-TES-5, AFA-TES-7, AFA-TES-10 and AFA-TES-35. All the cameras, except AFA-TES-5, are provided with removable filters, yellow, orange and transparent. The smoothing of illumination is performed by depositing a shading coat on the filter surface.

Camera AFA-TES-5 is intended for photography of large areas in small scales, mainly for geological mapping on the scales 1:100,000-1:200,000. It is provided with Russar-62 lens with aspheric optics. The lens has a constant yellow filter. The main optical characteristics of the camera are given in figure 79.1, where 1a is the principal optical scheme, 1b is the resolution on panchromatic film of 22-type with the total aperture obtained with absolute contrast mires in meridian M and tangential T directions, and 1c is the average radial distortion.

The aspheric lens enabled the improvement of illumination in the image plane at the camera angle up to 136.5°. But the difficulty of making aspheric surface did not allow decrease of photogrammetric distortion to the values suitable for precise photogrammetric measurements. For the test samples the maximum photogrammetric distortion is 0.05 mm, for the commercial ones it is 0.1 mm.

Very wide angle cameras AFA-TES-5, owing to their large angle and high image quality, are used successfully and make it possible to obtain a new type of geological information in studying stretched and weak structures.

The camera AFA-TES-7 is intended for photography of plain areas for the purpose of topographic mapping on the scale 1:10,000 and larger. It is provided with Russar-80 lens whose focal length is 70 mm; the angle of view is 120°; and the relative aperture is 1:6.8. The main optical characteristics of AFA-TES-7 are presented in figure 79.2.

The image quality improvement obtained with this camera enables a scale of photography 1.3 times smaller than that of the previous camera AFA-TE-70.

Camera AFA-TES-10 is intended for photography of hill areas on different scales. It is provided with Russar-71 lens whose focal length is 100 mm; the angle of view is 103°; and the relative aperture is 1:6.8. The main optical characteristics of AFA-TES-10 are presented in figure 79.3.

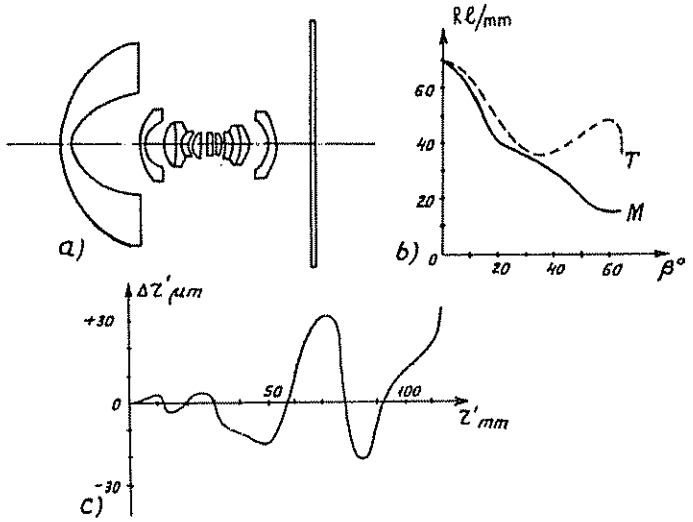
Using AFA-TES-10 for topographic survey of hill areas in the scales 1:100,000 and larger, for mapping, enables making photographs on a scale 1.4 times smaller.

Camera AFA-TE-35 is intended for photography of mountain regions, towns and localities. It is provided with Russar-68 lens whose focal length is 350 mm; angle of view is 40°; and relative aperture is 1:7. The camera enables the central rotor shutter to be used, the magnification in lens pupils being 0.7. Owing to this, with relative aperture being 1:7, the diameter of the aperture diaphragm, and therefore the shutter aperture, is equal to 35 mm. The main optical characteristics of AFA-TE-35 are given in figure 79.4.

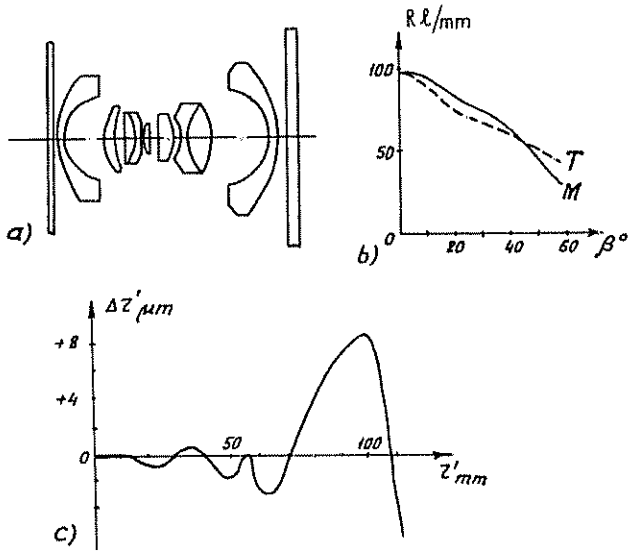
In camera AFA-TE-35, vacuum flattening of the film to the plane at the time of exposure is used. The choice of this method is due to the fact that images obtained with AFA-TE-35 are mainly intended for making photoplans with high enlargement when defects in the negatives, caused by mechanical damages of the glass and photographic layer that are inevitable in pressing the film to the glass, deteriorate the quality of negatives noticeably: and one need not use register-glass reseau.

Camera AFA-TE-35 enables reduction in the scale of photography by a factor of about 1.2.

The main technical characteristics of cameras of TES-type are given in the table.

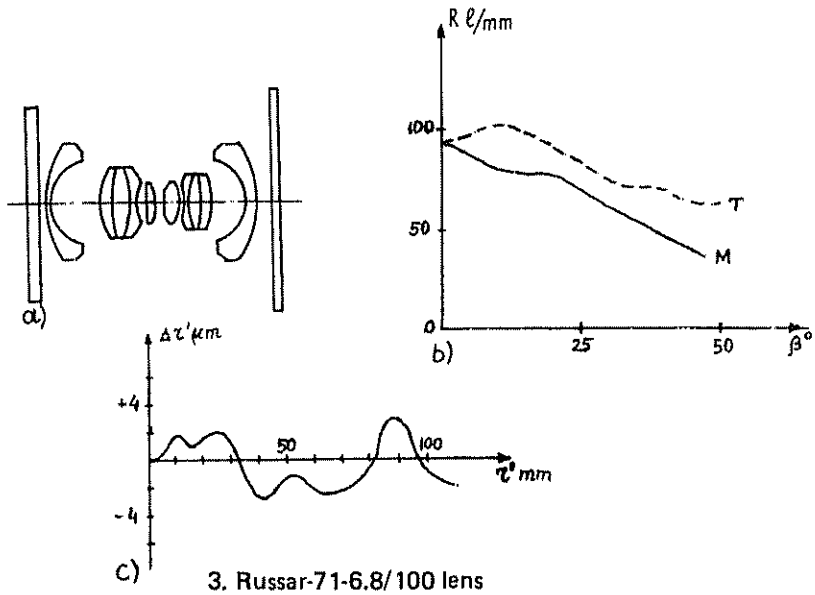


1. Russar -62-9/50 lens
   a) Principal optical scheme
   b) Resolution
   c) Average radial distortion

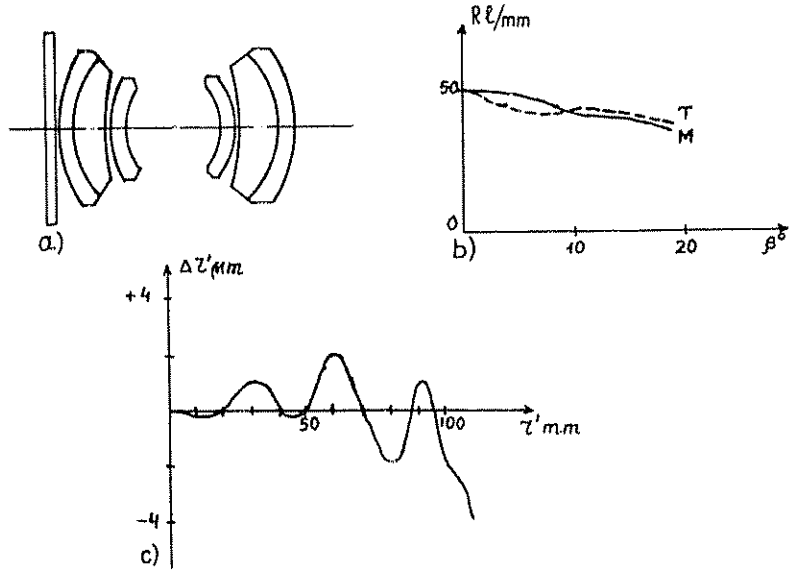


2. Russar-80-6.8/70 lens
   a) Principal optical scheme
   b) Resolution
   c) Average radial distortion

Figure 79. Union of Soviet Socialist Republics: TES aerocameras; Russar lenses



3. Russar-71-6.8/100 lens
   a) Principal optical scheme
   b) Resolution
   c) Average radial distortion



4. Russar-68-7/350 lens
   a) Principal optical scheme
   b) Resolution
   c) Average radial distortion

Figure 79 (continued)

TABLE THE MAIN CHARACTERISTICS OF THE TES-TYPE CAMERAS

Parameter 1	Units 2	TES-5 3	TES-5M 4	TES-7 5	TES-10 6	TE-35 7
Focal length	mm	50	50	70	100	350
Camera angle	degree		136.5	120	103	40
Relative aperture	—		1:9	1:6.8	1:6.8	1:7
Illumination	—		$COS^{1.48}\beta$	$COS^{2.7}\beta$	$COS^{3}\beta$	$COS^{4.78}\beta$
Stereoscopic fusion accuracy	μm		±3.3	±3.5	±3.0	±2.8
Resolution not less than	l/mm		16	25	30	35
Photogrammetric dispersion not more than	μm		100	10	10	10
Exposure range	s	1/70 -1/700	1/80 -1/240	1/70 -1/700	1/70 -1/700	1/70 -1/700
Cycle time	s	2.4- −1.4	2.4	2.4- 1.4	2.4- 1.4	2.4- 1.4
Register-glass-reseau		yes		yes	yes	no
AEC		yes	no	yes	yes	yes

GEODETIC FRAMEWORKS: THEIR RELEVANCE FOR DEVELOPMENT*

Paper presented by the United Kingdom of Great Britain and Northern Ireland

RÉSUMÉ

Le postulat faisant d'un canevas géodésique établi et ajusté de façon à répondre aux normes les plus élevées possibles une condition essentielle pour tous les travaux topographiques et cartographiques découle de l'absence déplorable de levés géodésiques avant 1950. La précision qu'on peut obtenir à présent est bien supérieure à ce qu'elle était alors, et dans bien des cas les levés effectués d'après un tel canevas sont désormais d'une précision jugée acceptable selon les normes admises précédemment. Les qualités exigées d'un canevas devant servir de cadre de référence pour les levés établis aux fins du développement peuvent être dissociées des exigences scientifiques. Certaines de ces qualités n'ont en effet rien à voir avec ces exigences. On peut en conclure que le moment est venu de redéfinir l'objet des canevas géodésiques et d'envisager séparément le financement des levés établis aux fins du développement et celui des études scientifiques. Lorsque les ressources sont très limitées, comme lorsque des projets de coopération technique s'inscrivent dans le cadre d'un programme d'assistance à un pays en développement, la première chose à faire est de financer les projets qui contribueront rapidement à l'amélioration des ressources nationales. L'établissement d'un canevas simplement suffisant pour répondre aux besoins des usagers en général — lorsque ce canevas n'existe pas encore — doit alors venir au premier rang des priorités. Des levés plus précis et plus coûteux peuvent se justifier dans certains cas mais on peut aussi bien s'en passer si la seule justification découle d'un postulat périmé. Il sera toujours possible par la suite de pousser les travaux plus avant pour répondre aux exigences scientifiques lorsqu'il sera plus facile de mobiliser des fonds.

THE PURPOSE OF A FRAMEWORK

In the United Kingdom the terms "geodesy" and "geodetic surveys" have always been applied to those surveys whose functions are to provide a framework for all other (and consequently lower order) surveys and also to further knowledge of the physical science of the earth, including determination of its size, shape and density. In the first half of this century definitions were given, or expanded, in British textbooks of which those given by Clark (1) and Bomford (2) are typical.** Clark listed 11 subjects of investigation pertinent to geodesy, including:

(*a*) Map making;

(*b*) The dimensions and figure of the earth;

(*c*) The mean density of the earth;

(*d*) Variations in the magnitude and direction of the force of gravity;

(*e*) The structure of the crust and its vertical movements;

(*f*) The intensity of magnetic force and the magnitude of declination and dip over the earth;

(*g*) Variations in latitude due to the changing direction of the rotation axis of the earth;

(*h*) Tidal observations.

He commented that the conduct of investigations on these subjects "although not so immediately useful to the general user of maps [which he saw as the primary object of a state survey department] are of the greatest service in promoting accuracy in practical geodesy and in the sciences of astronomy, physics, geology and meteorology".

*The original text of this paper, prepared by B. E. Furmston, Directorate of Overseas Surveys, appeared as document E/CONF.72/L.54.

**Numbers in parentheses are keyed to the reference list.

Bomford, writing later than Clark and just about at mid-century, summarized matters more concisely, giving the objects of geodetic triangulation (which was still essentially the only means of establishing a large framework) as:

(*a*) To constitute a framework on which less precise triangles may be based, which in turn may form a framework for topographical and cadastral maps;

(*b*) In combination with observations for latitude, longitude and gravity, to assist in determining the size and shape of the earth and the variations of density within it.

Commenting, he wrote,

> "Of these objects the first is a practical necessity . . . [since]...any attempt at the continuous mapping of a large area without either primary triangulation, or some substitute...will result in confusion. It is often difficult to justify expenditure on the purely scientific aspects of geodesy, and it is fortunate that triangulation, which is the most expensive of all geodetic processes, can be justified as indispensable to the surveyor."

It had become, and still largely remains, an axiom among surveyors that a geodetic framework, *observed and adjusted to the highest possible standard*, is an essential basis for all surveying and mapping, and that every effort should be made by survey administrators to secure funds for its establishment from their Governments. Such frameworks are very rarely financed by private enterprise and even Governments have not always been convinced of their necessity.

Since the 1950s, progress in the whole field of geodesy and geophysics has been remarkable, and achievable accuracy of measurement has been much improved. In geophysics the emergence of the theories of plate tectonics has thrown new and revealing light on the physical characteristics of the earth's crust, while developments in the instruments available for measuring the size and shape of large areas include complete new ranges of systems. Space technology has fostered the study of dynamic gravity models for the determination of the orbital elements of space satellites which have also, in turn, led to new systems of position fixing. The power of electronic computers has radically changed approaches to the art of the adjustment of observations.

It is not enough to accept without challenge that, simply because new developments have made it possible to achieve higher and higher orders of accuracy, these must automatically lead to revised, more precise, coordinate systems and the reconstruction of maps, if those already in existence serve adequately the needs of users. Warren (3), discussing the responsibilities of national survey departments, has written,

> "There is no doubt that the standards for control surveys which are needed by normal professional users are quite different from those discussed and accepted by geodesists at international conferences of geodesy. . . . What is not so certain however is whether the national survey departments should so readily accept responsibility for complying with these [international] standards. . . . These activities should be left to scientists and/or academics, since it is doubtful if they are the function of national departments unless the government has specifically provided finance for them in their budgets."

Past circumstances

At the time when the definitions mentioned earlier were formulated, there is no doubt that the map series of many countries were seriously deficient. Coverage at all scales was patchy, co-ordinate systems were often based on local origins and the projections in use were often unsuitable, so that problems were inevitable when patches of cover were extended and linked with others. Triangulation systems, whether national or local, were often poorly designed and extended from doubtful bases through inadequate figures so that scale errors posed problems for large-scale mapping. The only solution was framework triangulation which itself suffered from the practical limits of computing techniques. Because only figures of limited complexity could be adjusted in a single computation, junctions between adjoining figures inevitably gave rise to accumulating errors in both scale and azimuth. So it was essential to cover the ground in large figures, these in turn requiring extreme accuracy of angle observation.

Cadastral surveys suffered from the same deficiencies, with the added complication that as patches of survey were linked through the extension of local schemes, the theoretical ownership of land, as depicted on plans, could easily, and sometimes did, overlap by a considerable area or fail to include strips which actually existed. Again the only answer was to link local systems and reduce them to a common origin and projection through primary triangulation.

In scientific geodesy, the only means available for calculating the size and shape of the earth, and thus to derive a spheroid closely approximating to the geoid to facilitate further computations as well as to advance scientific knowledge, was to measure the surface distance of long arcs and to use these in conjunction with astronomical determinations of absolute position. Again triangulation with the longest sides consistent with the observation of the most precise angles possible, controlled for scale by painstaking and expensive base measurement, was necessary.

Present circumstances

Since the 1950s much has been achieved. Framework surveys have been extended over many countries then without. Substantial areas of continuous mapping have been produced, based on these frameworks, with a considerable degree of commonality of datum and projection. A mass of cadastral data has similarly been accumulated and tied to the framework values. Certainly many datums, using a variety of spheroids, exist but the differences are often small, particularly in terms of air and sea navigation.

The advent of electronic distance measurement techniques in the late 1950s at first served to show that the painstaking analysis of the probable errors of conventional triangulation, controlled by taped bases, had been optimistic. Scale errors well in excess of those predicted were found and, although at first challenged with suggestions that the new measurements were wrong, were soon proved to be widespread. Even so, almost all users of survey data engaged in tasks of development were quite satisfied with existing control where this was

now shown to have a scale accuracy of 1:50,000 or even less. In some parts of the United Kingdom the scale error of the framework in general use is known to be as much as 1:25,000, and yet the rare complaints come almost entirely from other surveyors on the ground that their new observations have to be distorted to fit the framework.

Electromagnetic distance measuring (EDM) was soon brought into use, not only as a tool to supply check measurements, but also as a standard device for injecting additional control into conventional networks and as a standard technique in the measurement of framework traverses. This certainly improved attainable accuracy but can equally well be seen as making the provision of a control framework to the old standard more economic.

Meanwhile the scope of computing technique was totally altered by the development of electronic computers. For the first time, it became feasible to adjust substantial networks in a single block, eliminating the errors associated with the transfer of scale and azimuth between figures. Provided a network design has taken account of the new technology by including appropriate redundant measurements a modern adjustment produces a homogeneous set of co-ordinates which is far less prone to include areas of lesser accuracy than that of the overall net.

Surveys of basic frameworks observed during and after the 1950s and computed using block adjustments generally reach standards of accuracy in the order of 1:50,000-1:100,000 in scale and 5″-10″ in azimuth or better. Yet with further generations of technology providing the possibility of even greater accuracy, calls for new observations and new adjustments are common. Geodesists press for an improvement in accuracy of one or even two orders. When computer simulation has been used to indicate an "optimum" set of observations to comprise a framework, this has almost always been seen as a means of increasing accuracy, not as a means of effecting economy in field-work to achieve a standard which satisfies the generality of users.

Fundamental requirements

What, then, are the essential characteristics of a survey framework and to what extent are the highest possible accuracies only required by a specialist and minority section of the community? Certainly all surveyors can agree with Bomford that continuous mapping requires a framework. For many users, however, as stated by Warren (3), maps are required only for locating position or for navigation (in the broadest sense). Even for those who require to take measurements from the face of a map, an accuracy of 1:5,000 is probably sufficient. This represents 1/10 mm in 1/2 metre on the map face, and few will seek to measure an actual distance any longer than this. Rather, smaller and smaller scale maps will be used as the distance over the earth's surface increases. Analysis by Adler *et al.* (4) reaches much the same conclusion by a different route. To achieve mapping of this order of accuracy, the first order framework need be no better than 1:100,000 with some localized error greater than this easily tolerable.

Cadastral surveys also need a framework if all the pieces of the jigsaw are to fit together. But again local accuracies of the order of 1:5,000 are generally tolerable and azimuths are rarely required, even by surveyors, to better than 10″. The survey regulations of many countries specify determinations of this order. In major towns and cities some localized increase in accuracy may be demanded—although it is necessary to distinguish between what surveyors themselves may consider desirable for their own convenience and what the user actually needs. Even so, local systems of higher accuracy may be merged into a national framework without necessarily raising the whole overall standard.

Certain aspects of engineering in development, for example road building, and irrigation schemes, involve long distances or large areas but the need for high precision in their survey requirements is confined to local works. In small localities great accuracy may be needed and the techniques developed for measuring first order framework may well be appropriate for use in miniature schemes. It is not necessary, however, for such local control schemes to be related to a national framework for their purpose is specialized and has no connection with other distant areas.

Height control calls for some special consideration if only for the simple reason that water will not flow uphill. The standards accepted for levelling networks are usually more precise than for planimetric control. Nevertheless, in all but quite exceptional cases the scope of water and drainage schemes is confined to a single catchment, and usually to a small area of a single catchment. Survey connection between such schemes need not be so precise and that between catchments even less so. The overall precision for a national-level network need only be sufficient to support topographical mapping, engineering reconnaissance and, perhaps, if mineral exploration warrants it, to support investigation of gravity anomalies. Lambert (5) considered it proved that a national levelling survey of third order levelling adjusted as a whole to peripheral tide gauges will provide results of sufficient accuracy for mapping and general engineering operations with any high precision levelling required for special purposes localized and funded on its merits.

Generally it is extremely rare to find user requirements that justify national frameworks with an accuracy better than some 5″ in azimuth, 1:100,000 in scale and with height differences correct to some 10-20 mm per kilometre. Local degradation in certain areas may well be acceptable, particularly if these are unsuitable for development. It would be interesting to see the results of objective research directed to an evaluation of the extent to which existing networks already meet these requirements and how, in areas still lacking a framework, such work could be most economically carried out using the most modern technology.

The demand for mapping to be continuous between separate land masses is confined to small scales and precise connections between their frameworks are usually irrelevant to development on land. Satellite systems afford a convenient method for offshore positioning and, for effective use, a connection between a "satellite" datum and that of a land framework is necessary. In both cases development does not depend on, or require, a complete readjustment and the adoption of a new world datum for the existing framework.

The expense of revising national survey records is not insignificant once a national system has been established. The rate of collection of data and the volume of data recorded in terms of existing networks have both

increased enormously in the last two decades. Although it may be claimed that modern computing power is such that record maps and co-ordinate data may be easily and quickly transformed to a new datum and control system, most such data are not held in forms assimilable by computer systems. Although there is currently much interest in computer-based information systems, most countries will, because transfer to such a system is dependent on high technology and an appropriate level of infrastructure and because it is expensive to initiate, be dependent for many years on written records and graphic records annotated on base maps. Further, whether computers can deal with the necessary transformations or not, the majority of the general public are not technically minded. It is very probable that recurrent "correction" of maps and co-ordinates on cadastral and control records will be misunderstood and will lead to confusion.

The scientific aspects of geodetic survey bring quite different factors into consideration. Geodesy, like any other scientific study, demands constant improvement of its data. The emphasis has, however, shifted in the last decade or two. Earlier, efforts to establish a spheroid that would most closely approximate to the size and shape of the earth were hampered by lack of data and the difficulty of inter-continental connections. Spheroid determination was given fresh and urgent emphasis by the drive to predict the behaviour of satellites but, in many ways, this has now been overtaken by results of measurements of the satellite orbits themselves. Advanced global gravity models rely for their refinement on observations of and by satellite systems. Global distances are now better measured by satellite-borne systems than by any earthbound method. Ground measurements for the study of tectonic phenomena have become important only in localized areas.

Despite this change in the global scene, the most precise measurements that can be achieved are desirable in certain localities. There are highly significant possibilities of supporting the efforts of geophysicists from other disciplines in explaining the mechanics of volcanoes and earthquakes, not only as a philosophical advance of knowledge but with practical value for citizens living in areas prone to these hazards. Further development of satellite and inertial systems is likely to require more intimate knowledge of the geoidal surface, including detailed investigation into its separation and angle of slope compared to a world spheroid, or other spheroids in general use.

Whether global or local, scientific studies have sufficient potential to justify their execution in their own right. But their funding and that of expenditure directed to their incorporation into revised national frameworks ought not to be confused with finance provided to support general survey and mapping.

Increasing separation between the specification appropriate to a framework for everyday survey needs and that for scientific studies has led to the adoption, by some countries, of two or more co-ordinate systems. For the first purpose, existing values are retained permanently (or at least for very long periods), thus avoiding the cost of effecting changes. As new measurements of increased accuracy may become available, readjustment of a selected network is effected, leading to a set, or a series of sets, of "scientific" co-ordinates. These countries may already be said to have abandoned the surveyors' axiom stated at the beginning of this article.

FUTURE DEVELOPMENTS

In the 1980s and beyond it may be that the fundamental geodetic survey network will lie, not in any ground framework, but in a constellation of satellites orbiting in space. A fundamental limitation to satellite positioning seems to be that local anomalies must affect the vector difference between stations close to each other even if translocation techniques are used, since even a complex geoidal model cannot take account of all such variations. Conventional measurement invariably meets a logical demand that, the closer two surveyed points are to each other, the more accurately their relative position may be determined. A new prospect which seems to conform to this demand is that of inertial surveying systems. While, until the present time, such systems have been designed to meet a navigational requirement, current development indicates that accuracies sufficient to meet more general survey demand may be possible.

Both satellite and inertial systems share a great advantage in that long lines of sight are no longer relevant to fixation. If they become commonplace, they will cause a complete break with the conventional attitudes of surveyors. The demand for surveyed stations has always been, with few exceptions, in accessible places where development has taken, or is taking, place. Much time and expense have been necessary in bringing control into such areas from framework stations necessarily established in remote locations simply because of the need to see long distances. The real demand may, in the future, be best met by framework stations established by satellite or inertial systems at points very close to the main communications network of a country. Conventional frameworks may even become redundant for both everyday and scientific purposes. Perhaps this is the stage at which the adoption of a new world datum will become of practical benefit.

A revised axiom

Whether these developments come to pass or not, it is already time for the earlier definitions of geodetic survey to be modified. The functions of geodetic survey might now be expressed as:

(*a*) To constitute a framework, to which less precise surveys may be connected, sufficient to ensure that national mapping, cadastral surveys and general surveys for development of large areas are based on a homogeneous co-ordinate system without discontinuities harmful to the general user;

(*b*) In combination with the studies of other specialists, to provide data of the highest possible precision for the definition of the geoidal surface, the geophysical character of the earth and the nature and occurrence of tectonic events.

The first of these objectives is essential to efficient land administration and the portrayal of information pertinent to land resources on maps and plans or in digital co-ordinate format. The degree of accuracy dictated by this requirement, however, may be met by a first order framework within which the positions of adjacent points are determined with a relative accuracy of the order of 1:100,000 and an important factor is the stability of the control data. The second objective may have immediate local practical significance, but justification of surveys of this precision will not, in general, follow from the essential nature of the first.

TECHNICAL CO-OPERATION

The concept of technical co-operation embraces all nations. Scientific investigation of the nature of the earth and its atmosphere cannot proceed without it and geodesy is one ingredient. For all manner of reasons the value of international co-operation cannot be over-emphasized. But when resources are limited it is inevitable that choice will be necessary in the allocation of funds. When technical co-operation projects form part of an aid programme those countries participating seek practical benefit of a developmental nature. The contribution of survey through mapping for the identification and development of the basic resource of land, the provision of an essential infrastructure, including support for urban growth and communications and the support of systems of land tenure by cadastral surveys, is clear. Whether surveys of precision greater than that absolutely necessary can be justified on a national scale using funds for which such necessities as housing, agriculture, education and health facilities are in competition is much more doubtful.

Until those requirements, sometimes termed basic needs, are satisfied, research in any community cannot take first priority. Indeed these basic facilities are often a prerequisite of effective scientific study which is not of immediate benefit. In those developing countries where survey is already based on a framework which meets the need of the general user, refinement for scientific purposes does not warrant priority. When a framework is not already adequate for these purposes or does not yet exist, the first aim should be to establish one which is, with prime regard for speed and economy and unnecessary refinement deferred until funds are more readily available. When a more accurate geodetic network is needed in a specific area to meet a specific goal it must be justified by argument which can be sustained against informed opposition. A real need may well be ignored if the justification rests on an outdated maxim.

REFERENCES

1. D. Clark, *Plane and Geodetic Surveying*, vol. II, 4th ed. (London, 1946).
2. G. Bomford, *Geodesy*, 1st ed. (Oxford, 1952)
3. D. E. Warren, "By whose standards", *Survey Review*, vol. XXIV, No. 187 (January 1978).
4. Adler, Papo and Perimuter, "The establishment of standards for lower order horizontal control", *Survey Review*, vol. XXV, No. 194 (October 1979).
5. B. P. Lambert, *National Geodetic Survey: A Modern Approach*, Proceedings of the 1st Symposium of Geodesy in Africa, Khartoum, 1974

NEW DEVELOPMENTS IN TERRESTRIAL AND SATELLITE SURVEY TECHNIQUES*

Paper presented by the United States of America

RÉSUMÉ

Au cours des 10 dernières années, les techniques géodésiques ont été marquées par un certain nombre de perfectionnements, à divers stades de développement, au service du géodésien et du topographe. Ces perfectionnements permettent naturellement à ces derniers d'accomplir des travaux exigeant un degré de précision plus élevé qu'auparavant; mais ils leur permettent aussi de le faire plus rapidement et plus économiquement puisque le coût des instruments de levé aussi bien que la rémunération des topographes ne cessent d'augmenter. Les conditions plus rigoureuses de précision accrue et d'économie imposées par les milieux civils et militaires ont conduit à perfectionner les techniques existantes et à mettre au point de nouvelles techniques. Ces techniques nouvelles ou améliorées ouvrent un vaste champ de possibilités et ont des degrés de complexité très divers, allant de systèmes tels que l'instrument de « station totale », capable de mesurer à la fois les angles et les distances pour les applications terrestres, au futur Système de positionnement global NAVSTAR, qui permettra de déterminer avec précision la position et la vitesse en temps réel d'objets se déplaçant sur terre, sur mer, dans les airs ou sur orbite terrestre.

Compte tenu de tous les changements qui surviennent dans le domaine de la géodésie, il est important de rappeler que la solution des problèmes actuels continuera de dépendre dans une large mesure des techniques géodésiques traditionnelles et des résultats obtenus tant par le passé qu'à l'heure actuelle. Il conviendrait également de ne pas oublier que nombre de ces perfectionnements dans le domaine des techniques géodésiques dépendent très largement des progrès réalisés dans des domaines aussi divers que nombreux (électronique et miniaturisation des semi-conducteurs, optique et laser, mathématiques et science informatique). Les techniques qui ont été mises au point pour la réalisation de levés géodésiques (établissement de canevas) et topographiques peuvent être divisées en deux principaux groupes : d'une part, les techniques terrestres et, d'autre part, les techniques spatiales. Les possibilités actuelles et futures de ces techniques sont abordées dans le document, assorties d'exemples représentatifs.

*The original text of this paper, prepared by Erich H. Rutscheidt, Defense Mapping Agency, appeared as document E/CONF.72/L.20.

Les techniques géodésiques terrestres classiques ressortissent aux domaines suivants : mesure des angles, ou triangulation, au moyen de théodolites; mesure des distances à la chaîne d'arpenteur ou à l'aide d'autres instruments; nivellement à l'aide de niveaux et de jalons-mires; observation des étoiles au moyen de théodolites servant à déterminer leur position et leur azimut; et mesure de la gravité à l'aide de pendules et de dynamomètres à ressort. On trouvera quelques exemples de possibilités qu'offrent les techniques géodésiques terrestres pour la mesure des distances; l'établissement de canevas astronomiques et l'utilisation de systèmes de positionnement par inertie.

La définition de points géodésiques par mesures astronomiques est désormais obtenue principalement à l'aide de satellites artificiels à orbite rapprochée. Ces satellites sont maintenant poursuivis et leur orbite calculée avec assez de précision pour que le topographe puisse, avec un récepteur Doppler adéquat, établir des positions au mètre près. En outre, le relevé des perturbations de leur orbite et l'altimétrie radar par rapport à la surface des océans en font aujourd'hui le principal moyen de déterminer les larges variations du champ de gravité. Plusieurs techniques nouvelles ont également été mises au point dans le cadre du programme spatial qui permettent de surmonter certaines limitations imposées par les systèmes classiques et de mesurer au centimètre près de longues lignes de base, la course des pôles, la rotation de la Terre, le mouvement des plaques tectoniques et autres mouvements dynamiques de faible amplitude tels que les marées terrestres et certains mouvements localisés de la croûte terrestre. La poursuite Doppler des satellites à orbite rapprochée est utilisée dans les programmes de recherche géodésique et dans les programmes opérationnels depuis 18 ans environ. Cette méthode de poursuite en tous temps permet une couverture maximale des satellites à partir d'un réseau donné de stations terriennes. Presque tous les résultats qui ont été obtenus jusqu'à maintenant l'ont été grâce au Navy Navigation Satellite System (Système à satellites pour la navigation maritime) des Etats-Unis d'Amérique.

Le succès de ce système a conduit le Ministère de la défense à envisager de mettre au point un nouveau système offrant de plus grandes possibilités ainsi qu'une plus vaste gamme d'applications. Ce nouveau système, actuellement en cours d'élaboration, a été baptisé NAVSTAR GPS (Système de positionnement global NAVSTAR) et devrait permettre une lecture continue des positions en trois dimensions, utile à la navigation aérienne et maritime, ainsi que le positionnement de points sur la Terre. Le GPS est un programme commun des différents services du Ministère de la défense, placé sous l'administration de l'Armée de l'air, et le système opérationnel comprendra 24 satellites sur trois plans orbitaux à une altitude de 20 400 kilomètres, plus un secteur terrien qui assurera l'étalonnage et la surveillance du système.

During the past 10 years a number of advances in geodetic techniques have been either initiated, continued, or implemented to assist the geodesist and surveyor. These advances have naturally made it possible for the geodesist and surveyor to accomplish those tasks requiring greater accuracy than had previously been needed, but they have also made it possible to accomplish tasks more rapidly and more economically since both the cost of surveying instruments and surveyors' salaries are forever increasing. More stringent requirements for improved accuracy and economy which have been put forth by both the civilian and military communities have paced the improvement of existing techniques and the development of new techniques. These new and improved techniques span a broad spectrum of capability and complexity, ranging from such systems as the "total station" instrument capable of measuring both angles and distance for terrestrial applications, to the future NAVSTAR Global Positioning System (GPS) which will be capable of precisely determining the real-time position and velocity of vehicles on the land, on the sea, in the air or in earth orbit.

With all of the changes that are occurring in the field of geodesy, it is important to remember that traditional geodetic techniques and results from both the past and the present will continue to have major application to current problems. Also, one should be aware of the fact that many of these advances in geodetic techniques are critically dependent on developments in many diverse fields such as electronics and solid state miniaturization, optics and laser engineering, or mathematics and computer science. Traditional techniques, in the context of this paper, include such things as spirit levelling for elevation; pendulums and gravity meters for the magnitude of gravity; triangulation, trilateration and traverse for direction and distance; and the directions of stars relative to a spirit level for the direction of gravity. Modern techniques include such things as electronic distance measuring equipment, precise photogrammetric techniques, free-fall devices for ultra-precise gravity measurements, radio interferometric determination of baselines, and spacecraft whose motions are carefully measured to infer the nature of the earth's gravity field or to determine the position of the observer.

The basic goals of geodesy help to establish a fundamental foundation from which most surveying can be conducted. Four broad areas of activity may be defined within the field of surveying and these include (*a*) geo-

detic or control surveys; (*b*) construction or engineering surveys; (*c*) property or cadastral surveys; and (*d*) topographic surveys. Within the scope of this report, only geodetic and topographic surveys (i.e., (*a*) and (*b*) above) will be addressed.

Specifically, geodetic or control surveys include determination of the earth's size and shape; selection of coordinate systems; establishment of vertical and horizontal control; geodetic information collection; storage and dissemination; and research and development to assure the continued advancement of the state-of-the-art. Topographic surveying utilizes the synergistic effects of such varied disciplines as conventional field techniques, remote sensing techniques, and photogrammetry to provide the basic information required for preparation of maps and charts. Within the United States, these efforts are addressed at the national level by such federal agencies as the Defense Mapping Agency, the United States Geological Survey, and the National Ocean Survey. Most states, and many of the counties and municipalities, have their own mapping organizations which prepare and maintain all types of maps.

The techniques which have been developed to accomplish geodetic (i.e., control) and topographic surveys may be divided into two main types—terrestrial techniques and space techniques. The present and future capabilities, with representative examples of these techniques, are discussed below.

TERRESTRIAL GEODETIC TECHNIQUES

Traditionally, terrestrial geodetic techniques have been concerned with angle measurements, or triangulation, using theodolites; distance measurements, using tapes or other devices; differences in elevation by spirit levels and rods; star observations, using theodolites for position and azimuth determination; and gravity measurements, using pendulums and spring balance devices. Some examples of the current level of capability in terrestrial geodetic techniques are described below for distance measurement, astronomic measurement, and finally inertial positioning systems.

Distance measurement

Over the last two decades, the technology involved in distance measurement has continued to evolve to the point where the state-of-the-art today is based on the principle and electromagnetic waves (i.e., visible laser, infra-red, and microwave) are transmitted from an instrument to a reflector and back to the instrument, the transit time is determined and the distance defined. This is a significant change of capability from the days of staking a line at 50-metre intervals and then measuring it precisely with invar wires or tapes. Today, there are more than 30 distance measurement instruments on the commercial market which have a tremendous span of capabilities available to meet the needs of the user community, from the construction engineer laying out a building to the geodetic surveyor running traverse lines across continents. More recent evaluation of this technology has led to the combining of several instruments to provide multiple functions for static measurements and even systems for dynamic position determinations.

Rangemaster II. The Rangemaster II, an electronic distance measuring device, is representative of the current capability in the area of long-range measurements. This tripod mounted instrument, weighing only 40 pounds, has a range of up to 60 km with a manufacturer-stated accuracy of ± 5 mm $+ 1$ ppm of the distance. It uses a phase comparison technique for range determination which utilizes a continuous wave, helium-neon laser light source with a maximum output of 2.2 milliwatts. The instrument is simple to operate. The measured distance in either feet or metres is automatically displayed on an 8-digit gas discharge display and can also be output to a printer. Only about 10 seconds are required to accomplish a distance measurement. This instrument is currently being used for precise traverse and trilateration in support of geodetic survey programmes. Testing of the instrument has verified the manufacturer-stated accuracy.

Terrameter. Uncertainties caused by changes in the refractive index at points along the ray path are the primary factor limiting the accuracy of long-range measurements. One possible solution to this problem is an instrument called the "terrameter", which is nearing the end of development and testing of a prototype has been completed. This instrument utilizes two optical wavelengths and one microwave wavelength to resolve the refractive index over the entire path being measured. The principle of operation relies on the fact that the two optical wavelengths propagate over the path at slightly different velocities, and the microwave signal is used to determine the average water vapour density along the path. It should be noted that the microwave channel is provided by a tellurometer CA-1000 interfaced with the main instrument. The advantage of this instrument is that it virtually eliminates the effects of atmospheric conditions on the distance measurement, thus achieving an order of magnitude increase in accuracy over single wavelength instruments.

Results of testing the prototype indicate that a precision of 1 part in 10 million or ± 0.1 millimeter, whichever is greater, can be achieved over a range of 1 to 15 km. The instrument will be used by DMA to obtain the required accuracy for test tracks at Holloman Air Force Base, New Mexico, and China Lake, California, for research and development at the national test ranges operated by the Department of Defense.

Total station instrument. One of the most recent developments in short-range electronic distance measuring devices is the combined function Hewlett Packard model 3820A electronic total station instrument which is capable of measuring both distances and directions.

This particular infra-red instrument has a ranging capability of up to 5 km with a manufacturer-stated accuracy of ± 5 mm $+ 5$ ppm of the distance. The light source is a solid state Gallium-Arsenic diode with a nominal wavelength of 830 nanometres. Direction measurements have a resolution of 1 second with a manufacturer-stated accuracy of ± 2 seconds for horizontal directions and ± 4 seconds for zenith angles based on readings with the telescope in direct and reverse positions. The system has the capability to automatically compensate for mis-level of the instrument by a dual axis, liquid surface reflection sensor. The instrument also has a microprocessor which computes, on request, the horizontal distance and the difference in elevation between the instrument and the target based on the measured slope distance and zenith angle.

The "total station" instrument can be used for azimuth and distance ties to secondary control points for

lower order triangulation and trilateration. The advantages of the instrument are the speed and simplicity of operation which make its use in support of military operations such as artillery surveys ideal. A further advantage of the instrument is the availability of an optional data recorder which eliminates the physical recording of the readings.

Astronomic azimuths and positioning

Advances in technology have started to impact the technique of establishing astronomic positions and azimuths. New timing equipment has already been developed and is currently in use. Other developments are in progress for the purpose of minimizing the effect of atmospheric phenomena, elimination of the "personal equation" and automation as well as decreasing the time required for the computations. The ever-increasing accuracy requirements to support the testing of defence systems, particularly inertial systems, demand that increased accuracies be achieved.

Automated azimuth measurement system. An automated azimuth measurement system is currently being developed in the United States to satisfy requirements for highly precise azimuths and the system represents the state-of-the-art for highly accurate, all-weather, automatic azimuth measurement. The system consists of the following major components: two integrated inertial sensors, an angle transfer system, a tilt meter array, and an LSI-11 microprocessor.

Traditionally, stellar observations have been used to determine azimuth; however, for certain applications this method can have drawbacks such as: observations required over long-time periods for precise results, prevailing weather conditions, correcting for such effects as polar motion and the uncertainty of atmospheric refraction. Although inertial azimuth systems are not affected by many of the things that influence the traditional methods, they are not without some disadvantages since most inertial azimuth measuring systems cannot distinguish between sensing earth rate and rates that are sensed due to tilt motions. This system has attempted to minimize this deficiency by incorporating tilt meters which are used to determine corrections which can be applied by the microprocessor for errors induced by tilts and tilt rates. Extensive laboratory and field testing has determined that the system accuracy yields a standard deviation for a single azimuth determination of approximately 2.1 arc seconds and a standard error of the mean of 0.6 arc seconds.

Continued improvement of the accuracy and automation of this system is planned and will address at least the following problem areas:

(*a*) Replacement of noisy electronics with precision linear power packs;

(*b*) Improvement of optics;

(*c*) Application of advanced hardware and techniques for the tilt meters;

(*d*) Utilization of the latest microprocessor technology to improve signal processing and the degree of automation.

Astronomic position determination. Over the last 20 years a number of attempts have been made to develop automatic astronomic position determination instruments. Efforts have also been made to improve the accuracy of astronomic positions. Efforts are currently under way to improve the accuracy of astronomic position determinations made with the reliable conventional instrument, the Wild T-4 universal theodolite. Two studies are currently under way and they include the development of the two-colour refractometer and the development of an impersonal eyepiece, the ultimate objective being the determination of an astronomical position with an accuracy of 0.1 arc second or better for a single observation utilizing a portable field instrument.

Impersonal eyepiece. Conventional astronomic positioning utilizes a variety of telescopes and theodolites with the human eye as the sensor in a system that relies on the reaction time of the observer (usually in excess of one hundredth of a second) to track a star with a drum micrometer. Various attempts have been made in the past either to minimize the effect of the observer's error (i.e. motor driven micrometers) or to eliminate the observer completely (i.e., the automated astronomic positioning system). The recent development and refinement of the technology for fabrication of sizeable arrays of photosensitive transducers (i.e., photo diodes, charge injection devices, charge coupled devices) have created the opportunity for new attempts to eliminate the observer's error completely.

An experimental demonstration-of-concept effort has been completed by the United States Army Engineer Topographic Laboratories in which the eyepiece of a Wild T-4 theodolite was modified so that a self-scanning photodiode array with 50 x 50 elements replaced the manual micrometer. The associated electronics and signal processing system had the capability to determine the position of the leading edge of the star image as it moved across the array.

Very limited field observations indicated that the system could detect stars as faint as +3.5 magnitude, but easily added cooling of the array could extend this to +7 magnitude. Aside from the cooling improvement, utilization of larger arrays (i.e., 512 x 320 etc.) and utilization of arrays which allow an element-by-element rather than just raw-by-raw mode of operation are all improvements that are technologically feasible today and which should improve systems performance. This effort is continuing as an R&D effort at present.

Two-colour refractometer. The development of the two-colour refractometer involves the design, fabrication and testing of a two-colour sensor system. This will be followed by a programme to measure the value of the atmospheric refraction as it affects the measurement of the absolute position of a star with respect to local gravity. The objective is to determine the power spectral density of anomalous refraction, i.e., the difference between the value of the measured refraction and the standard values from refractive tables, using local refractivity. The data will permit a direct evaluation of the expected effort of the experimentally determined anomalous refraction on measurements conducted with an absolute accuracy of systems which use arrays to replace the observer, or which use apparent stellar rates to obtain astronomical position. The combination of the anomalous refraction measurements, made under a variety of atmospheric conditions, with an analytic treatment of the atmospheric effect may provide the ability to extrapolate these data to sites other than those used in the tests.

Inertial positioning system (IPS)

During the past 20 years great strides have taken place in inertial navigation system technology. Inertial systems used for aircraft navigation have been refined and modified to produce a surveying tool which is versatile and cost-effective for many applications. Its utility has been demonstrated for densifying horizontal and vertical survey control between existing control points established either by conventional means or by Doppler point positioning. Systems that are now operational have been built by Litton Systems, Inc., and by Honeywell, Inc., and can be mounted in a jeep, helicopter or similar vehicles. The cost of the equipment is currently about one half million dollars or more per unit. Highly skilled operators and maintenance personnel are essential to the success of this highly complex equipment. When surveys are properly planned and the equipment operating according to carefully developed specifications, its productivity is such that it can outproduce conventional survey methods.

The basic unit consists of an inertial measuring unit, a data processing unit, a power supply unit, a control and display unit, and a data storage unit. The control and display unit is located next to the driver's/pilot's seat for easy access while the system is being operated. The inertial measuring unit contains two air-bearing gyroscopes and three accelerometers mounted orthogonally to measure acceleration along the north, east, and vertical axis. A computer monitors the accelerations in the horizontal channels which are integrated by time to give the distance travelled in the particular direction. In establishing positions with the system, an elevation and position update is performed at the traverse starting point at which time the known co-ordinates of the point are entered into the system. The system is transported over the traverse course, stopping at intervals for zero velocity updates and stopping to perform point position determinations where required, the closure error computed and the traverse adjusted. All data are recorded on a magnetic cassette.

Extensive field testing performed by the Bureau of Land Management, the Geodetic Survey of Canada, and the Defense Mapping Agency have resulted in the development of accurate, effective, and practical field operating procedures that have yielded an accuracy of ± 0.5 metres, 1 sigma for each component on reasonably straight lines with control points no more than 50 km apart. Azimuths determined by the north-seeking gyros can be transferred to a terrestrial target with an accuracy of ± 20 arc seconds, 1 sigma. The use of the IPS for determination of relative gravity and deflection of the vertical are currently in the developmental stages. Gravity determinations from 20 test traverses show a system accuracy of 1.5 to 2.0 mgals with the exception of several lines influenced by heading sensitivity problems. The accuracy of deflection determinations is generally less than 1.5 arc seconds in the meridional and prime-vertical components for missions of 2 hours or less. Results of 22 test traverses have shown an accuracy of $\pm 1.''3$ in the north/south component and $\pm 0.''8$ east/west component where the average traverse is 40-50 km in length. Larger errors were associated with traverses over 80 km in length with mission times greater than 3.5 hours.

A general problem with inertial systems is that to obtain optimum accuracy the system must be employed in a fairly straight line measurement procedure. The GEO-SPIN may minimize this problem. The Honeywell, GEO-SPIN system was delivered to the Defense Mapping Agency in early September 1979 and tests and evaluation were to be completed before this conference.

The high accuracy and stability of the Electrically Suspended Gyro Inertial systems such as GEO-SPIN, combined with the low noise content of their inertial sensors (1-3 cm of position uncertainty), offer major benefits to precision land survey. Current projections for GEO-SPIN measurement accuracies include 10-15 cm, rms, for position, 1-2 mgals for gravity anomaly, and 0.5-1.0 arc seconds, rms, for deflections of the vertical.

Land survey applications during the 1980s are expected to include at least the following:

Geodetic control (first and second order);

Detail surveys;

Urban densification (to accuracies of 8-10 cm, rms, with 800-metre monument spacing);

Ground control for aerial surveys;

Pipeline and transmission line survey;

Oil, gas, and coal exploration;

Horizontal and vertical profile mapping;

Cadastral survey;

Relative gravity mapping.

Users will include military organizations, other governmental agencies, and commercial surveying companies. World-wide use of this capability has already begun.

SPACE TECHNIQUES

Close artificial satellites have become the principal celestial means of obtaining geodetic positions. Their orbits are now tracked and calculated accurately enough that with an appropriate Doppler receiver the surveyor can recover positions accurate to about 1 metre. In addition, through orbital perturbations and radar altimetry to the ocean surface, satellites have become the principal means of determining the broad variations in the gravity field. The space programme has also developed several new techniques which overcome certain limitations of the classical systems and thereby have the potential of centimetre-level accuracy for the measurement of long baselines, polar motion, earth rotation, plate motions, and other small dynamic motions such as solid earth tides and local crustal motions.

The original tracking techniques for geodetic purposes were cameras and radio Doppler tracking. Radio ranging was also developed for geodetic purposes in the early 1960s. These systems obtained global networks of positions with about 5-metre accuracy by the early 1970s. Cameras had a fundamental limitation in that they depended on accurate positions of stars in the background of the satellite to obtain directions. This technique has now been superseded for geodetic purposes by laser ranging.

Doppler tracking of near-earth satellites has been utilized in geodetic research programmes and operational programmes for about 18 years. Its all-weather tracking capability provides maximum satellite coverage for a given network of ground stations. Almost all of the results thus far have been obtained using the United States Navy Navigation Satellite System (NNSS).

Satellite Doppler positioning

The Applied Physics Laboratory, Johns Hopkins University, and the Naval Surface Weapons Center, at Dahlgren, Virginia, have pioneered the major developments in the NNSS, also called the TRANSIT system, resulting in an extremely versatile survey tool, but public and private institutions world-wide have had access to the system and have contributed to its development and success.

The Department of Defense conducted a test programme in late 1971 by comparing relative positions of fixed sites derived from Doppler measurements with positions along the precise geodimeter traverse in the United States which had been established by the National Geodetic Survey. The comparison yielded root-mean-square differences of 1 metre in each position component for sites in the eastern half of the United States and about 3 m for the western sites. These results led to the adoption by DMA of the Doppler system as its primary geodetic satellite ground positioning system and which has proved to be the most effective system for accurate and efficient determination of both relative and absolute geodetic positions. The Defense Mapping Agency Doppler system is currently being used to support all the Department's mapping, charting and geodesy programmes and is also being used by a number of United States civilian agencies, such as the National Geodetic Survey, the United States Geological Survey and the Bureau of Land Management, as the primary geodetic satellite positioning system. The Doppler system, as currently being used in the United States for precise point positioning, consists of a tracking network (TRANET) for continuous world-wide observation of selected satellites from the NNSS and small quick response and short-term field survey teams deployed with portable Doppler instrumentation for the collection of tracking data from selected satellites and finally the combination of the precise satellite post processed ephemeris from TRANET data and the portable receiver tracking data for the computation of precise point positions.

A number of activities are currently being studied to increase the flexibility and accuracy of the Doppler system. These areas include the replacement of the current TRANET equipment with state-of-the-art equipment, improvements in reduction software, the study of atmospheric effects, and the evaluation of the ephemeris broadcast by the satellite, i.e., the "broadcast" ephemeris. All of these areas were discussed in great detail recently at the Second International Geodetic Symposium on Satellite Doppler Positioning in Austin, Texas.

The Physical Science Laboratory, New Mexico State University, is currently building under contract to the Defense Mapping Agency new satellite tracking equipment, since the present equipment is approaching 17 years of continuous service with a corresponding increase in failure rate and decrease in parts availability. The new equipment, called TRANET II, includes 10 stations which will replace 10 of the 15 operational TRANET stations of the network starting in early 1979 and ending in late 1979 when the fabrication of all equipment has been completed and operational. Each of the 10 new stations will be equipped with a rubidium frequency standard to ensure that high-quality data are recorded at all times.

The point positioning program DOPPLR was developed by the Defense Mapping Agency during the early 1970s as part of the effort by the geodetic community to achieve station point position solutions of geodetic quality from the Doppler tracking of the NNS using the then newly developed GEOCEIVER. Extensive testing of the programme occurred during the Defense Department testing of the GEOCEIVER and the programme was later furnished to the National Geodetic Survey where additional modifications were made and incorporated. The programme was also furnished to several countries possessing Doppler receivers in South America. The DOPPLR software was re-examined beginning in 1977 for several reasons. First, since submeter accuracy was not a specific goal at the time the programme was written, as it is now, it was possible that submeter biases and sources of noise in the software existed and would be of concern. Second, multistation reduction techniques (simultaneous point positioning, translocation and short arc) have been shown to be superior to single point positions when maximum relative accuracy is required. Personnel from the Defense Mapping Agency, the Applied Physics Laboratory of Johns Hopkins, and the National Geodetic Survey have made a concerted effort to examine and update, if necessary, the techniques used in the programme.

It has been obvious for some time that there are systematic differences in geodetic point positioning using the "broadcast" ephemeris versus the Defense Mapping Agency "precise" ephemeris. Doppler data reduced both ways have clearly demonstrated the differences, and the reason for these differences should be understood by the geodetic surveying community. A two-part study of the differences between the "broadcast" ephemeris and the "precise" ephemeris was recently conducted jointly by the Applied Physics Laboratory and the Defense Mapping Agency. Part one of the study consisted of a careful comparison of the software used to produce the two ephemerides, with the aim of ferreting out incompatibilities, which can produce systematic differences in point positioning. In the second part of the study, a world-wide distribution of surveyed sites is used to compare the geocentric point positions obtained from the two different ephemeris types.

Changes to the software by either the Defense Mapping Agency or the Navy Astronautics Group are expected to be accomplished during 1979. The adoption of these changes by the Agency and the Group will be of considerable interest to the Doppler positioning community since the result will lead to the compatibility between the broadcast and precise ephemerides. The changes to be adopted to obtain consistency include—use of same gravity coefficients, station co-ordinates, GM value, tidal parameters, and the speed of light. In addition, both systems should use the satellite electrical centre rather than the centre of mass; correction for UTC-UTI should be added; the orbit should be refit twice per day; the Navy Astronautics Group should implement the polar motion fitting programme and use 2-day arc for orbit fit; and finally DMA should implement the Jacchia density model for air drag.

In view of continued progress in the development of the NAVSTAR GPS, the obvious question raised by the navigation and Doppler surveying community is, "What is the status and future of the Navy Navigation Satellite System?"

Several years ago the Navy undertook the Transit Improvement Program to enhance and improve certain features of the system. The Program consisted of a number of developmental satellites and the design is in production for future operational use. The design is called NOVA and the first NOVA satellite is scheduled for launch in January 1980, with the second NOVA scheduled for launch six months later. The NOVA satellites contain a number of improved features, including drag compensation, improved time/frequency control, and programmable on-board computers. The user will not be able to distinguish between the current OSCAR satellites and the NOVAs except for the 3 to 4 db signal enhancement from the improved antenna and transmitters. Plans call for the maintenance of a mixed constellation of NOVAs and OSCARs until the implementation of a better system, namely the GPS. The Department of Defense has structured a programme to validate performance of GPS for its strategic programme purposes and to maintain and support TRANSIT until 1990 (and beyond if necessary) while developing and installing GPS equipment.

Satellite-to-satellite tracking

Another technique which has promise for the application of satellites to geodetic problems is the concept of satellite-to-satellite tracking. In this technique, one or more satellites that are assumed to have well-defined positions are used to track (i.e., determine the location of) a satellite of unknown position. This concept was tested in 1975 utilizing the synchronous altitude ATS-6 satellite at 35,786 km to track the low altitude GEOS-3 satellite at 843 km.

Satellite-to-satellite tracking has been shown through studies to have several MC&G applications. Based on the fact that the range and range-rate data can be used to provide an almost instantaneous determination of the position and velocity vectors of the satellite being tracked, one is then able to use this information to derive items of MC&G interest. For example, the position velocity vectors can be used in the integration of the total energy which may allow the gravity parameters in the potential to be recovered directly without requiring the use of the orbital mechanics for the satellite being tracked and also without having to use existing gravitational models which may be incomplete. Also, the satellite-to-satellite concept will provide a means of increased accuracy in tracking with the additional benefits of requiring fewer ground-based tracking stations which are subject to limitations as to where they can be placed, are influenced at some finite level of accuracy by atmospheric (i.e., ionospheric and tropospheric) effects, and present all types of logistical challenges in order to operate on a continuing basis.

In summary, the satellite-to-satellite concept is another of the technologies which are in the early stages of development and which appear to hold very good promise for developing into a useful tool for MC&G applications.

FUTURE TECHNIQUES

The new adjustment of the North American Datum (NAD) 1983 has been widely publicized and described in some detail in recent literature. The new adjustment by the National Geodetic Survey will span the United States, as well as Canada, Greenland, Mexico and the republics of Central America. Early in the decision-making process, consideration was given to the choice of datums and it was determined that a geocentric datum, that is, one whose centre closely coincides with the centre of mass of the earth, would be desirable, considering the total spectrum of users of the final geodetic products. This decision will obviously impact the surveyor. To facilitate the readjustment the unprecedented task of establishing a data base containing approximately 250,000 control stations as well as 2,500,000 observations in computer readable form has been undertaken by the National Geodetic Survey. The readjustment of the geodetic control followed by the development of a precise geoid of North America will provide valuable data for the NAVSTAR GPS applications in North America. The North American geoid will contain the Doppler positions, astrogeodetic deflections, surface gravity, and the latest earth gravity model (GEM-12). The accuracy of this new geoid should be 2 metres or better.

The availability of the readjustment of control data for NAD, based heavily on Doppler positions and a geocentric datum together with the development of the precise geoid, will facilitate the use of GPS in North America. Co-ordinates obtained from GPS observations will be referred to the WGS ellipsoid. The observed co-ordinates will require transformation to the local system (NAD 83) and the precise geoid information will be required to refer the GPS derived co-ordinates to sea level elevations. If a small minicomputer is available with the associated GPS equipment, the surveyor or geodesist can store at least parts of the geoid in the minicomputer in the form of a polynomial and perform the transformation and reduction to sea level in almost real time.

Future impact of the NAD 1983 adjustment on the geodetic and surveying community

One of the major scientific achievements of its day was the NAD 1927 in which the United States Coast and Geodetic Survey undertook and completed the adjustment of co-ordinates of points in the 48 contiguous states and parts of Canada, and put them into a single system with a relatively high degree of internal consistency. The quality of this work has been verified by satellite methods by determining chord lengths. Satellite methods have also made it apparent that the data which have been utilized for so long will no longer suffice. Fifty years of newer, more precise survey data along with satellite data are now available to be used in this new adjustment.

Present plans call for this adjustment to be completed in late 1982 and published in 1983. It will include all orders of geodetic control from the United States, Canada, Greenland, Mexico, and the republics of Central America which should be a total of about 2.5 million observations. With such a massive amount of data, it was necessary to utilize innovative approaches to the data processing including doing some adjustments on a "field project-by-field project" basis, partially reducing the normal equations of nearly 200 blocks by eliminating unknowns with fully formed coefficients, and utilizing a back substitution procedure to solve the entire system. Also, research has indicated that modelling of the geoid will allow deflections of the vertical to be predicted accurately enough to allow them to be used to apply corrections in an expeditious manner.

The concept for the new adjustments calls for a geocentric datum or one which is centred on the centre of mass of the earth. This concept does present several significant changes which surveyors, responsible for establishing control, must adjust to:

(*a*) Control surveyors will have to reduce measured distances through a longer distance than if a NAD were chosen. This correction would be less than or equal to 60 metres or approximately 10 ppm;

(*b*) Co-ordinates will be grossly different with a geocentric datum and "unfamiliar" to the users.

NAVSTAR GPS

The success of the TRANSIT Satellite Navigation System has led the Department to consider a successor which will have greater capabilities and wider applications. The new system now under development is called NAVSTAR GPS and is designed for continuous position read-out in three dimensions which is useful for aircraft shipboard navigation as well as positioning of points on the earth. GPS is a Department of Defense joint service programme under Air Force management, and the operational system will consist of 24 satellites in three orbital planes at an altitude of 20,400 kilometres, plus a ground segment which will calibrate and control the system.

At present GPS is in the Phase I, or concept validation, stage and activities include the testing of several equipment types. A Mobile Test Van has been fabricated which houses a GPS x-type receiver which has the capability to collect data from four satellites simultaneously and is designed to be more accurate than the y-type which observes multiple satellites one at a time in sequence or the z-type which can receive only a single channel. In contrast to the above receiver types which are based on the pseudo-range technique, there is another vehicle mounted receiver which was sponsored by the Defense Mapping Agency and which operates on the Doppler principle in a manner similar to present Agency-utilized positioning systems such as the GEOCEIVER and JMR-1. Extensive testing is planned for these two systems and possibly others as they concurrently occupy several sites in the United States and elsewhere.

The technology of GPS, when fully operational and accompanied by the full system of 24 satellites, is expected to produce navigation accuracies on the order of 10 to 15 metres and to require less than 1 second to produce such results. It also appears possible that specially designed equipment may be able to achieve accuracies that are comparable to those expected with Very Long Baseline Interferometry (VLBI) (i.e. several centimetres) for differential measurements over a few hundred kilometres.

There is no doubt even at this early phase in its development that GPS, on the basis of existing technology alone, will have a revolutionary impact on the entire geodetic and cartographic community. However, there are many issues needing verification in the future with regard to the utilization of GPS. What accuracies are attainable with standard navigational receivers using optimized ephemerides? Must navigation receivers be modified in order to obtain mapping control accuracies of approximately 1 metre? Is the addition of laser retroreflectors aboard GPS satellites either feasible or desirable? Can the navigational Doppler transmitter be utilized to obtain geodetic accuracies of less than 10 centimetres?

References

Allen, W. A. and Pi-Fuay Chen, "Automated astronomic position determination using self-scanned optical sensor array", Proceedings of the American Congress on Surveying and Mapping, Washington, D.C., 27 February-5 March 1977.

Beers, L. D. and E. W. Finnegan, "Future of satellite geodesy in MC&G applications", paper presented to the First United Nations Regional Cartographic Conference for the Americas, Panama City, Panama, 8-19 March 1976.

Bossler, J. D., "The new adjustment of the North American horizontal datum", *EOS*, vol. 57, No. 8, August 1976.

Brunswick, C., "Doppler data receivers", paper presented to the IAGS Technology Exchange Week, Panama City, Panama, 14-19 May 1979.

Currie, D. G., "Proposal for the study of two-color absolute astrometry", University of Maryland, College Park, Maryland, November 1976.

National Academy of Sciences, *Geodesy: Trends and Prospects* (Washington, D.C., 1978).

Hadfield, M. J., "Location, navigation and survey—adaptability of high precision ESG Inertial Systems in the 1980's", paper presented to the Position Location and Navigation Symposium, San Diego, California, 6-9 November 1978.

Mancini, A., "Inertial geodesy—results and applications", paper presented at the IX Brazilian Congress for Cartography, Curitiba-Paraná, Brazil, 4-9 February 1979.

Proceedings of the First International Symposium on Inertial Technology for Surveying and Geodesy, Ottawa, Canada, 12-14 October 1977.

Proceedings of the Second International Geodetic Symposium on Satellite Doppler Positioning, Austin, Texas, 22-26 January 1979.

Rutscheidt, E. H., "Future of satellite geodesy systems", paper presented at the XV International Congress of Surveyors, Stockholm, Sweden, 6-14 June 1977.

Sharp, C. B., "Surveying and geodesy overview", paper presented to the IAGS Technology Exchange Week, Panama City, Panama, 14-19 May 1979.

Vonbun, F. O. and P. D. Argentiero, "Orbit determination accuracies using satellite-to-satellite tracking", paper presented to the Position Location and Navigation Symposium, San Diego, California, 6-9 November 1978.

TEST RESULTS OF A HIGH-PRECISION ANALYTICAL PHOTOGRAMMETRIC SYSTEM*

Paper presented by the United States of America

RÉSUMÉ

Stimulé par les progrès réalisés dans le domaine de l'informatique et des techniques de mesure, le National Ocean Survey (Service océanographique national) a

*The original text of this paper, prepared by Chester C. Slama, National Ocean Survey of the National Oceanic and Atmospheric Administration, appeared as document E/CONF.72/L.25.

commencé à étudier en 1975 la possibilité d'utiliser un système de triangulation analytique de haute précision en vue d'accroître éventuellement la densité du canevas géodésique. Le système étudié utilise une chambre de prises de vues équipée d'un cône lenticulaire spécial avec trame incorporée. Tous les points au sol sont repérés avant les prises de vues, les mesures sont partiellement automatisées et l'on obtient une précision géométrique optimale des résultats photogrammétriques en utilisant un ensemble d'axes de vol spéciaux. Les erreurs systématiques qu'on rencontre normalement en photogrammétrie sont réduites au minimum par l'optimisation de l'image, l'étalonnage des éléments de l'objectif photographique au moyen de méthodes stellaires, l'étalonnage très poussé de la trame de la chambre de prise de vues, le recours à de multiples repérages lors de la prise des mesures, l'étalonnage complet du dispositif de mesure et le traitement rigoureux des observations dans le calcul des ajustements.

Lors d'essais effectués au-dessus de l'aire étalonnée de Casa Grande, on a réalisé huit séries différentes de photographies aériennes pour étudier le degré d'exactitude des résultats définitifs. Dans le meilleur des cas, les résultats définitifs ajustés indiquent une différence d'erreur moyenne quadratique de 0,046 m pour 225 points entre les levés géodésiques et les levés photogrammétriques. Cela représente un rapport de 516 158 entre l'échelle de la photographie et l'erreur en mètres, soit un résultat cinq fois plus précis que les résultats enregistrés par le Service lors d'expériences précédentes.

In the fall of 1971 Duane Brown (1971) presented a paper at the Semi-Annual Convention of the American Society of Photogrammetry (ASP) in which he discussed the potential use of analytical triangulation in place of ground surveying. In that paper he concluded that photogrammetry was "economically competitive with ground surveying in many applications calling for geodetic accuracies consistent with first- and second-order standards." This statement was based on a comprehensive analysis of time and costs of both systems and coupled with variations in geometry of the photogrammetric problem with their associated error propagations.

In the spring of 1973, at the ASP annual meeting, Duane Brown (1973) again presented a paper on aerotriangulation as a supplement to ground surveying. Using an analysis on photogrammetric projects carried out in the past, he showed that "photogrammetric densification... can cut overall project costs as little as one third... without compromising accuracies." Finally, at the XIII Congress of The International Society for Photogrammetry, Duane Brown (1976) reported the results of a pilot project conducted for the city of Atlanta and the Department of Transportation of the state of Georgia. There he showed results that proved some of his earlier estimates from a standpoint of both cost and accuracy.

Also at the latter Congress, R. G. Roberts (1976) showed that "test field" methods of analytical block aerotriangulation produced results that approach those using ground geodetic field methods.

Meanwhile, at National Ocean Survey (NOS) of the National Oceanic and Atmospheric Administration (NOAA), Hellmut Schmid recognized the need to pursue greater precision in the acquisition and reduction of analytical photogrammetric data. Before retiring as Director of the NOS Geodetic Laboratory, he contracted with Wild, Ltd, for the purchase (in 1974) of a special geodetic lens cone. This resulted in a NOS cooperative project between its Geodetic Laboratory and Coastal Mapping Division to investigate the potential of a high precision numerical photogrammetric triangulation system for geodetic control densification. A general description of that project, coupled with a discussion of some results, is the subject of this paper.

Because the project philosophy is discussed thoroughly in Munson and Baker (1974), Hull (1975), and Slama (1977), this paper will include only a general summary of the test project.

When one analyses the results of numerical extension, it becomes readily apparent that systematic errors are the major causes of inaccuracies in the interpolation process. Recognizing this, Brown suggested two avenues of approach open for the improvement of accuracies (Brown, 1974). One is the exercise of the process of "self calibration", and the other is the application of more accurate and more comprehensive corrections prior to adjustment. At NOS we chose the second approach as the primary goal for the test.

For control of the sensor, NOS procured a special Wild Universal Aviogon II lens cone that has a maximum aperture of $f/4$, a 15-cm focal length, and a projected reseau array in the focal plane. The cone is compatible with our present Wild RC-10 camera and therefore blends well with our present system. The most important feature of the lens is that it is designed for optimal resolution at a narrow band of the visible spectrum. This can provide several advantages to the system not normally available to regular mapping. First, since the aberrations are minimized for a particular wavelength, images of targets reflecting that color will be presented with the sharpest definition. Second, errors introduced into the system through the variation of lens distortions with color will be minimized by having all targets imaged by the same wavelength. Thus, the lens can provide a tool whereby transient systematic errors of pointing in the mensuration phase will be reduced by improved definition, and persistent systematic errors due to unmodeled lens distortion will be reduced by calibration to a narrow band of light.

Of major importance is the projected reseau pattern in the focal plane of the lens cone. This reseau will control one error source in photogrammetry that is a major contributor to the limitation in accuracy—the unpredictable deformations that take place in aerial film after the exposure. Without a reseau, the only means of pro-

viding stability was through the use of glass plates as a transport for the photographic emulsion. Obviously, glass is not only expensive, but also presents problems in logistics and storage. The reseau does not prevent the film from changing dimension but, when precisely calibrated, does provide a means of predicting the changes that have taken place by measuring their relative positions during the mensuration phase.

Upon receipt of the cone in late July 1974, several studies were initiated. First, an investigation of emulsion, target size and color, aperture, shutter speed and filters was conducted to obtain optimum image definition at various flying altitudes. Second, the cone underwent a complete stellar calibration, using techniques developed for the world-wide satellite triangulation program. The stellar calibration allows the determination of various internal perturbations of the lens that are not readily available from standard laboratory bench techniques. Finally, the cone was flown over a geodetic test field to further evaluate the internal geometry (coupled with atmospheric effects) in an operational environment.

The introduction of a reseau into the system carries with it the added burden of increased office mensuration. To compensate, NOS installed a Mann Automatic Stellar Comparator that is computer controlled to drive to any preselected position and has density centroid correlation circuitry for centering on symmetrical images such as reseau crosses or round ground targets. With this device the measurement process proceeds as follows. First, the approximate positions of all targeted ground points and the nadirs of the photography are plotted and identified on the latest existing map coverage. These points are then in turn digitized relative to the map graticule to establish their approximate geographic co-ordinates. Next, several key reseau crosses, and at least four ground point images on each photograph, are digitized; from these digitized ground points, a computer program computes a resection to determine the approximate photo co-ordinates of all control points "seen" by the photograph.

In addition, the program adds the point identifier and computes the approximate photo co-ordinates of the six reseau crosses nearest to the ground target. The identifier for each cross is also added to the output. The output of this program is a punch paper tape that serves as input to the automatic comparator. That is, the controller of the comparator "reads" the approximate photo coordinates and automatically drives the measuring mark to the ground target image and then sequentially to its surrounding reseau images. Thus, the operator is left free to concentrate on final pointings only and is not burdened with locating the target or the typing in of identifiers. Using this method, one operator is able to measure about nine photographs in one 8-hour shift, or roughly 3,200 pointings per day.

Although NOS presently has a new operational block triangulation program that is capable of adjusting the data, an effort is currently under way to introduce modifications for special geodetic applications. Namely, the solution is being expanded to allow for transient systematic changes to the camera. Brown and others have shown that an introduction of additional parameters into a standard block adjustment as a flexible "after treatment" or "self-calibration" is effective in the reduction of systematic biases and improves the accuracy of the final co-ordinates. Foremost, however, will be a concerted effort to identify and initially remove the systematic errors. The block will also be modified to allow for constraints in the ground control normally encountered in geodesy, such as azimuths between points and geodetic distances. Ultimately, I would hope that the calibration and control of the internal geometry of our camera would be adequate to support the investigation of external sensors such as APR, positioning devices etc.

The Casa Grande, Arizona, test range was selected as the site for the precision analysis phase of the project. The range is about 16 miles on a side, with geodetic monuments spaced throughout at 1-mile intervals. Each test point was pre-marked on the ground with a 30-inch plastic disk precisely centred over the monument. To provide contrast with the blaze orange marker, the disk was surrounded with an 8-foot-square tarpaper background. To guarantee a minimum pattern of nine control points per photograph, the flight altitude above terrain was set at 12,000 feet, resulting in the image size of 50-60 micrometres (μm.)

Early numerical simulations had shown the importance of geometry to the final adjusted positions. Specifically, adjustments of fictitious data indicated that one could hope for a mean error of about 2½ cm for each ground co-ordinate (horizontal), with 24,000 scale photography and measurement precision of about 3 μm. The fictitious data were generated in such a fashion that each ground point was "seen" by at least nine photographs. This can be accomplished two ways—by flying the area with photography having two-thirds overlap in both the forward and side direction, or by flying orthogonal coverage with two-thirds forward and one-third side overlap. To provide data for comparison, both were executed over the test range. That is, two-thirds forward and side overlap coverage was flown in the north-south direction, and two-thirds forward with one-third side overlap photography was flown from east to west. The resulting coverage afforded seven different combinations for adjustment, as shown in figure 80. The first three are considered standard type coverages, whereas the last four are special in that each ground point position is determined from at least nine directions.

Having assembled the data into eight different blocks as shown in figure 81, consideration was given to the basic control configuration. First, based on the results of error propagation studies of strips of photography by Schmid (1961) and Hallert (1958), a separation of seven airbases (eight photographs) was found to be optimum. (Hallert showed five airbases to be optimum.) As in test case A, then, horizontal and vertical points were placed at each corner of the area, plus halfway between, with one vertical only point in the centre of the figure. The mean errors of these co-ordinates were given as .1 mm, or absolutely known. For case B, the ground values were relaxed to 7.6 mm.

Recognizing the weakness of interpolating to a single point, test cases A and C were set up to include a second horizontal control point at each location. Test case D is an extension of this concept to four points for interpolation, with an increase in the number of base distances. Finally, cases E and F introduce a reduction, with control spaced at about five airbases.

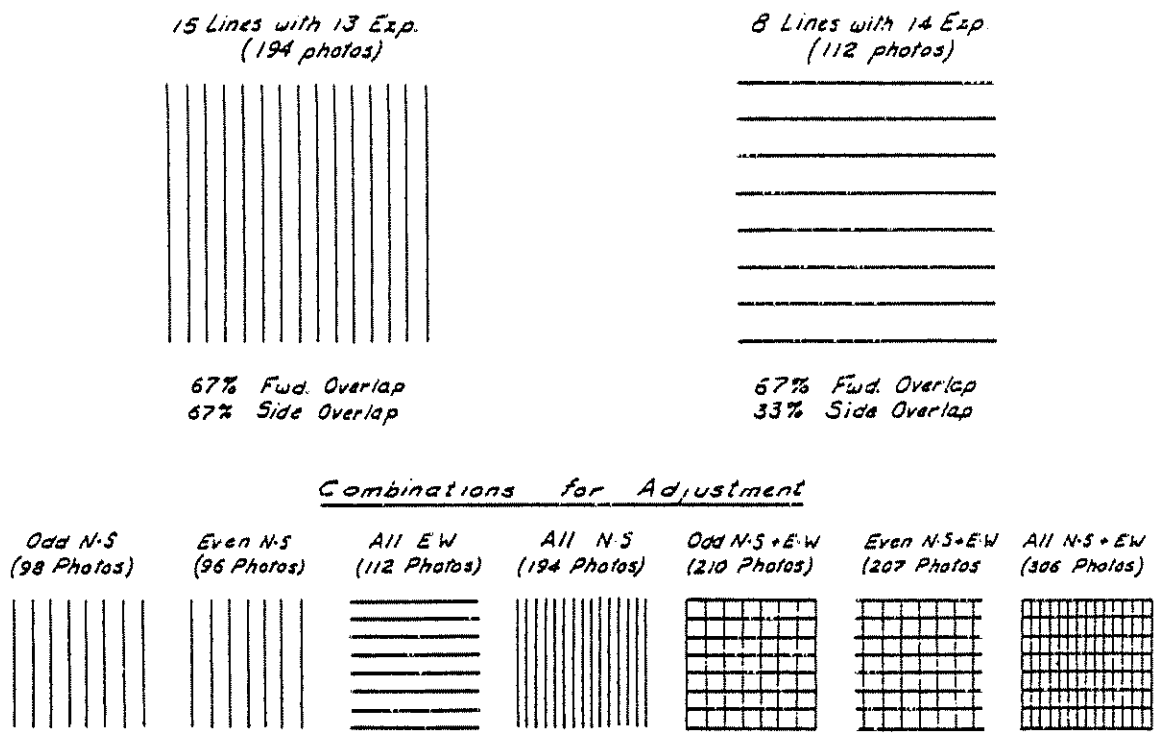


Figure 80. United States of America: flight coverage

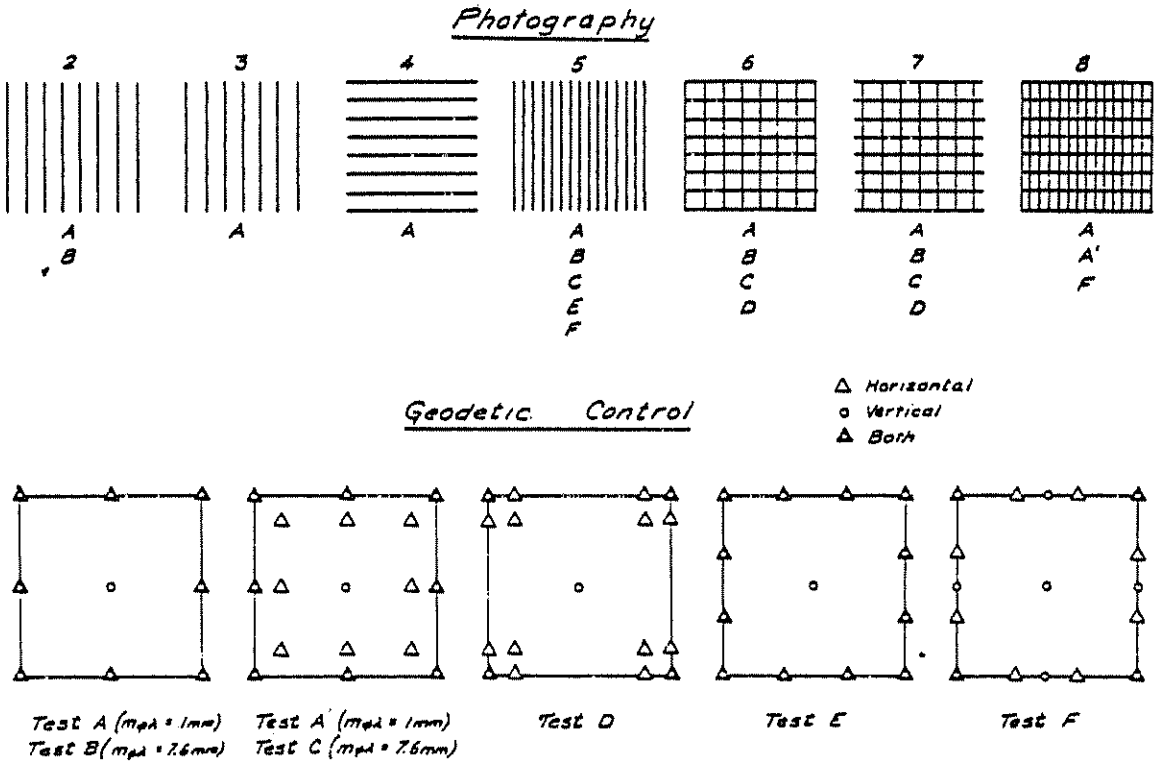


Figure 81. United States of America: configurations for adjustment

Figure 82 is a table of results of each of the cases computed. That is, the rows represent the configuration of photography, and the columns represent the control placement. In each case the upper two figures are the pooled standard errors in latitude and longitude (metres). In other words, the standard deviation in latitude and longitude for each withheld point from the error propagation was squared, summed, divided by the number, and the square root of the result taken. These numbers can be looked upon as representing the statistical significance of the computed ground positions, relative to the geometry and noise level of the observed data. The lower two figures are the root-mean-square (rms) difference between the geodetic and photogrammetric positions. The slight rise between the upper and lower pair indicates the presence of a remaining systematic bias in the photogrammetric model or in the geodetic control.

As a further analysis of the data, run 7C was looked at from a standpoint of differences in distance between adjacent points. A chord distance was computed from the given geodetic positions and compared to the same pair as determined photogrammetrically. The resulting vectors are shown in figure 83. Since there is a high correlation between adjacent points in a photogrammetric adjustment, it was reasoned that the geometric mean of rms difference in position of latitude and longitude should agree closely with the expected rms difference in distance between the points. This was borne out in the comparison, as evidenced in figure 83 by the values .057 m versus .059 m. From this result, it was decided that the geometric mean provides a reasonable single figure to describe the precision of a system and thereby make comparisons with other results.

By way of comparison, a search was made of the results presented to the XIII Congress of the International Society for Photogrammetry in Helsinki in 1976 (Hvidegaard, Jacobsen, Kupfer, Tegeler). These data are tabulated as the second six projects in the table below. The first entry is a result presented by NOS in 1969, and is included for contrast and to emphasize the increase in precision over the last decade. The last seven entries (UNPHOG 2-8) are the results of this test, keyed to figure 82. A single asterisk, in column 2, indicates a reseau-equipped camera, and a double asterisk, in column 8, shows those systems which applied "after treatment". All columns are self-explanatory, with the exception of columns 6 and 8. The values in column 6 are the geometric means of the rms differences between photogrammetry and geodesy in latitude metres and longitude metres. Column 8 is then the scale factor of the photography divided by the value in column 6. This number might be likened to a normalized measure of precision of the system. That is, given a scale factor of photography, this number when applied as a divisor will produce the expected accuracy of the resulting ground control in meters. In this way, one can hope to compare results from projects with varying focal lengths and flight altitudes.

In summary, one might conclude from the results that the accuracy potential of analytic aerotriangulation, coupled with the sophisticated block adjustment technique, can be exploited for many applications, especially for mapping, cadastral and engineering purposes. Generally, resources are not available for densifying uncontrolled areas in the United States in any brief span of years using classical geodetic methods. Geodetic control must be accomplished with utmost care and is relatively slow and costly, thus making it necessary to assign priority to those areas where accurate geodetic control of a high order is needed most. The importance of the photogrammetric system lies in the fact that control, having sufficient accuracy for mapping and many engineering and cadastral applications especially, can be established rapidly and profusely and at relatively low cost.

TABLE COMPARATIVE RESULTS

	Parameters							
1 Project	2 Camera	3 Altitude (m)	4 Scale factor	5 Number of photos	6 m_{ea}	7 Forward/Side overlap	8 Sf/m_{ea}
NOS	RC-9	6 100	70 000	180	.640	60/60	109 375
South Australia (1)	*RMK AR	2 000	12 700	48	.049	60/60	258 164
Alborg 1973 (2)	C = 15 cm	1 500	10 000	53	.041	65-70/25-70	243 902
Atlanta DBA (3)	*RMK 8.5/23	1 494	17 500	28	.073	60/60	**239 726
Hordorf FGR (4)	RC 10 15/23 RMK A 30/23		6 000	868	.025	60/60 CF	**240 000
Rheimback (5)	RMK A 15/23	1 690	11 000	69	.041	60/20 CF	**268 292
Konigshugel (6)	RMK A 15/23	1 155	7 600		.037	60/39	**202 829
UNPHOG 2	*RC 10 G	3 600	24 000	98	.105	66/33	229 374
UNPHOG 3	RC 10 G	3 600	24 000	96	.146	66/33	164 398
UNPHOG 4	RC 10 G	3 600	24 000	112	.129	66/33	186 619
UNPHOG 5	RC 10 G	3 600	24 000	194	.053	66/66	448 774
UNPHOG 6	RC 10 G	3 600	24 000	210	.052	66/33 CF	462 910
UNPHOG 7	RC 10 G	3 600	24 000	207	.057	66/33 CF	417 533
UNPHOG 8	RC 10 G	3 600	24 000	306	.046	66/66 CF	516 159

REFERENCES

Papers before the XIII Congress of the International Society for Photogrammetry, Helsinki

Brown, Duane C. (1976), "The bundle adjustment — progress and prospects", DBA systems, invited paper, Commission III

Hvidegaard, Jonna (1976), "Densification of trigonometric nets, practical experiences with bundle adjustment", Danish Cadastral Service, presented paper, Commission III

Jacobsen, K. (1976), "Control by bundle adjustment—test Konigshugel", Technical University of Hanover, presented paper, Commission III.

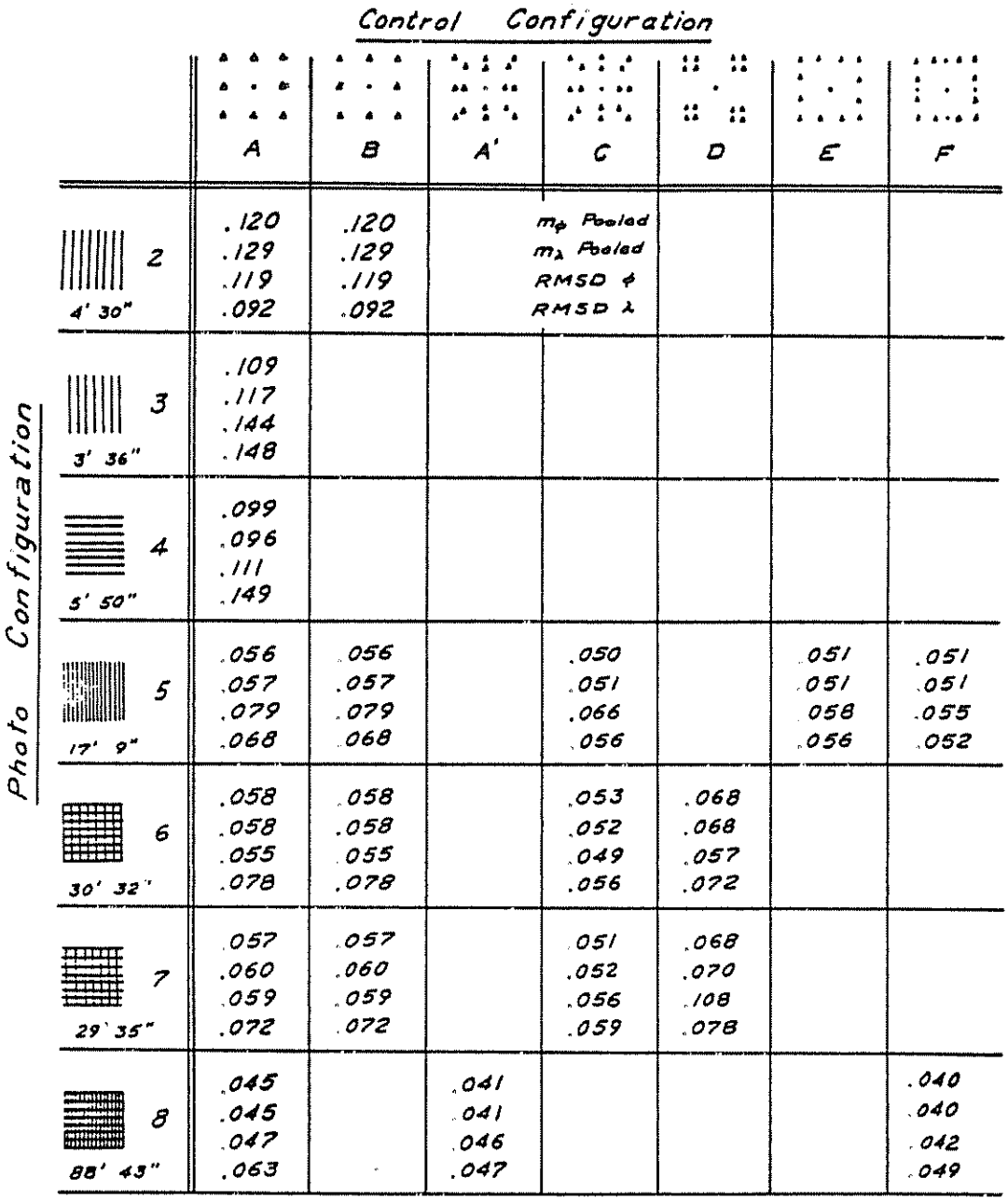


Figure 82. United States of America: adjustment results

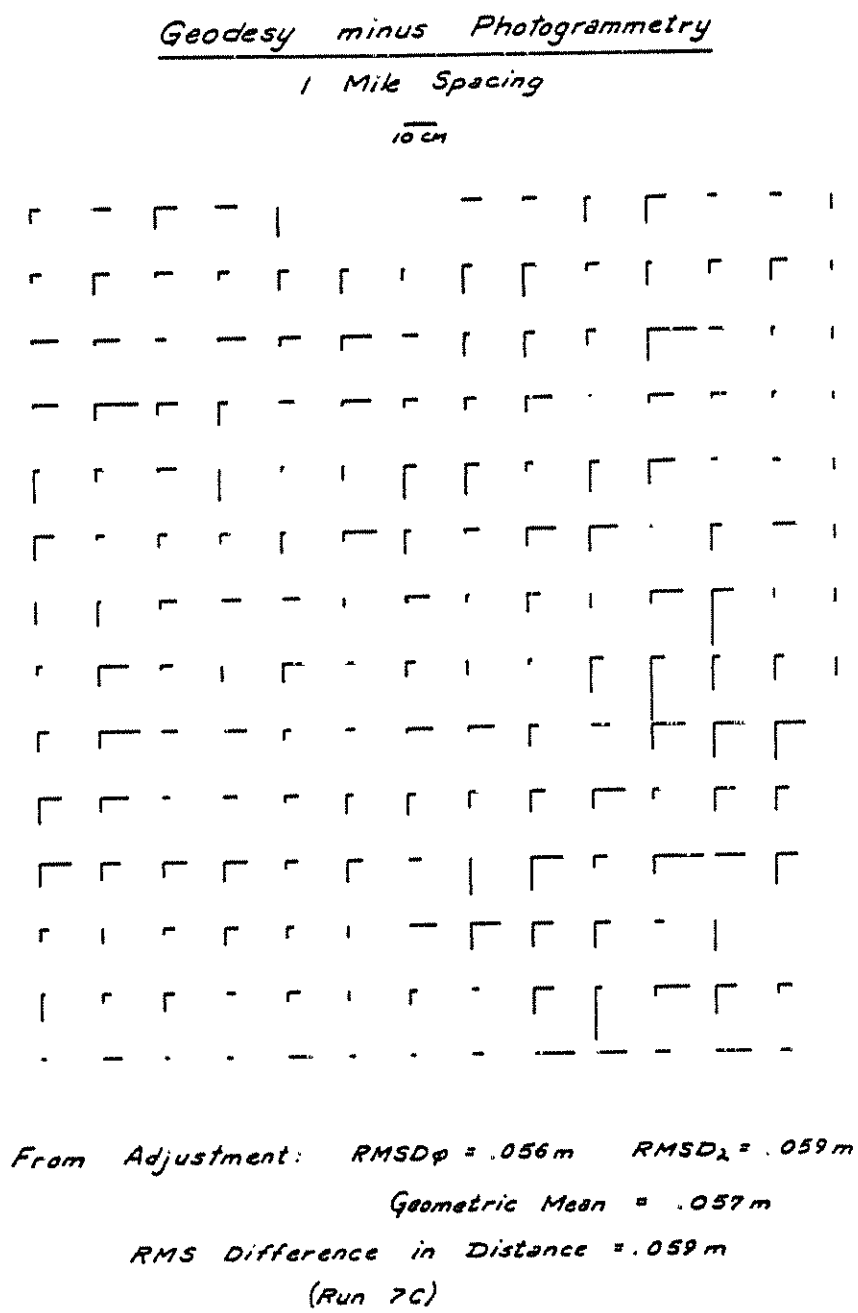


Figure 83. United States of America: differences in distances

Kupfer, Gunther (1976), "On accuracy achieved by different triangulation procedures", Bonn University, presented paper, Commission III.

Roberts, R. G. (1976), "Tests of bundle block adjustment for survey co-ordination", Department Lands, South Australia, presented paper, Commission III.

Tegeler, W. (1976), "Densification of trigonometric networks by bundle adjustment", Hanover, Federal Republic of Germany, presented paper, Commission III.

Papers before meetings of the American Society of Photogrammetry (ASP) and the American Congress on Surveying and Mapping (ACSM).

Schmid, Hellmut (1961), "Precision photogrammetry—A tool of geodesy", Semi-Annual Convention, New York, October 1961.

Brown, Duane C. (1971), "Analytical aerotriangulation vs. ground surveying", Fall Convention, San Francisco, California.

——— (1973), "Aerotriangulation as a supplement to ground surveying", Annual Convention, Washington, D.C.

Slama, Chester C. (1977), "Application of photogrammetric analytical triangulation to geodesy", Washington, D.C., March 1977.

Other

Hallert, B. (1958), "A theoretical investigation of aerial triangulation as a problem of maxima and minima", *Photogrammetric Engineering*, vol. XXIV, No. 5 (December 1958).

Brown, Duane C. (1974), "Evaluation, application and potential of the bundle method of photogrammetric triangulation", International Society of Photogrammetry, Commission III, Symposium, Stuttgart.

Munson, Robert C. and Leonard S. Baker (1974), "Application of numerical photogrammetry to high accuracy geodetic control", United States-Canadian Cartographic Conference.

Hull, Wesley V. (1975), "Control densification by analytic photogrammetry", paper presented to the ASCE Annual Convention, Denver, Colorado.

REPORT ON THE ACTIVITIES OF THE SUBCOMMISSION FOR SOUTH-EAST ASIA AND THE PACIFIC OF COMMISSION 10, INTERNATIONAL ASSOCIATION OF GEODESY*

Paper presented by Australia

RÉSUMÉ

Lors de la réunion de l'Association internationale de géodésie (AIG) tenue à Grenoble (France) en 1975, on a proposé la création d'une sous-commission pour l'Australie, l'Indonésie, la Nouvelle-Zélande et l'Océanie, rattachée à la Commission 10 des réseaux continentaux de l'AIG; cette proposition a été adoptée en février 1976 par le Comité directeur de l'AIG. Par la suite, cette sous-commission a pris le nom de « Sous-Commission pour l'Asie du Sud-Est et le Pacifique ».

La mission de cette sous-commission, qui consiste à aligner les données géodésiques des pays de la région sur un unique système mondial de référence, est de longue date l'un des principaux objectifs de la géodésie. La meilleure manière de l'atteindre est désormais de procéder à des observations Doppler par satellite grâce à des récepteurs appropriés. C'est là semble-t-il la seule solution pratique, compte tenu des très nombreuses îles de la région du Pacifique.

La Sous-Commission n'a ni budget ni prérogatives. Elle s'acquitte de sa mission en veillant à ce que les pays de la région : connaissent l'existence du plan d'intégration des réseaux géodésiques de tous les pays de la région; sont conscients des avantages que présente la possibilité de convertir leurs coordonnées géodésiques locales en coordonnées géodésiques mondiales et inversement; et bénéficient de conseils techniques sur les activités utilisant la méthode Doppler.

At the meeting of the International Association of Geodesy (IAG) at Grenoble, 1975, a subcommission for Australia, Indonesia, New Zealand and Oceania under IAG Commission 10, Continental Networks, was proposed and subsequently endorsed in February 1976 by the Executive Committee of IAG. Later, the name was changed to "Subcommission for South-East Asia and the Pacific".

The aim of the Subcommission's work—to establish the geodetic surveys of the countries in the area on a single world datum—has long been one of the major aims of geodesy. This can now be done best by making observations to Doppler satellites with suitable satellite receivers. With the many islands in the Pacific region there seems to be no practical alternative.

It is proposed to arrange at each site observations for about one week, enough to get forty-five passes to satellites for which a post-computed geodetic ephemeris is available. All observations should be made to an agreed standard specification. Each station should be substantially marked, and be tied into the local survey network with sufficient redundant observations to prove it free of error. Post-computed ephemerides of satellites are to be used exclusively, and all final computations are to be put through a single computer program.

The Subcommission has no funds and no power. It carries out its task by ensuring that the countries in the area:

(*a*) Know that there is a plan for the geodetic link-up of all the countries in the area;

(*b*) Are aware of the advantages of being able to transform their local geodetic co-ordinates into world datum co-ordinates and vice versa;

(*c*) Can get advice on Doppler work and in particular ensure that Doppler observations are of geodetic quality throughout the area and are:

(i) Made in a way that will be satisfactory for at least a century;

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF.72/L.41.

(ii) Observed to a suitable standard of accuracy;

(iii) Computed with a computer program that is free from flaws and uses the best available ephemeris for the satellites;

(iv) Documented, so that in the years to come it is clear to everyone exactly what has been done.

The advantages of linking together national geodetic networks over an entire continent—later, it is to be hoped, over the entire world—are:

(*a*) To strengthen and improve the accuracy of the individual national networks;

(*b*) To avoid discontinuities in mapping along international borders of the order of 100 metres—sometimes ten times as much;

(*c*) For coastal nations, to get the coastline on a common datum with its neighbours so that median lines and seabed boundaries can be accurately determined (a shift of a median line in an oil bearing area can have economic consequences running into millions of dollars);

(*d*) To enable satellite tracking stations, aircraft tracking stations and radio and optical telescopes to be accurately co-ordinated in relation to each other;

(*e*) To provide a strong world geodetic datum on which continental drift can, over a period of years, be recorded.

One of the greatest advantages to a developing nation of getting its geodetic network into terms with a world datum comes from the use of Doppler satellite receivers themselves. Once a number of geodetic Doppler stations have adequately established the relationship between the local datum and the world datum, mapping control on the local datum can then be established by further topographic Doppler fixes.

Communication has been established between the president and representatives of twenty-two countries in the region of the Subcommission. An address list current to mid-October 1979 is attached.

The first meeting of the Subcommission was held at Bandung in Indonesia in October 1977. The meeting was reported in *Bulletin Géodésique 52* (pp. 1-2). Representatives from Australia, Indonesia, Malaysia, New Zealand, Papua New Guinea, the Philippines and Thailand attended.

The second meeting of the Subcommission was held in Singapore in March 1979 with representatives from Australia, Indonesia, New Zealand, Malaysia, Papua New Guinea, the Philippines and Singapore. At this meeting A. G. Bomford presented a paper on "Geodesy in South-East Asia and the Pacific", and J. Rais gave his paper "Towards a South-East Asia and the Pacific Datum", which was followed by an hour's discussion. Progress with Doppler satellite observations in the various countries of the region was reported. Details of progress in Australia have now been published (Leppert, 1978), and copies were distributed. Substantial progress has been made or is planned in Indonesia, Papua and New Guinea, the Philippines and Thailand. The need to establish a map of the geoid before useful heights above sea level can be obtained from Doppler observations was emphasized.

At a special meeting of the Subcommission in Singapore at which representatives from Australia, Indonesia, Malaysia, the Philippines and Singapore were present, the proposals in the concluding paragraphs of Professor Rais's paper for a regional datum for South-East Asia and the Pacific was discussed. The consensus was that there was no need for a regional datum and that the work involved would not be justified. Countries in the region would probably maintain their own national datums, and determine transformation parameters (or graphs of changes in latitude, longitude and (N + H)) to convert to a world datum. For this purpose, World Geodetic Datum 1972 was preferred. At common points along a frontier it would be satisfactory for countries to adopt unadjusted co-ordinates for well-observed Doppler satellite stations computed with the precise ephemeris, though no objection would be raised if two countries agreed to combine their national networks on a single datum and include the common frontier Doppler stations as movable stations in the adjustment.

The next meeting of the Subcommission will be in Canberra in December 1979 at the time of the XVII General Assembly of IUGG at which the President (Mr. Bomford) will report on the extent of existing Doppler satellite stations in the regions. The planning of additional Doppler stations to bring all the islands onto a world datum will also be discussed. The following resolution is foreshadowed at this meeting:

> "That for common frontier stations included in the geodetic network of two countries, unadjusted co-ordinates, determined from well-observed Doppler satellites computed using the precise ephemeris, will usually be satisfactory."

After Canberra, the next meeting of the Subcommission is likely to be held in Fiji during October 1981, during the survey congress organized by the New Zealand Institute of Surveyors. It is hoped that many of the smaller countries of the Pacific will be represented at this meeting.

REFERENCES

Bomford, A. G. (1979), "Geodesy in South-East Asia and the Pacific", *Proceedings of the South-East Asian Survey Congress*, Institution of Surveyors, Sydney, Australia.

Leppert, K. (1978), "The Australian Doppler satellite survey, 1975-77", *Technical report 21*, Division of National Mapping, Canberra.

Rais, J. (1979), "Towards a South-East Asia and the Pacific Datum", *Proceedings of the South-East Asian Survey Congress*, Institution of Surveyors, Sydney, Australia.

THE 14TH CONGRESS OF THE INTERNATIONAL SOCIETY OF PHOTOGRAMMETRY

Paper presented by the International Society of Photogrammetry

The original text of this paper, prepared by Gottfried Konecny, Congress Director, appeared as document E/CONF.72/L.94. It consisted of the invitation sent to participants to attend the 14th Congress which was to be held from 13 to 25 July 1980 in Hamburg, Federal Republic of Germany.

REPORT ON THE ACTIVITIES OF THE SCAR WORKING GROUP ON GEODESY AND CARTOGRAPHY*

Paper presented by the Scientific Committee on Antarctic Research

RÉSUMÉ

Le Comité scientifique de recherche antarctique est l'organisme international responsable de la coordination des activités scientifiques des Etats parties au Traité de l'Antarctique. Il s'acquitte de la plupart de ses fonctions par l'intermédiaire de divers groupes de travail.

L'essentiel des travaux du Groupe de travail de la géodésie et de la cartographie, dont le secrétariat est installé en Australie, est inévitablement effectué par correspondance, mais le Groupe de travail a saisi l'occasion de deux réunions internationales récentes pour tenir plusieurs réunions.

SCAR is the Scientific Committee for Antarctic Research, the international body through which the Antarctic Treaty nations co-ordinate their scientific activities. Much of its work is accomplished through a number of working groups. The Working Group on Geodesy and Cartography has its secretariat in Australia. Most of the work of the Group is necessarily done by correspondence, but at two recent international meetings, the opportunity has been taken to hold meetings of the Working Group.

The first, an informal meeting convened at rather short notice, was held at the Royal Society in London on 2 August 1979, immediately following the Conference of Commonwealth Surveyors in Cambridge. Representatives from Australia, New Zealand, Norway, the United Kingdom and the United States of America attended with representatives from two new SCAR nations, the Federal Republic of Germany and Poland, which joined the Group for the first time.

On 10-11 December 1979, a formal meeting of the Group was held in Canberra during the General Assembly of the International Union of Geodesy and Geophysics. This was the first formal meeting since the Group met in Oslo in June 1970. Eleven countries were represented: Argentina, Australia, Chile, France, Japan, New Zealand, Poland, South Africa, the Union of Soviet Socialist Republics, the United Kingdom and the United States of America. Only Belgium, the Federal Republic of Germany and Norway were not present.

At both meetings, the Group discussed a new edition of the *Standard Symbols for use on Topographic Maps of Antarctica*. The existing standard symbols are ten years old and are somewhat dated. In view of the international character of Antarctica and the use made by the Treaty nations of each other's maps, an attempt is being made to increase the use of symbols and rely less on words and abbreviations in English or any other language. Most Antarctic maps are restricted to four colours, but few are printed by the four-colour process.

Because of the difficulty in much of the Antarctic of taking small-scale air photographs from long-range, high-flying aircraft and the absence of natural features over wide expanses of the ice, it seems unlikely that future series mapping at small scales will be made from air photographs, and increasing use will have to be made of LANDSAT. The Federal Republic of Germany hopes to instal a mobile LANDSAT receiver in the Weddell Sea area, and the Group recommended that NASA should instal a transportable LANDSAT receiver initially near McMurdo. However, LANDSAT imagery is not available south of 81°. The Russians already rely on photographs taken from satellites.

It is likely that the International Spheroid will be superseded for Antarctic work either by the World Geodetic System 72 or, more likely, by Geodetic Reference System 80 which was adopted by the International Union for Geodesy and Geophysics at its General Assembly in Canberra in December 1979.

The provision of heights above sea level in Antarctica has always been troublesome, particularly in areas without mountains: heights carried across the ice, even by spirit levelling, are subject to anomalous refraction. Doppler satellites give heights above the spheroid. Cartographers need heights above the geoid, sea level. The difference between the two, N, can be determined by taking Doppler observations at points of known height, and be used to control a map of contours of the geoid above the spheroid interpolated from gravimetric data.

At the meeting Australia tabled the first crude map of the geoid in Antarctica, accurate perhaps to three metres, and a co-operative programme was set in hand to improve it.

Australia tabled new 1:10,000,000 and 1:20,000,000 maps of Antarctica, superseding its 1969 editions.

*The original text of this paper, prepared by the Secretary of the SCAR Working Group on Geodesy and Cartography, appeared as document E/CONF.72/L.97.

(b) *Thematic and small-scale mapping (including remote sensing applications) and preparation and reproduction of maps (including automation, communication and geographical names)*

THEMATIC MAPPING IN AUSTRALIA*

Paper presented by Australia

RÉSUMÉ

L'Australie dispose de plusieurs collections de cartes thématiques scientifiques et administratives, d'une échelle comprise entre 1/100 000 et 1/1 000 000. Chaque collection fait l'objet d'une brève description où il est rendu compte de son développement jusqu'en 1979.

De nombreuses autres cartes thématiques sont en cours de réalisation dans le cadre des rapports régionaux pour la gestion des ressources. La réalisation récente de ces cartes et d'autres cartes thématiques hors collection fait l'objet d'un compte rendu sommaire, et un certain nombre de cartes sont énumérées en annexe.

Plusieurs atlas nationaux, régionaux et urbains réalisés au cours des dernières années sont décrits.

GEOLOGY AND GEOPHYSICS

Of the various thematic map series produced by federal and state authorities, the coverage of geological maps is the most extensive and detailed.

The Bureau of Mineral Resources, Geology and Geophysics has continued to produce various geological and geophysical maps of Australia and its Territories (including the Australian Antarctic Territory) and Papua New Guinea where the surveys had been completed before that country gained independence in September 1975.

Series geological maps

Preliminary maps shown only in line colours have been prepared at 1:100,000 scale in the Mount Isa geosyncline in central western Queensland and the Pine Creek geosyncline in the north-western part of the Northern Territory. At 1:250,000 scale, preliminary maps have been prepared in the western part of the Canning basin in the central northern part of Western Australia:

Full colour editions have been published at 1:100,000 scale in the Mount Isa geosyncline and at 1:250,000 in the Carpentaria basin in the Cape York Peninsula, in the Canning basin and in the Officer basin in the central eastern part of Western Australia.

Series geophysical maps

Maps of Bouguer anomalies at 1:250,000 and 1:500,000 scales have been published in Kimberley Basin of north-western Western Australia and in all of the northern part of the Northern Territory.

Airborne maps depicting flight line systems, magnetic contours, magnetic profiles, radioaltimeter, total count radiometric contours, total count radiometric profiles, uranium profiles, thorium profiles and potassium profiles have been published at 1:100,000 scale in the Yilgarm Block in south-western Western Australia at 1:250,000 in the following regions:

Bangemall and Officer basins in central and eastern Western Australia

Western part of the Arunta block in central western Northern Territory

Daly and McArthur basins in north-eastern Northern Territory

Southern part of the Lachlan geosyncline in Victoria

South-western part of the Murray basin along the Victoria-South Australia border.

At 1:1,000,000 there is complete coverage of Australia.

Marine geophysical maps at 1:1,000,000 scale depicting water depth profiles, survey lines, free air anomaly profiles and residual magnetic intensity profiles have been published for all the continental shelf.

Regional geological maps

Maps published at 1:500,000 and 1:1,000,000 scales of several morphological regions are listed in annex I.

Regional geophysical maps

Maps published at 1:500,000 and 1:5,000,000 scales are listed in annex II.

OTHER SERIAL MAPPING

The Division of National Mapping produces a series of thematic maps at 1:1,000,000 scale covering land use, nature conservation reserves and forestry, using the International Map of the World (IMW) as a base.

Land use

The mainland of south-eastern Australia is covered by maps in the Australia 1:1,000,000 Land Use Series. For each selected IMW sheet in the more intensively settled areas of Australia, three single-colour maps—land cover, land tenure and land use—are prepared. Experiments to produce microfiche copies from specially coloured film versions of each published map are in progress.

Nature conservation reserves

This series consists of 45 frequently revised maps. They show all reserves of over 400 hectares, and summarize maps and plans produced by about 14 bodies responsible for nature conservation. Information about nature reserves is being listed in a computer-based

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF. 72/L.27.

directory primarily as an aid for other thematic and topographic mapping projects.

Forestry

A similar series of 28 maps showing forestry reserves has been completed. The maps show all state forests and timber reserves of over 400 hectares and are revised frequently. They summarize forestry maps made by state authorities, mainly at 1:50,000 scale or larger, which show state forests, plantations, forest types and forest management.

Vegetation

Various state authorities and non-government organizations produce vegetation maps. Two of the twelve 1:100,000 maps covering the Moreton region of south-eastern Queensland have been published by the Queensland Department of Primary Industries. All of Western Australia is being covered by a combination of vegetation maps at 1:250,000 and 1:1,000,000 produced by the Department of Lands and Surveys, the Department of Agriculture, the University of Western Australia and Vegmap Publications Pty Ltd.

Australia 1:5,000,000 Map Series

The Division of National Mapping produces various 1:5,000,000 maps for the *Atlas of Australian Resources* or for other government departments. These maps are now incorporated into the Australian 1:5,000,000 Map Series and marketed as flat maps or folded with pictorial cover. By the end of 1979, nine maps were published: Population Distribution, Nature Conservation Reserves, Soil Resources, Principal Groundwater Resources, Dams and Storages, Relief Map of Australia, Statistical Divisions and Local Government Areas, Land Use and a new General Reference map of Australia.

NON-SERIES MAPS

An increasing number of regional thematic maps are being produced as part of regional reports, especially by state government bodies. These reports now cover a significant part of Australia and include a wide range of thematic maps dealing with land resources, management and planning. Major producers of these reports include the New South Wales Soil Conservation Service, the Queensland Department of Primary Industries and the Co-ordinator-General's Department, the Victorian Land Conservation Council, the South Australian State Planning Authority and the Commonwealth Scientific and Industrial Research Organization.

Interest in flood plain mapping is also growing, with some water authorities producing maps of areas inundated by specific floods or by floods with specific recurrence intervals.

Other major areas of non-serial thematic mapping include tourism and recreation, minerals and mining (especially in northern Australia) and transport.

THEMATIC MAPPING BULLETIN

Each year about 1,300 thematic maps are produced by nearly 100 organizations in Australia. About a quarter are maps appearing in reports published by government authorities. All are listed in the *Thematic Mapping Bulletin* published in May each year by the Division of National Mapping.

THEMATIC AND GENERAL ATLASES

The Australian National Atlas

Production by the Division of National Mapping of the *Atlas of Australian Resources*, 2nd Series, was finished in 1977, thus completing replacement of the 30 large map-sheets and accompanying booklet commentaries of the first series of 1953-60.

Publication of parts of the 3rd Series has now begun. The method of serial publication adopted is to issue the larger maps (mainly maps at scales of 1:5,000,000 and 1:10,000,000) separately, as soon as they are printed, then to follow with bound volumes containing the maps and illustrated texts covering several related topics. Already five maps have been published and, of the ten or so volumes foreseen, the first three—on population distribution, soils and land use, and agriculture—should appear in 1980.

The format of 3rd Series volumes is smaller than the large loose-leaf map binders of the 1st and 2nd Series, and the larger maps will be folded. The maps will be interspersed with commentary, which will be illustrated in colour.

State and regional atlases

Two atlases have been published by state authorities: *Queensland Resources Atlas* (1976); and *Western Australia: An Atlas of Human Endeavour, 1829-1979* (1979). These are bound atlases of wide scope with a preponderance of illustrated texts. Another state atlas, for Victoria, is now well advanced.

An *Atlas of New England* (1977), a regional atlas in two volumes (maps, texts) has been prepared and published by the University of New England (northern New South Wales).

City atlases

The Division of National Mapping, in collaboration with the Australian Bureau of Statistics, is now publishing an eight-volume *Atlas of Population and Housing* covering the eleven cities of over 100,000 population at the 1976 Census. Most of the 20-25 maps of each city are computer-drawn choropleth maps using the basic census collection areas and five or six shading patterns. The volume for Perth has been published, and at October 1979 Adelaide was in press.

Computer-drawn socio-economic atlases based on the 1976 Census are also being produced for Sydney, Brisbane and Adelaide by university-based research groups.

Climatic atlas of Australia

The Bureau of Meteorology has now issued six map sets (volumes) of its *Climatic Atlas of Australia*. It has four further sets in preparation or planned. Each map set consists of a number of isopleth maps at 1:12,500,000 with a general introduction.

General atlases

A number of such atlases, containing mainly general reference maps, have been produced in the last few years by Australian-based and overseas companies. One of them features complete coverage of Australia at 1:1,000,000, using the International Map of the World series (produced by the Division of National Mapping) with sheet edges altered to fit a smaller format.

Annex I

REGIONAL GEOLOGICAL MAPS

NON-SERIES

Gosses Bluff Impact Structure: Detailed geology . . . 1:7,500 scale (full colour)

Gosses Bluff Impact Structure: Regional geology . . . 1:50,000 scale (full colour)

1:500,000 scale

Geology of the Ngalia basin (preliminary edition, line colour only)

Geology of the Wiso basin (preliminary edition, line colour only)

Geology of the Victoria River region (full colour)

Geology of Bathurst Island, Melville Island and Cobourg Peninsula (full colour)

Geology of the Granites-Tanami region (full colour)

Solid geology of the Pine Creek geosyncline (full colour)

1:1,000,000 scale

Geology of the Northern Eromanga basin (full colour)

Geology of the North-western Eromanga basin (full colour)

Continental Shelf sediments, central and southern New South Wales (full colour)

Geology of the Officer basin (preliminary edition, line colour only)

Physiography of the Officer basin (preliminary edition, line colour only)

Geology of the Carpentaria and Karumba basins (preliminary edition, line colour only)

Annex II

REGIONAL GEOPHYSICAL MAPS

1:500,000 scale

Total count radiometric contours of the Pine Creek geosyncline (colour)

Magnetic contours of the Pine Creek geosyncline (colour)

Bouguer anomalies of the Pine Creek geosyncline (colour)

SH52-15 (Coompane), three-dimensional magnetic profiles

SH52-16 (Nullarbor), three-dimensional magnetic profiles

SH53-13 (Fowler-Nuyts), three-dimensional magnetic profiles

1:5,000,000 scale

Gravity map of Melanesia (colour)

Airborne magnetic surveys of Australia (colour)

Airborne radiometric surveys of Australia (colour)

FOUR-COLOUR REPRODUCTION*

Paper presented by Australia

La reproduction des cartes en quadrichromie a fait l'objet de discussions et d'essais depuis un certain nombre d'années. Dans de nombreux pays, toutefois, la hausse récente des coûts d'impression a favorisé l'utilisation d'un nouveau procédé d'impression en couleurs et de presses à tirage en quadrichromie, qui permet de réaliser des économies. Cette technique est également utilisée en Australie, comme en témoignent les cartes tant topographiques que thématiques établies en quadrichromie par les divers organismes compétents. Grâce à l'amélioration des techniques de reproduction et à l'apparition de machines tirant en quadrichromie, il est maintenant possible de produire en quadrichromie des cartes satisfaisantes du point de vue tant de la luminosité que de l'aspect esthétique.

La Division of National Mapping (Service cartographique national) envisage sérieusement d'effectuer des tirages en quadrichromie pour les cartes à l'échelle du 1/100 000, 1/250 000 et 1/1 000 000 et a effectué des essais d'impression à cette fin.

Compte tenu des résultats de ces essais, la Série nationale de cartes topographiques au 1/100 000 et au 1/250 000 sera probablement tirée en quatre couleurs spécifiques (noir, rouge, bleu et vert).

La série des cartes au 1/1 000 000, sur lesquelles on utilise du jaune pour les zones construites sera probablement tirée selon les procédés classiques d'impression en couleurs.

Four-colour reproduction of maps has been the subject of discussion and testing for some years. In many countries, however, increases in printing costs have given impetus to using process colours and four-colour printing presses in order to reduce costs. The trend is also appearing in Australia, as evidenced in both topographic and thematic maps produced in four colours by the various authorities. Successful four-colour production without detracting from the value of the map or its aesthetic appearance is now possible because of improved reproduction techniques and availability of four-colour machines.

The Division of National Mapping is seriously considering the use of four-colour printing for 1:100,000, 1:250,000 and 1:1,000,000 and has done test printing.

From experience with the tests, four specific colours —black, red, blue and green—will likely be adopted for the National Topographic Map Series 1:100,000 and 1:250,000.

The 1:1,000,000 series, which includes yellow for built-up areas, will likely be printed in the standard process colours.

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF.72/L.30.

MAP ACCURACY*

Paper presented by Australia

L'établissement de cartes modernes est une procédure complexe au cours de laquelle on peut identifier plusieurs étapes distinctes. Tout d'abord acquisition des photographies aériennes, puis vérifications sur le terrain — points planimétriques et altimétriques — pour s'assurer de l'exactitude du modèle. La restitution des photographies aériennes, à l'aide de divers appareils et techniques, est alors possible et enfin la carte est mise au net et imprimée.

Chaque étape comporte un élément d'erreur certain alors qu'au stade final la carte imprimée doit satisfaire des conditions de précision clairement définies. Selon les spécifications de la cartographie nationale, chaque détail doit se trouver à moins de 0,5 mm de sa position véritable, ce qui signifie qu'un détail indiqué sur la Série nationale de cartes topographiques au 1/100 000 doit se trouver à mois de 50 m de sa position réelle au sol. De même, les courbes de niveau doivent se trouver à moins de 10 m de l'altitude véritable.

En fait, il n'existe pas de moyen quantitatif de connaître les erreurs qui se sont accumulées à un stade donné ni d'en évaluer l'étendue si l'on ne dispose pas, pour les mesurer sur la carte définitive, de critères objectifs indépendants.

Afin de déterminer si nos nouvelles cartes au 1/100,000 répondent aux normes de précision, la Division of National Mapping (Service cartographique national) a entrepris en 1970 de vérifier l'exactitude planimétrique et altimétrique de plusieurs cartes du centre du Queensland. On a établi, par des méthodes de cheminement, des points de contrôle à divers détails significatifs et leurs coordonnées ont été calculées à l'aide du réseau géodésique puis comparées avec les coordonnées indiquées par la carte. Les vérifications altimétriques ont été faites à l'aide d'un compteur d'altitude, l'origine du nivellement étant prise sur le réseau de troisième ordre. Sur la base de ce programme de vérification sur le terrain, nous avons pu constater que la nouvelle Série nationale répondait bien aux spécifications. Nous en avons conclu également que notre système cartographique était valable.

Il existe maintenant des méthodes modernes de vérification et le Service a entrepris de vérifier, pour toute l'Australie, certaines feuilles dans les zones de cartes au 1/250 000 surtout lorsque les techniques cartographiques habituelles n'ont pas été utilisées. Nous avons voulu un système totalement indépendant, qui offre l'intérêt de permettre d'évaluer la précision absolue de la carte, sans avoir recours aux canevas utilisés pour son établissement. Pour les cartes du Queensland, on a utilisé les réseaux géodésiques et de nivellement de premier ordre qu'on avait également pris comme origine pour les canevas. En revanche les techniques Doppler par satellite fournissent un canevas tout à fait indépendant et nous avons maintenant adopté le matériel JMR pour les programmes en cours de vérification sur le terrain. Nous utilisons aussi le système JMR comme canevas pour le dispositif d'enregistrement des profils par laser, ce qui nous permet d'effectuer les vérifications altimétriques non seulement aux points de contrôle JMR, mais sur des lignes droites entre ces points. Cette méthode combinée a été utilisée avec succès en Australie occidentale. Il est prévu de l'étendre à d'autres parties du territoire.

Dans la région des cartes au 1/250 000 de Collier (SG50-4), en Australie occidentale, les cartes au 1/100 000 ont été établies par conversion d'orthophotocartes en cartes linéaires et non par stéréorestitution. C'est la principale différence avec le procédé utilisé pour les cartes vérifiées auparavant dans le Queensland.

La vérification systématique des cartes est une entreprise longue et onéreuse. Toutefois, les résultats obtenus jusqu'à présent ont montré que nos systèmes cartographiques répondent aux normes requises, ce qui suffit à justifier le travail de vérification. Au stade actuel, le Service poursuit son programme d'évaluation de la précision à un rythme relativement lent, en raison de contraintes financières et du manque de personnel.

The modern production of maps is a complex procedure within which a number of discrete steps are identifiable. The process starts with acquisition of aerial photography then goes through field control, both vertical and horizontal, to be extended to provide model control. The control is used to plot compilations from the aerial photos using a variety of plotting machines and techniques. Finally the map is fair drawn and printed.

Each step then has a definite error component which, when aggregated to the stage of the final printed map, must meet an unequivocal accuracy requirement. The National Mapping Specifications require detail on maps to be within 0.5 mm of their true position so that on the 1:100,000 National Topographic Map Series a significant point of detail shown on that map must be within 50 m of its true position on the ground. Likewise, detail on contours must be within 10 m of true elevation.

There is really no quantitative way of knowing what errors have accumulated at any particular step, nor can the error of any point be estimated unless there is some independent objective criteria for the measurement of errors on that final map.

In order to evaluate whether our new 1:100,000 maps met the accuracy standards, the Division of National Mapping undertook in 1970 to test the planimetric and altimetric accuracies of a group of maps in central Queensland. Using traversing methods test points were established at a number of points of significant map detail and their co-ordinates were computed from the geodetic network and then compared with scaled coordinates from the map. Altimetric testing was carried out with the elevation meter with datum on the third order levelling network. On the basis of this field testing programme we were able to conclude that the new series

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF.72/L.31.

did in fact meet the accuracy specifications for that series. We further concluded that our mapping system was sound.

Modern testing methods have become available and the Division has set out upon a programme of selectively testing map sheets in groups of 1:250,000 map areas throughout Australia, especially where there were departures from the normal mapping techniques. We have been seeking a totally independent system which has the attraction that it provides a measure of the absolute standard of accuracy of the map not based upon the control system used for its compilation. The Queensland study was based upon the primary geodetic and levelling networks which are also the datums for the mapping control. Doppler satellite technology, however, provides a totally independent system, and we have now adopted the JMR equipment for current field testing programs. We have extended the JMR to provide control for the Laser Terrain Profiler and can thereby expand the altimetric testing beyond the JMR test points to profiles along straight lines between these points. This combination has been used successfully in Western Australia. It is intended to use this on other map sheets around Australia.

The 1:100,000 maps in the Collier (SG50-4) 1:250,000 map area in Western Australia were produced by the conversion of orthophotomaps to line maps instead of by stereo compilation. This was the essential difference from the process used for the maps previously tested in Queensland.

The systematic checking of maps is time consuming and uses valuable resources. However, the results so far have shown that our mapping systems are meeting the specifications required, and this in itself makes the testing worthwhile. For the present, the Division is keeping its accuracy evaluation programme to a relatively low level due to financial and staffing constraints.

TOPOGRAPHIC MAPS: LAYOUT AND FOLDING*

Paper presented by Australia

En 1978, la Division of National Mapping (Service cartographique national) a modifié la présentation de ses trois principales séries de cartes au 1/100 000, 1/250 000 et 1/1 000 000. Son objectif premier était d'augmenter le volume des ventes de cartes en améliorant le pliage de celles-ci. Une économie d'environ 10 p. 100 des frais d'impression a été réalisée par surcroît.

Le nouveau pliage consiste à former six plis verticaux en accordéon, puis un pli horizontal. Cette méthode facilite l'accès à toutes les sections de la carte. Les frais d'impression sont réduits du fait que la couverture est imprimée sur la même face que la carte. Auparavant, il fallait une plaque et un passage sous presse supplémentaires pour imprimer une couverture monochrome au verso de la feuille. Désormais, sans frais additionnels, toutes les couleurs employées dans la carte peuvent être utilisées pour produire une couverture plus attrayante.

Le fait que les trois séries soient imprimées sur des feuilles de même format et pliées de la même façon constitue un avantage supplémentaire du point de vue de la présentation dans les points de vente au détail. Les couleurs de code des couvertures permettent d'identifier facilement les différentes séries.

En vue de réduire encore davantage les frais d'impression, on expérimente actuellement l'impression dos à dos de cartes contiguës d'une même série. Six paires de cartes au 1/100 000 ont été ainsi publiées, et l'on recueillera vers le milieu de 1980 les avis d'un large éventail d'utilisateurs afin de déterminer si cette méthode doit être adoptée.

In 1978 the Division of National Mapping introduced a new format for its three main map series at 1:100,000, 1:250,000 and 1:1,000,000 scales. The main object was to increase map scales by improving the fold. A saving of about 10 per cent printing costs was also achieved.

The new fold consists of six vertical concertina folds, followed by one horizontal fold. This system gives easy access to any section of the map. Printing costs are reduced as the cover is printed on the same side as the map. Previously an additional plate and press run were needed to print a single colour cover on the back. Now all colours used on the map can be incorporated in a more attractive cover with no additional cost.

A further advantage for retail outlet displays is that all three series are printed on the same size of paper with identical folds. The series have colour-coded covers for easy identification.

To achieve further savings in printing costs, the printing of adjoining maps of a series back to back is being tested. Six pairs of 1:100,000 maps have been published and in mid-1980 the views of a wide range of map users will be canvassed to determine whether the practice should be adopted.

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF.72/L.32.

AUSTRALIAN STANDARD FORMAT AND CODES FOR THE EXCHANGE OF DIGITAL MAPPING AND CHARTING DATA ON MAGNETIC TAPE*

Paper presented by Australia

Les normes ont été publiées sous forme de projet aux fins d'examen public par la Standards Association of Australia (Association australienne de normalisation) en décembre 1979. Elles seront adoptées comme normes une fois que les observations faites sur le projet auront été examinées et que le document aura été définitivement mis au point.

Ce projet a d'abord été préparé par un groupe de travail composé de fonctionnaires de l'administration centrale australienne, puis il a été révisé et complété par un petit groupe de travail composé de membres du National Mapping Council (Conseil national de la cartographie).

Il définit un système d'enregistrement aux fins des échanges de données cartographiques numériques enregistrées sur bande magnétique, y compris le codage des détails particuliers.

Il a été décidé d'adopter un système normalisé pour la présentation et le codage des données cartographiques numériques pour les raisons suivantes :

a) La nature de ces données au niveau de leur acquisition initiale et la forme sous laquelle elles sont stockées varient au sein des différentes organisations en fonction des exigences du matériel et du logiciel dont elles disposent;

b) Les données particulières produites par une organisation peuvent être communiquées à d'autres organisations afin d'éviter de coûteux chevauchements d'efforts;

c) Le travail de traitement des données de toutes les organisations qui sont amenées à utiliser des données fournies sur une base d'échange par d'autres organisations doit être réduit au minimum.

Ce système est principalement destiné à être utilisé par les organisations qui souhaitent échanger des données enregistrées sur bande magnétique. Il n'est pas destiné à être utilisé par les organisations intéressées aux fins de leurs propres opérations internes de stockage ou d'exploitation normale de données. La plupart d'entre elles ont leur propre système de présentation des données, élaboré d'abord en fonction de leur matériel et, ensuite, en fonction de la façon dont elles souhaitent manipuler leurs données.

En conséquence, pour pouvoir procéder à des échanges de données, chaque utilisateur aura besoin de deux programmes :

a) Un programme lui permettant d'obtenir une présentation normalisée à partir de son propre système de présentation;

b) Un second programme lui permettant d'obtenir, à partir du système normalisé, une présentation conforme à son propre système.

On prévoit que, d'une manière générale, les organisations adapteront rapidement à leur propre mode de présentation les données figurant sur les bandes magnétiques échangées. En conséquence, les normes ont été conçues de manière à faciliter cette adaptation et à minimiser les pertes en cas d'altération d'un enregistrement. On n'a pas estimé qu'il importait de réduire au minimum l'espace occupé sur une bande magnétique.

Les détails dont la position est définie numériquement sont accompagnés d'un indicatif composé d'un code et d'un modificateur facultatif. Le but de ce modificateur est de permettre au fournisseur d'opérer à volonté une classification non normalisée des détails. Une liste des modificateurs utilisés doit être communiquée par l'organisme qui fournit les données à celui qui les reçoit.

A draft of this standard was issued for public review by the Standards Association of Australia in December 1979. It is to be adopted as a standard after comments on the draft have been considered and the document completed.

It had originally been prepared by a working party consisting of members of Australian government departments and was later revised and enlarged by a small working party of members of the National Mapping Council of Australia.

It specifies a recording system for the exchange of digital mapping and charting data on magnetic tape, including the coding given to individual features.

A standard for the format and codes of digital mapping and charting data was established because:

(*a*) The nature of data at initial acquisition and the form in which they are stored within the different organizations varies with the hardware and software constraints of those organizations;

(*b*) Specific data generated by one organization may be passed to another in order to avoid costly duplication of effort;

(*c*) The data processing effort of all organizations needing to use data from other organizations on an exchange basis should be minimized.

The standard is primarily intended for use by organizations who wish to exchange data on magnetic tape. It is not expected to be used by users for the purpose of storage or normal operation within the user's own establishment. Most users have a working format which has evolved, first, from the equipment they use, and secondly, from how they wish to manipulate their data.

For the purpose of data exchange, each user would therefore need two programs:

(*a*) One to convert from his working format to the standard;

(*b*) Another to convert from the standard into the user's own preferred working format.

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF.72/L.35.

It is expected that exchange tapes will generally be converted to a working format at an early stage. Accordingly, the standard has been designed for ease of conversion and to minimize loss in the event of a record being corrupted. The need to occupy minimum space on the magnetic tape has not been regarded as an important requirement.

Features locationally defined digitally have, associated with them, a feature header composed of a feature code and an optional feature modifier. The purpose of the modifier is to permit a non-standard breakdown of features at the supplier's discretion. A list of the modifiers used is to be supplied by the donor to the receiver.

LANDSAT IN AUSTRALIA*

Paper presented by Australia

L'Australie utilise les images LANDSAT, notamment celles de l'analyseur multibandes, depuis le lancement de LANDSAT 1 au milieu de 1972.

Ces images sont utilisées en agriculture, en géologie, en sylviculture, en hydrologie et, dans une certaine mesure, en cartographie.

Les données numériques LANDSAT sur bandes exploitables par ordinateur sont traitées dans presque toutes les universités australiennes et dans les divisions de recherche informatique, de physique minérale, de gestion des ressources en terres et de recherche sur l'utilisation des sols de la Commonwealth Scientific and Industrial Research Organisation (Institut de recherche scientifique et industrielle du Commonwealth). Le Commonwealth Bureau of Mineral Resources (Bureau des ressources minérales du Commonwealth) ainsi que le Lands Department (Département des affaires foncières) d'Australie occidentale et plusieurs grandes sociétés minières travaillent à la mise au point d'un système de traitement.

En 1977, le Gouvernement australien a approuvé l'installation d'une station de réception LANDSAT près d'Alice Springs et d'un centre de traitement à Canberra. La station d'Alice Springs doit commencer à fonctionner en novembre 1979 et le centre de traitement en avril 1980.

En Australie, les images LANDSAT ont rarement été utilisées en cartographie. Les deux principaux exemples d'application à mentionner sont les suivants :

SÉRIE DE CARTES DE RECONNAISSANCE DES RÉCIFS DE LA GRANDE BARRIÈRE

Quarante-huit feuilles à l'échelle du 1/250 000 établies par la Division of National Mapping (Service cartographique national) indiquant les formes et les positions relatives des récifs, révisées à l'aide d'images LANDSAT non vérifiées.

SÉRIE D'IMAGES LANDSAT AU 1/500 000 DE L'AUSTRALIE MÉRIDIONALE

Cette série qui a été terminée à la fin de 1977 par le Service cartographique national présente l'ensemble de l'Australie méridionale en 18 photocartes.

Ces cartes ont été établies à partir d'images LANDSAT redressées de la bande 7 de l'analyseur multibandes, dont les contrastes ont été accentuées au 1/1 000 000 par la Division de physique minérale de l'Institut de recherche scientifique et industrielle du Commonwealth.

Le Service cartographique national qui a également établi les mosaïques redressées, a effectué le redressement et l'agrandissement à l'aide d'un Zeiss SEG V.

Australia has been utilizing LANDSAT imagery, mainly of the Multi Spectral Scanner (MSS) type, since LANDSAT 1 was launched in mid-1972.

LANDSAT imagery in Australia is used by agriculturists, geologists, foresters, hydrologists and to some extent by map makers.

Computer processing by digital LANDSAT imagery on computer compatible tapes (CCT) is carried out at almost all universities in Australia, and by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in its divisions of Computing Research, Mineral Physics, Land Resource Management and Land Use Research. The Commonwealth Bureau of Mineral Resources (BMR) is developing a processing system as are the Lands Department in Western Australia and a number of major mining companies.

In 1977 the Australian Government approved the establishment of a LANDSAT receiving facility near Alice Springs and a processing facility in Canberra. The Alice Springs facility will become operational in November 1979, and the processing facility in April 1980.

Applications of LANDSAT imagery to mapping in Australia have been few. Two major applications are:

GREAT BARRIER REEF RECONNAISSANCE SERIES

Forty-eight sheets at a scale of 1:250,000 compiled by the Division of National Mapping with shapes and relative positions of reefs revised from uncontrolled LANDSAT images.

SOUTH AUSTRALIA 1:500,000 LANDSAT IMAGERY SERIES

This series, completed in late 1977 by the Division of National Mapping covers the whole of South Australia in 18 photomaps.

These maps were compiled from rectifications of enhanced LANDSAT imagery of MSS Band 7. The enhancement of imagery was done by the Division of Mineral Physics of CSIRO at a scale of 1:1,000,000.

The rectification and enlargement was done on a Zeiss SEG V by the Division of National Mapping who also prepared the rectified mosaics.

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF.72/L.38.

THE APPLICATION OF LANDSAT DATA TO THE MANAGEMENT OF PASTORAL AREAS IN WESTERN AUSTRALIA*

Paper presented by Australia

RÉSUMÉ

Une partie importante des terres de l'Australie occidentale sont détenues au titre de concessions pastorales pour la production d'ovins et de bovins. Pour assurer une utilisation efficace mais sans excès de cette ressource, une certaine forme de contrôle général est nécessaire. La responsabilité en incombe au Pastoral Appraisement Board (Conseil d'évaluation des pâturages) qui est composé de représentants du Department of Lands and Survey (Département des affaires foncières et des levés) du Ministère de l'agriculture et de la Pastoralists' and Graziers' Association of Western Australia (Association des éleveurs et bergers d'Australie occidentale). Le Conseil a lancé un certain nombre d'enquêtes sur l'état des parcours afin de contribuer à la gestion efficace d'une ressource précieuse.

En raison des contraintes dues essentiellement à la taille et à l'étendue des concessions pastorales, il n'était pas rentable d'effectuer des enquêtes régulières sur l'état de la totalité des parcours. Plus récemment, l'apparition des données obtenues par télédétection grâce au satellite LANDSAT a fourni le moyen de contrôler les zones de pâturages régulièrement, économiquement et en temps opportun. La réalisation rapide de l'intérêt d'utiliser les données LANDSAT pour une approche à plusieurs niveaux de la gestion des ressources a permis d'instaurer une politique clairement définie en Australie occidentale.

A significant area of Western Australia is held under pastoral lease for the production of sheep and cattle. To ensure that this resource is used effectively, but not excessively, some form of overall control is required. The Pastoral Appraisement Board, consisting of representatives from the Department of Lands and Survey, the Agriculture Department and the Pastoralists' and Graziers' Association of Western Australia, has this responsibility. The Board has instigated a number of range condition surveys to assist in the effective management of a valuable resource (figure 84).

Owing to the limitations caused primarily by the size and extent of pastoral leases, it was economically impractical to undertake regular total range condition surveys. More recently, the advent of LANDSAT satellite remotely sensed data has offered the potential to monitor pastoral areas regularly, economically and in a timely manner. The early recognition of the use of LANDSAT data in a multi-level approach to resource management has resulted in a clearly defined policy within Western Australia.

CO-ORDINATION

Initially, and at the request of the Prime Minister, the establishment of a channel of communication between the Department of Science and an appropriate state government department was necessary. This action was taken in mid-1976, when at a meeting of permanent and/or professional heads of all Departments concerned with surveying and mapping in Western Australia, it was agreed that the Chairman would advise the Premier that the single point contact for remote sensing, including LANDSAT data, should be the Surveyor General.

Further to this, the resolution envisaged the use of the Central Map Agency as the single repository of appropriate data within the public service. Since then, it has become increasingly obvious that Western Australia, by nature of its size and natural wealth, has many uses for satellite data including pastoral studies, water resources, geological surveys, mineral exploration, forest mapping, flood and fire monitoring and environmental monitoring. It was this knowledge that in 1977 prompted co-ordinated representations to be made to the Minister for Science on behalf of state government departments to ensure that the Australian LANDSAT station was so located as to cover the western third of Australia.

The formalization of a co-ordinating agency necessarily implied the statement of objectives, which aim to promote a better understanding of the application of satellite remote sensing technology; foster communications between users; liaise between those developing the methods and those applying the methods; advise on training and interpretation techniques.

More recently the formalization of a State Liaison Committee on Remote Sensing has been undertaken not only to examine State remote sensing requirements but to act as a forum for discussions on matters affecting the Australian Liaison Committee on Remote Sensing by Satellite.

PROCESSING EQUIPMENT

Following the formalization of the co-ordinating role of the Surveyor General's office on remote sensing matters, consideration was given to providing data processing facilities. If the decision to co-ordinate remote sensing activities in the state was to have any meaning, early attention to the requirements of users was essential. Obviously there is little point in data analysis work being done in Canberra on imagery covering Western Australia: the user loses control of the interpretive func-

*The original text of this paper, prepared by the Department of Lands and Survey, Western Australia, appeared as document E/CONF.72/L.45.

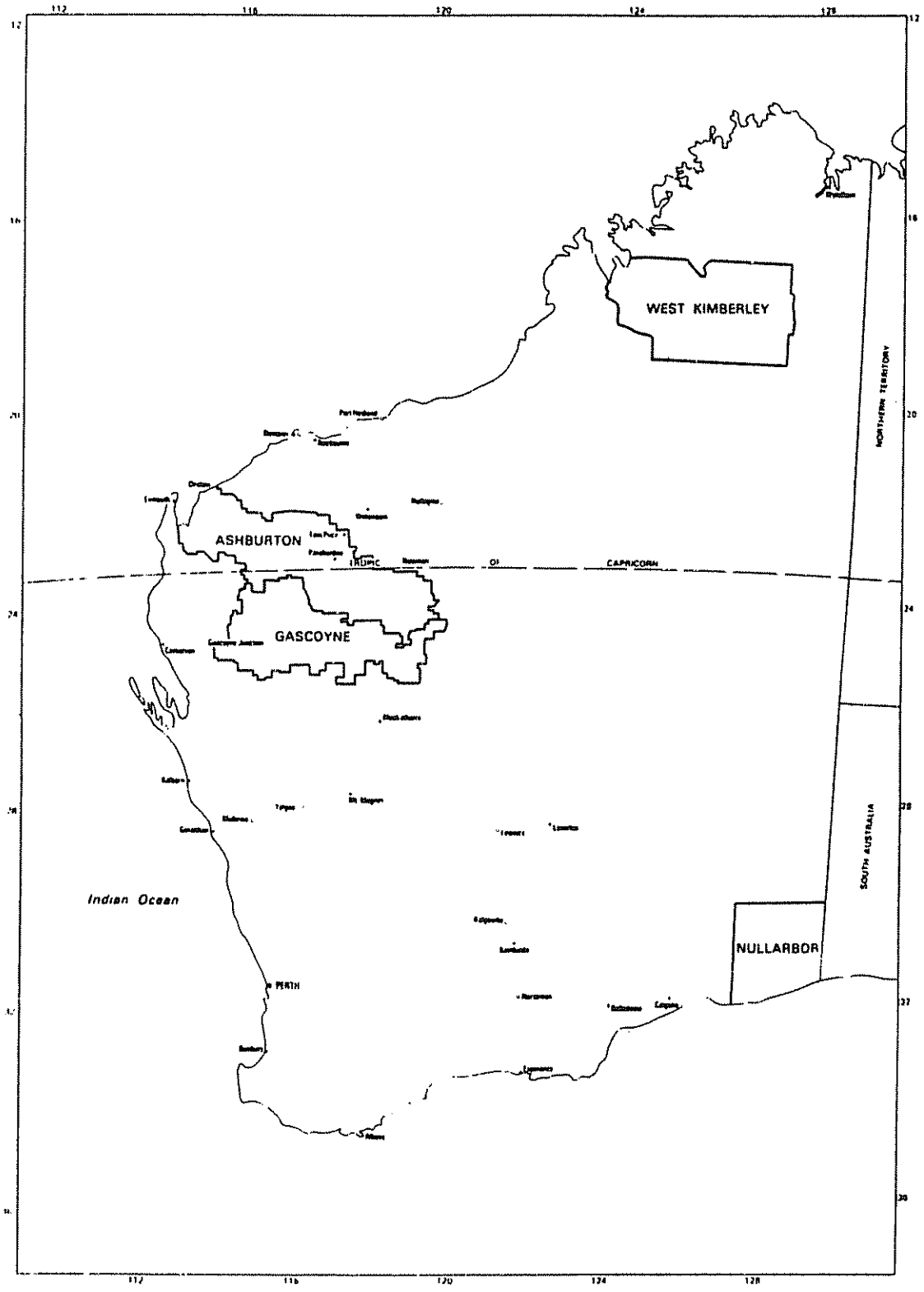


Figure 84. Australia: management of pastoral areas in Western Australia; location of range condition survey areas

tion. It was this philosophy which resulted in the purchase of equipment suitable for processing digital data. The routine production of first generation high quality imagery from LANDSAT digital data on computer compatible tape enhanced to user specifications was considered a prime objective.

The equipment purchased to date consists of a Photomation P1700 Mark II image read/write unit, suitable for film sizes of up to 25 by 25 cm. It is possible to digitize photographic material, as well as generating imagery, at resolutions of 25, 50 and 100 microns. Colour photography can be digitized into its three primary colour components using appropriate filters. The unit is controlled by a Digital Equipment Corporation PDP11/04 processor, and data are transferred using a 9 track 800/1600 bits per inch magnetic tape driver. Off-line data processing is done on an in-house PDP 11/70 computer or on other computing facilities available to the office. Thus the capacity exists to control the type of product generated on this stand-alone system. It is planned in 1980/81 to develop this equipment into a full image processing facility by adding an interactive colour visual display unit capable of performing a wide variety of analysis functions, including theme extraction, area calculation and image registration for comparison studies.

In addition to this equipment, two ERTS ground truth radiometers are used to gather ground truth in the same four spectral bands as the LANDSAT multi-spectral scanner channels. These units are based for gathering spectral data on ground detail for use with LANDSAT analysis procedures, and they will be used for establishing standard targets on LANDSAT scenes. This in turn will permit a more accurate assessment of the contribution of atmosphere effects to the solar reflectance values recorded by LANDSAT. Studies into their use in aircraft to more closely represent the LANDSAT resolution of 0.45 hectare have been done in conjunction with scientists from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Division of Land Resources Management. This and other applied research using ground and airborne techniques is aimed at extracting the maximum amount of useful information from LANDSAT data, when they become available on a regular basis, in a timely and efficient manner.

Pastoral Applications

In a state of approximately 253 million hectares, pastoral leases cover 97,371,511 hectares supporting 427 station businesses, about 45 per cent of the state's cattle and about 7 per cent of the state's sheep. The nature and extent of this resource is such that a regular monitoring programme, using ground and aerial methods would be impractical. LANDSAT offers the potential to cover large areas rapidly, economically and at regular intervals. A combination of satellite, aircraft and ground data may enable an interpretation of changes over large areas without at the same time demanding an increase in the number of staff required. It is important to appreciate that to undertake studies of this nature and scale some form of interpretive equipment must be available or accessible.

Several joint applied research projects have been undertaken to determine the suitability of LANDSAT data to map land systems, quantify eroded and degraded areas, and possibly to monitor change. One such project is continuing in the Ashburton River Catchment Area on Minderoo Station; another involves parts of several stations in the Kimberley region of Western Australia.

The Ashburton study, using LANDSAT remotely sensed data in addition to aerial photographs and ground survey data aims to map erosion and different vegetation patterns, and to identify and monitor changes within several different vegetation communities.

To date, using 1975 LANDSAT data, eroded areas have been identified and mapped (figure 85). It is proposed to use later imagery to check the erosion maps, and at the time of exposure field-check and collect field data on the different vegetation types.

Under direction from the Pastoral Appraisement Board, and in conjunction with the Department of Agriculture and the CSIRO, Division of Land Resources Management, investigations into the use of LANDSAT data to detect and monitor eroded and/or degraded pastures have commenced in the East Kimberley region of the state.

The project aims to:

(*a*) Investigate those aspects of ecosystem structure that reflect grazing impact in several major Kimberley vegetation sites;

(*b*) Determine which of these aspects can be exploited by radiometric data collected by LANDSAT in order to provide a measure of range condition and subsequent trend.

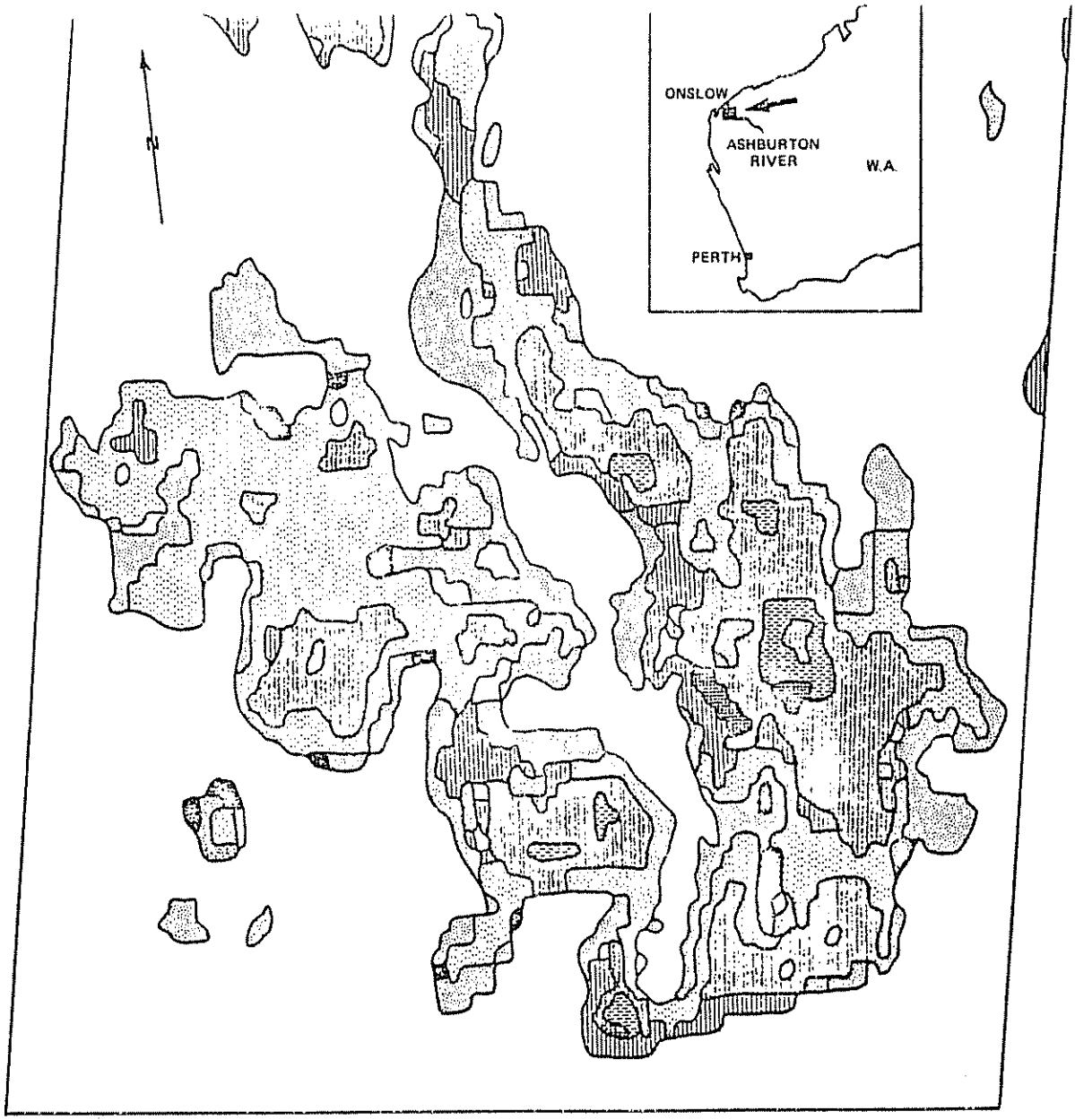
Study sites have been selected within each range site which can be considered to cover the gradient in range condition, from excellent (ungrazed) to severely overgrazed. Each area covers approximately 1.5 ha (5 x 5 LANDSAT picture elements) as a minimum. The areas are visually uniform internally and are so located as to be readily located on both aerial photography and LANDSAT imagery to aid later computer processing. Study sites numbering 20 have been located on Moola Bulla Station where some test sites have already been established by staff of the Surveyor General's office to investigate erosion detection by LANDSAT.

With co-operation from NASA, regular LANDSAT coverage has been arranged to coincide with ground measurements of vegetation from the test sites. The data gathered will be used to arrange the sites on an objective basis and the task in data analysis will be to correlate LANDSAT radiance data with the range condition gradient or with range condition classes as defined by both vegetation and soil parameters.

Monitoring studies, such as the Kimberley and Ashburton pastoral investigations, using multi-level sources of remotely sensed data will develop operational procedures for future surveys. LANDSAT data is to be used in the Nullarbor pastoral appraisement study, initially as a reconnaissance aid, and later as a basis for analysis, in conjunction with other remotely sensed information and ground data.

Conclusion

The basis of informed resource management is the availability of data relevant to that resource. Remotely sensed data supplied, analysed and summarized economically and rapidly assists this process. In Western Australia the co-ordination of activities has avoided



ASHBURTON RIVER EROSION STUDY APRIL 1975					
E-2076-01392				APRIL 1975	
ROW : 1379.		COL : 2718.		SCALE	1 : 25000
UN-NORMALIZED PARALLELOPIPED CLASSIFICATION					
SYMBOL	UN-NORMALIZED SIGNATURE RANGES				DESCRIPTION
	4	5	6	7	
\	22 :26.	62 :74.	70 :80.	24 :28.	CLAYPAN SIG
|	21 :25.	59 :71.	67 :77.	21 :25.	CLAYPAN SIG
	16 :20.	43 :55.	53 :63.	17 :21.	CLAYPAN SIG
=	22 :26.	61 :71.	73 :83.	21 :23.	CLAYPAN SIG
√	26 :30.	69 :79.	72 :82.	22 :24.	CLAYPAN SIG
7	25 :27.	50 :62.	57 :69.	21 :23.	EROSION SIG
	25 :27.	54 :66.	62 :74.	24 :26.	EROSION SIG
	20 :22.	40 :52.	51 :63.	21 :23.	EROSION SIG
	18 :20.	38 :50.	49 :61.	20 :22.	EROSION SIG
	21 :23.	43 :55.	49 :61.	19 :21.	EROSION SIG
	22 :24.	47 :59.	56 :68.	21 :23.	EROSION SIG
	24 :26.	47 :59.	58 :70.	23 :25.	EROSION SIG
	22 :24.	47 :59.	58 :70.	24 :26.	EROSION SIG

Figure 85. Australia: the application of LANDSAT data to the management of pastoral areas in Western Australia

unnecessary duplication of effort and equipment and has provided a single point contact for remote sensing within the State. The importance of this action in view of the imminent commissioning of the Australian LANDSAT Station and the subsequent flood of remotely sensed data to state government users is clear. Monitoring programmes being developed for managing the pastoral resources of the state aim to use this data in an efficient manner to determine eroded and/or degraded areas on a regular basis and to assist the interpretation of change over large areas.

REFERENCES

"The present and future pastoral industry of Western Australia", report to the Ministers for Lands and Agriculture, April 1979.

Honey, F. R., W. F. Holman and I. Taply, "Soil erosion monitoring, Ashburton River district, Western Australia", Proceedings of the LANDSAT '79 Conference, May 1979, Sydney.

QUESTIONS TECHNIQUES RELATIVES À L'ÉTABLISSEMENT DE CARTES : LES CARTES TOURISTIQUES À L'INSTITUT GÉOGRAPHIQUE NATIONAL*

Document présenté par la France

The National Geographic Institute of France (IGN) publishes more than 160 different tourist maps. The number of copies printed and sold is about the same as that of the 5,500 normal topographic maps.

According to the dictionary definition, a tourist map is a map used by those who travel for pleasure. Although normal topographic maps are quite suitable for such purposes, i.e. at medium and large scale for journeys on foot and at small scale for those travelling in cars, making it difficult to differentiate between technical and tourist usage, one may consider the so-called tourist map as being primarily destined for pleasure travel, and it should be specially designed for that purpose.

Presentation. Tourist maps are printed in large format, so that a single sheet covers the maximum useful area. It is folded to facilitate storage, filing and transportation;

Content. Tourist maps show clearly the information of interest to tourists, e.g. footpaths, huts and water sources for the hiker, lay-bys, filling stations, pay-boxes and restaurants for motorists. They are therefore printed in striking colours with symbols and representations that can be easily identified and immediately understood.

Use. Tourist maps are intended for different types of users and, except for the 1:100,000-scale map, which is multi-purpose, it is necessary to adapt them to different tourist activites by creating specific series.

The basic collection of IGN tourist maps includes the following maps:

(*a*) Road-maps at scales equal to or less than 1:1,000,000 for France and certain other countries;

(*b*) Cultural maps showing castles, museums, artistic festivals and archeological sites at 1:250,000 for motorists;

(*c*) 1:100,000-scale maps for various purposes;

(*d*) Maps of national parks and regional natural parks adapted to the objectives and resources of each park;

(*e*) Maps of state forests for hikers, horseback-riders and cyclists;

(*f*) Maps of islands for fishing, sailing along the coast and walking around the islands.

This wide variety of tourist maps shows that the IGN has been able to satisfy certain types of users and the successful distribution and sale of those maps all over the world proves that the Institute has completely mastered the necessary techniques and that its well-adapted resources are able to meet the needs of clients everywhere.

L'Institut géographique national édite quelques 160 cartes touristiques qui, en nombre d'exemplaires imprimés ou vendus, représentent sensiblement le même volume que les 5 500 cartes topographiques classiques.

Qu'est-ce qu'une carte touristique? Selon la définition du dictionnaire ce serait une carte destinée aux personnes qui voyagent pour leur agrément. Bien que la carte topographique soit parfaitement utilisable pour ce type de déplacement, à moyenne et grande échelle pour des déplacements pédestres, à petite échelle pour des déplacements motorisés, et bien que, par conséquent, ses usages techniques et ses usages touristiques soient difficilement dissociables, on peut considérer qu'une carte dite touristique est celle qui est essentiellement destinée aux voyages d'agrément et conçue à cet effet.

Du point de vue de la présentation, la carte touristique est un document de grand format afin de couvrir en une feuille la plus grande surface utile, mais c'est aussi un document plié pour faciliter son rangement, son classement et son transport.

Du point de vue du contenu, la carte touristique doit faire apparaître clairement et rapidement les renseignements qui intéressent le touriste : sentiers, refuges, points d'eau pour le randonneur pédestre, aires de stationnement, stations-service, péages, restauroutes pour l'automobiliste utilisant les autoroutes. Elle comporte donc des surcharges de couleur vive avec des symboles ou pictogrammes facilement identifiables et immédiatement compréhensibles.

Du point de vue de l'utilisation, la carte touristique s'adresse à différents types d'usagers et, mis à part la carte au 1/100 000 qui a une vocation multiple, il est indispensable de l'adapter aux différentes activités touristiques en créant des séries spécifiques.

*Le texte original de ce rapport, préparé par M. Cuenin, Institut géographique national, a paru sous la cote E/CONF.72/L.59.

La collection de base des cartes touristiques de l'Institut géographique national comporte les cartes suivantes :

a) Cartes routières à échelle égale ou inférieure au 1/1 000 000 pour la France et certains autres pays.

b) Cartes à vocation culturelle détaillant les châteaux, les musées, les manifestations artistiques, les curiosités archéologiques à l'échelle du 1/250 000 pour le tourisme motorisé.

c) Cartes au 1/100 000 à vocation multiple.

d) Cartes des parcs nationaux et des parcs naturels régionaux adaptées aux objectifs et aux ressources de chaque parc.

e) Cartes des forêts pour les promenades à pied, à cheval et à bicyclette dans les forêts domaniales.

f) Cartes des massifs montagneux destinées à la randonnée à pied et à ski ainsi qu'à la pratique de l'escalade.

g) Cartes des îles pour la pêche, les activités nautiques le long des côtes et les promenades à l'intérieur des îles.

Une telle variété de cartes touristiques montre combien l'Institut géographique national a eu le souci de satisfaire certains usagers, et la réussite acquise dans la diffusion et la vente de ces cartes dans le monde entier est sans aucun doute la preuve que nous maîtrisons actuellement parfaitement les techniques nécessaires et que nous disposons des moyens les mieux adaptés pour répondre aux demandeurs, de toutes les régions du monde.

LA RÉVISION DE LA CARTE TOPOGRAPHIQUE DE BASE DU TERRITOIRE NATIONAL*

Document présenté par la France

The term "maintenance" is a very general one, covering all precautions and interventions necessary to keep a map as close as possible to actual conditions while preserving its original qualities in both form and substance (base map revision, partial revision, total revision, local revision, map supersession, updating and continuous cyclic revision).

Seeking the most economical and effective means to prevent aging of the cartographic patrimony, carried out and accumulated with difficulty, is now among the foremost preoccupations of all the world's institutes. Though most desire progress, only half of them undertake systematic research and experimentation in this field.

The report takes stock of the situation at the Institut géographique national and describes its experiences and projects.

*Le texte original de ce rapport, préparé par G. Alinhac, Institut géographique national, a paru sous la cote E/CONF.72/L.61. Il n'est pas reproduit pour des raisons techniques.

Le terme d'entretien, très général, recouvre l'ensemble des précautions et des interventions destinées à tenir la carte aussi proche que possible de l'actualité tout en lui conservant ses qualités d'origine dans le fond et dans la forme (révision, révision partielle, révision totale, révision locale, réfection, mise à jour, révision continue et révision cyclique).

La recherche des solutions les plus économiques et les plus propres à empêcher le vieillissement du patrimoine cartographique réalisé et accumulé à grand-peine est actuellement au premier plan des préoccupations de tous les instituts mondiaux.

Bien que la plupart des instituts aspirent à des progrès méthodologiques, la moitié seulement d'entre eux se livrent à des recherches et des expérimentations systématiques dans ce domaine.

Le mémoire se propose de faire le point de la situation à l'Institut géographique national, de ses expériences et de ses projets.

INTERPRETATION OF SATELLITE IMAGERY FOR DETERMINATION OF LAND-USE DATA*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

Le Ministère fédéral de la planification régionale, de la construction et de l'aménagement urbain a lancé un projet portant sur l'établissement d'une carte thématique d'occupation des sols à l'échelle du 1/200 000 dérivée d'images LANDSAT, afin de déterminer les possibilités d'utilisation des données transmises par satellite aux fins de la planification régionale. Le Haut Commissariat fédéral à la recherche aérospatiale a évalué par des moyens numériques (système DIBIAS) les images correspondant à la feuille couvrant la région de Mannheim. On a constaté que l'interprétation des données transmises sur les quatre canaux LANDSAT par les méthodes classiques d'analyse multispectrale donnait des résultats plus fiables que le système numérique et permettait d'établir des classifications plus détaillées des modes d'occupation des sols. Cependant, le progrès technique et l'amélioration des

*The original text of this paper, prepared by S. Schneider, Ministry of Regional Planning, Building and Urban Development, appeared as document E/CONF.72/L.65.

méthodes devraient permettre de remédier aux imperfections des systèmes de traitement actuels et de recourir de plus en plus largement à l'exploitation numérique des données pour la planification régionale.

In the Federal Republic of Germany, the regional planning authorities (the Ministry of Regional Planning, Building and Urban Development and the Ministers' Conference for Regional Planning, consisting of the representatives of the various *Länder*) have been interested in learning if and how LANDSAT imagery might be used for deriving thematic land-use maps. The problem was less to get a better knowledge of the land-use situation in the country, than to acquire actual and multitemporal data for comparison and monitoring the land-use changes. It was not yet known if making a thematic map, with all its severe geometrical and interpretation conditions, was possible by using LANDSAT data.

All over the world industrialized countries are now interested in an inventory of land-use data. Whether the use is applied to acquisition of current areal data or to land-use mapping, whether the data are derived through computer-aided methods or by conventional interpretation, it is obvious that users' interest in the results is increasing. The advantages of a synchronous and synoptic overview of larger regions, relatively rapid reimaging of the same areas, geometric rectification, and adjustment of imagery to conventional topographic map frames, facilitate the use of LANDSAT imagery. A presumed disadvantage is the often-cited "low resolution": although differentiation of spectral reflection and distinction of objects in LANDSAT's four channels is primarily a matter of interest to the interpreter of the imagery. The demand for higher resolution—which will be to some extent satisfied with future satellite sensors—will also create a greater data mass. The interpreter is nevertheless required to consider more closely the classification of land-use categories on the basis of spectral reflection. This is the main problem in the application of satellite imagery, particularly the determination of "mixed signatures". Only in cases where interpretation of satellite imagery has been combined with accurate air-photographic and ground-truth data, has a classification system of required accuracy and positive result been obtained. As is known from conventional air-photographic interpretation experience, it is only with the help of ground-truth sampling that a correct identification of objects and associations can be reached; and this applies also to interpretation of LANDSAT imagery for the Federal Republic of Germany. Air photography, taken synchronously with the satellite overflight, is a valuable aid in interpretation. All the above possibilities should be more intensively applied in future projects, for instance, for surveying forested mountainous areas cut through by deep shadowed valleys.

At present the results of land-use presentations obtained from LANDSAT data through a geographer are far better in accuracy and diversity and in time and cost savings[1] than through computer-aided presentations. Digital processing of satellite imagery will undoubtedly become more advantageous in the future, when increased consideration of necessary ground-truth and application of multi-temporal comparative analysis of higher-resolution imagery, as interactive computer-aided methods, will constitute a future technique with which conventional interpretation will not be able to compete.[2] The Battelle Institute has recently analysed the possibilities of an engineering use of LANDSAT-imagery for planning purposes; the computer-assisted results have been satisfying.

Planners require various combinations of data from various sources as a basis for their decisions. As a consequence, a high degree of accuracy is necessary for individual facts before these can be combined with data from other sources for computer processing.

In the test area of the Working Group (DFVLR/IfP) of the Mannheim sheet (topographic map CC 7110 (1:200,000)) it was attempted to transform the magnetic-tape data for LANDSAT 1 and 2 into land-use classes. The report is grouped according to the following main areas:

(*a*) Description of obvious and relevant characteristics as applied to planning for the test area;

(*b*) Data used;

(*c*) Description of processing methods suitable for bulk data;

(*d*) Description of methods used according to the steps rectification of satellite imagery, and adjustment of imagery to the Gauss-Krüger co-ordinate system;

(*e*) Combination of satellite scenes of varying dates;

(*f*) Computer-assisted classification;

(*g*) Determination of erroneous classification by comparison of machine-assisted satellite data classification with results of air-photographic interpretation;

(*h*) Combination of assembled satellite data with additional data;

(*i*) Observation of the state-of-the-art and consideration of the possibility of evaluation methods applied to the entire area of the Federal Republic of Germany.

Aerial and satellite imagery is composed of a multitude of single items. Management of these data according to such aspects as economy, quality and target-date of completion, requires a possibility of intervention in the individual sequence of operations, as included in the DIBIAS (Digital Image Processing System (Digitales Interaktives Bildauswertungssystem)) of the DFVLR. With the DIBIAS interactive image evaluation system, the data processing results are displayed on a colour TV screen and can be verified and corrected by the user. Additional information and image data can be read interactively by the user when necessary.

Computer-assisted classification of satellite imagery is carried out by the maximum-likelihood method. The method presumes that each image pixel can be determined as belonging to a specific land-use class, such as "densely built-up area", "less intensive built-up area", "coniferous forest land" etc. Hereby the class is

[1] C. Wälder, "Land-use interpretation from LANDSAT-imagery by conventional methods" (Saarbrücken, 1979).

[2] W. Fink, "A strategy of computer assisted land-use classification" (Frankfurt am Main, Battelle Memorial Institute, 1979).

apparent as a spectral characteristic, i.e. composed of a span of colour intensities reaching from visible into near infra-red. Differing from classical air-photographic interpretation, where the interpreter uses differences in grey/ colour tones as one of the various distinction possibilities for features on imagery—generally distinctions are made on the basis of form, texture (pattern) and relief (viewing stereoscopically)—computer-assisted methods have not yet been able to determine relationships between neighbouring image elements, which is necessary for distinction of structural combinations. As a result, reduced interpretation efficiency is an attribute of computer-assisted classification systems. Additionally, tone intensities of LANDSAT-MSS can be determined at present for image elements with a size of 79 x 79 m as the smallest registered entity; so that in areas with extremely small land-use parcels, such as prevail in the Federal Republic of Germany, the results of computer-assisted classification systems will be drastically reduced in accuracy.

Use of available satellite image data for maps or special planning purposes requires that the data be adjusted to a geometric reference system. The reference system also is the base for correlation of classification results with additional data, such as administrative boundaries, land-use statistics, cadastral maps etc. The computer-assisted classification for this project was carried out in the steps hereafter described.

In the selected research area—a region covered by the topographic map CC 7110 Mannheim (1:200,000)—training sites[3] were selected from previously rectified LANDSAT scenes taken on 9 August and 28 August 1975 and statistically analysed. For each training site the mean intensity values and variances were calculated for each of the four bands. The regions of the spectrum composed a "feature space"; in the above case a four-dimensional feature space equivalent to the four spectral bands of LANDSAT. Within a feature space dot concentrations occur (dot clouds), which are a characteristic for a particular land-use class.

When this method is applied to each of the selected land-use classes, a particular and characteristic appearance for each land-use class results for the feature space. The programmed computer can then assign all pixels within the research area to a particular land-use class according to following axiom: each pixel is assigned to the land class to which—on the basis of the previously conducted statistical analysis—it most properly belongs.

The present study shows that the accuracy of computer-assisted classification is strongly dependent on the number of selected land-use classes, that is, on the basis of data currently available. The minimal requirement for planning purposes is to distinguish eight land-use classes through computer-assisted classification: water, densely built-up areas, less intensively built-up areas, vineyards, pasture and gardening, cropland, deciduous forest and coniferous forest. With DIBIAS, eight classes are the maximum possible for distinction; classification accuracy varied, depending on object class, between 25 per cent and 75 per cent. The source of error is chiefly due to the fact that the theoretical and actual areas are not always coincident. This is often the case in areas of small-parcelled land use (cropland, pasture) or on the subdivided fringes of larger land-use areas—(forest, settlement zones).

The results of this study showed that the accuracy of computer-assisted evaluation increased in relation to reduction of selection of land-use classes; the question is, how valuable is such a simple classification for regional planning purposes? Combination of land-use classes "low-density built-up area" and "high-density built-up area" into a common class, "built-up area" increased the accuracy of computer classification for this category to 83 per cent. Combination of the classes "deciduous forest" and "coniferous forest" to a common class "forest" increased classification accuracy to 88 per cent; a common class "open areas", which included the classes "cropland", "pasture" and "vineyards"—could be classified with an accuracy of 97 per cent.

A technological improvement of the satellite-sensors can be currently observed. The possibility of increasing the classification accuracy for land-use purposes from LANDSAT data are indicated by the "Folio of Land Use in the Washington, D.C. Urban Area" map 1:100,000, 3rd ed. (United States Geological Survey, 1978).

Comparison of land-use map Mannheim 1:200,000 (map 2 in pocket) made by computer assisted methods with the land-use map Mannheim 1:200,000 (map 3 in pocket) classified by conventional interpretation methods demonstrate the present advantage of using conventional methods.

SEASAT, which was started in 1978, carries an active microwave radar sensor, with a ground resolution of 20 x 20 m. However, there has been relatively little experience in interpretation of active microwave imagery, possible identification accuracy of land-use classes and correlation of such imagery with imagery produced in optical bands.

In LANDSAT-3, data from the return-beam Vidicon (RBV) camera system have been included along with the multi-spectral scanner (MSS) data; this material will be available in film negatives at a scale of 1:50,000. The ground resolution of RBV imagery will be 38 x 38 m, which is considerably higher than the 79 x 79 m ground resolution of the MSS imagery.

Evaluation of LANDSAT-3 thermal infrared imagery has not yet been carried out for technical and scheduling reasons. The results of such interpretation will be similar to those obtained from the United States National Oceanic and Atmospheric Administration (NOAA) and HCMM (heat capacity mapping mission) imagery: planners will have to take ever more into account the thermal influences of the earth's surface, atmosphere and water, on the environment as a whole.

In comparison to the RBV system, the LANDSAT four-channel MSS system has a higher spectral resolution; combination of both types of imagery should provide accurate thematic maps constructed according to the requirements of planners. Although only a minimal amount of RVB imagery is at present available for experimentation purposes, the possible future developments in relation to planning needs should be kept in view. Still existing technical problems will probably be solved in the near future using RBV imagery. Until then, it should be attempted to:

[3]Training sites are small areas representing as exactly as possible one of the selected classes—i.e. deciduous forest, pasture, cropland, built-up areas or water.

(*a*) Improve rectification methods; provide for a central office where exactly rectified LANDSAT scenes of the four MSS bands are available (as original scale or enlargements), in order to register therein land use classes distinguished on conventionally interpreted aerial photographic images;

(*b*) Further develop a computer-assisted evaluation method, with which the minimum accuracy of the herein presented land-use classes reaches 75 per cent and with a corresponding reduction of operating costs.

The original question regarding uses of satellite imagery for the production of a thematic map series for land-use classification, conducted as a pilot study for the area of topographic map Mannheim at a scale of 1:200,000, could be presented only as a preliminary report. The results of the study showed that:

(*a*) An automatic image evaluation is at present not possible. An interactive computer-assisted interpretation system for land-use mapping will be possible within the near future;

(*b*) It is necessary to carry out multitemporal interpretation of images to compare and to provide more accurate results;

(*c*) Conventional interpretation with rectified imagery is a currently available method, which although limited in terms of rapid map production nevertheless offers some advantages;

(*d*) Satellite imagery of higher resolution is considered desirable, but the processing of increased data amounts should not lead to higher costs for the systems.

The present study shows that uses of satellite imagery for regional policy and planning programmes and environmental protection requirements are of benefit, despite past and currently existing difficulties in processing systems. With regard to currently available methods and future improvements in technology and methodology it can be expected that uses of satellite data processing will provide a valuable aid to solution of the demands of increased data flow for regional planning purposes.

THEMATIC ATLASES: A CONTRIBUTION TO THE SOLUTION OF REGIONAL PLANNING PROBLEMS*

I. ***Atlas zur Raumentwicklung***
II. ***Deutscher Planungsatlas***

Paper presented by the Federal Republic of Germany

RÉSUMÉ

L'*Atlas zur Raumentwicklung* (Atlas de l'aménagement du territoire) est une nouvelle forme d'atlas thématique. Cet atlas présente deux caractéristiques principales :

a) Les experts, de même que les non-spécialistes intéressés, disposeront de renseignements sur les faits et problèmes régionaux;

b) Différents moyens d'information concernant la présentation des faits et problèmes régionaux sont à la disposition de l'utilisateur s'intéressant à des questions spécifiques.

Cet atlas contient des cartes, des diagrammes et des tableaux ainsi que des notes explicatives sur chaque feuille. Le texte d'accompagnement contribuera à compléter le contenu de la base statistique de certaines cartes. Ainsi, ce type d'atlas peut présenter un intérêt pour pays dont les statistiques officielles ne sont pas encore très fiables.

Le *Deutscher Planungsatlas* (Atlas de planification) vise à fournir aux Länder de la République fédérale d'Allemagne des atlas thématiques aux fins de la planification régionale. Les travaux, commencés en 1946, seront bientôt achevés; l'atlas comptera 10 volumes et près de 1 000 feuilles au total. Pour établir les suppléments, on recourra à toutes les nouvelles techniques afin de répondre aux problèmes concrets du développement régional. Les suppléments seront constitués d'une à cinq cartes accompagnées d'un texte explicatif. Il serait possible d'y ajouter des cartes établies par ordinateur. De cette manière, on pourrait recourir plus largement aux cartes thématiques comme moyen de recherche pour les structures, interactions et processus régionaux.

I

Atlas zur Raumentwicklung: A NEW THEMATIC ATLAS FOR REGIONAL DEVELOPMENT

A favoured but by no means the only possible way of transmitting information on regional facts and data is by a thematic map. There is a tendency to overestimate the value of thematic cartography as a means of communication. The reason is partly to be found in a too favourable assessment of the intellectual acquirements of most map users. Only a small group of experts has skill in map reading; for many people the acquisition of information via illustrations and tables is much easier. Furthermore, many facts can be explained neither by cartographic nor by graphic methods.

Thus, textual information remains an important

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medium of communication. The results of user analyses conducted with regard to existing atlases have shown that thematic atlases that are to appeal to a wider public have to offer information relating to one subject in various forms. It may be said that a thematic atlas represents much more than a geo-statistical work of reference in the shape of maps.

Content of the Atlas

The *Atlas zur Raumentwicklung* (*Atlas for Regional Planning*) which is in its final stages of compilation and cartographic preparation by the Bundesforschungsanstalt für Landeskunde und Raumordnung aims at spreading information beyond the borders of the Federal Republic of Germany on problems of regional planning that are being discussed by experts. Apart from communicating facts and data, it analyses structures and processes, confronts essential social problems with aims and objectives of regional planning policy, and hopes to stimulate critical assessment of these problems.

This implies that editorial and other principles of national atlases have been deliberately disregarded when preparing the *Atlas zur Raumentwicklung*. Instead of mapping comprehensively the diverse aspects of a country, ranging from geology, climate and vegetation to population and economic and social developments, a selection has been made of social issues in their present-day context.

Even a country with a standard of living like that of the Federal Republic of Germany shows structural differences in its macro-regions that bring about unequal conditions between regions. The result has been the development of some disparities.[1] Conurbations and metropolitan regions show favourable conditions with regard to employment and well-equipped social and educational infrastructure but, concomitantly, poor standards of natural environment. Conditions in rural areas of the Federal Republic of Germany show exactly the opposite characteristics.

Regional policy, as conceived by the Federal Government, aims at influencing macro-regional disparities, which are showing a tendency to increase.

The reasoning behind this concept for the *Atlas zur Raumentwicklung* contains the criteria applied when selecting the subjects to be represented in it. General guidelines may be defined as stimulation of public interest and orientation towards regional planning problems. Other principles are:

(*a*) Comparison between various regions of the territory of the Federal Republic of Germany is necessary, because comparable information relevant to planning aims for the national territory as a whole is lacking, as territorial local government reform has reduced the number of authorities and created fewer, much larger units, often regardless of old boundaries. New bases for comparison have therefore to be created;

(*b*) Each theme has been divided into several distinct subjects in order to facilitate its more or less comprehensive treatment. Thus users will find answers to specific questions more easily;

(*c*) Themes, as well as specific contributions that illustrate certain facts and data, are subject to strict selection in order to limit the size of the atlas in the interest of its readability and comprehensive overview.

Analysis of user groups

The concept just described aims at serving particular groups of users, as follows:

(*a*) The *Atlas* has been designed as a working basis for authorities and institutions dealing with planning of sectoral or physical nature on national, provincial, regional and city levels;

(*b*) The *Atlas* hopes to stimulate ideas in professional staff of university and other research institutions with regard to their own projects;

(*c*) The *Atlas* will be suitable for teaching purposes in final classes of secondary and grammar schools as well as university seminars;

(*d*) The *Atlas* will consider the existing interests of political parties and industrial and other interests on problems of regional and social planning;

(*e*) The *Atlas* will serve as background information for mass-media work;

(*f*) The *Atlas* hopes to satisfy the increasing demand for information within the countries of the Common Market, and to supply a synopsis of regional planning problems within the Federal Republic of Germany to the other member States.

In order to ascertain the needs and wishes of the above tentative groups of users, a market analysis was conducted in 1972. Oral answers (87) and written answers (1,000) to questionnaires showed which user groups judged the concept of the *Atlas zur Raumentwicklung* favourably. At the same time the opinions of potential users regarding a tentative programme of maps (themes and single maps) were ascertained. Furthermore, some ideas were gained as to graphic outlay, size of the print order, sales price and an advertising campaign.

Selection of themes and maps

In accordance with the basic concept and the results of the market analysis, the original programme, which contained 14 themes, was reduced to 11 themes. They are:

Labour
Education
Traffic and transportation
Population
Housing
Leisure
Land use
Environment
Disadvantaged areas
Regional planning
Territorial local government reform

This selection of themes is influenced by the assumption that in an economic system based on the principles of a social market economy, regional development is primarily being decided by locational decisions of entrepreneurs. Education and traffic and transportation are

[1] The regional planning programme of the Government has characterized this situation by introducing the term *"zweiseitiges Disparitätengefälle"* (bilateral gradient of disparities). See "Raumordnungsprogramm für die großräumige Entwicklung des Bundesgebietes (Bundesraumordnungsprogramm)", *Verh. d. Dt. Bundestag*, Drucksache 7:3584, vol. 30 (April 1975).

two important sectors of infrastructure that depend on production and location of production. These facts then influence migration decisions of the labour force, which migrates to regions where sufficient choice of employment is available. Next to the necessity to work, housing and leisure are of importance to human existence. Under the subject heading of "Disadvantaged areas" a combination of data gained from other subjects dealing with regional disparities will be found, and will be completed by additional information, e.g. equipment with social infrastructure. Under the subject heading of "Regional planning" these results are then confronted with the aims, objectives and planning proposals for a regional planning framework.

Each theme is introduced by one map which depicts the situation at the beginning of this decade. Next, each theme is represented by five to eight maps showing different elements of the theme at significant moments in time. For each theme the following maps are obligatory:

(*a*) The regional map shows selected data for six exemplary areas based on local government units. Thus, intraregional differentiations of areas can be shown that would otherwise have been considered to be homogeneous;

(*b*) The sheet "Europe" aims at a comparison of regions within the Federal Republic of Germany with regions of other member States of the Common Market, Switzerland and Austria;

(*c*) The "up-to-date" sheet contains an analysis of developments between 1970 and the date of appearance, based on data available at that time.

Textual explanations of the various sheets are standardized as far as possible.

Concept for the design

The graphic design of the *Atlas zur Raumentwicklung* is based on the combination, on one sheet, of map, diagram, table and text, making use of the results of the market analysis.

In order to achieve the closest possible co-ordination of map and textual information a distinct separation of three levels of information has been created:

First level: The lower half of a sheet contains the main maps, which have been kept free from information on their margins.

Second level: The legend contains concise, multilingual titles of the main map, the legend proper, frequency distributions and a short, interpretative text to the main map.

Third level: The textual information in the upper quarter of the sheet represents a survey of problems connected with facts and data shown on the maps. It is completed by tables, diagrams and small charts.

These three levels are kept together by grey tinting of the background. Each theme has been provided with a signature colour, a strip of which forms the top margin of the sheet.

Colours used in the main maps have been standardized. The representation of complex content necessitates a colour scale of up to eight tonal values. It encompasses three basic colours of the spectrum, and at the same time pays attention to sufficient clarity of the colour gradation. Two kinds of scales have been applied:

(*a*) Intensity scales showing degrees of increasing intensity, starting with the lightest and finishing with the darkest colour value at the end of the scale;

(*b*) Intensity scales for displaying balances (e.g. migration balances) with decreasing and increasing intensities, arranged with the lightest values in the centre and the darkest values at either end of the scale.

The type image is characterized by easy readability. This has been achieved by using an unpretentious type style (Univers) and light embossing depth of the ragged right margin type setting. At the same time, limitation to a few font heights makes for an economical composer production.

The map basis has been designed to facilitate orientation as quickly as possible, at the same time keeping the maps free from surplus information. Consequently, administrative borders have been generalized to a great degree, and the water system has been reduced as far as possible. In order to make orientation easier, the higher ranking central places and the long-distance network of the German Federal Railways has been included.

The format (DIN A2, 59 x 42 cm) permits use as a desk atlas. At the same time, sufficient readability at meetings of up to 20 persons has been achieved. Corresponding to the selected scale, one sheet can accomodate one, two or four maps.

Editorial concept

The results of the market analysis have shown that the number of potential users of the *Atlas zur Raumentwicklung* amounts to approximately 6,000. An extrapolation shows that roughly 2,600 interested persons voiced an intention of buying the complete atlas or a set of sheets for different themes. Experience with other market analyses have shown that the number of actual buyers amounts to roughly 50 per cent of those who have shown their interest to buy. Consequently, it is being thought realistic to calculate a sold issue of 1,300 copies.

A combination of sales price and sales probability for the complete atlas has shown a relative optimum at DM 300, and for one theme at DM 40, in 1972. Up to now, a price increase of about 40 per cent can be deemed to be adequate.

An advertising campaign for the *Atlas zur Raumentwicklung* will aim as directly as possible at the different user groups. It will put its emphasis on the display of sheets that have already been printed and/or on sections of them.

The *Atlas* is being edited by the Bundesforschungsanstalt für Landeskunde und Raumordnung. Scientific and editorial work for the various themes is within the responsibility of the corresponding subdivisions of the Bundesforschungsanstalt. Selection, assembly and graphic presentation of all relevant information required for the preparation of the maps, as well as for the colour separation, are computer-aided. Cartography, reproduction and printing are being undertaken by the technical subdivision of the Bundesforschungsanstalt.

CONCLUSIONS

A prerequisite for the preparation of a collection of maps of the size and content of the *Atlas zur Raument-*

wicklung is the existence of data that is adequate for representation of the selected material. Although the Federal Republic of Germany has a well-organized system of official statistics, it is often rather difficult to obtain significant data in its necessary regional differentiation.

II

Deutscher Planungsatlas: A THEMATIC ATLAS FOR REGIONAL PLANNING; EXPERIENCES AND TRENDS

About 50 years ago, the first attempts were made in Central Europe to utilize thematic cartography for the purpose of regional planning.[2] These attempts coincided with the publication of analytical and complex regional atlases which in Germany, from 1929 on, provided information as on the changes in administrative boundaries.[3] Because of their orientation towards questions of regional planning, these attempts went beyond simple geographic representations.

This research had to be continued intensively after the end of the Second World War. The displacement of great masses of the population, the enormous destruction, the restoration of the food sector and the revival of industrial production called for diverse information for reconstruction and economic development. Because of this situation, special emphasis had to be placed on regional interrelations between the most important problems. Thematic atlases were considered to be appropriate instruments for representation of natural, demographic and economic resources and of problems of reconstruction. From 1946, the great project *Deutscher Planungsatlas* (*German Planning Atlas*) was planned; after 1950, research proper was started. The *Deutscher Planungsatlas* is prepared and edited by the Akademie für Raumforschung und Landesplanung (Academy for Regional Research and Regional Planning) in collaboration with the *Länder* (provinces) of the Federal Republic of Germany.

Concept

The objective of this atlas is to provide information for regional planning and development. When starting the research, the responsibility for regional planning and development rested primarily with the *Länder* of the Federal Republic of Germany.

For this reason a separate atlas had to be prepared for each of the *Länder*. Nowadays, this publication comprises 10 volumes with nearly 1,000 map sheets. In 1960, the first three atlases were published. The last volume will be completed in the near future. With these atlases all *Länder* of the Federal Republic of Germany now have at their disposal basic data of thematic representations that, according to their respective requirements, can be used and supplemented. For all 10 volumes the bound shape was chosen. The last three volumes were supplemented with single editions comprising 1 to 3 map sheets and an explanatory text. Owing to the shape of these additional copies, up-to-date supplements are made possible.

Regional planning is a task of the administration. For this reason representations with administrative units and boundaries were preferred as far as possible. These administrative units should be as small as possible to be able to distinguish details of structural and evolutionary interrelations between social and economic phenomena and natural conditions. Moreover, small spatial units generally show more homogeneous structures and thus make existing interrelations more distinguishable. The compromise between favourable size and small administrative units resulted in large scales between 1:800,000 and 1:200,000, mostly 1:500,000.

The content of the atlases comprises natural resources and physical conditions, demographic phenomena, agricultural problems and industrial actitivies, transportation and communication patterns, social infrastructure and, last but not least, planning maps. Because planning problems have a regionally different character and change in the course of time, a standardized list of individual map themes is hardly possible. Therefore the 10 separate editions of the *Deutscher Planungsatlas* observe a fundamental scheme but simultaneously strive to meet specific regional requirements. The number of the planning maps reflects the changes that have taken place in the 30-year course of preparation. The first volumes do not contain any maps of this kind because at that time no planning aims had been fixed. As to the last volumes, already more than 10 per cent of the map sheets show aims and plans for regional structures. Analytical as well as synthetical and complex representations have been utilized as map types.

Simultaneous research activities

The research work took advantage of the scientific progress made in "thematic cartography" and its recognition as a scientific discipline. In some research committees of the Academy the following subjects were discussed: aims of thematic maps, problems of generalization, different aspects of the forming of types.[3,4] More emphasis was placed on investigations covering the utilization of electronic data processing and automatic cartography.[5] This research work has been systematically compiled by Werner Witt, a leading scientist in regional planning as well as in thematic cartography, and his outstanding publication is still the scientific basis for atlas works applied to regional planning.[6]

In the Federal Republic of Germany, regional planning, as a task of Government, is integrated into all administrative levels. The specific aims of regional planning lead to a particular orientation of thematic cartography towards a planning cartography. Although a great number of publications exist, issued by regional planning offices, and thus a great number of maps with representations of regional planning aims, scientific systematic planning cartography is still at its inception.

[2] For example, "Merseburger Planungsatlas" 1932 (See Martin Pfannschmidt, "Landesplanung im engeren mitteldeutschen Industriegebiet", *Raumordnung und Landesplanung im 20. Jahrhundert* (Hanover, 1971), p. 17 ff.).

[3] Cf. Werner Witt, *Thematische Kartographie*, 2nd ed. (Hanover, 1970), p. 805 ff.

[4] *Untersuchungen zur thematischen Kartographie, 1. Teil* (Hanover, 1969); *2. Teil* (Hanover, 1971); *3. Teil* (Hanover, 1973), Forschungs- und Sitzungsberichte der Akademie für Raumforschung und Landesplanung, vols. 51, 64 and 86.

[5] "Thematische Kartographie und elektronische Datenverarbeitung" (Hanover, 1977), Forschungs- und Sitzungsberichte der Akademie für Raumforschung und Landesplanung, vol. 115.

[6] Werner Witt, *Thematische Kartographie, Methoden und Probleme, Tendenzen und Aufgaben*, 1st ed. (1967), 2nd ed. (Hanover, 1970), vol. 49, *Abhandlungen der Akademie für Raumforschung und Landesplanung*.

Experiences and trends

After about 30 years of research work on thematic atlases for regional planning purposes, it has become apparent that regional planning still calls for a basic equipment of thematic maps on natural resources, demographic and economic phenomena and all sorts of infrastructure. Beyond that, regional planning requires supplementary up-to-date thematic maps for the solution of actual problems. The basic atlases cannot, of course, deal with all relevant problems but can represent only parts of a manifold reality. The atlas volumes serve as a basis for intensified and actual research.

Modern techniques such as electronic data processing and automatic cartography are extremely valuable means for answering questions of topical interest. They are being used to an increasing degree. It has become apparent that these techniques are particularly helpful with respect to statistical data when researching characteristics or threshold values, but that they can only be applied in part with respect to synthetic and thematic maps.

After completion of *Die Bundesrepublik Deutschland in Karten* (*The Federal Republic of Germany on Maps*), a basic equipment of thematic representations of structures and processes, and the *Deutcher Planungsatlas*, compromising thematic atlases for the *Länder*, further research work may focus primarily on selected actual problems. The *Atlas zur Raumentwicklung* (*Atlas of Regional Development*), presented in this paper in part I, above, may serve as an appropriate example. Supplementary copies are also being prepared for the volumes of the *Deutscher Planungsatlas*. Relevant data will be extracted from the Census of 1981. Important subjects will be: problems of population trends, qualities of economic locations, etc. Attempts will be made to analyse and present basic information required in future about natural resources, long-term socio-economic trends, and actual spatial processes by means of thematic maps. The discussion on the stable value of maps in thematic atlases has shown that about 40 per cent of the maps permit long-term and about 30 per cent medium-term usage. About 30 per cent of the map themes require immediate supplementation. In view of the long compilation and processing time of such atlases, this can be considered a satisfactory result. Integrating, standardizing and synthetic maps for structures and processes are of highest stable value.

A result of existing basic equipment, modified techniques and modified constructive methods of procedure is the change in the arrangement of the editions. Thus, the *Atlas zur Raumentwicklung* is being published in 11 editions covering specific topics. Prior to this, the 10 atlases for the *Länder* (*Deutscher Planungsatlas*) were already being supplemented by individual editions covering specific single topics. To both, text is added. On some map sheets of the *Atlas zur Raumentwicklung* a brief descriptive text is included. Each of the new single editions of the *Deutscher Planungsatlas* comprises 1 to 5 folded map sheets with a more comprehensive analysing text.

These publications show a trend towards more intensive interpretation and analysis of the thematic maps by which it has become possible to analyse problems of spatial structure and to solve problems of regional planning. This edition system offers the possibility of combining a synthetic or complex map with a desired number of simple thematic maps from "computer-cartography" as an element of analysis. This development has resulted in various possibilities for utilization of thematic maps. Nowadays a thematic map is an excellent source of information: within its two dimensions, it is an instrument of research.

More than 30 years of research work on thematic maps and atlases have effected many changes. Political, economic and social conditions have changed; moreover, the aims of regional planning have changed from the planniing of a final condition towards the solution of single problems within a process of spatial development. This, in turn, has caused a change in the demands of thematic cartography as a source of information for spatial planning. Furthermore the technical basis of thematic cartography has changed, and finally the receptiveness of the population to thematic representations has changed. The new school atlases of the Federal Republic of Germany and other countries contain many thematic maps covering spatial structures and processes, with a considerable number of regional planning problems. Owing to this, future generations will have a better ability to deal with thematic maps, and this consequently will lead to better understanding of regional development problems.

APPLICATION OF INTERACTIVE GRAPHIC SYSTEMS IN CARTOGRAPHY*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

L'utilisation de systèmes graphiques interactifs en cartographie exige des caractéristiques particulières du matériel : les conversions analogique-numérique sont exécutées par des numériseurs et, depuis peu, en partie par des analyseurs, les conversions numérique-analogique étant effectuées par des vectographes et, dans un proche avenir, par des traceurs à balayage. Il n'est pas possible d'effectuer en différé ou de façon entièrement automatique la numérisation des données, le traitement des données analysées, ni leur transformation en cartes nouvelles. Il faut qu'un opérateur établisse un dialogue avec un ordinateur et qu'il y ait donc une interaction homme-machine. Cela exige des terminaux alphanumériques et graphiques ainsi

*The original text of this paper, prepared by Aloys Heupel, Institut für Kartographie und Topographie of the University of Bonn, appeared as document E/CONF.72/L.78.

que différentes possibilités d'entrée (telles que claviers, pupitres à curseurs, entrée vocale). Il est donc indispensable que l'ordinateur réponde rapidement à plusieurs postes de travail. Compte tenu de ces éléments, il est recommandé d'employer un mini-ordinateur moderne à système d'exploitation en temps réel avec accès multiples, qui servira de module de commande des périphériques graphiques (interactifs).

Une fois établi qu'une tâche se prête à l'emploi d'un système graphique, on procède à l'analyse et à la programmation avant de passer à l'application pratique. L'analyse et la programmation exigent une coopération entre les informaticiens et des cartographes versés dans les systèmes graphiques. Ils auront également à déterminer s'il vaut mieux mettre au point un logiciel spécial ou utiliser des ensembles de programmes existants. Si l'on choisit de mettre au point des programmes spéciaux, le logiciel de base, que l'on trouve généralement sous forme de sous-programmes, aidera à l'exploitation des périphériques graphiques. Si l'on a recours à un ensemble de programmes interactifs existant, l'un des membres de l'équipe devra se familiariser avec les programmes-sources afin de pouvoir les adapter le mieux possible aux problèmes particuliers et les développer par la suite.

Une série d'applications cartographiques a été effectuée en République fédérale d'Allemagne, dont on ne peut ici que donner des exemples. On établit les cartes topographiques au moyen d'ensembles de programmes interactifs tels que l'ARISTO CD 400 et le CIPS Contraves. Cependant, l'automatisation générale n'est pas encore terminée. Les plans cadastraux à grande échelle, existant sous forme d'*Inselkarten* (cartes par îlot) établies selon un système de coordonnées locales, sont numérisés selon le mode interactif au moyen d'un ensemble de programmes mis au point par l'Institut für Kartographie und Topographie de l'Université de Bonn, après quoi ils sont transposés dans le système national et transformés en *Rahmenkarten* (cartes détaillant l'ensemble d'un secteur). D'autres applications portent sur la cartographie thématique et la planification, activités dans lesquelles certaines phases importantes des travaux visant le remembrement des terres pourraient être automatisées.

En résumé, on peut dire qu'avec le matériel existant, en adaptant le logiciel, on devrait pouvoir résoudre les problèmes des pays en développement, par exemple dans les domaines de la production et de la révision des séries de cartes topographiques et de la gestion des terres. Il est possible de transposer les méthodes sans aucune difficulté. Toutefois, si l'on veut aborder les problèmes propres aux pays en développement, il importe que ceux-ci élaborent également des projets de solution. Peut-être la présente Conférence contribuera-t-elle à instaurer une coopération plus étroite dans le domaine de l'application des techniques de transfert graphique.

Automation, the application of data processing systems, is determining working procedures in an increasing number of fields. During more than 30 years that have elapsed since the first computer was developed, new applications have been added constantly. Comparing working procedures before the introduction of electronic data processing (EDP) with those after its introduction, we are confronted with fundamental changes. This fact, as well as the considerable advances made in EDP, entitle us to speak of a second industrial revolution.

In looking for the conditions necessary for such a development we find two: first, the computers must be brought to a standard of performance which permits the solution of problems of increasing complexity: this includes not only pure software but also the computer-specific software, such as operating system, compiler, utilities etc. Second, potential users must familiarize themselves with the methods of EDP, analyse their own problems carefully, represent them in algorithms and—perhaps in co-operation with computer scientists—convert them into computer-compatible form (programs).

These two aspects must be observed when data processing is applied to cartography. For this reason, instrumental requirements for automation in cartography will be dealt with before questions of software development are discussed and some typical cartographic applications are pointed out.

Hardware components of cartographic systems

When in this paper the hardware of a graphic system is discussed, emphasis is placed on the cartographic peripheral units. Other peripherals, or the control computer, will be dealt with only if the cartographic application has special requirements.

The product of cartography is, as a rule, a map; often a map is also the starting point for cartographic work: from one map another one is derived.

On maps the information is represented in analog form. If data processing systems are to be applied to support cartographic work, the analog information must be converted into digital data. Essential components of an automation system suitable for cartography are therefore devices for analog-digital conversion for data acquisition from maps and, vice versa, devices for digital-analog conversion for data output in analog form, i.e. as maps.

Data acquisition devices

For analog-digital conversion two basically different types of devices can at present be used: digitizer and scanner.

A digitizer consists of a desk with printed circuits and a freehand cursor. The circuit running through these printed circuits is recorded with the cursor and used for the determination of the table co-ordinates. While digitizing, the operator must move the cursor along each feature to be digitized. The time required for this operation naturally reduces the effectiveness considerably. The acquisition of the contours of a topographic map at 1:50,000 takes about 200 hours.

An alternative to this is the scanner. With this device a map is full-automatically scanned, line by line, with a photo sensor, and in doing so it is decomposed in raster pixels of different grey values. From these, the single features must for further processing be put together again as point sequence and feature-coded (contour, road, terrain etc.). Considering that the mere acquisition of one point sequence, which then represents one contour, from this vast quantity of raster data can be achieved only with an enormous computing expenditure, it is clear that the problem of automatic pattern recognition is not solved yet. Here, exactly, lies the bottleneck with the scanner: while the full-automatic acquisition of the contours takes only about 15 minutes, the assignment of the spot heights to these contours and the closing of the gaps which must be done by the operator, requires approximately one week. From this expenditure of time needed for the evaluation of a relatively simple geometric structure such as contours, one clearly recognizes the restrictions on the possibilities of application that at present still exist.

Data output devices

The second group of the graphic peripheral units are the digital-analog converters. By this we understand all types of computer-controlled drafting systems. As examples may be mentioned precision drafting tables, which are best suited for topographic cartography and, especially for thematic applications, drum plotters and microfilm plotters which rendered the "misuse" of the line printer as a cartographic output device almost superfluous. The disadvantages of the precision drafting tables are, for one, their susceptibility to breakdown, attributable primarily to their many mechanical components; and, for another, their slowness, which becomes a nuisance as soon as map originals with very rich content are to be produced.

An alternative, which excludes both disadvantages, is in the course of development: the raster plotter which can be considered a conversion of the scanner. The map symbols to be represented are line by line exposed on film by means of a lighted ray. This procedure is known from the production of printing originals. The problem with respect to the hardware consists in reaching the resolution of 700 lines/mm for a format of approximately 1 x 1 m which is needed for topographic maps. As far as the software is concerned, the data available in vector form must be converted into raster data, which is by far not so time-consuming as is the reverse problem occurring with the scanner.

Interactive peripherals and control computer

All devices mentioned so far can be operated off-line. They either write the obtained, or for control purposes required, data on data carriers such as punched tapes, magnetic tapes, floppy disks etc., or they read them off these carriers. For that operation only a low "local intelligence" is needed, usually in the form of firmware. For data processing, a large-capacity computer can be intercalated. However, this method is only practical for the solution of very limited problems, e.g. the smoothing of lines. It is a characteristic feature of graphic data processing that it often supports the work of men very well but can hardly ever substitute men completely in all single steps. The reason for this is not a poor system analysis or too low a computer performance. Especially graphic problems often require creative steps which cannot be solved full-automatically.

Here, men must be given the opportunity to intervene in the process, to decide on a problem that was processed by the machine and to return it to the machine to perform further steps. It is also unsatisfactory with this equipment configuration, that eventually erroneous partial results of automatic processing by the computer can be detected only on the end product, the finished map, and that these errors can only be corrected with a great expenditure of time. Furthermore, the off-line digitizing lacks process control as well as protection against operating errors. All that makes it imperative for graphic systems to provide a possibility for dialogue between men and machine. This dialogue, also called interaction, can for the control of the program flow be done, for instance, via an alphanumeric terminal. In such a dialogue the operator is offered several possibilities from which he must select the right one and pass it on to the computer via an input device (keyboard, menu of the digitizer, voice input). For this, the operator needs little training time: the operation is considerably facilitated. For graphic problems an alphanumeric terminal does not suffice; the interaction is done in addition via a graphic terminal. Here two different types must be distinguished:

(*a*) Memory tubes, by means of which the image is permanently generated with a cathode ray on the phosphorous coating of the tube until the entire representation on the screen is erased; though new image parts may be added, a deletion is possible only by new formation of the entire image;

(*b*) Refresh terminals, by means of which the phosphorous coating is excited only for a short period of time and thus must be activated from a memory several times per second. Image parts are no longer activated when the equivalent locations in this refresh memory are erased and thus are moved from the screen. The advantage of the refresh terminal—faster reaction with changes in the representation—is at present still confronted with lower resolution and essentially higher costs for an owned refresh computer with memory.

With on-line connections of the graphic peripherals and interactive work, as is usually necessary for the solution of graphic problems, the computer requirements are not entirely met by the use of a large-capacity computer. This computer is intended for batch processing and cannot guarantee either real-time operations as

they occur in the control of graphic peripherals or short response times as needed for interactive work. For this, a minicomputer must be used as process computer, which is equipped with disk drives for fast access to the cartographic data base. Besides, the process computer must work with a real-time multiprogramming operating system, so that several applications can be performed quasi-simultaneously. Printing terminals, line printer, magnetic tape drives etc. complete the equipment for program development, data securing and data exchange. The large-capacity computer is merely used for computing extensive programs with great quantities of data, e.g. for line smoothings. For data transfer an interprocessor link between process computer and large-capacity computer is recommended.

The attached schema shows the configuration of an interactive graphic system which meets the mentioned requirements (figure 86).

SOFTWARE COMPONENTS

Besides the operating system, compiler and subroutines, each different field of application of such a graphic system requires, first of all, the development of the corresponding user software. This means that after it has been recognized that a very specific task could be solved by applying computer-aided procedures, a rather thorny path is still to be covered to its realization. The specific problem must be analyzed carefully and divided into single steps for which algorithms must be set up and finally programmed. This task is the more difficult, the more complex the problem is. Unfortunately, graphic problems are always very complex. Besides, one must bear in mind that generalization problems or plannings require a high degree of "intuition" so that the analysis phase is the most difficult one. On the other hand it is not only an eventual automatic solution that profits of such an analysis but also the conventional method which is better substantiated theoretically and thus often even improved practically.

The development of user software is facilitated if the graphic basic software, e.g. for the production of drawings on the drafting table or on the graphic terminal or for the digitizing, is available in the form of subroutines. Such software is often offered together with the corresponding peripheral units and is recommended for those cases where a system is configurated independently and is purchased without a closed program system. If this software is not available then, in addition to the hardware interface, at least the software interface (system driver) for the specific operating system must be purchased.

Graphic systems with interactive software systems are, of course, offered. This way the time between procurement and production can be considerably reduced. Most of the problems so far discussed do not apply. One must, however, take into consideration that these systems have been developed for only one specific field of application, e.g. for the processing of topographic maps. The solution of other tasks is complicated or not possible at all. Besides, the user has only a little knowledge, or no knowledge at all, of the program-technical realization of his problems. Thus he cannot apply any changes whatsoever while such a possibility exists with his own developments. There is merely the possibility of inserting user programs via predefined software interfaces.

Another disadvantage is that such program systems are often tied to very specific hardware, i.e. they are not portable. This means that the latest state of the rapidly advancing EDP developments often cannot even be reached in the procurement. If, after a couple of years, an important component fails, the entire system is endangered.

Both possibilities, own development and purchase of a ready system, have their advantages and disadvantages, so that a decision depends on the specific individual requirements. The ideal solution is many times a synthesis: the user's own staff makes the analysis and works out the program requirements, and EDP experts develop the programs. Afterwards, however, they should disclose their sources and document them in detail so that the interactive program system loses its "black-box" character. In such a manner the advantages of both variants can be combined very well.

APPLICATION EXAMPLES

In the following, some typical cartographic applications will be described, as they have been realized in the Federal Republic of Germany.

For many areas, large-scale cadastral maps are available only as *Inselkarten* (maps on which only a selected area is mapped in full) in local co-ordinate systems. Neither the maps nor their drawing quality meet present-day requirements. This is where automation comes in: the single maps are digitized interactively. For process control and error detection the already digitized parts are displayed on the graphic terminal; via an alphanumeric terminal the operator is offered instructions which he can input into the computer via menu, keyboard or cursor button for the control of the program flow.

After this, the single maps are automatically combined to a closed system and plotted as "Rahmenkarten" (maps on which details extend over the whole area) in the national co-ordinate system. Only if there are larger marginal gaps, an intervention of the operator is needed. The data record can be updated so that after some time a new drawing can be produced with the latest state.

On account of the relatively little digitizing expenditure this automated solution surpasses the conventional manual methods. The software has been developed at the Institut für Kartographie und Topographie of Bonn University.

The production of topographic maps can be supported in a similar way. In Germany, the interactive program systems ARISTO CD 400 and Contraves CIPS are used for this purpose. The problem is that the acquisition expenditure for the topographic maps, with their very rich content, is so great that the mere plotting of the data for one map series yields no economic benefit as compared to the conventional procedures. Therefore several map series must be derived from one data record. For this, generalization measures are needed whose automated solution is not yet concluded. In this connection, mention should be made of the publications in the *Nachrichten aus dem Karten- und Vermessungswesen*, issued by the Institut für Angewandte Geodäsie.

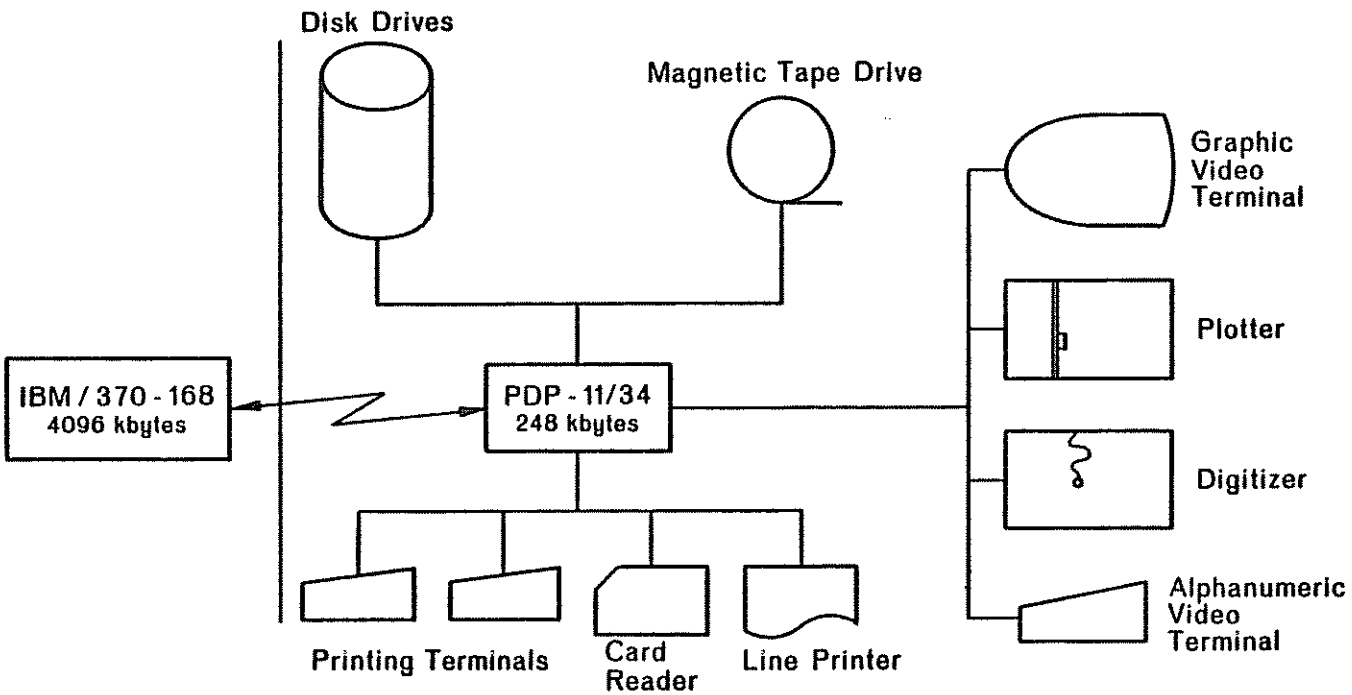

Figure 86. Federal Republic of Germany: typical interactive graphic system

Thematic cartography, in particular, offers good possibilities to apply interactive systems. To support regional planning, the information available in digital form must often be provided with the necessary areal reference by representing it on maps. For this, a topographic base once digitized, e.g. boundaries of an administrative district, can always be used again.

After the threshold values have been determined, the plotting of the designed map on the display according to pre-given symbols is done automatically. Here an interactive intervention, e.g. to improve the symbol positioning etc., is possible. Furthermore, it is possible to judge, before the originals are produced, the map appearance at least approximately and, if need be, to replace it by a new one according to a different legend. Further support in this field may be expected in the near future by colour displays which will permit an even better judging of the designed map.

Another application is the support in planning activities, taking as example land consolidation. Before the consolidation proper is started, the land utilization and ownership maps with the corresponding soil values are digitized. After the new network of roads and water courses has been established, different allocation variants can be worked out interactively directly on the graphic terminal. Further support for the planners is intended by the indication of allocation-relevant information on the screen.

This enumeration of different fields of application shall only be of exemplary character. With the available hardware and the modification or further development of the existing software similar problems can also be solved, e.g. in the production and revision of a topographic map series or in land organization, which are particularly urgent in developing countries. The methods developed by us can be transferred without any difficulties.

To enter into the specific problems of the developing countries it is, however, necessary that contributions on the development of solution concepts be submitted on their part too. Perhaps this Conference will contribute to initiating increased co-operation in the application of graphic data processing.

REFERENCES

Christ, F., "Untersuchung zur Automation der kartographischen Bearbeitung von Landkarten", *Nachrichten aus dem Karten- und Vermessungswesen*, No. 41, 1969.

_____, "Vollautomatische und halbautomatische interaktive Generalisierung, Symbolisierung und Lichtzeichnung einer topographischen Karte kleinen Maßstabs", *Nachrichten aus dem Karten- und Vermessungswesen*, No. 71, 1977.

Heupel, A., "Automation in der topographischen Kartographie. Grundsatzfragen der Kartographie", *Sonderband der Österr. Geographischen Gesellschaft* (Wien, 1970), pp. 132-139.

_____, "Überlegungen zur Datenverarbeitung in der topographischen Kartographie", *Untersuchungen zur thematischen Kartographie (Teil 2)*, report of the Committee on Thematic Cartography of the Akademie für Raumforschung und Landesplanung (Hanover, 1971), pp. 37-44.

_____, "Die kartographische Generalisierung unter dem Aspekt der Datenverarbeitung", *Fünfundzwanzig Jahre Deutsche Geodätische Kommission*, Deutsche Geodätische Kommission, series E, No. 17 (Munich, 1978).

Johannsen, Th., "Automationsgestützte Erfassung und Aufbereitung kartographischer Daten", *Nachrichten aus dem Karten- und Vermessungswesen*, No. 73, 1977, pp. 149-156.

Knorr, H., "Ein Automationssystem für die Herstellung und Fortführung topographischer Karten", Deutsche Geodätische Kommission, series B, No. 192.

Oest, K. and P. Knobloch, *Untersuchungen zu Arbeiten aus der thematischen Kartographie mit Hilfe der EDV*, publication of the Akademie für Raumforschung und Landesplanung, *Abhandlungen*, vol. 72 and 74 (Hanover, H. Schroedel Verlag, 1974).

Rase, W. and H. Schäfter, "Computerunterstützte Herstellung thematischer Karten", *Öffentliche Verwaltung und Datenverarbeitung*, No. 5 (1974).

Staufenbiel, W., "Automatische Datenverarbeitung in der topographischen Kartographie", *Kartographische Nachrichten* (1976), pp. 83 ff., 123 ff., 161 ff., 217 ff.

REMOTE SENSING APPLICATION: CHANGES OF FOREST COVER DETECTED THROUGH AERIAL PHOTOGRAPHY—A CASE STUDY OF THE PROVINCE OF LAMPUNG SUMATRA, INDONESIA*

Paper presented by Indonesia

RÉSUMÉ

Le document traite de l'exploitation des photographies aériennes pour l'étude de l'évolution de la couverture forestière dans la province de Lampung. Les lignes de partage des eaux définissent un certain nombre de zones géographiques dans lesquelles on étudie l'évolution de la couverture forestière d'après des photographies aériennes en noir et blanc à l'échelle du 1/50 000 prises sur film infrarouge en 1969 et de photographies à l'échelle du 1/100 000 prises sur film panchromatique ordinaire en 1976. L'analyse de ces photographies a révélé qu'entre 1969 et 1976 la couverture forestière avait diminué de 3 529,37 km².

L'Agence nationale de coordination des travaux géodésiques et cartographiques (BAKOSURTANAL) doit publier une carte thématique à l'échelle du 1/250 000, établie selon la projection Mercator transverse universelle, qui illustrera l'évolution de la couverture forestière dans la province de Lampung.

*The original text of this paper, prepared by the National Co-ordination Agency for Surveys and Mapping (BAKOSURTANAL), appeared as document E/CONF.72/L.101.

In Indonesia increasing activity in agriculture, forestry, communication and industry is creating major changes in land cover. In many cases the process of development imposes claims on forest areas. In Lampung Province, shifting cultivation was thought to be a major cause of the loss of forest lands; however, lack of information about forest cover or the dynamics of its change, reduces our understanding of the impact of development. To gain a clearer view of the nature and scale of forest cover changes in Lampung Province, the National Co-ordination Agency for Surveys and Mapping examined past aerial photography taken in 1969 and 1976. By comparing areas under forest cover on two different dates, an estimate of the scale of forest change was derived and the principle agents of change, such as shifting cultivation or estate crop plantations, was identified.

The use of air-photo analysis provides a valuable tool for analysing historical changes in forest cover and provides a rapid and relatively inexpensive method of updating forest cover information.

General setting

Lampung is one of the eight provinces of Sumatra and is located in the south-western corner of the island (figure 87 and inset). Within the province, the area to the north and east of the Barisan mountain range is characterized by an uplifted and dissected peneplain consisting mainly of reworked Quarternary acid volcanic tuffs. The so-called Lampung tuff overlies folded Tertiary deposits (Verstappen, 1973). The Lampung plain is slightly tilted towards the north-east.

Historically, the forest cover of the province has been affected by shifting cultivation practised by the native population and, more recently, by the agricultural practices of spontaneous migrants from Java. Shifting cultivation is not new, having been started by the native population and adopted by migrants; however, the rapid growth of shifting cultivation is causing concern to the regional government and control may be instituted to reduce the pressure on forest areas.

Recently, renewed interest in Indonesia's "wastelands" has prompted us to quantify the influence on shifting cultivation on soil conditions with the help of previously collected data from an area with podzolic soils (Driessen, 1976).

Materials and method

Analysis of forest cover change was conditioned by the availability of existing aerial photography and land cover information. The main sources of information were the following (see figures 88 and 89):

1. *Aerial photography, 1969:* Aerial photography flown by FAO INS 1, black and white, infra-red, scale 1:50,000, covers almost all of Lampung Province except for a hilly area adjacent to the south-east coast. This aerial photography was interpreted by the Soil Research Institute and published in the form of a *Land Use and Vegetation Map* at scale 1:100,000 (1970).

2. *Aerial photography, 1976:* Aerial photography flown by the National Co-ordination Agency for Surveys and Mapping (BAKOSURTANAL) in co-operation with Australia, on black and white, Panchromatic emulsion, scale 1:100,000. The photographs were interpreted by the National Co-ordination Agency for Surveys and Mapping, based on topographic maps at scale 1:250,000.

3. *Supporting data:* Forest concession maps of Lampung Province at scale 1:500,000 published by the forestry service of Lampung Province. Topographic maps at scale 1:250,000, (1974). UTM map grid, published by the Army Topographic Service (JANTOP TNI AD).

The method used to detect changes of forest cover is as follows:

(*a*) The 1:250,000 scale topographic map is used as a base map on which the data are stored in grid cells of 0.6931 sq km for the equatorial area;

(*b*) The acreage of the forest area is based on the watershed divisions in the Lampung area;

(*c*) Other supporting data are the acreage of each watershed, and the distribution of slope areas of more than 15°.

Table 1. Forest area, Lampung Province, 1970 data

Watershed (Numbers keyed to figure)	*Watershed area (sq km)*	*Forest area per watershed*		*Slope area more than 15°*	
		sq km	*percentages*	*sq km*	*percentages*
1. Mesuji	2 500	870.53	34.82	—	—
2. Tulangbawang	9 125	2 583.87	28.32	605.77	6.64
3. Seputih	7 251.25	1 644.82	22.68	117.13	1.62
4. Sekampung	4 531.25	487.95	10.77	510.80	11.27
5. Semangko	1 250	33.96[a]	11.72	425.56	34.05
6. Combination, W. Balak, W. Wako, W. Menjangan, W. Sekopong	1 875	808.15	43.10	—	—
7. Combination of small rivers flowing to Sunda Strait and Java Sea	2 062.50	398.53	19.32	698.65	33.87
8. Combination of small rivers flowing to the ocean and Sunda Strait	3 212.50	—	—	—	—
9. Combination of small rivers flowing to Ranau Lake	256.25	—	—	—	—

Sources:
1. Topographic map 1:250,000
2. Land-use map of Lampung area 1:100,000, surveyed by the Soil Research Institute, Bogor, using air-photo interpretation and ground checks, INS 1, 1969, at scale 1:50,000.

[a]Some data are not available.

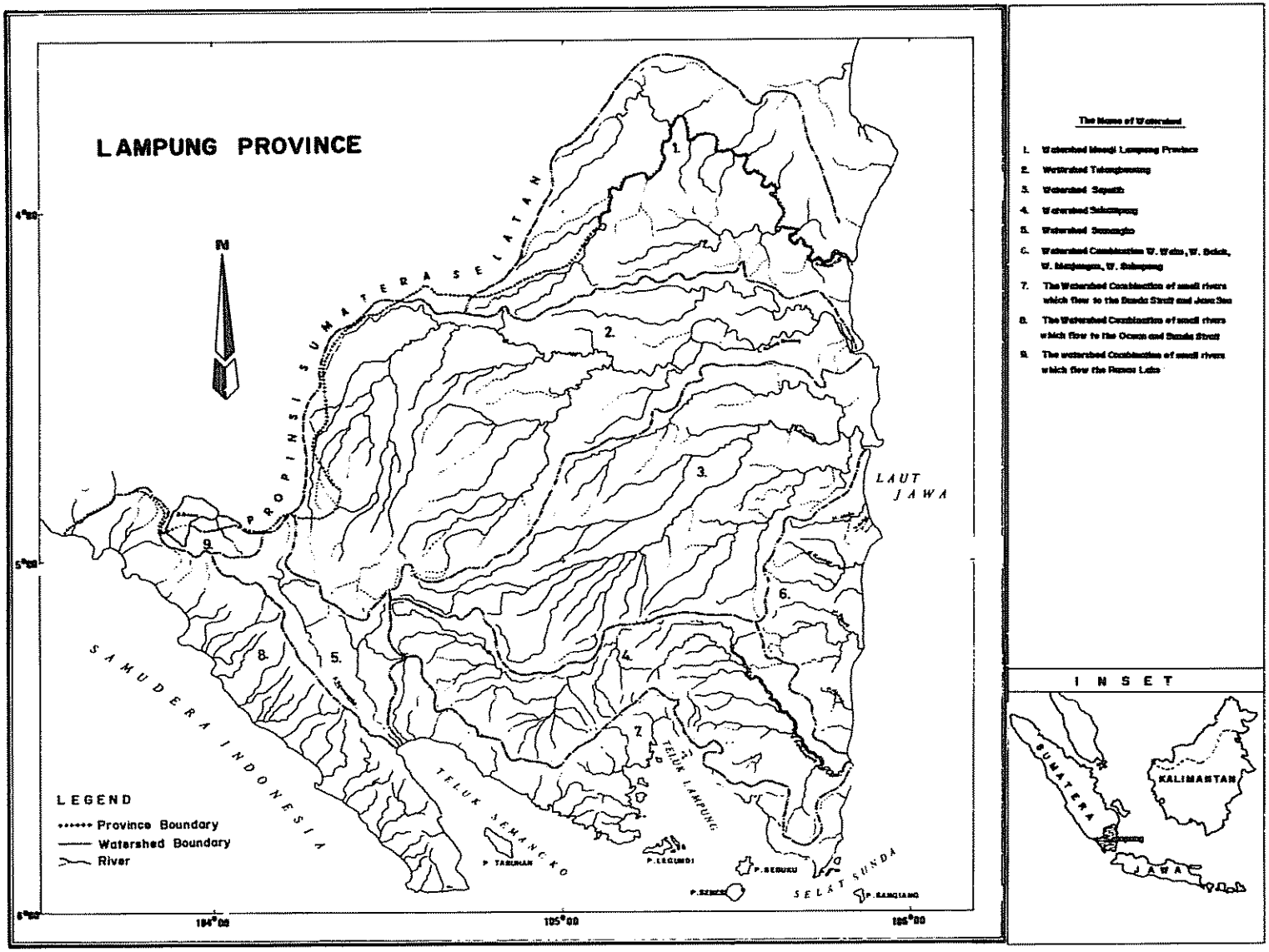

Figure 87. Indonesia: watersheds, Lampung Province

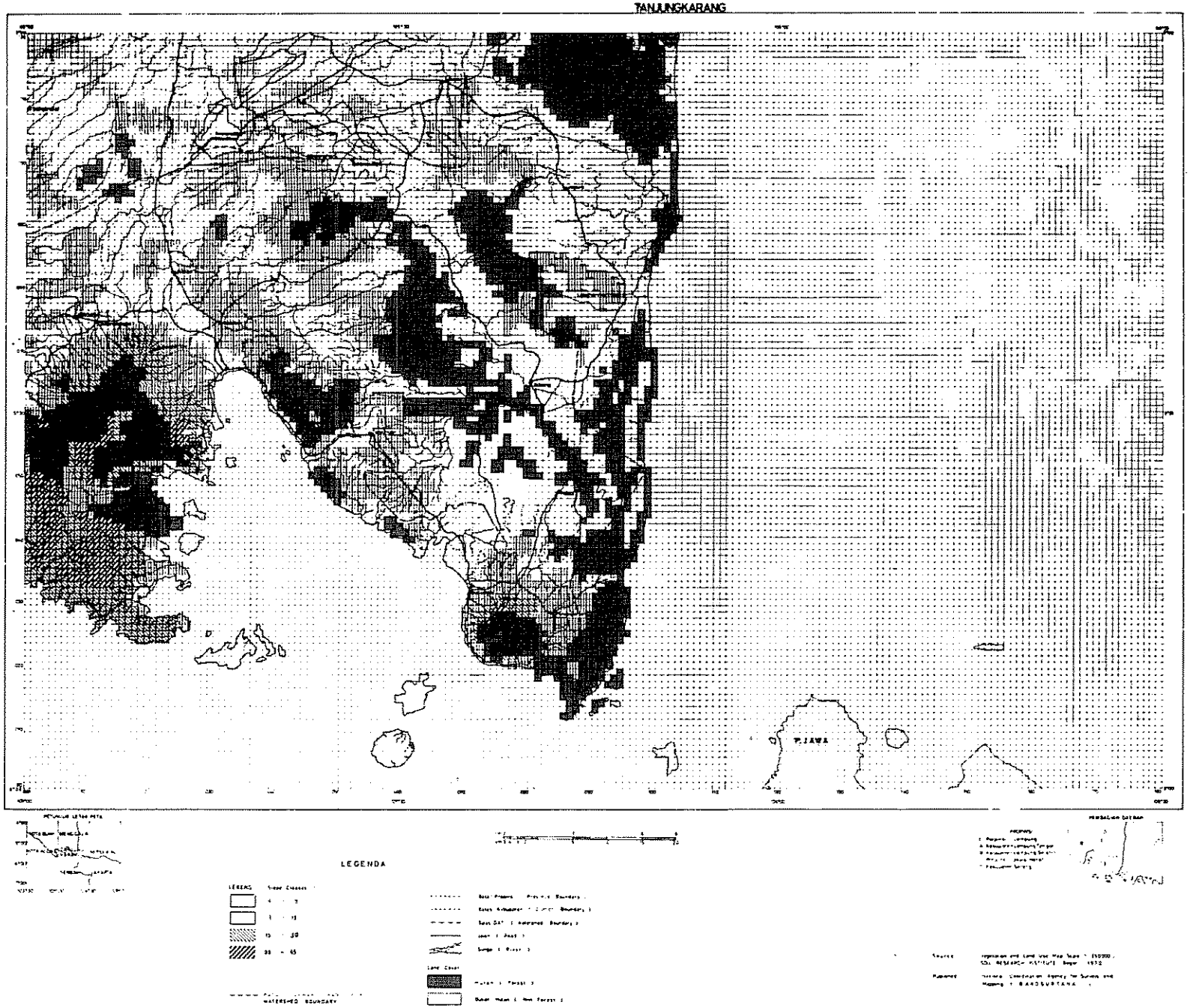

Figure 88. Indonesia: forest cover of the Lampung area in 1970 shown on reduced 1:250,000 map

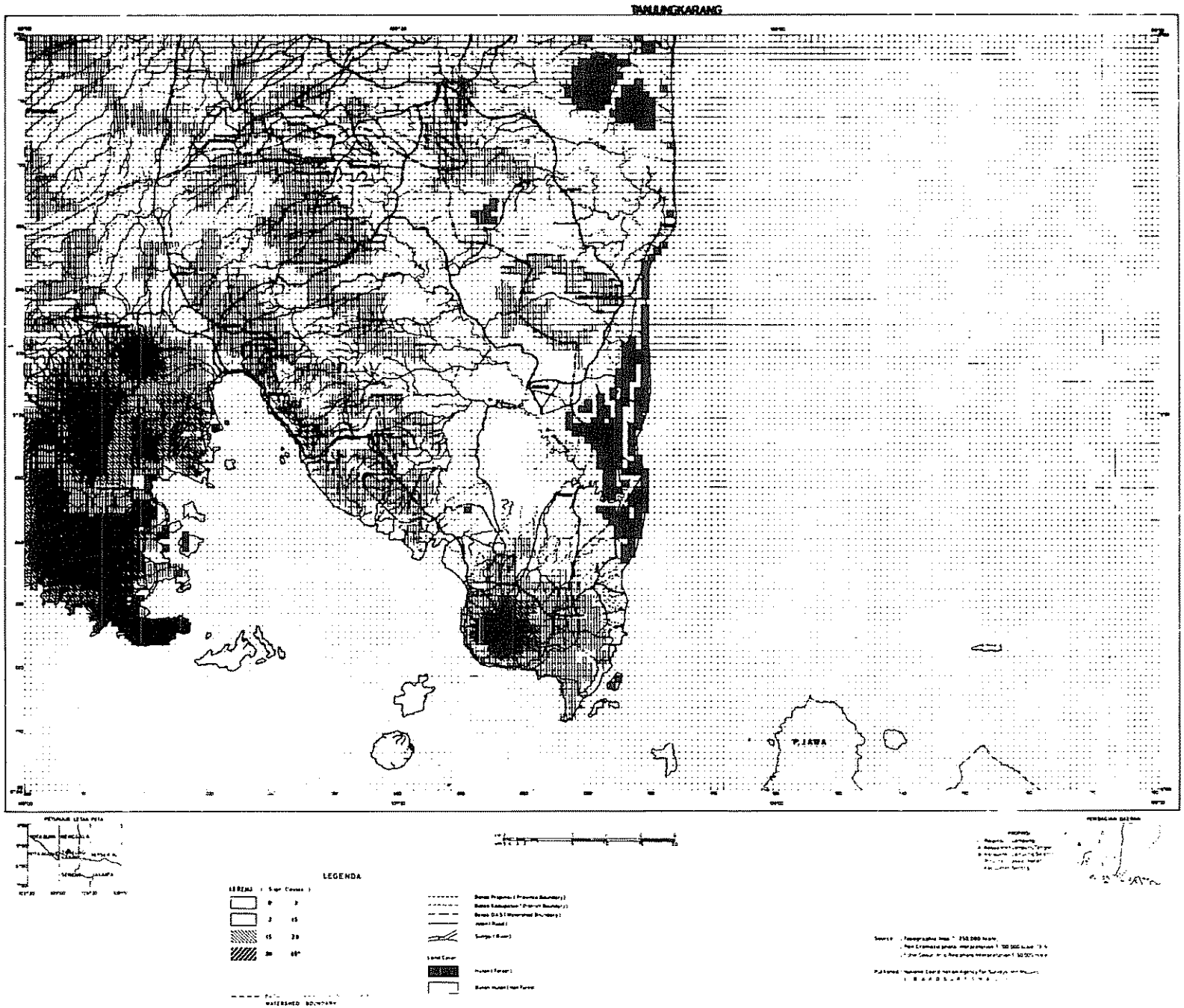

Figure 89. Indonesia: forest cover of the Lampung area in 1976 shown on reduced 1:250,000 map

TABLE 2. FOREST AREA, LAMPUNG PROVINCE, 1976 DATA

Watershed (Numbers keyed to figure)	*Watershed area (sq km)*	*Forest area per watershed*		*Slope area more than 15°*	
		sq km	*percentages*	*sq km*	*percentages*
1. Mesuji	2 500	593.26	23.73	—	—
2. Tulangbawang	9 125	1 596.28	17.49	605.77	6.64
3. Seputih	7 251	770.03	10.62	117.13	1.62
4. Sekampung	4 531.25	261.99	5.78	510.82	11.27
5. Semangko	1 250	710.42	56.83	425.56	34.05
6. Combination, W. Balak, W. Wako, W. Menjangan, W. Sekopong	1 875	388.13	20.70	—	—
7. Combination of small rivers flowing to Sunda Strait and Java Sea	2 062.50	328.50	15.93	698.65	33.87
8. Combination of small rivers flowing to the ocean and Sunda Strait	3 212.50	1 876.22	58.40	1 456.90	45.35
9. Combination of small rivers flowing to Ranau Lake	256.25	54.70	21.35	106	41.37

Sources:
1. Topographic map 1:250,000.
2. Forest maps of Lampung area 1:250,000 by the National Co-ordination Agency for Surveys and Mapping, using air-photo interpretation at scale 1:100,000, 1976.

TABLE 3. DECREASE IN FOREST AREA, LAMPUNG PROVINCE 1970 TO 1976

Watershed (Numbers keyed to figures)	*Forest area 1970 per watershed (sq km)*	*Forest area 1976 per watershed (sq km)*	*Decrease of forest*	
			sq km	*percentage*
1. Mesuji	870.53	593.26	277.27	31.85
2. Tulangbawang	2 583.87	1 596.28	987.59	38.22
3. Seputih	1 644.82	770.03	874.79	53.19
4. Sekampung	487.95	261.99	225.96	46.31
5. Semangko	33.96[a]	710.42	—	—
6. Combination, W. Balak, W. Wako, W. Menjangan, W. Sekopong	808.15	338.13	470.02	58.16
7. Combination of small rivers flowing to Sunda Strait and Java Sea	398.53	70.03	328.50	17.57
8. Combination of small rivers flowing to the ocean and Sunda Strait	—	1 876.22	—	—
9. Combination of small rivers flowing to Ranau Lake	—	54.70	—	—

Sources:
1. Land-use of Lampung area 1:100,000 surveyed by the Soil Research Institute, Bogor, using air-photo interpretation and ground checks, INS I FAO 1969, at scale 1:50,000.
2. Forest map of Lampung area, 1:250,000 by the National Co-ordination Agency for Surveys and Mapping, based on aerial photography 1976, at scale 1:100,000

[a]Some data not available.

RESULTS

To understand the changes of forest cover from 1969 to 1976 it is necessary to analyse the following:

(*a*) The forest area per watershed base on the air photography flown in 1969 (table 1): this table shows that forest area differs for each watershed, and is generally less than 30 per cent;

(*b*) The forest area per watershed based on the air photography of 1976 (table 2);

(*c*) Comparison between the two tables: table 3 shows that significant decreases in forest area have occurred in several watersheds. In extent, one of the greatest forest decreases among the watersheds is the Tulangbawang watershed. In percentage per watershed, the greatest forest decrease concerns the rivers flowing to Sunda Strait.

CONCLUSION

Aerial photography can provide a valuable source of information about historical changes in forest cover. Analyses of aerial photography for Lampung Province, Indonesia, have provided a clearer understanding of the nature and scale of land-cover changes and the impact on forest cover.

This form of analysis permits us to utilize existing information and to improve policies regarding efficient control of development.

REFERENCES

Asmoro, Pranoto (1978), "The application of remote sensing in support of the national program for the inventory and evaluation of country's natural resources", country report, Twelfth International Symposium on Remote Sensing of Environment, Manila, Philippines, 20-26 April.

———, Kardono Darmoyuwono, Jacub Rais, Zd. Kalensky (1978), "Integrated resource mapping by multi-stage and multi-sensor remote sensing in Indonesia", International Symposium on Remote Sensing for Observation and Inventory of Earth Resources and the Endangered Environment, Freiburg, Federal Republic of Germany, 2-8 July.

Darmoyuwono, Kardono (1978), "Experiments in the applications of remote sensing for the inventory of natural rubber", document No. 20/1978, National Co-ordination Agency for Surveys and Mapping (BAKOSURTANAL).

Driessen, P. M., P. Buurman, Permadi (1976), "The influence of shifting cultivation on a podzolic soil from Central Kalimantan, Indonesia", Soil Research Institute, Bogor.

Verstappen, H. Thn., (1973), *A geomorphological reconnaissance of Sumatra and adjacent islands (Indonesia)* (Groningen, Wolters Noordhoff).

COUNTRY REPORT OF MALAYSIA TO THE UNITED NATIONS GROUP OF EXPERTS ON GEOGRAPHICAL NAMES, ASIA, SOUTH-EAST DIVISION*

Paper presented by Malaysia

RÉSUMÉ

Le 30 août 1975, la Malaisie et l'Indonésie ont déclaré conjointement qu'elles harmonisaient l'orthographe des noms géographiques dans leurs langues nationales respectives, le Bahasa malaisien et le Bahasa indonésien. On trouvera à l'annexe I une brève explication du nouveau système d'orthographe.

Les deux pays sont aussi convenus d'adopter des terminologies communes en ce qui concerne la géographie et la géologie. Jusqu'à présent, le Conseil linguistique Malaisie-Indonésie a adopté 1 181 mots commençant par les lettres A à H de l'alphabet.

On 30 August 1975, Malaysia and Indonesia jointly declared the adoption of a standard form of spelling for their respective national languages which are Bahasa Malaysia for Malaysia and Bahasa Indonesia for Indonesia. A brief explanation of the new system of spelling is given in annex I to this paper.

Both countries have also agreed to adopt common geographical-geological terminologies. To date the Malaysia-Indonesia Language Council has approved a total of 1,181 words listed in the "A" to "H" alphabets.

IMPLEMENTATION OF THE SYSTEM

The implementation of the full use of the new spelling system on all maps, plans and charts published by the Directorate of National Mapping, Malaysia, based on a guideline approved by the Permanent Committee on Bahasa Malaysia established by the Language and Literary Agency, Malaysia (see annex II) took effect on 1 March 1979. All place names and notes on new maps published after that date will be spelt in the new system.

The Directorate of National Mapping, Malaysia, is in the process of compiling a complete national gazetteer of place names for Malaysia in the standard system.

In view of the urgent need to standardize some marine and sub-marine features in and around the waters of Malaysia, the Directorate, working in close co-ordination with other competent authorities in the country, has defined and listed 17 such features. (See annex III.)

PROGRESS REPORT OF JOINT DIVISIONAL PROJECTS UNDERTAKEN BY MALAYSIA

Political Map of South-East Asia, 3rd edition —Printed
Physical Map of South-East Asia, 2nd edition —Printed
Concise Gazetteer, 1st edition—Printed
Regional Gazetteer, 1st edition—Printed

*The original text of this paper, prepared by the Directorate of National Mapping, appeared as document E/CONF.72/L.92.

Annex I

A SHORT NOTE ON THE NEW SPELLING SYSTEM FOR BAHASA MALAYSIA

1. THE ALPHABET

The letters used in the romanized alphabet of Bahasa Malaysia are as follows:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z

2. THE VOWEL SYSTEM

There are six vowel phonemes in Bahasa Malaysia, symbolized by letters a, i, u, e, and o. The letter e symbolizes two phonemes, e as in "pet" and *e* as in "number".

Examples:

/a/ a A	*a*pi (fire), p*a*ya (swamps), lup*a* (forget)
/e/ +e E	*e*nak (nice), p*e*rak (silver), taug*e* (bean sprout)
/ə/ +e E	*e*mak (mother), k*e*ra (monkey), sosialis*me* (socialism)
/i/i I	*i*tu (that), s*i*mpan (keep), tal*i* (rope)
/o/ o O	*o*leh (by), k*o*ta (fort), pidat*o* (speech)
/u/ u U	*u*lang (repeat), b*u*mi (earth), tip*u* (cheat)

3. VOWELS IN FINAL CLOSE SYLLABLES

Vowels i and u are used in final close syllables if the preceding syllable contains vowels a, i, u, e.

Examples:

a i	kasih (love), katil (bed), habis (finish)
a . . . . . u	basuh (wash), batuk (cough), kabus (mist)
i i	bilik (room), piring (saucer), fikir (think)
i . . . . . u	tidur (sleep), tikus (rat), pikul (carry)
e (ə) i	betik (papaya), petir (thunder), lebih (extra)
e (ə) . . . . u	betul (correct), telur (egg), ketuk (knock)
u i	putih (white), suling (flute), lukis (draw)
u . . . . . u	tubuh (body), pukul (beat), ukur (measure)

Vowels o or e are used in final close syllables if the preceding syllable also contains vowel o or e.

Examples:

o . . . . . o	pokok (tree), tolol (stupid), gopoh (hasty)
o . . . . . e	boleh (can), bogel (nude), kolek (small boat)
e . . . . . o	tempoh (period), serong (skew), benjol (swelling)
e . . . . . e	leher (throat), beres (settled), teleng (tilt)

The vowels in final syllables do not influence the type of vowels in the preceding syllables.

Examples:

dewan (hall)	not	diwan

bina (to construct a building)	not	bena
girang (happy)	not	gerang
indah (beautiful)	not	endah
kilang (factory)	not	kelang
ringkas (brief)	not	rengkas

Exceptions are made in the case of those Javanese, Arabic or Sanskrit words that have long been absorbed into the Bahasa Malaysia.

Examples:

aneh (strange)	not	anih
pamer (exhibit)	not	pamir
lapor (report)	not	lapur
perabot (furniture)	not	perabut

In spelling foreign words or terms introduced into Bahasa Malaysia, importance is stressed on the visual formation of the original spelling. Changes to foreign phonemes is only done when required (see also para. 6 below).

Examples:

kartun (cartoon)	not	katun
unit (unit)	not	yunit
traktor (tractor)	not	teraktor
dialog (dialogue)	not	dailog

4. Diphthong

There are three diphthong phonemes in Bahasa Malaysia symbolized by three pairs of vowel letters.

Examples:

/ai/	ai	*ai*b (shame), gh*ai*rah (passion), pand*ai* (clever)
/au/	au	*au*ta (bluff), s*au*dara (relative), harim*au* (tiger)
/oi/	oi	b*oi*kot (boycott)

5. Consonants

Twenty-four consonant phonemes are in current usage in Bahasa Malaysia and these are symbolized by 24 consonant letters.

Examples:

/b/	b	*b*ahasa (language), se*b*ut (say), arna*b* (rabbit)
/c/	c	*c*akap (speak), *c*aca (glass), Ma*c* (March)
/d/	d	*d*ua (two), a*d*a (exist), aba*d* (century)
/f/	f	*f*ikir (think), na*f*i (deny), maa*f* (forgive)
/g/	g	*g*una (use), ti*g*a (three), be*g* (bag)
/ğ/	gh	*gh*aib (disappear), mag*h*rib (west), mubali*gh* (preacher)
/h/	h	*h*ari (day), sa*h*am (share), bua*h* (fruit)
/j/	j	*j*alan (road), ker*j*a (work), kole*j* (college)
/k/	k	*k*ami (we), pa*k*sa (force), kata*k* (frog)
/x/	kh	*kh*usus (exclusive), a*kh*ir (last), tari*kh* (date)
/l/	l	*l*ekas (fast), ma*l*as (lazy), kesa*l* (regret)
/m/	m	*m*akan (eat), ka*m*i (we), dia*m* (silent)
/n/	n	*n*ama (name), a*n*ak (child), dau*n* (leaf)
/ŋ/	ng	*ng*eri (scared), a*ng*in (wind), peni*ng* (headache)
/ñ/	ny	*ny*ata (clear), ha*ny*a (only)
/p/	p	*p*isang (banana), a*p*a (what), sia*p* (ready)
/q/	q	*Q*uran (Koran), Fur*q*an (between truth and lies)
/r/	r	*r*isau (worry), da*r*a (virgin), puta*r* (twist)
/s/	s	*s*ampai (reach), asli (original), lema*s* (drawn)
/š/	sy	*sy*arat (condition), i*sy*tihar (declare)
/t/	t	*t*ali (rope), ma*t*a (eye), rapa*t* (close)
/v/	v	*v*ariasi (variation), universiti (university)
/w/	w	*w*anita (women), Ha*w*a (Eve)
/ks/	x	X-ray (x-ray)
/y/	y	*Y*oga (yoga), pa*y*ung (umbrella)
/z/	z	*z*alim (cruel), la*z*at (delicious), lafa*z* (say)

6. Consonant clusters

Consonant clusters in Bahasa Malaysia are limited to foreign words or terms which have been introduced into the language.

Examples:

bd	bdelium
bl	blok (block)
br	bromid (bromide)
cz	czigani
dr	drama
fl	fleksibel (flexible)
fr	frekuensi (frequency)
lt	kobalt (cobalt)
rd	standard
rm	kloroform (chloroform)
rs	Mars
ns	sains (science)
lf	halfton (halftone)
sf	stratosfera (stratosphere)

Annex II

GUIDELINE FOR CONVERSION OF THE EXISTING SPELLING OF PLACE NAMES TO THE NEW STANDARD SPELLING SYSTEM

All ordinary words or features, or any with geographical characteristics used in conjunction with other words to form a place name, should be spelt in the Standard Spelling System.

Example:

Empat (four)	not	Ampat
Enam (six)	not	Anam
Habuk (dust)	not	Abuk
Hilir (lower reaches of a river)	not	Ilir
Hulu (upper part of a river)	not	Ulu
Nyior (coconut)	not	Niyur or Niyor
Hitam (black)	not	Itam
Lubuk (deep part of a river)	not	Lubok
Sungai (river)	not	Sungei
Tasik (lake)	not	Tasek
Gunung (mountain)	not	Gunong
Teluk (gulf)	not	Telok
Alur (furrow)	not	Alor
Tanjung (cape)	not	Tanjong
Air (water)	not	Ayer
Kampung (village)	not	Kampong

Place names using the names of persons or people will remain in the original spelling of the names concerned.

Example:

Fraser's Hill	to become	Bukit *Fraser*
Slim River	to become	Sungai *Slim*
Shah Alam	to remain	Shah Alam

Place names originating in common words which have their original meanings, or whose meanings can still be traced, should be spelt in the new spelling system.

Example:

Kuching (Sarawak) meaning "cat" to become *Kucing*, the right spelling for "cat" in the language.

Ampangan (Negeri Sembilan); *Ampang* should be *empangan* meaning "dam"

Ampangan	to become	*Empangan*
Ampang Jaya	to become	*Empang* Jaya

Original spelling of place names with obscure or untraceable meanings can be accepted with changes only in their consonant letters such as *ch* to *c* and *sh* to *sy*, etc.

Example:

Bukit *Ch*urok	to	Bukit *C*urok
Sungai *Sh*ian	to	Sungai *Sy*ian

Place names which were spelt according to English or other now-Malay dialects should be respelt to suit the standard spelling system.

Example:

*Kl*ang	to	*K*elang
Tanjung Bu*ngah*	to	Tanjung Bu*nga*
*A*mpang	to	*E*mpang

Place names which were wrongly transliterated from their Arabic characters should be corrected to suit the new spelling system.

Example:

*Tr*engganu to become *Ter*engganu

Kota *Bh*aru to become Kota *Bah*aru.

Spelling of place names should be based on local characteristics, and on socio-linguistic and public acceptance.

Example:

Lubok *Antu* (Sarawak) could be spelt as Lubuk *Hantu;* "hantu" means "ghost", but in the local dialect of Sarawak "antu" is also "ghost". No change is therefore necessary except in the vowel letter *o* of the word lubok to *u*.

Pasir *Mas* (Kelantan) could be spelt as Pasir *Emas*; "emas" means "gold" but "mas" is also a spelling variation of "emas". Pasir Mas to remain.

Annex III

STANDARDIZED MARINE AND SUB-MARINE FEATURES

English	*Malay*	*Definition*
Bank	Permatang	An elevation located on a continental shelf or island shelf, over which the depth is comparatively shallow but usually sufficient for surface navigation. The term should not be used for features rising from the deep ocean
Bay	Telukan	A comparartively gradual indentation in the coastline, the seaward opening of which is usually wider than the penetration into the land
Beacon	Matarah	A mark constructed of wood, metal, concrete or masonry or a combination of these materials, erected on or in the vicinity of danger, or on shore, as an aid to navigation. Beacons are often surmounted by topmarks; they sometimes exhibit lights and may be fitted with radar reflectors
Buoy	Boya	Floats of standard colours and shapes moored as aids to navigation, particularly for marking fairways and detached dangers. Buoys are described by their colours and shapes; they may carry topmarks, be fitted with reflectors, exhibit lights and sound bells, gongs, whistles or horns
Cay	Pulau Kecil	A small insular feature usually with scant vegetation; usually of sand or coral. The term is often applied to the smaller coral shoals
Islet	Anak Pulau	A comparatively small insular mass, i.e. smaller than an island but larger than a cay
Channel	Saluran	A comparatively deep waterway, natural or dredged, through a river, harbour, strait etc., or a navigable route through shoals, which affords the best and safest passage for vessels or boats. The name given to certain wide straits or arms of the sea, e.g. English Channel, Bristol Channel
Patch	Tompok	A portion of water or land which has distinctive characteristics, e.g. dry patch (of land, ground, sand etc.), shoal patch (of water) and discoloured patch (of water, rock etc.). In British hydrographic usage "patch" may be used as an alternative to "shoal", both being limited to a detached area which constitutes a danger
Reef	Terumbu	An area of rocks or coral, detached or not, the depth over which constitutes a danger to surface navigation. The term may also be used for a low, rocky or coral area, some of which is above water
Rock	Batuan	An extensive geological term, but limited in hydrography to hard, solid masses of the earth's surface rising from the bottom of the sea, either completely submerged or projecting permanently, or at times, above water
Haven	Lindungan	A harbour or place or refuge for vessels from the violence of wind and sea. In the strict sense it should be accessible at all states of tide and condition of weather
Breakers	Hempasan	Waves or swell which have become steep, either on reaching shoal-water or on encountering a contrary current by the action of wind, so that the crest falls over and breaks into foam
Flat	Dataran	An extensive area, level or nearly so, consisting usually of mud but sometimes of sand or rock, which is covered at high water and is attached to the shore; sometimes called tidal flats
Gulf	Teluk	Part of the sea partly enclosed by land, usually to a greater extent and relative penetration than a bay
Spit	Tanjungbeting	A long narrow shoal (if submerged) or a tongue of land (if above water), extending from the shore and formed of any material
Danger	Bahaya	The term is used to imply a danger to surface navigation, as opposed to submarine navigation
Shoal	Beting	A detached area of any material the depth over which constitutes a danger to surface navigation. The term "shoal" is not generally used for dangers composed entirely of rock or coral

AERONAUTICAL CHARTING*

Paper presented by New Zealand

RÉSUMÉ

Les services cartographiques peuvent aisément effectuer des travaux cartographiques pour les autorités aéronautiques civiles et militaires. La souplesse des méthodes dont ils disposent pour la production et la présentation des cartes leur permettent d'améliorer sans cesse les normes cartographiques.

La coordination au niveau des besoins prioritaires et des ressources est assurée en Nouvelle-Zélande par un service interministériel, le Comité de cartographie aéronautique, qui se réunit tous les trois mois.

De nombreuses cartes sont publiées conjointement par la Division de l'aviation civile et par l'Armée de l'air néo-zélandaise, ce qui réduit le nombre des séries et les frais de production, accroît la sécurité des vols et abrège les cycles de révision. On a pu réduire ainsi considérablement les chevauchements d'activités.

L'aviation internationale est tributaire de la coopération entre toutes les nations. La Nouvelle-Zélande travaille avec l'Australie à la production d'une carte de radionavigation de la mer de Tasman et s'efforce, en vertu d'un accord, de la faire en se conformant aux mêmes spécifications dans la mesure possible. Le Guide aéronautique du Pacifique Sud, publié par la Nouvelle-Zélande, regroupe des cartes établies pour le compte de divers pays insulaires du Pacifique, ainsi que des reproductions de cartes établies par l'Australie et les Etats-Unis d'Amérique.

L'efficacité du programme de production dépend du degré de confiance entre les participants et du soin apporté à la planification.

La conception se caractérise par la fréquence des révisions, l'exactitude de la présentation et du contexte, la nécessité de satisfaire des utilisateurs tributaires, donc exigeants, et par la diversité des graphiques spécialisés. Les accords internationaux de normalisation et les conditions réelles d'utilisation déterminent les critères de conception.

Les cartes de radionavigation sont des documents graphiques où la clarté et l'exactitude des données sont primordiales. Elles donnent très peu d'indications géographiques.

Les cartes de navigation à vue doivent donner une bonne image du terrain tout en présentant avec clarté différentes informations aéronautiques. Ces deux conditions peuvent être difficilement compatibles, et il faut alors donner la priorité à l'information aéronautique.

L'établissement, en 1974/75, des cartes aéronautiques de l'Organisation de l'aviation civile internationale (OACI) au 1/500 000 a été l'occasion d'orienter les lignes de raccord en fonction des itinéraires de vol courants et de modifier les spécifications de l'OACI compte tenu des besoins de la Nouvelle-Zélande. La nouvelle série de cartes a reçu un accueil favorable et elle existe également comme carte à usage général, sans renseignements aéronautiques en surimpression.

On a également commencé à convertir la nouvelle carte topographique métrique au 1/250 000 en carte aéronautique, principalement à l'intention de l'Armée de l'air néo-zélandaise. Sur la première feuille, le relief était indiqué uniquement par cotes de niveau et par estompage. Cela s'est révélé insuffisant et une série de teintes hypsométriques a été établie à partir des teintes existantes avec addition d'une planche jaune. On s'est efforcé d'obtenir un jeu de teintes correspondant à des intervalles verticaux égaux pour la majeure partie de la gamme, en utilisant des tons de vert pâle, de jaune et de brun clair dont la valeur diminue et la coloration augmente avec l'altitude. Les teintes hypsométriques sont conçues de manière à renforcer l'impression de relief créée par l'estompage, et non à fournir des indications d'altitude exactes.

On établit actuellement à partir de la carte aéronautique au 1/250 000 une série de cartes d'approche à vue où les détails topographiques sont compatibles avec ceux de la carte mère, mais où les indications relatives aux agglomérations sont fortement réduites pour permettre de présenter davantage de données concernant la navigation aérienne et l'espace aérien.

Le document examine aussi brièvement les techniques d'impression et de distribution, l'utilisation des ordinateurs et les tendances qui se dessinent pour l'avenir.

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*The original text of this paper, prepared by G. D. Aitken, Divisional Cartographer, Department of Lands and Survey, appeared as document E/CONF.72/L.10.

The responsibility for civil aviation in New Zealand is vested in the Civil Aviation Division of the Ministry of Transport, whose duty it is to promote aviation development and safety. Within the Civil Aviation Division, the Aeronautical Information Service is responsible for the provision of aeronautical charts. These form part of the Aeronautical Information Publication or are supplementary to it.

The Cartographic Branch of the Department of Lands and Survey provides a cartographic production and publication service for both civil aviation and the Royal New Zealand Air Force (RNZAF). Each of these organizations, however, retains the responsibility for the accuracy and completeness of aeronautical data (see figure 90).

Civil aeronautical charting is guided by the International Civil Aviation Organization (ICAO), and most New Zealand Aeronautical Chart series are drawn to, or guided by, detailed specifications developed and published by ICAO.[1,2,3]* RNZAF is a member of the Air Standardisation Co-ordinating Committee (ASCC).[4] ICAO and ASCC standards have come much closer together in recent years, and in many areas the ICAO standard is accepted as an alternative by ASCC. Where a particular standard cannot be met, a difference is registered with the appropriate organization.

JOINT CIVIL-MILITARY CHARTING

The aviation industry is full of fast developing technologies, and this is reflected in the constant need for chart revision, the design of new charts and the development of old ones to meet an increasingly complex use and a more demanding user. Civil and military aircraft have very different handling characteristics and flight patterns, but must use the same airspace and many of the same radio-navigation aids. Some airspace is restricted for military use, as are some of the more sophisticated radio aids.

To ensure that both civilian and military pilots are using the same information, and to conserve cartographic effort, as many charts as possible are published jointly for parallel distribution and use. This co-operation is dependent on the understanding of each other's responsibilities and an appreciation of the cartographic effort required for production and revision.

Charting priorities and resources are co-ordinated by the Aeronautical Charting Committee. The Committee meets every twelve weeks under the chairmanship of the Assistant Surveyor-General and has members appointed from the Civil Aviation Division of the Ministry of Transport, the Royal New Zealand Air Force and the Department of Lands and Survey. The minutes of meetings are distributed to many different organizations within New Zealand and overseas.

Although daily operations of the Aeronautical Charting Division are dealt with at working level between the Divisional Cartographer, the Superintendent of Aeronautical Information and the Staff Officer, Navigation, it is necessary to maintain the frequency of the Aeronautical Charting Committee meetings to ensure that all needs are being fulfilled, all liaisons and systems are functioning, and all priorities, dates and standards are met.

The frank, relaxed and purposeful nature of these meetings bear testimony to the success that has been achieved in building the understanding and co-operation that has been basic to joint civil-military charting.

As well as the advantage of all users having the same chart there are obviously many production economies at

*See reference list at end of text.

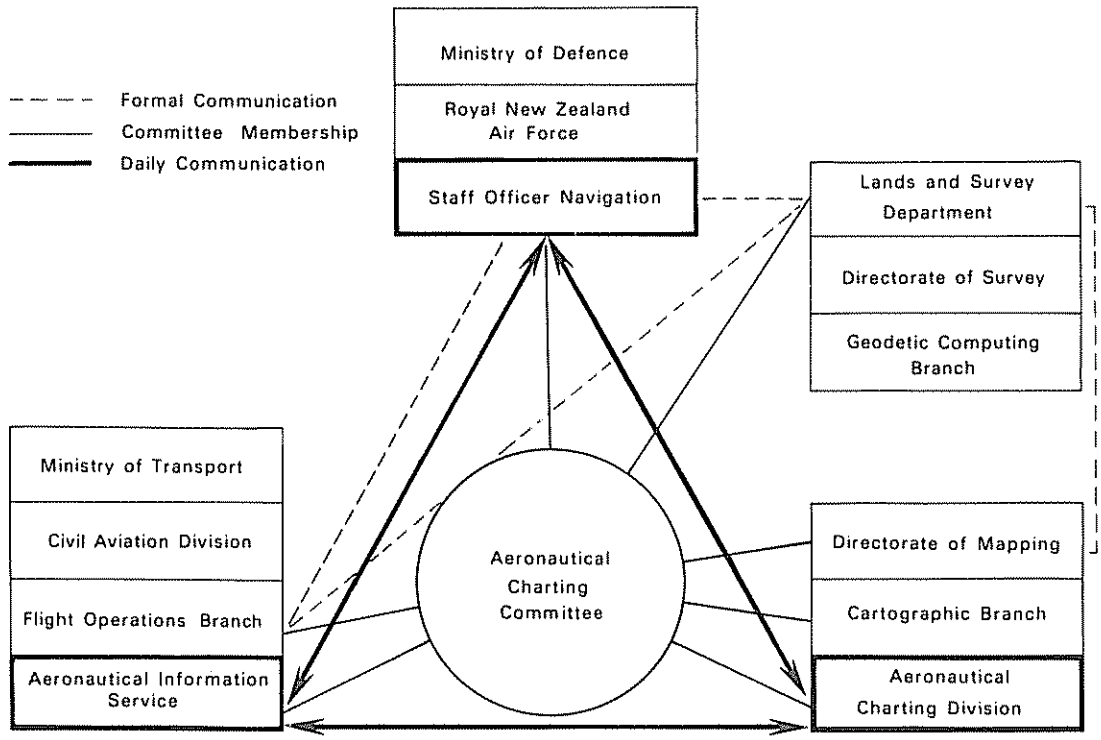


Figure 90. New Zealand: liaison between organizations

all stages. To increase the usage of RNZAF plotting charts, and thus reduce the unit cost, the 1:1,000,000, 1:3,000,000 and 1:6,000,000 scale series are also available for civil use, and meet a surprisingly high demand.

An unusual feature of the joint civil-military co-operation has been the publication of the RNZAF's low level jet routes as an overprint on the 1:500,000 civil aeronautical charts. This information enables the aerial agricultural contractor to avoid operating near routes on days when they are being used, reducing the risk of incident or collision.

A few special charts are produced for RNZAF use only. These include charts for jet navigation, navigation training and anti-submarine warfare. A recent addition on some of these charts is the Exclusive Economic Zone, together with the associated restricted fishing and licence areas.

The major effects of joint civil-military charting have been the increase in chart usage, reducing unit cost, and a reduction in the number of charts and chart series. This has allowed a greater capability for shorter revision cycles and more up-to-date charts. The reduction in duplication of effort has been considerable and is expected to continue.

INTERNATIONAL CO-OPERATION

In 1972 a major agreement was reached between Civil Aviation authorities in New Zealand and Australia to standardize, as much as possible, the presentation of radio navigation charts, and to reduce charting duplication by sharing one chart covering the trans-Tasman routes. This chart, produced in Melbourne, has New Zealand's Pacific chart printed on the back, for New Zealand distribution; and an Australian radio navigation chart printed on the back for Australian distribution. The charts are printed and air-freighted to New Zealand within our normal production time scale.

Last year, at the initiative of New Zealand, the agreed specifications were amended to include some ASCC symbols and presentation techniques in areas where the ICAO standards were deficient or not suited to New Zealand usage.

Another area of considerable interest in the field of international co-operation is the development of the South Pacific Flight Guide in a similar style to New Zealand's Instrument Flight Guide. This new guide is designed to cover all aviation requirements in the South Pacific and includes charts published on behalf of many Pacific Island nations (see figure 93). Almost a complete AIP on its own, the SPFG includes charts reproduced from Australian and United States publications to provide authoritative coverage.

The distribution of the Guide has doubled since it was introduced in 1974. This increase has proved the need for a comprehensive publication serving this geographical area, which has fast developing inter-island air transport services.

INTER-RELIANCE

To be effective, it is vital that the authors of various charting data in the Civil Aviation Division, and the publishers of the data in the Cartographic Branch, have a thorough understanding of each other's responsibilities and capabilities, and have confidence in each other's support.

The Department of Lands and Survey provides support services through its Survey Directorate (aerodome obstruction surveys), and Geodetic Computing Branch (great circle and rhumb line bearing and distance, airspace definitions etc.).

The responsibilities of the Cartographic Branch encompass the accuracy and completeness of topographical and transmission line data, as well as the provision of expertise on graphic presentation and technical production methods.

Civil Aviation is responsible for the timely provision of accurate and complete aeronautical data for publication within an agreed programme, the final clearance of this data on pre-printing proofs, and the distribution of the printed charts, the exception being that all plotting charts and stocks for RNZAF use are held and distributed through the Lands and Survey Map Centre.

Through its wide contacts with aviation at all levels within New Zealand and overseas, Civil Aviation also provides the Cartographic Branch with a "filtered funnel" through which the needs of the aviation industry, and our responses to them, can be monitored.

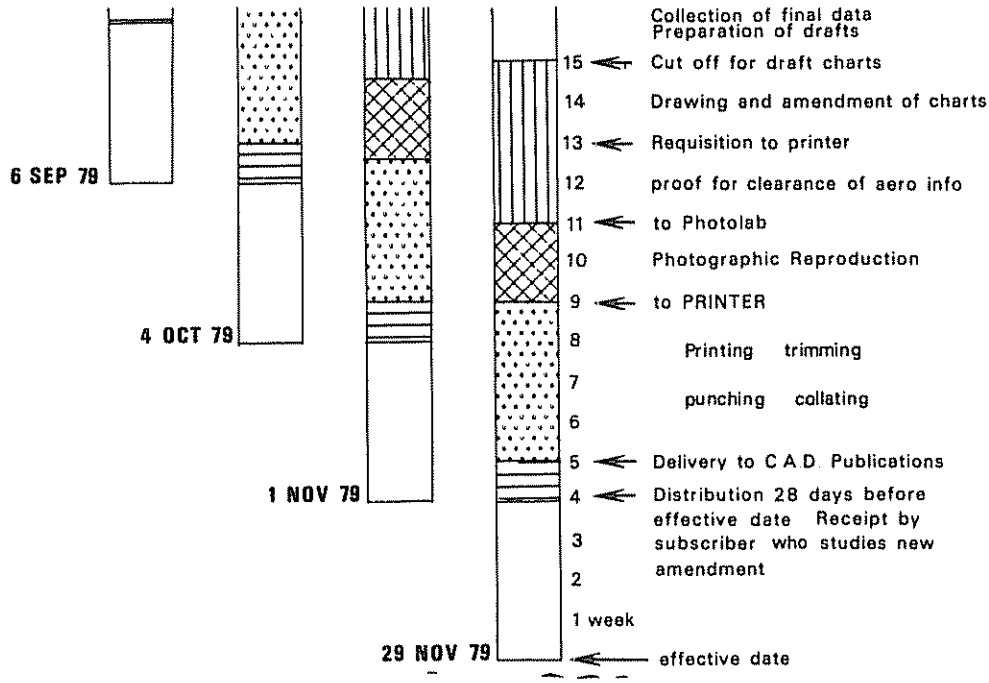
PLANNING CONSIDERATIONS

Basic to any production system are the limitations of the manpower available. The Cartographic Branch has been fortunate in this respect, having the flexibility to vary the number of staff available to meet its needs. Over the past few years the staff engaged on aeronautical charting has varied between twelve and six. The present establishment is seven.

Most of the staff are 18 to 22 years of age and make up for their inexperience with enthusiasm. The rather different cartographic tasks from those practised elsewhere in the Branch require additional training, including two field trips to obtain a working knowledge of chart use in the air and the various ground facilities and air traffic control centres. These flights and visits are guided by Civil Aviation personnel and are extremely valuable. The rotation of staff through other divisions within the Cartographic Branch builds up a pool of broadly experienced staff and maintains their interest.

Being part of the Cartographic Branch, the Aeronautical Charting Division has a wide variety of quality cartographic techniques available to it, and access to the Photographic Laboratory on a priority basis. This assists in speed and flexibility of production, choices of quality and the widespread use of preprinted formats, symbols and lettertype. Priority access to the Photographic Laboratory when required is essential to virtually all production programmes. The flexibility of staffing and the availability of these cartographic processes enables a wide variety of tasks to be undertaken within the Division, including the preparation and adaptation of topographical base maps for later overprinting as aeronautical charts.

Inherent in the over-all planning of chart production is the requirement for each chart to become effective on a predetermined date to co-ordinate with other operations. These dates are fixed internationally by ICAO and are known as AIRAC cycle dates. They are 28 days apart. Any approach chart or landing chart can be programmed to be effective on any AIRAC date, depending upon operational requirements, the number of minor changes and the stock position. New Zealand



(Each column represents the programme for the production of an AIP Amendment List.)

Figure 91. New Zealand: continuously overlapping production cycles

Radio Navigation and Terminal Area charts have the provision for revision on four monthly cycles. If insufficient significant amendments occur, a revision cycle can be omitted. (See figure 91.)

Should stocks be insufficient to last until the next edition the current edition can be reprinted at a convenient time.

Printed charts and text pages are collated and distributed as "Amendment Lists" to the subscribers to the Aeronautical Information Publication (AIP) or its associated publications:

The *Instrument Flight Guide (IFG).*
Contains approach, landing and departure charts, navigation, procedural and air traffic details and the New Zealand Radio Navigation and Terminal Area Charts.

The *Visual Flight Guide (VFG).*
Contains landing charts, procedural and air traffic details, and includes the Visual Terminal Charts as well as the Radio Navigation and Terminal Area Charts.

The *South Pacific Flight Guide (SPFG).*
Contains instrument approach, landing and departure charts, as well as a considerable amount of legal entry conditions because of its international nature. The Pacific Radio Navigation and Terminal Area Charts are included in the SPFG.

The *Military Flight Guide (NZAP276).*
A combination of the above three guides, with modifications to the approach minima, and some special procedures and additional material.

To ensure that sufficient stocks of charts are available, a stock-take of all charts (except approach and landing charts) is made every month. Stocks of approach and landing charts are checked, bi-monthly. Where necessary a reprint or revision is initiated so that stocks of current editions are always available.

Co-ordination with the government printer and printing contractors, and printing supervision, is provided by the Map Reproduction Officer in Masterton and his assistant in Wellington. A three-month printing programme is provided at the same time as the printing requisitions for the next month. This programme details printing incomplete at the time of preparation; printing which will definitely be required for the coming month; and a forecast of the following month's workload.

Further advance notice is given for base map printing where large numbers of maps and colours are involved, and any special requirements. Urgent tasks occur from time to time and are usually programmed at the expense of topographical maps.

The printing of AIP text, "Notices to Airmen" (NOTAM) and NOTAM diagrams and charts is arranged with the government printer by the Aeronautical Information Service.

During most months 30-60 approach and landing charts are revised and published. On months of the radio navigation or visual navigation revision cycles the number of other charts is usually reduced.

During the financial year 1978/79, 396 approach and landing charts, 54 visual, radio navigation and plotting charts, and 173 NOTAMS and other charts were produced.

DESIGN CHARACTERISTICS

Aeronautical charting is unique in many aspects. These include the frequency of chart revision, high demands on accuracy of presentation and context, a critical and dependent user, and the variety of specialized graphics.

The nature of air travel usually demands detailed flight planning, which includes navigation as one of many considerations. Although time, good lighting and a steady table may be available for the pre-flight naviga-

tional plot, none of these may be available when the chart is being used. The actual usage conditions control the design criteria.

For visual navigation a good representation of the terrain is essential. Hydrography and roads produce unique patterns across the landscape and should be shown in clear colours and fine detail. Cultural detail, railways and the man-made features also need to be shown clearly. Simple symbolization is required when scales decrease. Nomenclature is usually retained only on major identifying features.

Radio navigation charts are closer to being cartograms than maps, although geographic integrity is usually maintained. The nature of the navigation system dictates that most data relate to radio aids (represented by point symbols), or are route data which increase in complexity closer to each aid. Surrounding and through each of these complex arrangements are often the boundary and details of the airspace designed to protect air traffic. In some areas Terminal Area charts are provided to show additional route structures and greater detail than would be possible on the parent Radio Navigation Chart.

The frequency of revision and necessity for fast production turnaround, in many cases, dictate simple methods that require a minimum of effort and time delay. Stocks of all symbols, and frequently used wording and numerals in appropriate sizes and styles, are kept on stripping film for immediate use. A large bank of negatives is maintained from which more copies can be ordered. Unusual wording, notes and text are set on DIATYPE and QUADRITEK typesetting machines within the Branch.

Three units of measurement are used on New Zealand charts. Relatively short distances, e.g. runway dimensions, are measured in metres, as are visibilities. All navigation distances are measured in nautical miles. Vertical measurement, both terrain and airspace, remain in feet. In spite of the increasing coverage of new metric mapping at 1:50,000 and 1:250,000 scales, no change in elevation and altitude units are envisaged.

Recent design challenges

The 1:500,000 Aeronautical Chart

In 1973 four of the seven charts of this scale covering New Zealand required revision or reprint action due to the shortage of base stocks for overprinting. On investigation it was found that the coverage of 1:63,360 mapping that had been produced in the 1960s ruled out both of these alternatives, and redrawing to include this new material was essential. The various possibilities for production were explored and discussed at length with representatives of Civil Aviation and RNZAF, both of whom made considerable contributions in planning the layout of the sheets. The previous 7-sheet series had hampered users because of the east-west orientation of the sheets. The shape of the country, major flight routes and the maximum printing image size available were basic considerations for the new series.

The final layout is a four-sheet series orientated to suit the shape of the land and the most commonly used flight-routes. The inconvenience often found with large charts has been overcome by utilizing a double concertina fold. Unfortunately, the size of the charts requires them to be folded by hand, which is many times more expensive than machine folding. Large overlaps between the charts now allow most flights to be planned on one sheet.

The new series fulfils New Zealand's obligation to the International Civil Aviation Organization to provide a medium-scale visual aeronautical chart.

Before the specifications were finalized, charts at this scale from Canada, Finland, France, Switzerland and the United Kingdom were studied to compare their interpretations of the ICAO Standards and Recommendations. This was a valuable exercise. The fine detail shown by some nations, and the complex visual jumbles of others, provided many useful lessons.

The colour scheme is basically that specified by ICAO, but benefited from experience on some sheets of the earlier 1:500,000 series and also the Visual Terminal Charts.

One notable departure from the ICAO Standard is the use of brown roads instead of red, which was required as one of the colours for the aeronautical overprint. Another departure from previous series was the addition of a detailed relief drawing in pale grey to show the shape of the land. This is particularly useful in low-lying areas, and where the terrain falls between the hypsometric tint layers.

Up to 44,000 bases were printed of each sheet in eleven colours. Although this may sound expensive, the large number printed reduces the unit cost significantly. Due to the eight-month revision cycle this is only sufficient for about five years. The base map is also available for purchase as a road map, and small numbers are used from time to time for the overprinting of electoral districts etc. [5]

An indication of relative costs can be obtained from the following table:

Drawing cost	34 per cent	(includes all materials, labour and processing)
Base printing	25 per cent	(44,000 copies, 11 colours each sheet (1976))
Overprinting	7 per cent	(5,100 copies, 2 colours each sheet (1979))
Bindery cost	34 per cent	(trimming and hand folding)

The purchase price of the 1:500,000 aeronautical chart is $2, which includes a mark-up for overheads, storage, handling and postage.

A major difficulty with all topographic aeronautical charts is maintaining legibility of the aeronautical information among diverse combinations of natural and man-made features. This is particularly shown in densely populated areas on some overseas charts, but the problem exists here too. In relatively undeveloped areas it is easy to place symbols and type clear of base detail, but in built up areas the temptation to show too much base detail tends to clutter the background, at the expense of obstruction symbols and other aeronautical information.

One answer, of course, is the use of large-scale charts in these areas.

The 1:250,000 Aeronautical Chart

The current series of Visual Terminal Charts was introduced in 1972 to provide a large-scale chart which would enable light aircraft pilots to navigate safely through, or avoid, the more complex areas of airspace around the international airports. Other mapping

coverage at 1:250,000 scale was available covering the country, and although an aeronautical chart at this scale had been suggested it was thought that there was insufficient requirement at that time.

In 1978, the new metric series of 1:250,000 topographic maps began to be published and RNZAF identified a requirement for continued availability of mapping at this scale, using the latest information but with elevations in feet, for use by helicopters and strike aircraft.

This new series is being developed from the drawings and reproduction material of the topographic maps, with a minimum of conversion and the addition of some "permanent" aeronautical information. The charts will also be available for civil purchase.

The first sheet was printed in August 1979 (NZMS 303 Kaikoura), and although it was found to be acceptable in exercise use, some changes suggested by the pilots have been adopted. These include the increase in colour strength of the roads and grid and the introduction of hypsometric tints similar to the 1:500,000 maps. It was found that the grey relief drawing was too subtle to read in an aircraft and the relative elevation of the terrain needed to be reinforced.

A simple colour set of hypsometric tints was sought that would have even steps throughout the range. It was found expedient, however, to introduce a half-interval step at the bottom of the range, to accentuate relatively minor changes of elevation in low lying areas, and to group the land above 8,000 ft into a single step. These latter areas are restricted to the Mount Cook region, are relatively small in area, and are broken by glaciers and snowfields. The vertical intervals are similar to those used on the Visual Terminal Charts and the 1:500,000 chart.

The colour scheme is centred on a range of yellow tints, with a pale green lowest layer and increasing tones of brown at the highest end of the colour set. Although the colour set and steps were based on previous experience, further empirical experiment was required to simplify the colour scheme.

It was desirable to introduce as few extra colours as possible due to the limited number of charts to be printed. This was achieved by the introduction of process yellow as the basic hue. A screen of the forest colour was used to produce a tint of green at the bottom of the colour set and screens of the road colour to produce a series of brown tints to overprint the yellow tint at the top end of the set.

Different screen intervals for each colour were used to try to balance the differences in colour value and create an even visual appearance between the steps. The colour set increases in chroma with ascending altitude, with a corresponding decrease in value. Only relatively small changes in hue are introduced at each end of the set. The upper value limit and the number of discriminatory value steps available were limited by the need to be able to read clearly the spot height and aeronautical information overprinted on the highest end of the colour set.[6]

An over-all effect was sought that would produce a light, attractive-looking map with good legibility in lowland areas where aeronautical information tends to be concentrated. The hypsometric tints were required to provide a relative altitude impression to reinforce the relief shading. It was not intended that the tints would be used to provide absolute elevation data. For this reason contours, which could have cluttered the chart with additional lines, were omitted.

The new series will provide RNZAF with a New Zealand equivalent of the aeronautical version of ASCC's Joint Operations Graphic (JOG/AIR).

Visual Terminal Charts

This series, covering the major airports, was designed to suit New Zealand conditions after studying examples from Australia and the United States. There is no ICAO Standard for this type of chart.

The scale of 1:250,000 provides greater aeronautical detail than the 1:500,000 visual en-route chart, and is complementary to it. However, the topographic detail is limited. Selections of roads and rivers have been chosen to provide some locational information and place names severely edited and shown in a condensed style. Relief is shown by hypsometric tints and spot heights. Aeronautical information is shown boldly in two colours.

In 1979 the opportunity was taken to update the Ohakea sheet by incorporating new mapping and refining some design aspects. It was decided that the charts should contain the same line information, i.e. roads, rivers and railways, as the 1:250,000 aeronautical chart so that the two series could be used together. The new chart was reorientated to suit the traffic flow, and the topographic detail bled through the east, north and west edges to facilitate overlapping with the 1:250,000 aeronautical charts. Relief is to be shown by the same range of hypsometric tints as the parent series. The possibility of adding relief shading will be studied.

The airspace delineation is to remain the prime purpose of the chart, and to help accentuate this a new black drawing was made showing only railways, cities and major towns and selected detail used for visual reporting.

Use of the new chart will be studied during the redrawing of the other Visual Terminal Charts and the specifications modified if necessary.

The challenge to the cartographer in the design and production of all these visual navigation series is to provide a clear terrain and cultural detail image sufficient for accurate visual navigation, together with a legible complex web of airspace, navigation and hazard data. The success of our response to this challenge can be inferred from the sales of these charts.

	Average sales of NZMS 19E (1975)
Sheet 1	20
2	50
3	25
4	50
5	45
6	45
7	25
	260 per month

	Average sales of NZMS 242A (1979)
Sheet 1	90
2	130
3	90
4	100
	410 per month

Sales of the new 1:500,000 Aeronautical Chart have increased by 60 per cent, in spite of the reduction in sheets from seven to four.

PRINTING

As stated earlier when discussing programming considerations, the Cartographic Branch has a Map Reproduction Officer resident in Masterton, where all large

charts are printed by the government printer. His assistant in Wellington supervises the printing of approach and landing charts by a contract printer. It is the duty of these two officers to ensure that the programme is adhered to and that quality standards are met.

Recently, light-fast inks in Pantone standard colours have replaced special colour mixes, and locally manufactured papers have replaced imported papers for short-life charts. Mataura Canary Bond is used for approach and landing charts and Kinleith White Offset for radio navigation charts. These papers are about half the cost of imported equivalent papers. Imported chart paper is still used for some topographic base maps and plotting charts.

Distribution

The Aeronautical Information Publication and the various Flight Guides are usually purchased by annual subscription, which includes the monthly amendment list of replacement pages and charts and also the weekly Notices to Airmen. Included with the Flight Guides are the appropriate radio navigation, terminal area and visual terminal charts. These charts can also be purchased individually.

The other visual en-route charts can be purchased individually through Civil Aviation Publication offices. The plotting charts can be purchased through the Department of Lands and Survey, Head Office, Map Sales.

Chart holding and distribution for RNZAF is handled by the Department of Lands and Survey's Map Centre.

Proposed computer applications

The Department of Lands and Survey is developing a capability for computer graphics. Some of the projects that will be investigated include anaglyphs of approach areas, specified holding pattern clearance areas, obstruction surveys and charts, air traffic control radar videos and land outline/projection transformations.

Future trends

Even though a large degree of automation has been already attained in international navigation, charts are still required as universally understood graphics and as official documentation.

The effects of fuel shortages may reduce the number of hours flown but its effect on charting sales is likely to be restricted to the slowing of its growth.

In some areas, such as radio navigation, further specialization of charting can be expected, particularly if area navigation equipment and techniques become more common.

It is hoped that the spirit of co-operation that exists between civil and military aviation interests in New Zealand will continue and that their charting requirements can continue to be met to their satisfaction.

References

1. International Civil Aviation Organization, "Convention on International Civil Aviation", annex 4, edition 7, 1978. (Amended March 1978.)
2. _____, "Aeronautical chart manual" (8697-AN/889), edition 1, 1968. (Amendments to December 1976.)
3. _____, "Aeronautical chart catalogue" (7101-MAP/565/23), edition 23, July 1978.
4. Air Standardisation Co-ordinating Committee—Working Party 64, "Standardisation agreements".
5. K.-H. Meine, "Aviation cartography", *The Cartographic Journal*, vol. 3, No. 1, June 1966.
6. R. M. Taylor, "Empirical derivation of map colour specifications", paper presented to the 9th International Conference on Cartography, Maryland, United States of America, 1978.

AERONAUTICAL CHARTS IN COMMON USE, 1979

	Series or purpose	*Scale*	*Projections*	*Sheets*	*Edition*	*Spec*	*Number of colours*	*Number printed*
NZMS								
200	Aero-plotting chart—Pacific	1:3m	M	6	1979	ASCC	2	500-2000
214	Navigation training chart	1:2m	M	1	1980	ASCC	3	500
218	Aerodome obstruction charts	1:15000	—	33	1965-79	ICAO	1	40
228	Radio navigation and terminal	Various	LC	10	1979	ICAO	3	8250
242A	ICAO visual enroute charts	1:½m	NZMG	4	1979	ICAO	11+2	5400
242A(LL)	VEC + RNZAF low level routes							
244	Aero-plotting chart—Pacific	1:6m	M	3	1978-79	ASCC	2	
247	Anti-submarine warfare charts	1:1.16m	M	9	1977-79	USN	2	1000
248	Operational navigation charts	1:1m	LC	2	1979	ASCC	10+1	970
253	Aero-plotting charts—New Zealand	1:1m	M	2	1978	ASCC	2	700-1400
255	Approach and landing charts	Various	LC	600+	1974-79	ICAO	1	500-8000
256	Visual terminal charts	1:¼m	TM	4	1979	ICAO	11+2	7450
257	Jet navigation chart—New Zealand	1:2m	M	1	1978	ASCC	9+3	300
302	42 Sqdn VIP passenger briefing	1:4m	LC	1	1979	—	6	4000
303	Visual enroute	1:¼m	NZMG	(18)	1979	ASCC	7	500+?
L&S								
61	ATC radar video maps	Various	EA	15	1975-79	—	Video slide	—
115	New Zealand isogonals and isopors	1:4m	LC	1	1979	—	—	30
115	New Zealand and Pacific isogonals and isopors	1:20m	M	1	1979	—	—	15
270	VHF radio coverage maps	1:2m	LC	55	1977	—	Microfilm	—

Projections: M = Mercator, LC = Lambert conformal, TM = Transverse Mercator, NZMG = New Zealand Map Grid, EA = Equidistant azimuthal

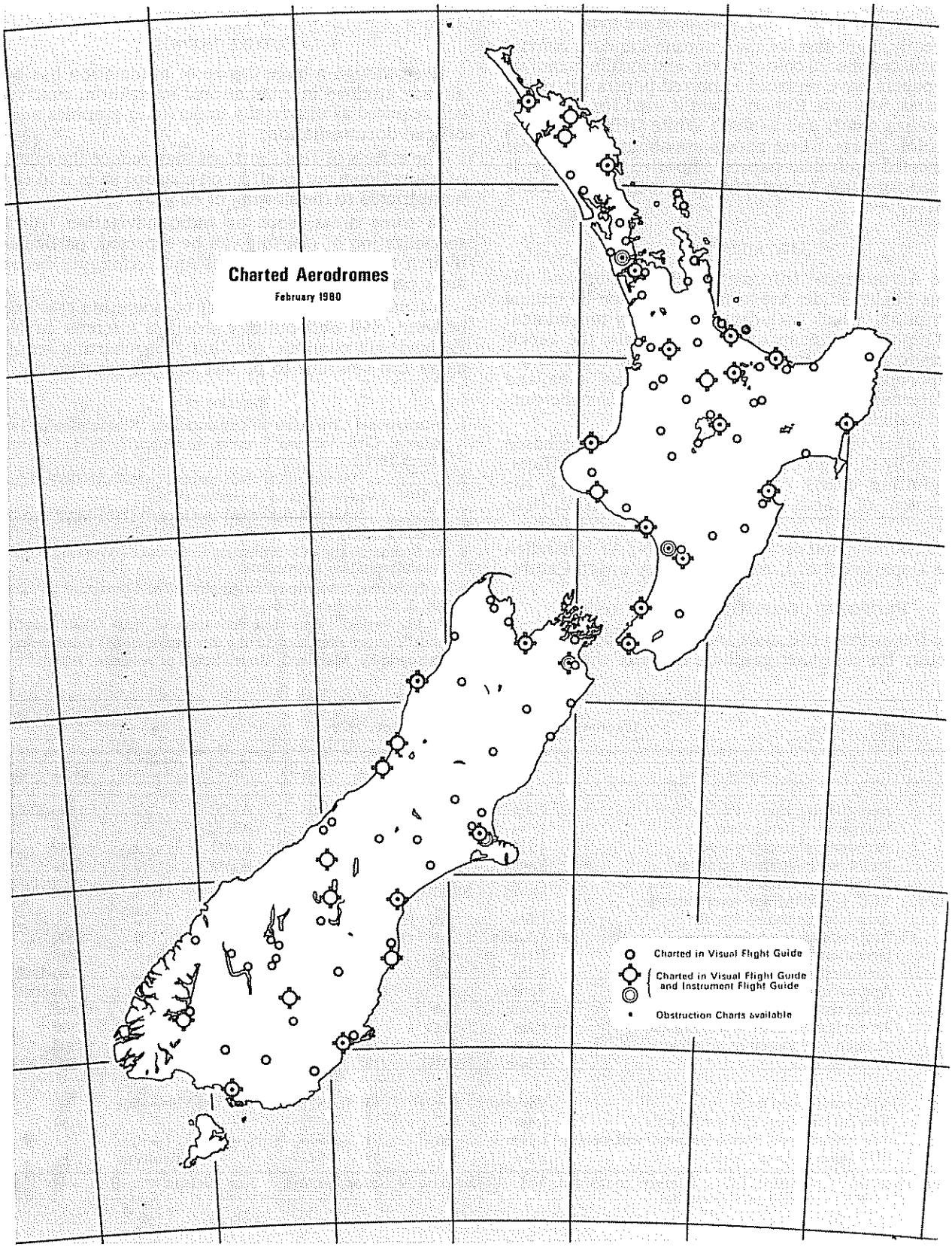


Figure 92. New Zealand: charted aerodromes, February 1980

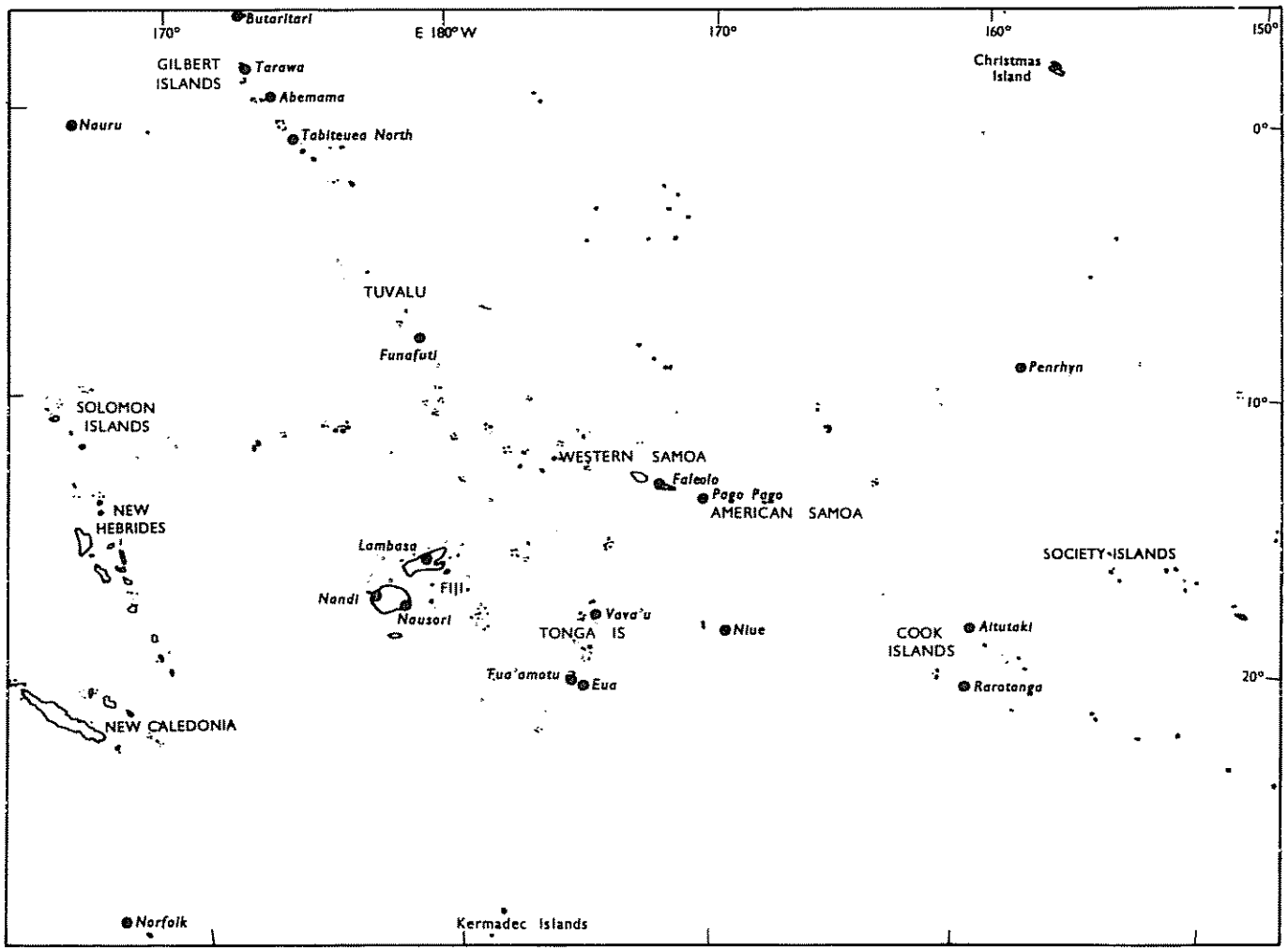
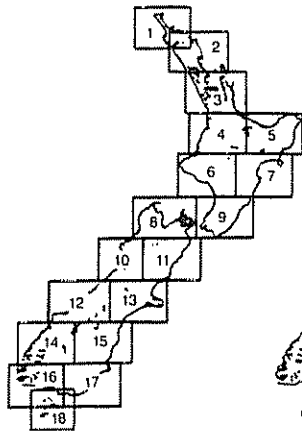
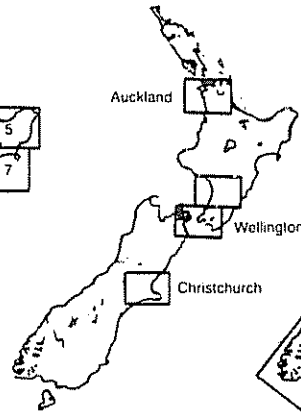


Figure 93. New Zealand: aerodromes charted in the South Pacific Flight Guide

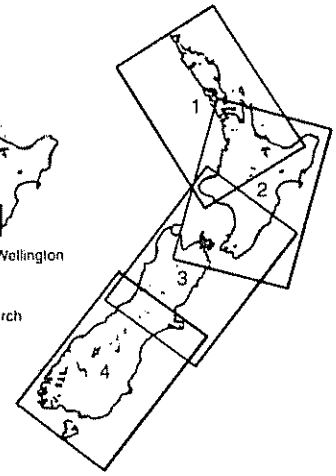
Visual navigation charts



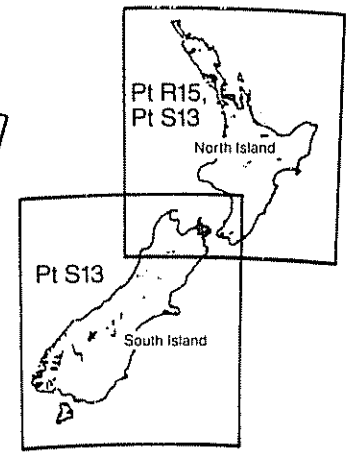
Visual en-route charts
NZMS 303 1:250,000



Visual terminal charts
NZMS 256 1:250,000

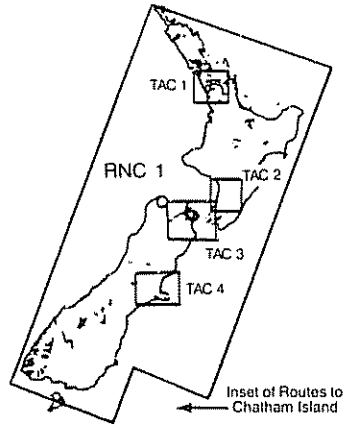


Visual en-route charts
NZMS 242A 1:500,000

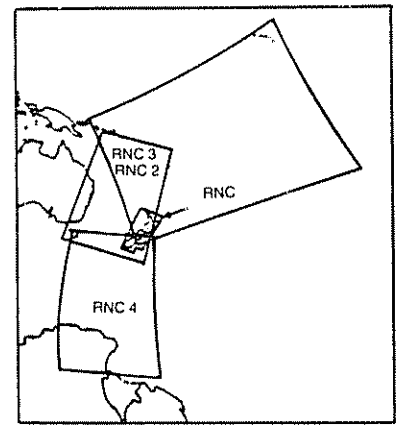


Operational navigation charts
NZMS 248 1:1,000,000

Radio navigation charts



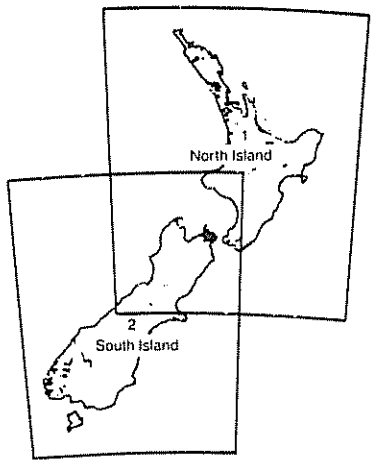
RNC 1 & TACs 1, 2, 3 & 4



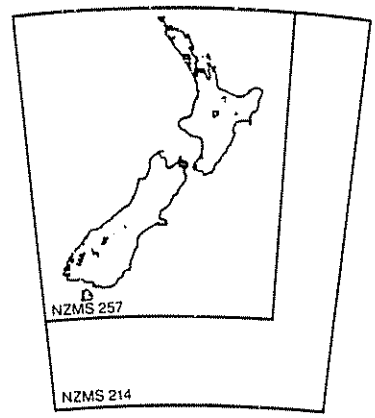
RNCs 2, 3 & 4 TACs 6 & 7

Radio navigation and terminal area charts NZMS 228

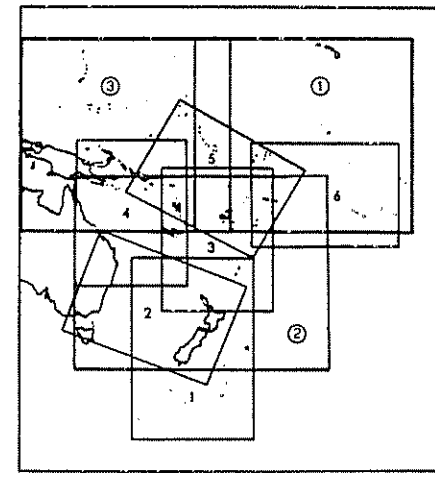
Aeronautical plotting charts



NZMS 253 New Zealand
1:1,000,000



NZMS 214 Navigation training
NZMS 257 Jet navigation
1:2,000,000



NZMS 200 Pacific (6 sheets) 1:3,000,000
NZMS 244 Pacific (3 sheets) 1:6,000,000

Figure 94. New Zealand: visual navigation, radio navigation and aeronautical plotting charts

DERIVED MAPPING*

Paper presented by New Zealand

RÉSUMÉ

La Nouvelle-Zélande a entrepris de remplacer la série de base NZMS 1 de cartes topographiques de la Nouvelle-Zélande à l'échelle d'un pouce pour 1 mille (1/63 360) par la série NZMS 260 au 1/50 000, réalisée à partir de nouveaux documents photographiques au 1/25 000, suivant le quadrillage cartographique de la Nouvelle-Zélande. Cette série sera complétée par la série cadastrale NZMS 261, établie à même échelle et suivant le même découpage, qui est maintenant presque achevée. Cet ensemble de cartes, qui sont très précises, constitue les séries de base fondamentales à partir desquelles sont établies les cartes dérivées de la Nouvelle-Zélande.

Ces cartes dérivées se répartissent en deux catégories principales :

a) Celles qui sont entièrement établies à partir de réductions ou d'extraits des séries de base;

b) Celles qui sont établies sur la base d'un canevas obtenu à partir de ces séries et sur lequel on ajoute des renseignements supplémentaires, souvent de caractère thématique.

La plupart des cartes dérivées sont produites par le Department of Lands and Survey (Département des affaires foncières et des levés), le Department of Scientific and Industrial Research (Département de la recherche scientifique et industrielle) et le New Zealand Forest Service (Service forestier), et le reste par quelques sociétés privées, des services locaux (surtout pour les cartes d'aménagement du territoire) et des particuliers et organismes fabriquant des cartes sous licence.

The basic topographical mapping covering New Zealand is the 1 inch to 1 mile (1:63,360) New Zealand Map Series (NZMS) 1 series currently being superseded by the 1:50,000 NZMS 260 series which is on the New Zealand Map Grid projection with new photogrammetry at 1:25,000. Complementary to this, at the same scale and on the same sheet-lines, is the 1:50,000 NZMS 261 Cadastral series now nearing completion. These form the "bread and butter" mapping base from which the greater part of New Zealand's derived mapping is produced.

Derivations fall into two main categories:

(*a*) Maps which are wholly compiled from reductions of or extractions from these basic series;

(*b*) Maps for which a base drawing is derived from the series to be fleshed out with additional, often thematic information.

In both categories the bulk of derived mapping is produced by the Department of Lands and Survey, the Department of Scientific and Industrial Research and the New Zealand Forest Service complemented by a small private mapping industry, local bodies (largely planning maps) and individuals and organizations producing maps under copyright licence.

Category (a)

Looking at the first category, there are the obviously topo-based smaller scale derivations covering New Zealand at decreasing scales of 1:250,000, 1:500,000, 1:1,000,000, 1:2,000,000 and 1:4,000,000. The 1:250,000 metric NZMS 262 series now in production supersedes the older 1:250,000 NZMS 18 series which had imperial heighting by spot and contour. The new series has no contours but a much improved shaded, half-tone relief depiction reinforced by a close network of spot elevations in metres. The 1:500,000 NZMS 242 series covers New Zealand in four sheets departing from conventional north-south orientation to achieve good, overlapping coverage on a 1,270 x 965 mm sheet of chart paper, the largest printed for a New Zealand map. At this scale, hypsometric tints based on the International Map of the World (IMW) standard shades are introduced, continuing on the successively smaller scales. Although basically a topographical series, large, untrimmed stocks are held for overprinting as aeronautical charts, electoral maps and other special maps. The 1:1,000,000 NZMS 83 sheets cover North and South Islands on separate sheets and have recently been revised and fully redrawn. These are the most widely used "general" maps of the country. The smaller 1:2,000,000 and 1:4,000,000 maps are also popular.

Category (b)

For many years the above topographical and cadastral series have been used as an accurate platform on which a wide variety of cartographic products have been constructed.

The general policy of the Department of Lands and Survey has been to make this information readily available to other government departments, local authorities and private concerns. With the latter, a system of royalty payments operates at various rates governed by the quantity of the derived map reproduced, area copied, scale and other factors.

The basic compilation for the standard cadastral and topographical series are the 1:10,000 cadastral record sheets, regularly updated, and the photogrammetric topo-plots which for the new topographical series are at 1:25,000.

*The original text of this paper, prepared by D. D. McCormack, Department of Scientific and Industrial Research, appeared as document E/CONF.72/L.11.

Map material made available may therefore be the actual maps themselves (or their reproduction material) or the record sheet information or topo-plot information.

In addition, the Department of Lands and Survey may also supply other cadastral survey information, larger-scale photogrammetry and aerial photographs, but for the purpose of this paper comment will be restricted to the mapping actually derived from the basic cadastral and topographical mapping.

Main clients for this basic map information are: Department of Scientific and Industrial Research (DSIR), New Zealand Forest Service and Ministry of Works and Development. In addition, the basic mapping is used within Lands and Survey to produce a wide variety of derived mapping for others such as the Ministry of Transport (aeronautical and meteorological charts) and for the Department's Street and National Park series, amongst others.

In DSIR, the basic topo-plots are enlarged to provide geological field sheets at 1:12,500 and 1:10,000. For soil mapping the tendency is for the DSIR cartographic unit to prepare base maps scribed from the Lands and Survey base information (omitting unwanted detail). At the final survey scale, prints from these are then used in the field by pedologists. This is an over-simplification of a complex scene in which a wide variety of derived maps are produced with the original Lands and Survey mapping as an accurate basis. These range from large-scale sheets of coal-fields to very small-scale maps of New Zealand and surrounding oceanic areas on which factors such as salinity, ocean temperature etc. are overdrawn. For many of the latter, base information is also obtained from hydrographic charts produced by the Ministry of Defence.

New Zealand Forest Service produces a great deal of mapping, particularly large scale mapping of forest areas, from aerial photography as a separate product. Their use of Lands and Survey base mapping is mainly to derive selective base information for a wide variety of ecological, planning and conservancy maps at scales of 1:63,360 to 1:2,000,000.

The Ministry of Works and Development has used the NZMS 1 series as a base to produce a land use capability inventory series for New Zealand at a scale of 1:63,360. These maps are designed to aid in the assessment of the potential for maximum sustained production within management units. The Ministry has also derived a base from the Lands and Survey 1:250,000 topographical series on which various aspects of erosion are shown: this series is being produced co-operatively by the two departments.

Many years ago preoccupation with basic topographical and cadastral coverage tied up almost all of the available cartographic skills and manpower. Today, with a much wider use of more sophisticated map graphics, there is still great emphasis on provision of improved metric topographical coverage. However, a larger portion of cartographic effort than before is concentrated on the derivations discussed above. When total coverage of the metric topographical base has been achieved, even greater attention will be placed on derived mapping with the prospect of computer-assisted manipulation a reality in the coming years.

MAP DISTRIBUTION IN NEW ZEALAND*

Paper presented by New Zealand

RÉSUMÉ

Le document fournit des renseignements détaillés sur les points suivants :

Attributions générales et rôle du Centre cartographique national et organisation de ses travaux.

Accords d'échange conclus à l'échelle mondiale et quantités totales détenues en stock pour les besoins du service et pour la vente.

Besoins organisationnels et administratifs du Centre, avec énumération des sections des divers bâtiments renfermant les stocks, etc.

Liste, par titre et par échelle, des cartes tenues en stock pour les besoins publics et privés.

Entretien des stocks de cartes et des divers stocks de réserve.

Description du système utilisé pour effectuer la réception et la mise en vente des stocks reçus en vrac de diverses sources.

Détail du système utilisé pour classer les cartes à la World Reference Library (Bibliothèque de référence mondiale).

Catalogue des cartes du Department of Lands and Survey (Département des affaires foncières et des levés), avec détail de certaines parties du catalogue et du service trimestriel de mise à jour.

Modes de publicité utilisés pour atteindre les utilisateurs de cartes et informer le grand public de la mise en vente des nouvelles cartes et des cartes révisées.

Autres activités y compris la liste des cartes disponibles en dehors des cartes publiées par le Département.

*The original text of this paper, prepared by B. M. Sinclair, Department of Lands and Survey, appeared as document E/CONF.72/L.12.

Historique du Centre cartographique depuis son installation dans ses nouveaux locaux en 1952.

Illustrations des travaux réalisés par le Centre cartographique ainsi que de l'accroissement et de la distribution des cartes.

THE NATIONAL MAP CENTRE

The role and responsibilities of the National Map Centre are:

(*a*) To maintain present co-operative arrangements and exchange agreements with overseas authorities and negotiate to extend these agreements where this is felt desirable;

(*b*) To maintain stocks of maps, aeronautical charts, mosaics and publications, both local and overseas;

(*c*) To administer general office and accounting procedures;

(*d*) To maintain stocks and distribute maps for sale purposes to civilian users;

(*e*) To maintain working and reserve stocks of aeronautical charts for the Air Force;

(*f*) To maintain working and reserve stocks of topographical maps for the Army;

(*g*) To maintain maps, mosaics etc. for civil defence purposes and for search and rescue purposes;

(*h*) To compile a world reference library containing two reference sets of all maps, charts etc. published by the Department of Lands and Survey and also by local and overseas mapping organizations;

(*i*) To maintain stocks of aeronautical charts/publications for the Civil Aviation Department;

(*j*) To meet the requirements for maps of departments of Government;

(*k*) To maintain bulk stocks for the Department of Lands and Survey, Head Office, Map Sales and district offices, for sales and reference purposes;

(*l*) To appoint private reselling agents and process orders for maps (the Department's maps are sold in New Zealand and overseas by some 620 agents);

(*m*) To process overseas orders, requests for maps and inquiries regarding maps.

HISTORY OF THE MAP CENTRE

Prior to the year 1952, maps were housed in the Government Buildings Annex in very poor conditions, sharing 1,000 square feet of space with the Map Mounter and a family of friendly rats. The Map Library was crowded into a small space in the Cartographic Branch, some one and a half miles away in the old Army Base Records building (since demolished). The office was on the top floor of the Government Buildings.

Negotiations with the RNZAF led to the Department taking over an underground Air Command Post building. This had been intended as an Air Force control centre but the war ended before it was brought into operational use. For some years the Air Force had been using the building to house various gear and old furniture.

The Department took it over and converted it into a two-storey Map Centre. The hill-side was cut away, and an office was built on top of what was an entrance tunnel. A wooden first floor, designed to take the great weight was built and a full air-conditioning unit installed. This unit runs continuously, with a bank of four filters for dust control, a fuel oil-furnace for heating, a water-spray unit and a refrigerator section and humidity control; the air in the whole building is replaced once every hour.

The map stocks and library moved into their new roomy area in April 1952, and in the latter part of that year all aerocharts held at Air Headquarters were transferred to the depot. In 1953 a national reserve of topographical maps was established for New Zealand. Maps held in different places in Wellington were brought under one roof. The year 1961 saw an area of 750 sq ft of open space floored over to take maps in the area of interest of the South-East Asia Treaty Organization (SEATO). Since moving from the old cramped quarters of 1,000 sq ft, we had grown to 6,336 sq ft and were soon investigating the possibility of a new area to house bulk stocks of maps for overprinting at a later date.

Bulk stocks of Army working stocks and untrimmed stocks were moved to the Professional Uniform building across the road (302 Taranaki Street) on 1 December 1965. The 3,400 sq ft of space is now nearly full and, with a growth-rate of 7 per cent per annum over the last 10 years, space is now at a premium.

In 1976 2,500 sq ft of storage became available at 51 Vivian Street, three quarters of a mile away, for the storage of packing material, mailing tubes and untrimmed maps and charts.

Plans are now under way for a new 20,000 sq ft Map Centre at Masterton. It will have the latest materials-handling equipment with maps housed on the newly designed racking and walk-way layout.

ORGANIZATION OF THE MAP CENTRE

The Map Centre has three sections and a total staff of six to run the many and varied functions of the Centre.

Administration centre

This is the main office where action is taken on orders and correspondence and such functions as:

(*a*) Requisitions from district and head office map areas;

(*b*) Appointment of private map reselling agents and the processing of agents selling maps in some 620 outlets;

(*c*) The administration of actions listed in the preceding section.

World Reference Library

(*a*) World map and chart reference library (includes complete set of New Zealand maps);

(*b*) Accounting section for the Map Centre;

(*c*) Gazetteer and geographical library;

(*d*) United Nations card library (over 45,000).

Dispatch area

(*a*) Receipt and issue of maps and charts/packing and postal area;

(*b*) Storage area for civilian stocks, working maps/reserve stocks for the Army and the Royal New Zealand Air Force;

(*c*) National reserve for Air Force, Army, Civil Defence and Search and Rescue.

BULK STORES

(*a*) Bulk store, housing maps and charts for overprinting and general stock purposes at 302 Taranaki Street;

(*b*) Mailing materials and untrimmed stocks at 51 Vivian Street.

TYPES OF MAPS HELD

Civil use

Street maps—1:12,500/1:20,000
Topographical—1:25,000 (not being maintained)
1:63,360
1:50,000 (metric)
1:250,000
1:250,000 (metric)
1:500,000
General maps—1:1,000,000
1:2,000,000
1:4,000,000
1:8,000,000
Miscellaneous maps—Various scales
National parks—Various scales
Recreational maps—Various scales
Cadastral maps—1:50,000 (metric)
1:63,360 (being replaced by metric maps)
Various town maps available in plan print form only
Mosaic maps (photomaps)—1:10,000
1:15,840 (available as bromide or document prints)

RNZAF aeronautical requirements

Aeronautical—Aeronautical route and terminal charts
1:250,000
1:500,000
1:1,000,000
1:3,000,000
1:4,000,000
1:6,000,000

Army maps: the most suitable coverage for land operations

Topographical—1:25,000
1:50,000
1:63,360
Street maps
Any civil maps requested as above

MAINTENANCE OF STOCKS

Stock totals

(*a*) Totals of maps, aeronautical charts, mosaics, park handbooks and general publications. Totals are based on continuing needs as shown by our annual map stock returns;

(*b*) Service requirements in terms of scales and type of maps used and the areas covered;

(*c*) Totals of maps stored are based on the computer returns and necessary known and anticipated stocks to maintain adequate stock levels and reserves.

Stocks held

(*a*) Civilian stocks (sale purposes);
(*b*) Army stocks (working and reserve);
(*c*) RNZAF stocks (working and reserve);
(*d*) Civil Defence stocks (reserve);
(*e*) Search and Rescue stocks (reserve).

Operational and reserve stocks

(*a*) Army emergency stock, sealed and held permanently;

(*b*) RNZAF: a six-month stock of overseas aeronautical charts is held based on usage figures for the past year;

(*c*) Reserve stocks of Lands and Survey maps.

MAP RECEIPT AND ISSUE

Maps and charts etc. are received from:

(*a*) New Zealand government printer;
(*b*) New Zealand Aerial Mapping Ltd., Hastings;
(*c*) Various park boards;
(*d*) Geological Survey, Department of Scientific and Industrial Research/government printer;
(*e*) National Mapping, Australia;
(*f*) Defense Mapping Agency, Aerospace Centre, United States of America.

On receipt of these items a manual count is taken and flat maps are taped at each 100 copies; folded maps are banded in groups of 25. They are then brought onto charge with an into-stock J67 form and issued on our issue docket J68A.

Automatic issue is made in the terms of the office manual:

(*a*) *Civil maps*
- (i) Agreed number sent to district offices;
- (ii) 1,000 of the main topographical series put into army service working/reserve, search and rescue reserve and civil defence stocks;
- (iii) Where possible, monthly complimentary issues made to local and overseas authorities, universities, libraries etc.;
- (iv) Two copies each to Lands and Survey reference library;
- (v) Folio reference copies to district offices;
- (vi) V.I.P. reference folio sets;
- (vii) Reference sets to 60 overseas embassy reference kits.

(*b*) *Service/Army/RNZAF maps*
- (i) Agreed totals to Army and RNZAF bases;
- (ii) War emergency/reserve and working stocks;
- (iii) Issue to overseas official service mapping authorities;
- (iv) Two copies each service map/chart to Lands and Survey (reference purposes).

WORLD REFERENCE LIBRARY

The Centre maintains a reference library of maps and charts, covering the world on various scales. Owing to space restrictions, scales of 1:250,000 and smaller are mainly kept. Larger-scale maps are kept of town plans, street maps and, where possible, Pacific island groups.

The maintenance of up-to-date world coverage of maps of medium and small scale with special emphasis on the New Zealand defence area is fraught with problems and requires constant attention.

Maps and charts are received on reciprocal exchange agreements with most official overseas mapping authorities. These include Australia, Canada, Denmark, France, the United Kingdom and the United States of America. There is a small but growing collection of Antarctic maps issued by SCAR nations.

In addition to overseas maps, the library holds reference sets of maps, charts (two each) and mosaics published by the Department; those published by other departments, where available; and copies of maps published under licence by private firms.

Being a reference library, the items held are not for sale and in the main not available for inspection by the general public. The main usage is by the armed forces, External Affairs, External Intelligence Bureau and government departments. There is a growing call for maps for use in overseas aid programmes. One of the important functions of the library is to keep our Cartographic Branch informed of the latest overseas trends in mapping.

A very modern and complete system of cataloguing is employed. The manual of map classification issued by the Geographical Section, General Staff (United Kingdom), adapted for New Zealand conditions, is used. The usual 8" x 5" cards in steel drawers are used. The map series or single sheet map is then described listing the main specific topographical features, relief, vegetation, drainage, road pattern, projection and scale.

The world is divided into zones to enable maps to be classified easily and quickly. The aim is simplicity, and care is needed to keep areas to a minimum. Letters are issued to main divisions such as: "B" for world, "C" for Europe and "D" for Asia. Australasia is shown as "I" and New Zealand as "12" so that a map in the Topographical Series 1:63,360 (NZMS-1) will be stamped on the back of the sheet as "I:12:—(41)". (The 41 shows that this is the first map held in the scale bracket for 1:63,360 maps of New Zealand. The next would be 42 etc.).

Information is shown on white cards, scale on green cards, cross references on yellow cards. Catalogues for most series are kept with the indexes filled in as received in red/blue. A printed series list shows: sheet number, sheet name, edition, date and the number of copies held. One copy is filed and one is placed with the maps in the steel drawer.

With space at a premium it is not possible to keep stocks of overseas maps for resale purposes.

MAP CATALOGUE

All available map series published by the Department of Lands and Survey are shown with a description of series and a series list of sheets published, giving sheet number, sheet name, edition and date. Each of the main series is covered by a map index showing the area covered. The catalogue is divided into the following parts:

Index to New Zealand Map Series numbers

1. General and miscellaneous
2. Cadastral
3. Topographical
4. Mosaics
5. Aerial photos

The catalogue is maintained by the automatic quarterly amendment service.

PUBLICITY

Mailing lists

(*a*) A regular mailing list is issued covering all maps that are available for resale; also newspaper advertisements are taken;

(*b*) Map brochures are issued free of charge, covering the main series, and are kept up to date as often as possible;

(*c*) A map sample booklet, showing the map series cut from the map, is available, as well as agency wall posters;

(*d*) Wire display map racks are issued free of charge to agents;

(*e*) Issuing and servicing of over 63 wooden map display units are supplied to overseas posts;

(*f*) Various leaflets, price lists and display posters are sent to our private resale agents. Over the years the Department has appointed some 620 selling agents.

OTHER ACTIVITIES

Geological maps produced for the Department of Scientific and Industrial Research

We maintain small stocks for resale through the Head Office, Map Sales, and the various district offices.

National park publications

Stocks are maintained for general distribution by our private selling agents and district offices to the general public of handbooks, charge leaflets and free park leaflets.

Australian maps

We have been appointed agent for the sale of maps published by the Department of National Resources, Division of National Mapping, Australia. Small numbers of various maps are held for general sale as requested.

World maps (DMAAC-United States)

Stocks are held for Service issue; mainly, the single sheet map is sold to the public.

Write-off of obsolete map stocks

When editions of a map are superseded by a newer edition, all older stock (if any is left) is withdrawn and disposed of in various ways:

(*a*) Restricted maps are shredded or burnt;

(*b*) Maps with no restrictions can be used for wrapping/packing;

(*c*) Suitable maps are padded for use as pads and issued to district offices and the Head Office.

Packing parcels

Maps are sent out from the Map Centre in various ways, special effort being taken to ensure that maps are not damaged in transit.

Annex I

SUMMARY OF WORK DONE 1978/79

Maps issued—466,426
Maps received—674,236
Value of maps issued—$475,008
Number of private resale agents—619
Number of maps issued to resale agents—125,534
Value of maps sold by resale agents—$127,000
Parcels dispatched—5,489
Crates of maps issued—311
Letters, mailing lists etc.—45,000
Postal charges—$4,779
Freight, goods rail, rail/air—$3,300
National park publications issued—1,448
World Reference Library
Average new maps/charts received per year—2,000
Total number held in Library (approx.)—300,000

Gross Holdings

1960	*1965*	*1975*	*1978*
800,511	922,451	1,850,098	2,014,674

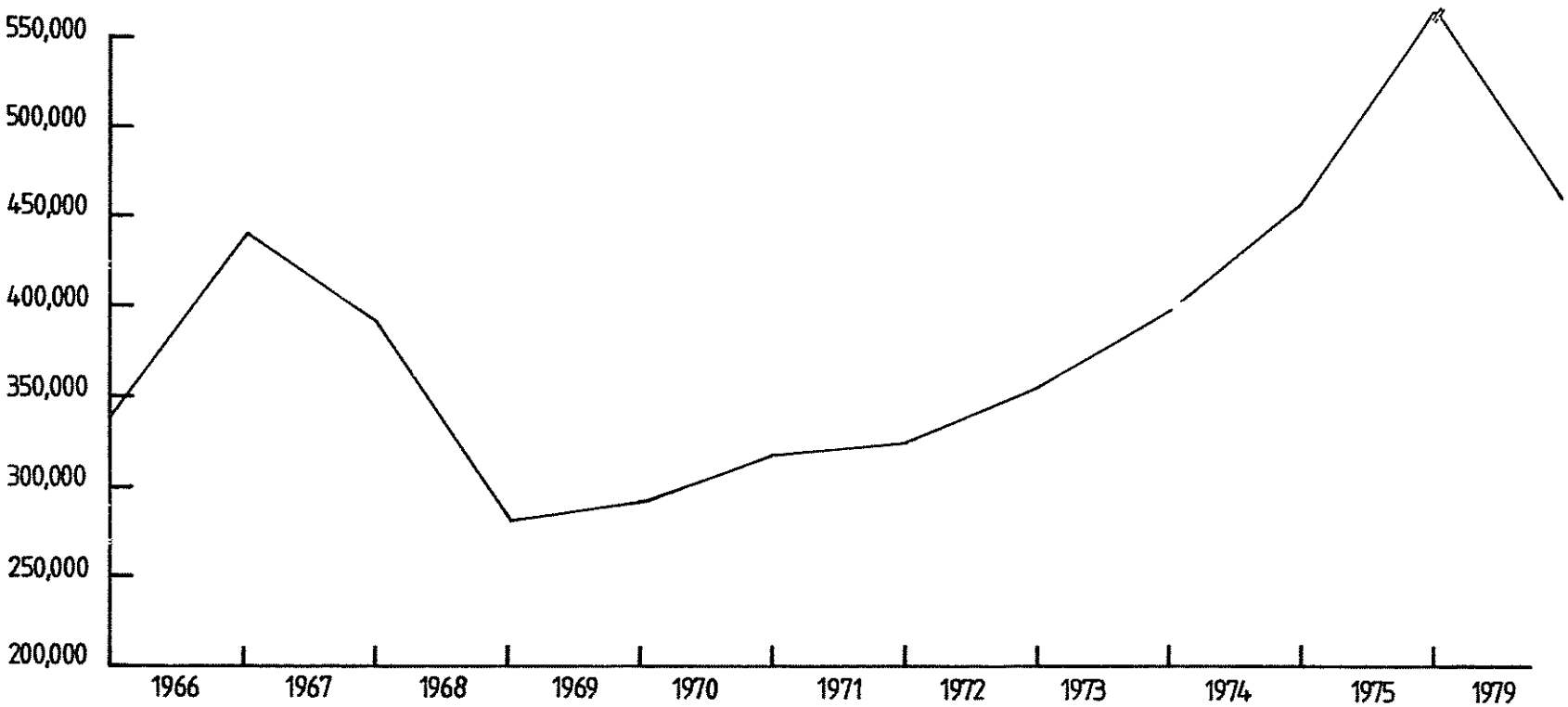


Figure 95. New Zealand: maps and charts issued from the Map Centre

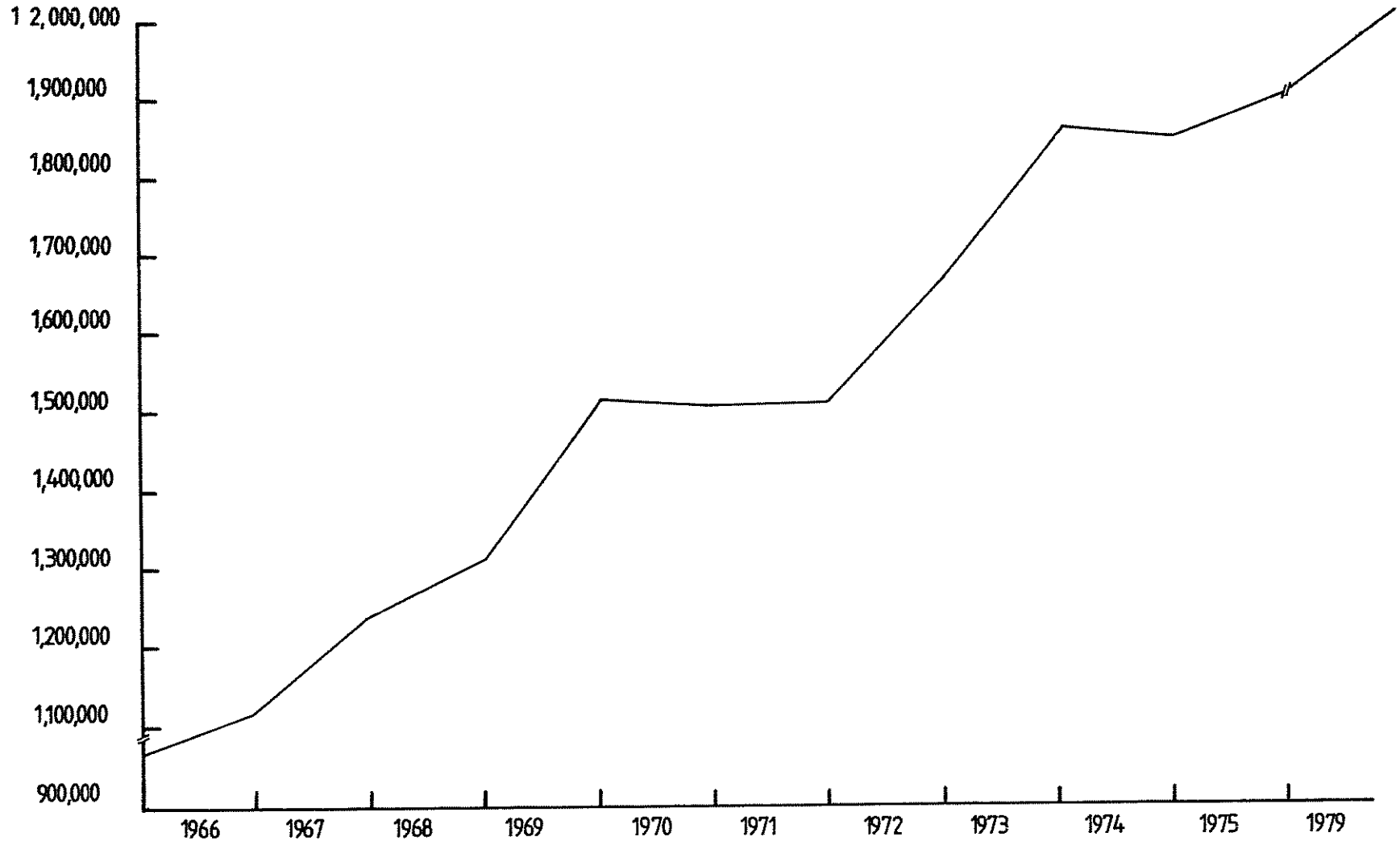


Figure 96. New Zealand: gross holdings at the Map Centre and bulk store

THE NEW ZEALAND LAND INVENTORY HANDBOOK*

Paper presented by New Zealand

SUMMARY

Changes in the use of rural land and competition between various uses are a common feature of land use in many parts of New Zealand. Adequate information about land resource is required if full advantage is to be taken of its potential value. It is important that those who are involved in land-use planning and decision-making should be aware of the information available, and what particular needs can be met.

The aim of the Handbook is to show the form and range of information that can be obtained through the New Zealand Land Inventory. The Department of Lands and Survey presents the information on behalf of a number of departments concerned with resources and sciences. The Handbook is meant to ensure that the form and coverage of the data provided in the New Zealand Land Inventory should become widely known. All of the data and the accompanying maps in the booklet are available to the public, interest groups, *ad hoc* agencies, local authorities, educational institutions, land-owners and government departments.

*The original text of this paper, prepared by the Department of Lands and Survey, appeared as document E/CONF.72/L.111. It is not reproduced for technical reasons.

RÉSUMÉ

Les changements intervenus dans l'emploi des terres rurales et la concurrence entre les différentes utilisations sont des caractéristiques communes à de nombreuses régions de la Nouvelle-Zélande en matière d'occupation des sols. Il est indispensable de disposer de renseignements précis sur les ressources en terres et leur utilisation pour pouvoir tirer pleinement parti du potentiel qu'elles représentent. Il faut que ceux qui sont chargés de la planification ou qui prennent les décisions en matière d'utilisation des sols sachent que des données sur les terres sont disponibles ou peuvent être obtenues en vue de répondre à des besoins particuliers.

L'objectif du manuel est de définir la forme et l'étendue des renseignements fournis par l'inventaire foncier néo-zélandais. Le Department of Lands and Survey (Département des affaires foncières et des levés) présente ces données au nom d'un certain nombre de départements scientifiques et techniques. On espère, grâce au manuel, faire largement connaître la nature et l'étendue des données contenues dans l'inventaire foncier néo-zélandais. Toutes les données et les cartes correspondantes qui figurent dans le manuel sont mises à la disposition du public, des groupes d'intérêt, des agences spéciales, des autorités locales, des établissements d'enseignement, des propriétaires fonciers et de l'administration.

THE REGIONAL ECONOMIC ATLAS OF ASIA AND THE FAR EAST**

Paper presented by Thailand

RÉSUMÉ

Aidé par quelques pays membres, mais utilisant essentiellement ses propres ressources humaines, matérielles et financières, le Royal Thai Survey Department (Service topographique thaïlandais) a publié les deux premières feuilles d'un atlas en se servant de la carte de base que ce qu'on appelait alors la Commission économique pour l'Asie et l'Extrême-Orient avait déjà employée pour établir la carte des ressources en pétrole et gaz naturel de l'Asie et de l'Extrême-Orient. Une nouvelle carte de base fiable, adaptée aux besoins cartographiques régionaux, a été tracée, mise au point, réalisée et finalement acceptée à la Conférence de Tokyo en 1973.

De nouvelles cartes de l'atlas, ayant trait aux transports, aux ressources forestières et à la répartition démographique, sont en cours d'établissement sur cette nouvelle carte de base, et le travail, dans la mesure du possible, est effectué sans aide financière internationale.

La Conférence cartographique régionale des Nations Unies pour l'Asie et l'Extrême-Orient a depuis 1961 préconisé la coopération internationale entre ses membres en vue de la réalisation d'un atlas économique régional de l'Asie et de l'Extrême-Orient pour lequel 15 thèmes ont été proposés.

La Thaïlande a spontanément accepté de se charger du travail de préparation et de publication de l'atlas économique régional. Le Service topographique thaïlandais, à qui a été confiée la responsabilité de la réalisation du projet, a en vain essayé à plusieurs reprises d'obtenir à l'échelon international le soutien et la coopération demandés dans les résolutions de la Conférence.

**The original text of this paper appeared as document E/CONF.72/L.113.

The United Nations Regional Cartographic Conference for Asia and the Far East recommended in 1961 that States Members of the United Nations should co-operate in achieving a regional economic atlas of Asia and the Far East covering 15 proposed topics.

Thailand voluntarily accepted the task of compilation and publication of the atlas. The Royal Thai Survey Department (RTSD) which was given the responsibility of carrying out the project tried in vain, several times, to acquire international support and co-operation as was requested in the Conference resolutions. Some member countries vigorously tried to implement the recommendations by submitting the required source data and source maps to the Map Information Centre of the Royal Thai Survey Department, although some of the information supplied was not suitable for the compilation of a homogeneous regional map. Most countries, however, did not forward the necessary data.

With the assistance of a few member countries, but principally based on its own manpower, resources and funds, the RTSD published the first two atlas sheets, using the same base map as the then ECAFE Oil and Natural Gas Map of Asia and the Far East.[1] A new reliable base map for regional mapping purposes was plotted, compiled, produced and finally accepted by the Seventh United Nations Regional Cartographic Conference, held at Tokyo in October 1973. At present, additional maps of the atlas are being compiled on the new base, i.e. those dealing with transportation, forestry and population distribution, and the work is being carried out as far as possible without international financial assistance.

The major difficulties in production of the atlas have arisen from the fact that in many cases national thematic maps of the required topics do not exist in the region countries. In other cases existing maps cannot be compared owing to the differences of topical classification. Standardization of the various keys for a regional map has to be accomplished by the compiler of the map.

The compilation of a regional atlas should not be entrusted solely to a national mapping institution that cannot call upon experts in the various fields of thematic mapping and is not in a position to secure the assistance of the countries concerned; and which has not the funds to creditably produce and distribute the atlas maps. If the atlas project had been undertaken by international organizations, these problems would not have arisen. Examples of successful international co-operative mapping projects are the geologic and bioclimatic maps of Africa and Europe by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the various geologic maps of Asia by the Mineral Resources Section of the Natural Resources Division of the Economic and Social Commission for Asia and the Pacific (ESCAP).

Up to the present, 10 out of the 15 proposed topics have been published by various organizations as shown in the annex.

Thailand, therefore, has had to resolve on terminating the task. The Ninth United Nations Regional Cartographic Conference should ensure the completion of the atlas project by entrusting it to relevant international organizations, the foundations having been laid by the RTSD. The Cartography Section of the Department of Technical Co-operation for Development of the United Nations Secretariat, in co-operation with the experts of ESCAP, UNESCO and the Food and Agriculture Organization of the United Nations (FAO), could compile the missing maps. What seems to be more important is the dissemination of the maps to the various Governments and departments concerned in order that the Regional Economic Atlas of Asia and the Far East may be utilized, according to its aim, as a tool of regional planning in the economic and social development of the region as a whole.

[1] The Economic Commission for Asia and the Far East (ECAFE) was subsequently renamed the Economic and Social Commission for Asia and the Pacific (ESCAP).

Annex

LIST AND STATUS OF PROPOSED TOPICS

1. *Basic mapping status.* A brief presentation of the status of world topographic mapping has been published in the United Nations publication, *World Cartography*, vol. XIV, 1976 (ST/ESA/SER L/14).
2. *Climatic maps and diagrams.* The climatic regions map of Asia and the Far East was published by the RTSD in 1973.
3. *Natural vegetation and forest resources.* The forestry map was compiled and published by the RTSD in 1979 in spite of the inadequate supply of data from the countries of the ESCAP region.
4. *Soils.* The soil map of the world was compiled and published by FAO/UNESCO in 1977.
5. *Geology.* The geological map of Asia and the Far East was compiled and published by the Mineral Resources Section, Natural Resources Division, ECAFE, in 1955 (2nd ed., revised, 1971).
6. *Agriculture.* Some maps of agriculture were included in the world atlas of agriculture, compiled and published by the International Association of Agricultural Economists in 1969.
7. *Industrial centres.* Not available.
8. *Population.* The population density map of Asia and the Far East was compiled and published in 1970, and an incomplete set on population distribution in accordance with the 1970 census was published in 1979 by the RTSD.
9. *Communication.* Not available.
10. *Transportation.* The transportation map of Asia and the Far East was compiled and published by the RTSD in 1978.
11. *Minerals.* The mineral distribution map of Asia and the Far East was compiled and published by ECAFE in 1963 and the oil and natural gas map of Asia and the Far East in 1975.
12. *Water resources.* Not available.
13. *Power resources.* The energy atlas of Asia and the Far East was compiled and published by ECAFE in 1970.
14. *Animal resources.* Not available.
15. *Tourist resources.* Not available.

DEVELOPMENT OF AN INTEGRATED CARTOGRAPHIC INFORMATION SYSTEM IN THE UNITED STATES*

Paper presented by the United States of America

RÉSUMÉ

Les cartes occupent une place de plus en plus importante dans la vie de l'homme moderne. Il les élabore, les collectionne, les étudie ; elles lui servent par exemple à choisir l'emplacement d'une nouvelle capitale, le tracé d'une nouvelle route, ainsi qu'à localiser les villes et les terres agricoles ; en outre, les professionnels de la cartographie doivent être en mesure de répondre à des questions telles que celles-ci : existe-t-il des photographies aériennes récentes de telle région, ou datant d'une dizaine d'années ? La côte ouest a-t-elle fait l'objet de levés précis ? Quelle a été l'évolution des utilisations agricoles au cours des 100 dernières années ? A-t-on dressé la carte des zones de failles actives ou des zones sujettes à des glissements de terrain ? Quelles sont les parties du pays riches en ressources minérales ? Quel était le nom de tel village en 1940 ? Existe-t-il des images spatiales du pays ? Où peut-on trouver des renseignements cartographiques ? Quels sont les services qui détiennent ce type de données ?

Dans la plupart des pays, de nombreux groupes différents recueillent divers types de données cartographiques. Malheureusement, en règle générale, nul ne sait avec précision qui a quelles données, où elles se trouvent et comment en obtenir des copies. D'où l'utilité d'un système intégré d'information cartographique.

Ce système devrait contenir des renseignements d'ordre général décrivant et localisant les collections de données cartographiques, dont les cartes terrestres et marines, les photographies aériennes et spatiales, les images spatiales, les données du canevas géodésique et autres données cartographiques numériques. Il n'est pas nécessaire que le centre ou le service qui exploite ce système détienne matériellement les données, mais il doit avoir des catalogues des différentes collections et être en mesure d'indiquer la marche à suivre pour commander des copies des données recherchées. Cette méthode permet de réaliser d'importantes économies car une fois que l'on sait où trouver l'information, il est souvent possible d'utiliser les supports existants sans devoir en réunir ou en établir de nouveaux.

Les étapes principales de la mise en place d'un service d'information cartographique sont les suivantes :

a) Conception d'un système informatisé, de microfilms et de méthodes manuelles pour le traitement des données;

b) Acquisition des données à intégrer dans les systèmes d'information;

c) Mise sur pied d'un réseau de communications et de postes d'accès régionalisés;

d) Préparation de brochures, bulletins d'information, graphiques et instruments de références afin de faire connaître le centre, ses services et ses systèmes;

e) Création d'un groupe de services à la clientèle chargé de donner suite aux demandes de renseignements, d'effectuer les recherches nécessaires et de s'occuper des commandes;

f) Fourniture d'une assistance technique et de services de formation à l'utilisation de la production cartographique.

INFORMATION SYSTEMS

Not every bit of information about a photograph or a map must be encoded and entered in an information system. Only the most essential items should be chosen and entered. The inventory should also be organized by levels of information. For example, an information system can describe an entire series of maps in a general entry. By adding a graphic to this system and plotting where the maps are located, another level of information is established. A system that contains enough detailed information to describe each map in a series represents the most detailed level.

To meet the current and expected requests for cartographic data in the United States, the integrated cartographic information system was designed to:

(*a*) Extract cartographic data described within the system by latitude and longitude;

(*b*) Select cartographic data by subject matter and scales;

(*c*) Identify maps or charts having multiple sheets, insets, or a combination of both;

(*d*) Select historical editions of the same product;

(*e*) Allow the data-base maintenance staff to add free text, administrative or descriptive commentary about the product;

(*f*) Geographically display requested information on a plotted index;

*The original text of this paper, prepared by Gary W. North, United States Geological Survey, appeared as document E/CONF.72/L.1.

(*g*) Search for information for a given point, point and radius, polygon or corridor;

(*h*) Incorporate machine-readable data base listings from other agencies;

(*i*) Record multiple sets of information for the same product descriptor. For example, under the "Date" descriptor for maps, the date of the aerial photography would be entered, the date of the ground survey, the date of compilation, the date of revision etc.

Part of the United States integrated cartographic information system is the Aerial Photography Summary Record System (APSRS), which stores information about aerial photography projects flown by both Government and private mapping concerns. APSRS stores and recalls, in easy-to-access computer listings and graphics, information about the types of aerial projects, including date flown, the most recent project and the film holder. Microfiche sets are also produced which describe each photographic project in detail, including the type of photography (colour, infra-red, or black-and-white), amount of cloud cover, camera type and exposure date.

Another part of the United States integrated cartographic information system is the Map and Chart Informations System (MCIS), in which each map is described by its own basic identifier—the map name, dates (publication, survey revision and photography), horizontal and vertical datums, contour intervals, projection, grids, co-ordinates relief and microfilm location if a microfilm copy has been made.

Up to 999 sheets with intermixed insets may be entered and related to a basic map, map index or atlas.

One of the most important aspects of MCIS is its ability to plot the location of different maps and charts to meet a user's requirements. The mapped areas are plotted on an outline map and numerically indexed from south to north.

Some information for the MCIS is being transcribed from known digital data listings, such as the Library of Congress' Machine Readable Catalog and the Defense Mapping Agency's Topographic Data Library System. Data are also being entered by co-operating agencies through direct encoding of selected source materials.

The range of maps and charts about which information must be gathered, stored and made ready for dissemination is diverse. Unfortunately there are also very few machine-readable indexes to these products, consequently most of the encoding is done by hand. Currently the system contains maps and charts from the Army Corps of Engineers, the Defense Mapping Agency, the Federal Highway Administration, the Library of Congress, the National Ocean Survey and the Geological Survey.

Data acquisition

Efforts are being made to expand the information in the system to include cartographic data for all federal, state and private organizations. This means establishing co-operative data-acquisition programs to make sure that we do not miss any cartographic products.

Acquiring data to go into the information system is basic, necessary and time-consuming. Priorities for data must be based on knowledge of which data is most frequently requested by the customers. Holders of data are asked to provide us, if possible, with encoded information that can be placed directly in the system. Often, however, some organizations that hold large collections of data are reluctant to co-operate because of lack of funding or other reasons. As long as the holder can and is willing to provide access to or copies of the data, however, we need only to acquire the information about the data.

Descriptive information is best distributed through a decentralized network of co-operating offices. We are establishing this network across the country with one co-operative organization in each of our state governments—to date, 21 states are participating. These state agencies are given the responsibility for encoding locally held data and operating a customer service centre. We supplement this approach with our own capability for encoding descriptive information for data held by other producers.

User guides, brochures and other information aids

Many people who could use cartographic products do not know how to describe them or what to ask for. To help them become better informed, pamphlets and user guides were developed for each product line or type of cartographic data. A few pages, written simply, are useful not only in explaining and showing samples of a particular product, but they also can be used to provide background information useful in responding to requests for information.

A series of audiovisual programs was also prepared to aid in explaining the programs to potential co-operators and users.

Customer services

To fill the requests for cartographic information, it was necessary to establish a customer services section staffed by cartographic technicians, cartographers and geographers knowledgeable in the fields of geography, geodesy, cartography and remote sensing. This group handles the requests for information, researches extensive requests, and advises customers as to which available products will be the most useful in meeting their needs. Mail routing, response checking and accounting functions are also performed within the customer service operation. It is imperative that all user requests be recorded and traced, that replies be noted and that appropriate billings be completed—all on a timely basis.

Technical assistance

Once the cartographic information system design and implementation is completed and as a large percentage of the nation's cartographic holdings are entered, it will be necessary to establish a technical assistance and training programme within the customer services group. They will be responsible for teaching people about the use of cartographic products, and their availability and providing guidance to cartographic data producers on areas where specific products are lacking.

CONCLUSION

The physical and economic development of our nation requires the use of many and varied cartographic products. To insure that their availability is known and that people have an opportunity to use them, the United States established the National Cartographic Information Center as part of its national mapping programme. By establishing this centralized source for information, search times have been reduced, duplicate collection projects have been greatly reduced or eliminated, more people can now have access to the materials and true multi-purpose use of products can be made.

THE NATIONAL OCEAN SURVEY'S AERONAUTICAL OBSTRUCTION DATA: PHOTOGRAMMETRIC VERIFICATION PROGRAMME*

Paper presented by the United States of America

RÉSUMÉ

L'Office of Aeronautical Charting and Cartography (Bureau de cartographie aéronautique) du National Ocean Survey (Service océanographique national) de l'Administration nationale de l'océan et de l'atmosphère vient d'achever un programme de vérification photogrammétrique des obstacles représentant un danger pour la navigation aérienne. L'avion utilisé pour les missions photographiques est équipé d'une chambre de prise de vues aériennes Wild RC8. Il s'agit d'un système classique de chambre de prise de vues aériennes couramment utilisé par les services cartographiques, normalement de pair avec un système de visualisation stéréoscopique permettant d'interpréter, de mesurer et d'évaluer les éléments d'information fournis par les documents photographiques. La gamme des instruments stéréoscopiques utilisés pour analyser les données photogrammétriques comprend aussi bien de simples instruments destinés uniquement à mesurer les différences de parallaxe que des appareils extrêmement perfectionnés permettant d'effectuer des opérations d'aérotriangulation. Etant donné que le succès d'un programme de vérification photogrammétrique entrepris aux fins d'établissement de cartes aéronautiques dépend de la crédibilité des résultats que peuvent fournir des instruments de haute précision, on a choisi l'Aviographe Wild B8S pour l'analyse et la mesure des données. Cet appareil s'est révélé très précis et très fiable et il est actuellement largement utilisé dans l'ensemble du Service océanographique national. Les procédés utilisés pour analyser les données photogrammétriques étant fondés sur des méthodes qui ont fait leurs preuves et qui sont couramment utilisées par les services cartographiques, le propos des auteurs n'est pas de présenter un traité sur les techniques de photogrammétrie. Le principal objet du document est d'exposer les activités de vérification des obstacles à la navigation aérienne entreprises par le Bureau de cartographie aéronautique et de retracer l'évolution du programme photogrammétrique correspondant.

The National Ocean Survey (NOS, see diagram 1) is charged with the tasks of conducting surveys, investigations, analyses and research and technology developments in the fields of geodesy, gravity, astronomy, aeronautical charting, hydrography and nautical charting, oceanography and marine technology. The specific task of providing charts for the safety of air navigation is the responsibility of a major element of NOS, the Office of Aeronautical Charting and Cartography (AC&C). The Aeronautical Data Section, within AC&C, maintains information on all navigational aids, air/ground communications, airports and flight hazards for areas covered by aeronautical charts and publications produced by NOS. Data are collected, evaluated, processed and filed for use in co-ordinated revision of respective aeronautical chart products. One of this section's critical areas of work is the establishment of verified data on elevations and positions of flight hazards or obstructions.

DEFINITION OF OBSTRUCTIONS

The Inter-Agency Air Cartographic Committee (IACC) came into existence in 1965 as a result of the need "to develop final chart and textual material specifications which provide acceptable flight information materials for operation in the airspace and for adequately controlling operations in that airspace". It was this same committee which defined the term "obstruction" from an aeronautical viewpoint:

> "All cultural features which extend 200 feet (60 metres) or more above surrounding terrain shall be considered as a 'vertical obstruction' ".

Since specifications further instruct and call for the cartographic depiction of such obstructions on visual chart products, data collection, evaluation and maintenance are critical. Additionally, a 1978 interagency memorandum of understanding between the National Oceanic and Atmospheric Administration (NOAA) and the Federal Aviation Administration (FAA) identified respective requirements for cartographically validated obstacle data to support various digital data bases, airspace determination and procedure development supporting the charting programmes. As a result of this memorandum, NOS's responsibilities with regard to its obstacle programme have been defined as:

"(1) Verify obstacle data that the FAA forwards to the NOS....

"(2) ...forward to the FAA, any obstacle data received through the NOS Flight Check Program and various correspondence, for storage and dissemination.

"(3) Maintain an obstacle file in support of its various charting programs.

"(4) Flight check all areas covered by the visual chart series on a continuous cycle and notify the FAA of any obstacle data that changes status (i.e., dismantled, altered, or built without required notification).

*The original text of this paper, prepared by Stanislaw Grzeda and Russell A. Hoover, National Ocean Survey of the National Oceanic and Atmospheric Administration, appeared as document E/CONF.72/L.2

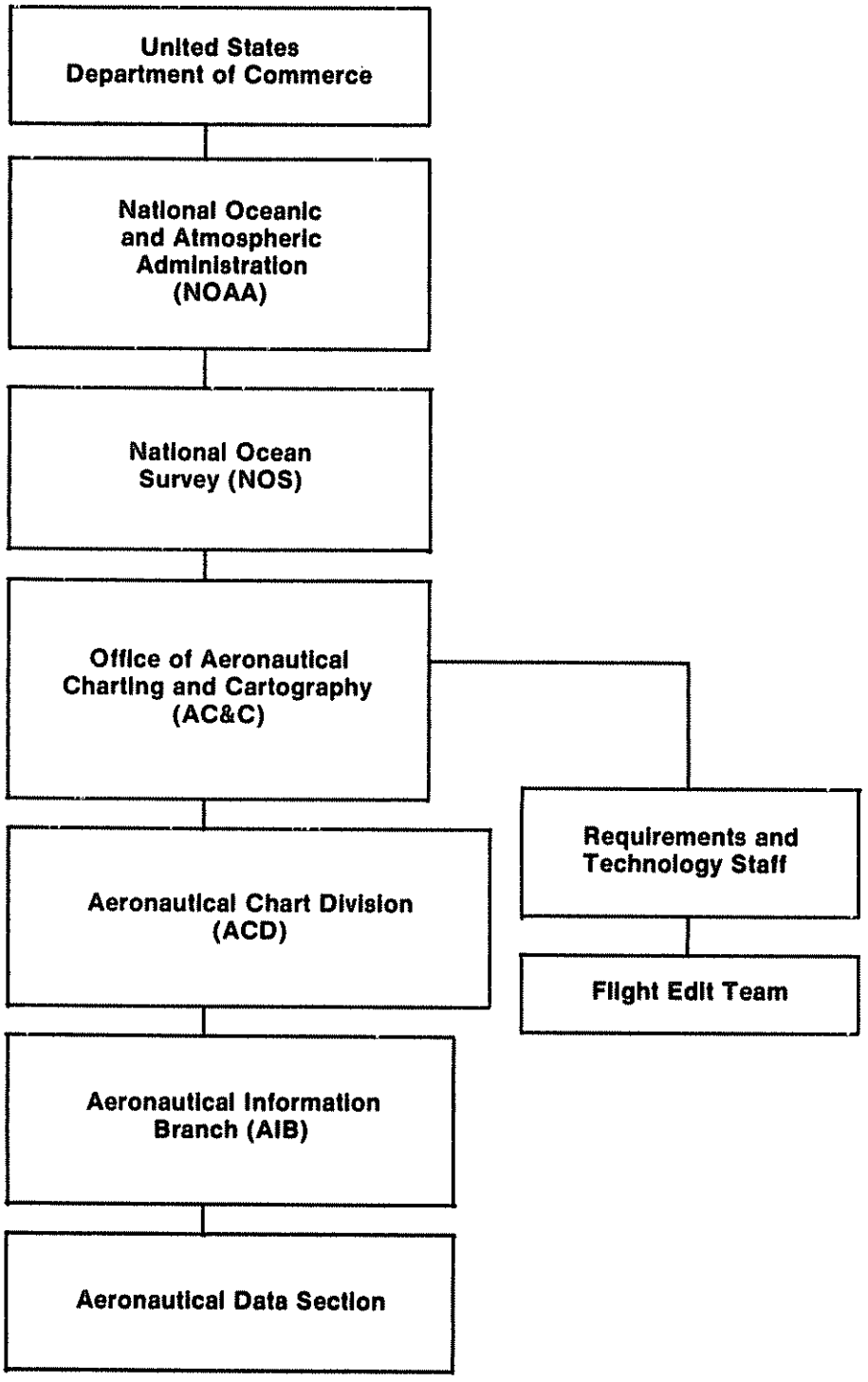


Diagram 1. Organizational structure

"(5) Provide all obstacle data specified under the obstruction chart program, as well as determine the geographic position and elevation of all obstacles requested by the FAA".

Aeronautical Data Section

The Aeronautical Data Section's Hazards Group function may be very simply defined as the collection, verification, storage and dissemination of aeronautical obstruction data of the United States and its territories. While these data come from varied sources, processing standardizes the information into nine elements prior to data base entry. These elements consist of: (*a*) an identifying number; (*b*) unverified or verified classification; (*c*) nearest city to obstruction; (*d*) obstruction latitude/longitude (to the nearest second); (*e*) one-word description; (*f*) height above ground level (AGL); (*g*) mean sea level (MSL) elevation; (*h*) type of lighting (r-red, n-none, s-strobe); and (*i*) FAA study number. All unverified data are processed by asking the owner for verification of information on his respective aeronautical obstruction. Once this is accomplished the data are entered into the verified file.

The Aeronautical Data Section currently maintains an obstruction file containing over 40,000 obstructions. An elevation of the FAA National Flight Data Digest, NOS flight checks, notification of new obstacles from the Department of Defense, the Federal Communications Commission, the general public and other sources indicates that an additional 70,000 to 100,000 may exist within the United States. There are presently 5,531 aeronautical charts in a continuous state of revision and update that utilize the obstruction file data. Prior to 1979 these obstruction data were collected from the following sources:

The National Flight Data Digest (NFDD) produced by the National Flight Data Center, FAA;

Department of Commerce Form 76-10 (self-mailed) for obtaining data on construction, alteration and/or removal of obstacles;

Federal Communication Commission (FCC) list;

Telephone reports;

Letter reports;

The FAA study (Forms 7460-1, 2 and 11);

National geodetic surveys (NGS) horizontal control data (HCD) and Landmark for Charts change reports (LMCS);

NOS flight edit.

Verification of data received from these sources was based solely upon the integrity of the reporting individual and the methodology used to derive these data. In many cases, the reliability of the data was questionable at best and valid certification could be accomplished only by ground survey techniques. The unfeasibility of these techniques in terms of cost and manpower solicited valid certification for all but the most critical areas, such as obstructions penetrating the imaginary surface of aircraft terminal area facilities. With the constant expansion of the use of the nation's airways, and an increase in FAA accuracy requirements, it became necessary for the AC&C to develop methodology that would provide the user with more reliable obstruction data. To achieve this goal, the Photogrammetric Obstacle Verification Program was developed.

The Photogrammetric Obstacle Verification Programme

Purpose and scope

The purpose of the Photogrammetric Obstacle Verification Programme is to provide a cost-effective means for both identifying and certifying any new obstructions as well as validating positional and elevation data on obstructions currently known to exist.

Accordingly, the scope of the Programme is to provide obstruction data at a rate comparable to the expansion of the needs of the FAA and the general public, and will range from verification of obstruction data currently in the NOS Obstruction File to eventual identification and verification of every obstruction that presents a hazard to aeronautical navigation within the United States.

Development of the programme

The initial study to research the application of photogrammetry to obstruction height and position determination was performed by the Coastal Mapping Division, NOS, in co-operation with the Requirements and Technology staff of AC&C. This study explored the time-proven classical photogrammetric approach to height and position determination. In this approach, two overlapping vertical photographs of the area or object to be measured are taken from an aircraft and a stereo model is constructed. Through the use of conventional instrumentation techniques, the stereo model can be oriented to its true ground position and both horizontal and vertical measurements can be obtained for any point on the stereo model.

The camera used in this initial study was a Wild RC9. This conventional aerial mapping camera produces 9-inch (22.5-cm) negatives with a 6-inch (15-cm) focal length. The photographs were taken at altitudes varying from 6,000 to 9,000 feet (1,800 to 2,700 metres). The test data consisted of five obstructions which had both geographic positions and elevations determined by ground survey methods. The obstructions selected represented the three most common types of obstructions depicted on aeronautical charts: smokestacks, wide-based, open-faced steel towers and radio transmission towers. These obstructions varied in height from 200 to 700 feet (60 to 210 metres) above ground level (AGL). The data reduction (mensuration) was performed on a Zeiss C-8 stereoplanigraph, which is a universal first-order instrument specially designed for photogrammetric mensuration.

The results of this test confirmed that AGL elevations could be determined to within ± 10 feet (3 metres) of the surveyed elevation and that the ground positional accuracy would be dependent upon the accuracy of the ground control. It was immediately apparent that surveyed ground control for each obstruction would be too costly to obtain; therefore it was necessary to develop a more cost-effective method for obtaining the horizontal position. After thorough evaluation of available source material, it was determined that the most practical source for ground control was the United States Geological Survey (USGS) 1:24,000-scale quadrangle maps. Taking into account instrumentation and operator mensuration error, and the National Map Accuracy Standard (NMAS) error, the anticipated horizontal positional error would be ± 100 feet (± 30 meters).

As mentioned earlier, this initial test was conducted using a standard format aerial mapping camera and an aircraft modified specifically for photogrammetric missions. Since AC&C at this time did not possess this mission capability, the Requirements and Technology staff decided to investigate the possibility of equipping the Cessna C4 Skymaster (which was used for the AC&C visual flight edit missions) with a small-format camera to determine if the accuracies of the first test could be achieved. The camera selected for this test was a 70-mm Hasselblad camera and the same five obstructions were photographed at the same altitudes as in the previous test. It was immediately apparent that the small-format camera could not provide the necessary ground coverage for scaling to the USGS quadrangle maps.

Based on the results from these two tests, the Requirements and Technology staff realized that in order to implement a photogrammetric verification programme of the magnitude required by AC&C, it would first be necessary to acquire a standard aerial mapping camera possessing the metric qualities of the Wild RC9 camera that was used in the first test, and larger aircraft capable of accommodating such a camera. Secondly, it would be necessary to acquire a stereoplotter capable of meeting the desired mensuration accuracy requirements.

Equipment procurement and training

When the lease on the Cessna C4 Skymaster aircraft expired in August 1979, the Requirements and Technology staff was able to begin immediately the necessary procurement procedures for the lease of an aircraft capable of meeting the photogrammetric mission requirements. The aircraft selected was a Rockwell International Shrike Commander. This is a high-wing, multi-engine, high-performance aircraft and was custom-equipped with the following state-of-the-art navigational equipment: VHF, Omni-directional Range, UHF distance measuring equipment, Aera Navigational Computer, VHF communications equipment, Radar Beacon Transponder system and L/MF automatic direction finder. The aircraft was also equipped with a hydraulically operated camera hatch.

About the same time a Wild RC8 Automatic Film Camera equipped with a 6" Avigon lens cone was obtained on loan from the Coastal Mapping Division, NOS, and a Wild B8S aviograph stereoplotter was purchased from the Heerburg Instruments Inc., Heerbrugg, Switzerland.

Upon delivery of the Shrike Commander, the flight mission pilots received training from the Coastal Mapping Division photographers in the operational use of the Wild RC8 camera, and five cartographers from the Aeronautical Information Branch attended a two-week "crash" course in photogrammetric instrumentation techniques given by the Army Engineer School in Fort Belvoir, Virginia.

Accuracy testing

Before the operation could begin, it was necessary to test the total system methodology and operator performance. This testing was accomplished by photographing and measuring the same five obstructions that were measured by the Coastal Mapping Division in the initial photogrammetric study. Each of the five newly trained operators was then required to set up each stereo model and measure each of the five surveyed obstructions. The purpose of this test was to determine if the horizontal and vertical positional data accuracies of the Coastal Mapping Division test could be obtained. The results were vertical accuracies within ±10 feet (± 3 meters) of the surveyed elevation and ± 100 feet (±30 meters) of the surveyed ground position, thus duplicating the accuracies of the Division's study.

Knowing that the system was capable of meeting the desired accuracy requirements, it was then necessary to develop an accuracy confidence level that could be applied to an overall coding system for each photogrammetrically measured obstruction. To develop this confidence level, a sample group of fifty surveyed obstructions located on or near the approach areas of Baltimore-Washington International; Hagerstown, Maryland; Martinsburg, West Virginia; Salisbury, Maryland; and Dulles International airports were photographed at altitudes ranging from 4,000 to 8,000 feet (1,200 to 2,400 metres). The respective stereo models were constructed on the B8S stereoplotter and leveled to within ± 1.0 foot (± 30 cm) of the surveyed ground control plotted on the respective 1:10,000-scale NOS airport obstruction charts (OCs). Each of the five operators was then instructed to measure and record the position and elevation of each of the selected obstructions.

Computation of standard deviation based on the normal distribution revealed a total system/operator mean standard vertical error of ± 15 feet (± 4.5 metres) at the 90 per cent confidence level.

The horizontal error at plotting scale was ± 1/50 inch (.05 cm). The source map errors were then determined as follows:

$$\textit{Horizontal error (in feet)} = \pm (K1 \times V1 \times K2)$$

Where: $K1 = 1/50$, $K2 = 1/12$, *and* $V1 = Scale/1.0$

$$\textit{Vertical error (in feet)} = \pm (K3 \times C1)$$

Where: $K3 = 1/2$, *and* $C1 =$ *contour interval*

(Probability is equal to 90 per cent.)

Combining the system/operator error with the source map errors, the overall system error per any obstruction measured could be computed as follows:

$$\textit{Horizontal accuracy} = \sqrt{(\textit{Source horizontal accuracy})^2 + (\textit{System/Operator accuracy})^2}$$

$$\textit{System/Operator horizontal accuracy} = \pm (1/50'')^* (\textit{map scale}) (1/12)$$

$$\textit{Vertical accuracy} = \sqrt{(\textit{Source vertical accuracy})^2 + (\textit{System/Operator accuracy})^2}$$

$$\textit{System/Operator vertical accuracy} = (\pm 15')^*$$

A coding assignment based upon these computed error factors is currently carried by each photogrammetrically verified obstruction. The following table depicts these codes:

Horizontal		*Vertical*	
Code	*Tolerance*	*Code*	*Tolerance*
1	± 15 (5 meters)	A	± 3 (1 meter)
2	± 50 (15 meters)	B	± 10 (3 meters)
3	± 100 (30 meters)	C	± 20 (6 meters)
4	± 250 (75 meters)	D	± 50 (15 meters)
5	± 500 (150 meters)	E	± 125 (38 meters)
6	± 1000 (300 meters)	F	± 250 (75 meters)
		G	± 500 (150 meters)
		H	± 1000 (300 meters)

For example, an obstruction measured using a 1:24,000-scale quadrangle map with a 10-foot (3-metre)

*Current oper./system accuracy to 90 per cent level.

contour interval as the source would have its accuracy code computed as follows:

Source horizontal accuracy =

$$\pm \left(\frac{1}{50} \times 24{,}000 \times \frac{1}{12}\right) = \pm 40 \text{ feet (absolute 80 feet)}$$

Source vertical accuracy =

$$\pm \left(\frac{1}{2} \times 10\right) = \pm 5 \text{ feet (absolute 10 feet)}$$

System/operator horizontal accuracy =

$$\pm \left(\frac{1}{50} \times 24{,}000 \times \frac{1}{12}\right) = \pm 40 \text{ feet (absolute 80 feet)}$$

System/operator vertical accuracy = ± 15 feet (absolute 30 feet)

Horizontal accuracy = $\sqrt{(80)^2 + (80)^2} = 113$ feet

Vertical accuracy = $\sqrt{(10)^2 + (30)^2} = 32$ feet

These values are rounded down to the nearest value in the table (± 100 and ± 20, respectively) to give us an accuracy code of 3C.

Present Operation

The present photogrammetric operation consists of three operational phases:

Flight mission planning;

Flight edit photo mission;

Photogrammetric data reduction and mensuration.

Following is a narrative description of each of these three phases.

Flight mission planning

The photo mission planning is performed by a senior cartographer within AC&C who serves as liaison between the Flight Edit Team and the Obstacle Verification Unit. Prior to each photo mission, the flight planner furnishes to the chief pilot of the Flight Team a 1:500,000-scale plot oriented to the Sectional Aeronautical Chart covering the geographical area that is scheduled for the flight edit. This plot contains all obstructions presently depicted on the aeronautical chart as well as those obstructions that have been reported but are currently unverified. The flight mission planner also furnishes information concerning the optimum flight altitude, sun angles, foliage obscuration, terrain and aircraft heading that will assure adequate horizontal and vertical control of the resultant photography. Also, prior to each photo mission, the flight mission planner co-ordinates with other branches within AC&C and includes on the flight edit plot any areas of interest that would require photographic verification.

Flight edit photo mission

The flight edit photo mission is accomplished by the AC&C Flight Edit Team, which is composed of three members of the NOAA Commissioned Officer Corps. The Flight Team, using the flight edit sectional chart plot, along with other data supplied by the flight mission planner, photographs as many of the requested obstructions covering the Sectional Chart area as time and weather will permit. If any new obstructions are noted during the visual flight edit, they are also photographed and the approximate positions are annotated on the flight edit plot. For individual obstructions, three photographs, overlapping each other by approximately 60 per cent (stereo-triplet) are sufficient. In built-up areas, such as large cities or industrial complexes, overlapping flight lines consisting of up to 20 or more exposures may be necessary.

Once a roll of aerial film has been completely exposed, it is mailed from the field directly to the Imagery Processing Laboratory in the Main Commerce Building, Washington, D.C. The negative film is immediately processed and forwarded to the flight operations planner for evaluation. If the negatives are of questionable quality due to improper exposure, camera vacuum failure, or other reasons, the Flight Edit Team is immediately contacted and recommendations are made to correct the problem. If the negatives are acceptable, paper prints and film diapositives are ordered and placed in an active file to await photogrammetric mensuration.

Photogrammetric data reduction and mensuration

The data reduction process begins with photo indexing. Once the paper prints and diapositives are received from the Imagery Processing Laboratory, the individual photo coverage is plotted onto the respective USGS quadrangle maps, and a corrected camera altitude is computed for each pass, based upon distance between corresponding points on both the photo and the map source. The photos and their respective source maps are then filed by mission and pass to await further processing.

It was apparent to the Requirements and Technology staff that the AC&C Photogrammetric Obstacle Verification Programme, unlike normal photogrammetric map compilation, would possess none of the immediately obvious analog error checks, such as visual orientation of linear features or the matching of topography to a previously compiled source. Also, since most obstructions to be measured are unverified and lack surveyed ground control, the measurement accuracies would be solely dependent upon the mathematical accuracies obtained by the operator during setup procedure, and the accuracy of the 1:24,000-scale USGS source map. In order to minimize measurement ambiguities between the individual operator setups and standardize all mathematical calculations, a "menu type" FORTRAN programme was developed. This programme eventually evolved into a multi-purpose quality control tool that performs the following operations:

Instructs operators in all phases of stereomodel setup;

Performs all mathematical calculations;

Provides quality control of model setup and mensuration;

Provides for storage and retrieval of all stereomodel and obstruction mensuration data.

In essence, this programme provides for a semi-analytical approach to the analog model setup procedure.

There are currently eight cartographers within the Aeronautical Information Branch who have received sufficient training to perform the obstacle mensuration. In order to maintain individual operator proficiencies, as well as reduce the "boredom factor" sometimes associated with work of this nature, these personnel are rotated on a bi-weekly basis. As a result of this rotation and the semi-analytical approach to model setup procedure, the mensuration time has decreased from 3.3 to 1.5 man-hours per obstruction since production began in June 1979.

Conclusions

The Photogrammetric Obstacle Verification Programme became totally operational on June 6, 1979,

after approximately 12 months of research and development. Over 200 obstructions were verified photogrammetrically in the first four months and it is anticipated that the monthly verification rate will eventually exceed 100. A programme of this particular scope in terms of accuracy requirements and volume of data has not been undertaken by any other mapping agency of the United States Government. So it is difficult to evaluate the total cost-effectiveness based upon a few short months of implementation. The Programme is, however, currently providing accurate and reliable obstruction data that could not be collected by any other means. In terms of air safety, the relatively small investment in equipment and manpower has yielded a substantial return.

AERONAUTICAL CHART AUTOMATION: CONCEPT AND STATUS*

Paper presented by the United States of America

RÉSUMÉ

Les cartes aéronautiques établies par le National Ocean Survey (Service océanographique national) de l'Administration nationale de l'océan et de l'atmosphère servent à l'aviation civile des Etats-Unis d'Amérique, y compris un grand nombre d'utilisateurs indépendants d'avions privés, d'entreprise et commerciaux. Ces dernières années, on fait de plus en plus appel au système aérospatial national des Etats-Unis; on utilise des types d'avions de plus en plus perfectionnés et de nouveaux instruments d'aide à la navigation, tant aéroportés qu'au sol, et les règlements et procédures de contrôle du trafic aérien deviennent de plus en plus complexes, ce qui a d'importantes incidences en ce qui concerne l'établissement et le maintien à jour des cartes aéronautiques essentielles à la sécurité aérienne. Pour répondre à cette tâche, le Service a recours à une technique informatique perfectionnée et cherche à augmenter le rendement du personnel en mettant au point un système d'établissement informatisé de cartes aéronautiques afin de pouvoir faire face au volume de travail accru.

Le 20 décembre 1978, un contrat a été passé avec la Synectics Corporation de Fairfax (Virginie) portant sur un projet de cinq ans concernant la conception d'ensemble, la mise au point et la mise en application de l'Aeronautical Charting Automated Production System. Pour établir une conception d'ensemble du système, on a mis au point un logiciel de programmation par paramètres pour assurer les services suivants : vérification des données, extraction des données, définition des symboles, accès à une base de données, description sur graphique de la carte, édition cartographique interactive et production de calques de haute qualité. Une conception orientée vers le logiciel, alliée à une méthode pragmatique « descendante » permettra 1) de mettre au point un logiciel normal tout en mettant à profit les améliorations en matière de matériel qui devraient intervenir au cours des deux ou trois premières années du projet et 2) d'assurer au maximum la normalisation et la transférabilité du logiciel. Pour assurer tout cela et pour tenir compte des facteurs humains de façon optimale, le cocontractant a acquis et installé un matériel qu'il utilise expérimentalement avec le système de logiciel en évolution pour définir les problèmes et trouver des solutions. La méthode orientée vers le logiciel et l'utilisation expérimentale de programmes et de matériel en évolution permettent de concevoir et d'appliquer, dès les phases initiales du projet, toute une série de moyens informatisés pour étayer le processus de production manuel actuellement employé. Ces moyens permettent de répondre à des besoins essentiels de l'établissement de cartes tels que : établir une liste des données à modifier sur telle ou telle carte; présenter l'état des travaux; permettre aux utilisateurs l'accès à une base de données cartographiques centralisée et faire les calculs nécessaires.

The aeronautical charts produced by the National Ocean Survey (NOS), National Oceanic and Atmospheric Administration (NOAA), serve the needs of civil aviation of the United States, including many independent users in civilian, business and commercial aviation. In recent years, increased use of the United States National Airspace System, and more complex air traffic control regulations and procedures, have heavily impacted the task of producing and maintaining aeronautical charts vital to air safety. To meet this challenge, the NOS is turning to the use of advanced computer technology to increase productivity of existing personnel by developing a computer-assisted aeronautical chart production system to handle the increasing work-load requirement.

OBJECTIVE OF THE COMPUTER-ASSISTED SYSTEM

The objective of the project is to design, develop and implement a computer-assisted system in which the judgement and decision-making abilities of the profes-

*The original text of this paper, prepared by Dave Pendleton, National Ocean Survey of the National Oceanic and Atmospheric Administration, appeared as document E/CONF.72/L.3.

sional cartographer are incorporated into the production of the final cartographic products. Moreover, the system should significantly reduce the manual time-consuming functions of data acquisition, storage and retrieval; relate data to specific charts; allow cartographers to interactively manipulate data portrayal; eliminate or drastically reduce drafting; and produce separation overlays for finished charts, publications and tabulated data.

INFORMATION PROCESSING WORK REQUIREMENTS

The fundamental activity common to all aspects of the manual production of aeronautical charts is the processing of data received from external sources. A major task during the initial system design period has been in finding efficient ways to eliminate redundant handling of data/information elements to narrow the resource/work-load gap. Methods of combining ease and speed of data accessibility with techniques of automatically relating data to cartographic products for production personnel who have use for it have been defined in the first stage of system development.

The information processing activities were found to consist of:

Data collection;

Data verification and editing;

Data validation and resolution of cartographic questions of data inconsistencies;

Archival retention of data;

Graphic interpretation and transformation of data in order to meet the requirements and intent of official specifications.

Analysis of each of these major manual activities revealed that the new system must address the following design features:

(*a*) Provide a centralized data repository easily accessible to all components of the organization;

(*b*) Eliminate redundant data handling across all components of the organization;

(*c*) Provide for data interpretation to adhere to official specifications and then conversion of the data to a graphic base in an accurate and consistent manner independently of the cartographic personnel involved;

(*d*) Insure accurate and consistent portrayal of data in overlapping areas between products and across product lines;

(*e*) Provide various labour-saving aids for specified high-payoff work areas to increase cartographic productivity.

These findings have been used to generate a system concept that provides for these factors in addition to the automated graphic display and plotting features conventionally found in automated cartographic systems.

ALTERNATIVE APPROACHES CONSIDERED

Several alternative methods of addressing the information processing requirements were considered:

1. The use of line-following digitizing equipment to store and update automated chart products as files of digital codes to represent points, lines, circles and other graphic primitives.

This approach was rejected owing to the excessive cost in time and human resources necessary to create and maintain a digitized, or "spaghetti file", type of data base. This approach was estimated to cost two and one half times the cost of the other alternatives. Just as importantly, it did not fulfill the information processing work requirements in that it could not relate data to products and would automate the drafting process only—a process which does not consume a large part of the present manual resources.

2. The use of a traditional Data Base Management System (DBMS) software package such as TOTAL, System 2000 etc.

This approach was rejected because its generality made it unsuited to the full scope of the cartographic problem. The benefits associated with a reduction in required software development were more than offset by the capital expenditure for acquisition of the package and the need to develop customized application programs to make full use of the DBMS in a production cartographic environment. The total cost of this approach offered no cost advantage over the selected approach.

3. The development of individual stand-alone automated systems for each product.

This approach was considered to be excessively fragmented from a system design point of view. The approach would generate interfacing problems, create unnecessary duplication of effort and proliferate hardware requirements. It did address the unique aspects of the cartographic problem, but would incur expenses out of proportion to the benefits produced while requiring an excessive number of computer personnel to co-ordinate and maintain the individual product systems generated. The cost of this approach was found to be one and three quarters the cost of the selected alternative.

4. The centralized data base approach.

This alternative was selected and contains some features of all of the above, but differs in the way in which the overall system design is assembled as well as tailored to meet the unique requirements of the cartographic production cycle. It satisfies all of the work requirements and contains a centralized data base subsystem including significant customized data verification, extraction and graphic depiction features. Its investment costs are comparable with the last two alternatives discussed and it represents the lowest net present value cost. The software investment is large, but no larger than that required for the tailoring needed to fit a commercial DBMS to the unique requirements of the cartographic problem. The approach satisfies two very important system design criteria: modularity and relative hardware independence. The planned step-by-step implementation allows systematic development and consolidation of the system in a unified and complete status at each level of development. As each subsystem is made operational, development can continue at each stage, or stop as resources allow. Benefits are accrued incrementally as each subsystem module is added, and the savings necessary to accommodate the increasing work-load is realized as subsystems achieve production status.

SYSTEM CONCEPT

Before discussing the manner in which the system is envisioned to function, it is important that the system components and their roles are understood. Refer to figure 97.

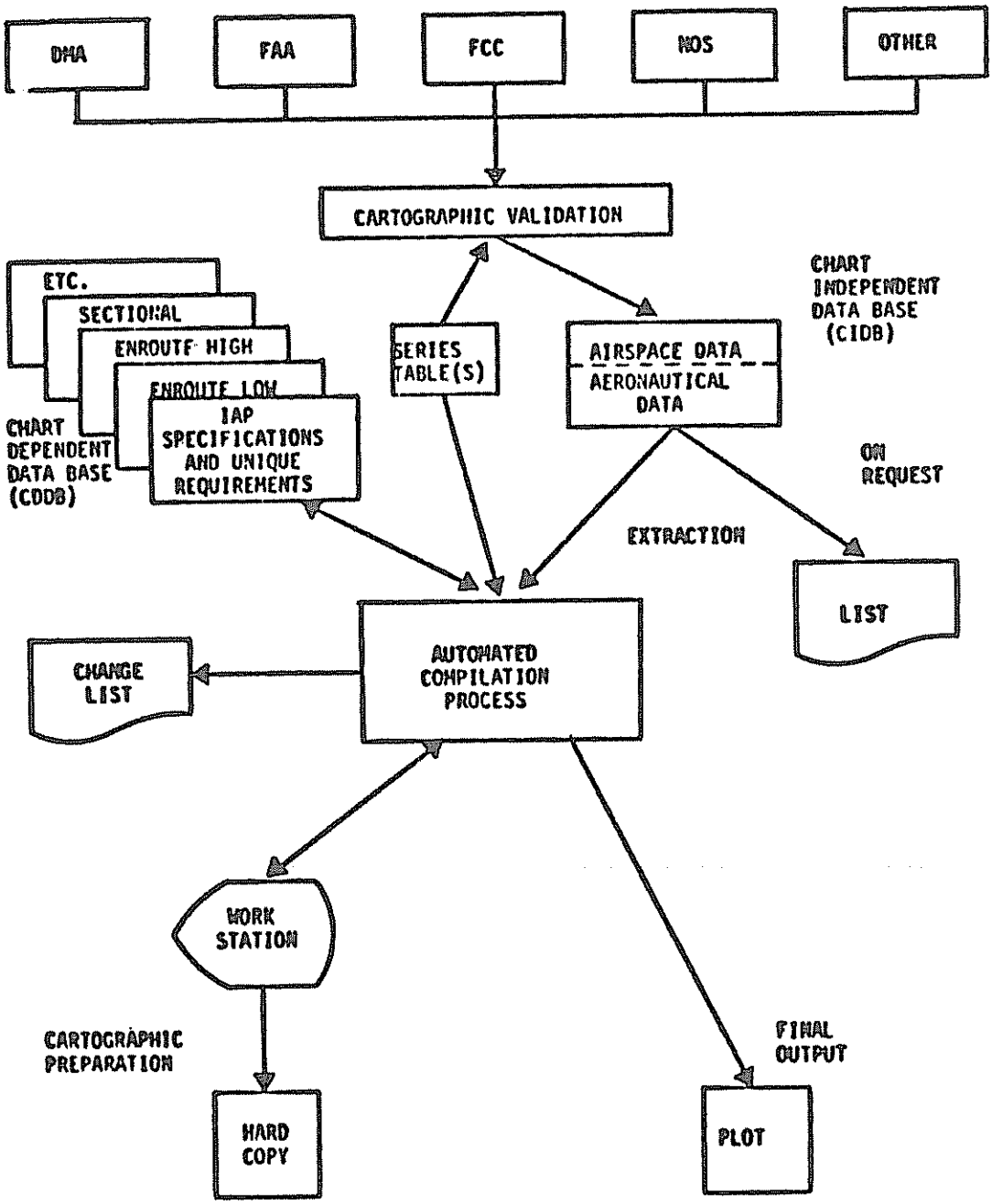


Figure 97. United States of America: system concept block diagram

Chart Independent Data Base (CIDB)

The CIDB contains information that potentially applies to all charts or publications. The data in the CIDB describe physical objects (such as navaids, obstacles, runways etc.) and defined objects (such as intersections, airspace, procedures etc.). (All ground-locatable data will carry their latitude and longitude in the CIDB.) Data can be proposed or real, and unreviewed or reviewed. By default, CIDB functions use real reviewed data. The CIDB comprises part of the United States Federal Aviation Administration's (FAA's) automated data base, the NOS data files and existing special-use data files. It is contemplated that CIDB functions will support most of the files used by the automated production system. The major functional components of the CIDB are:

Query;

Data element dictionary;

File management;

Maintenance.

The CIDB will be accessible by cartographic users and by the system's software programs. The cartographer will access all CIDB data by the use of Query. Query will be performed by either using a menu descent method or explicitly defining the data elements. The data in the CIDB will be down-dated (archived) data, current data and future (not yet effective) data. Specified data base maintenance personnel will be able to add, delete or modify data elements contained in the CIDB. These actions will be subject to the user's security level and to the nature of the data elements. Whenever CIDB data elements are changed the old data will be down-dated and archived in the CIDB.

These actions will not actually destroy the old data, they will only archive it. All data changes will be subject to the verification rules (in the series table) that apply to them.

The Data Element Dictionary (DED) will be used to describe, access, and interpret information in all system file records. This information will be used when an access program is extracting the value of the element from a record or placing a value into an element in a record. In order to describe all current and future data elements, the DED will allow new definitions to be added.

The definition of an element in the record describes the element's length, location, units, verification rules, identification and other real descriptive data. A file directory will be maintained by keeping a table of files to facilitate the addition and deletion of files as needed. The Open/Close File commands allow system access to files as a user application rather than a hardware-manufacturer-dependent interface. The file management function is intended to write a track at a time and, if needed, expand the file.

Maintenance functions will be needed in the system to keep the data base current, because data base records will change in time. Publication cycles for the various chart products differ, making it necessary to access and store all data by effective date. Past, present and future data for the same element must be accessible by the same function.

Chart Dependent Data Base (CDDB)

The Chart Dependent Data Base contains data related exclusively to specific charts, such as:

The corner co-ordinates or the boundaries of the charts;

The publication cycle information that the chart subtends, for example, its effective date, its expiration date and the cut-off date for the chart; these elements are relevant in terms of what information is going on that chart;

The requirements for the projection tick marks on that chart;

Exception files containing cartographic amendments to automatic pre-compilation decisions;

The requirements for the legend on that chart;

The scale of the chart;

A pointer to the series table(s) which defines the series to which the chart belongs.

The CDDB and CIDB share the same software file access methods, maintenance functions and file management functions. The CDDB function also encompasses the maintenance of a chart and chart insert directory which allows an exception list and chart-dependent graphics to be associated with the charts.

Automated compilation process

Automated chart compilation is obtained by the activities of system software components which use the CIDB, CDDB, and series tables to produce a graphic display of a chart. These major software components are Graphics Edit, TAC, TAOS and Chart Dependent Graphics.

The Graphics Edit component allows users at cartographic work-stations to display and modify charts; users will access, add, delete, restore and modify chart text and symbols via a graphics display at the user work station. Graphics edit actions will be subject to the user's security level and applicable verification rules. To access or modify graphics, the Graphics Edit component permits the compiler to successively descend (by repetitive pointing) from groups of symbols (e.g. a whole air route) to graphic primatives (e.g. lines, text and circles) using visual feedback provided on the graphics display device (e.g. highlight or blink) to verify cartographic intent.

The basic symbol modifications consist of moves and rotates. Compass roses may be expanded or shrunk. In specific cases the end-points of air routes may be clipped. Text leading and character spacing may be adjusted. Some symbols (compass roses) may have sections blanked (erased) from them. Symbol modifications will be stored in the CDDB by the system (as exceptions). The cartographer will also be able to zoom in on specific chart areas for detailed examination.

The Graphics Edit component is intended to interface to a graphics display terminal with refresh capabilities so that the cartographer will receive visual feedback to immediately confirm cartographic intent.

Series table/TAC/TAOS

A series table is a computer-readable set of user-defined rules that govern the system's data verification, data extraction and limited automated chart compilation capabilities. Users will create series tables with the aid of a series table generator program. This generator program acts as an interface between the internal storage format of the rule, the Table Activated Commands (TAC) and the user. This interface will allow the user

to select general commands from a menu, respond to interactive prompting programs, and define depiction criteria using chart-based examples. A series table is stored as a system file; its presence is made known to the system by recording it in the series table file which is processed by the Table Activated Operating System (TAOS), a program which implements files of Table Activated Commands.

The software required to implement the series table concept will be developed in a modular fashion. That is, it is possible to independently develop the TAC rules and TAOS driver components which support any combination of verification, extraction and chart compilation functions. Furthermore, anticipated software overlay of these functions should make it easier to develop subsequent functions based upon the initial development of any of the required functions.

In terms of production subsystem modularity, only those portions of the series table required for each product subsystem need to be implemented to support that product subsystem.

Chart Dependent Graphics

The Chart Dependent Graphics (CDG) function will allow the cartographer to construct text and graphics that do not have any sources in the CIDB. The user interfaces with the CDG graphics capabilities via a menu. The menu contains graphic primatives, fonts, depiction parameters and commands.

Publications

The publications function allows users to generate (extract from CIDB), edit and format publications and other text products or job aids (e.g. text waxups). The publication function will interface with and contribute working software to the CIDB, CDDB, and Series Table functional components. The capabilities achieved by implementing this subsystem include:

(*a*) Publication capabilities;

(*b*) Text editing/formatting;

(*c*) Report generation;

(*d*) Automatic updating of publications containing CIDB information (analogous to chart updating);

(*e*) Support of product indexes;

(*f*) Support of data base subsystem architecture (transportable software);

(*g*) Support of job aids including text waxups, tabs etc.

The devices with which the publication function must interface are: the final output device, a proof printer, a photo-typesetter and the graphics display terminal keyboard located at the user's work station.

System utilities

System utilities are, in general, device drivers. These drivers are isolated device-dependent functions which interface between the output devices and the main-line system tasks. These drivers are an independent (modular) function of the system. The capabilities realized by isolating the drivers are:

(*a*) To ensure output device independence;

(*b*) To facilitate a software-driven approach;

(*c*) To achieve modular expandability.

Application utilities

The application utilities differ from system utilities in that the system utilities represent independent tasks each responsible for an output device, whereas application utilities relate to work-station tasks accessible as user functions. Examples of these types of functions are distance/bearing calculations, slope calculations and mapping projections. A primary consideration in designing these utilities is the user interface. Particular attention will be paid to making the utilities easy to operate.

Vendor interfaces

The intent of this function is to make the software created on the developmental hardware as machine-independent as possible. Vendor interfaced functions are those functions which, when converted to software in the detailed design, will not be machine transportable. In general, these functions may include:

(*a*) Multi-tasking capabilities;

(*b*) Machine language peculiarities;

(*c*) Clock/date services;

(*d*) Machine and operating system specific tasks.

While none of these capabilities forms an integral portion of the concept, they cannot be wholly avoided during software development. Whenever it is determined to be cost-effective, functions that would traditionally be categorized as vendor interfaces will be incorporated into systems utilities. Conscious attempts will be made to limit vendor dependencies to a "universal" subset. Software design will attempt to isolate and modularize further the vendor interfaces, but the final interface functions cannot be fully defined until final hardware selection occurs.

Definition of hardware functions

Figure 98 depicts generic hardware components and the broad-based information flow of the system. Since the detailed system design stage of the project is just beginning, no attempt is made here to describe the hardware components in terms of specifications, quantities or exact configuration. This information will be available after the system design state is completed. Achieving the highest attainable degree of hardware independence will allow specifying and choosing the final hardware from the broadest possible range of available state-of-the-art components.

A number of general purpose minicomputers, in combination with work station components, will support cartographers at graphics work stations and at data entry terminals for data collection, data verification, preparation of initial chart compilations, revision and review of initial compilation and the production of plotter control tapes which are used to produce final separation overlays. Other functions of the minicomputer systems include processing of data base updates, transaction edits, management activities and various overhead requirements. Communications, as well as management and operations interfacing, will be supported.

Rotating disk memories will function as on-line storage devices for the chart-related data bases, system and applications software and management, work, transaction and display files.

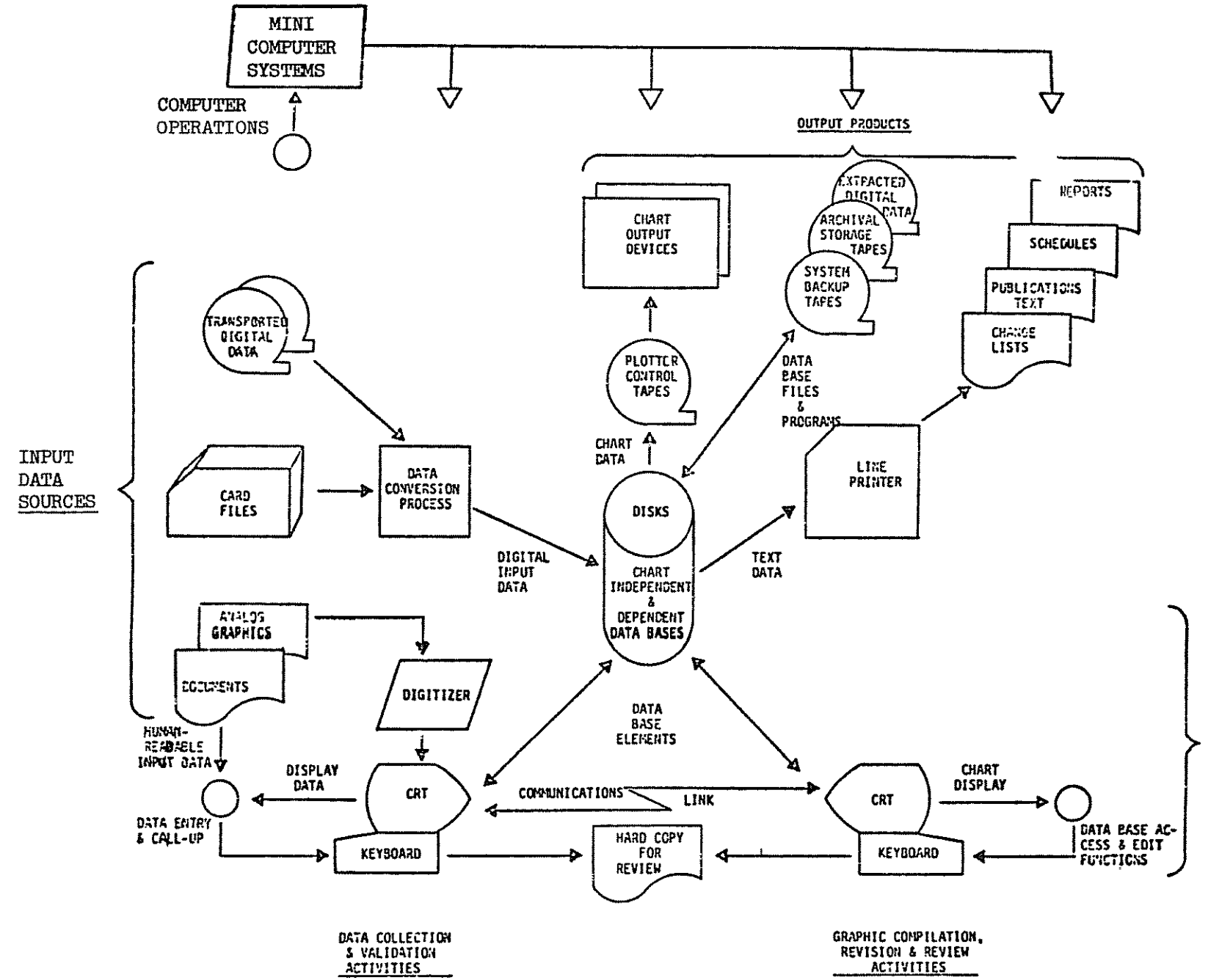


Figure 98. United States of America: ACAPS hardware functions

Magnetic tapes will function as off-line repositories for system backup and archival data. They also represent one means of transporting remote digital data to the system for input, providing system-produced chart data to remote chart output devices, and holding data base extracts for transmittal to other agencies. These devices will translate the digital data into chart overlays.

Printers, printer/plotters, and plotters will provide hard-copy output in both graphic and textual formats. The graphic output will allow immediate review of chart construction progress, while textual output will provide change lists, publications text review and various reports and schedules.

Digitizers will allow the cartographer a graphic means of entering positional data into the current chart construction work files.

Message transmissions among work station, management and operation terminals will be provided by communications links.

System function

The following highlights the manner in which the system is envisioned to function as shown in figure 98.

Airspace, aeronautical, and pure textual information are entered into the system manually on-line, and in machine-readable form. Airspace data are geometric point designators and attributes that define (or update) routes, boundaries, zones and transition areas within three-dimensional airspace. Aeronautical data represent the physical entities (or changes to them) of the United States National Airspace System, such as navigation radio aids, airports, obstructions and supplementary data related to all of them. All of these data are real-world data which undergo verification by being passed against the appropriate series table (for each data element) editing commands. The data must still be visually reviewed and approved by cartographic personnel, who use various review job aids (e.g., lists, plots, and soft-copy displays) for cartographic validation before authorizing the data for use on chart products. Reviewed and unreviewed data will be available for access by all system users. The system will support one other category of data, that is, proposed data. Proposed data are data that can, at some future point, be used on chart products. The use of the proposed data is restricted solely to use for planning purposes and for such tasks as conducting airspace calculations and determining the effects (upon routes, etc.) of proposed airspace changes. Each data element in the CIDB has associated with it an "effective date" for its use. As new data supersede the old, the affected data are archived, thus maintaining a complete audit trail for each data element. Access to data in the data base is through a series table that defines access, extraction, update etc., parameters for the data element. Typical CIDB reports that will be available from the data base will be listings of data base elements, data logs and audit trails.

Chart-dependent data appearing in the CDDB are data that apply to a single chart (or chart series) and characterize the chart in terms of which data elements of chart-independent data apply to a specific chart and how such data are to be represented graphically. Basic information contained in the CDDB includes chart characteristics such as latitude and longitude corner coordinates, scale, symbology, primary geographically oriented text position and color attributes. Additional information will include positioning of text, position and content of all borders and panel information, air routes on the chart and depiction rules, together with a list of any non-chartables and exceptions for the chart. The data in the CDDB are chart-specific and are supported by a series table that defines the rules for the chart's compilation. The CDDB works in conjunction with CIDB for compiling new chart products and for automatically maintaining and updating existing charts included in the ACD's production cycle.

The system will automatically schedule charts that are due for work. Scheduling aids will include product-by-product change lists, work in process, and work completion reports and in some cases, the actual production schedule. When the cartographer sits down at the work station to update a chart, he will not be required to define fonts, graphic content, colour etc. The system will automatically perform such functions. The cartographer will direct the system to generate chart depictions and then will make cartographic decisions for their best placement, using the display on the graphics terminal. He will work through a detailed up-to-the-minute change list and will confirm each depiction and/or correct it for best cartographic presentation.

When the cartographer completes the update, the resulting graphic depiction is placed into a queue and scheduled for review. The reviewer will not be allowed to make any changes. The reviewer will be directed through every change the cartographer has made, and will be allowed to leave notes (stored by the system) for the cartographer when he disagrees with any depiction. The chart is then rescheduled for additional work for completion. The cartographer then makes any appropriate changes to the graphic depiction as suggested by the reviewer and/or resolves any differences with the reviewer. When agreement is reached, the depiction is signed off by the reviewer and is ready for final chart output, which will consist of producing camera-ready copy for the charts using the final output device.

During the chart's work in process, job aids, such as hard copy proof aids, will be made available to the users as they are required. Errors detected in data either by the cartographer or by the reviewer, during the chart's work in process, will be brought to the attention of data store management personnel in a timely fashion.

Charts are scheduled for work based on the amount of work reflected by the change list. That is, if a change list for a chart contains changes sufficient to warrant work, the chart is automatically scheduled by the system. This decision process will be a part of the Data Base Subsystem. The management and scheduling functions will be implemented for a product subsystem when it is made operational.

STATUS OF THE PROJECT

Project plan

Figure 99 summarizes the system development plan currently in effect. The plan shows initial use of a developmental hardware system for design, software development, and data base development activities. This system is a Perkin-Elmer (interdata) 8/32 minicomputer with 768 K bytes of central memory and two 80 million byte rotating disk units. The Data Base Subsystem is scheduled to be developed and operational on this computer system in 1981.

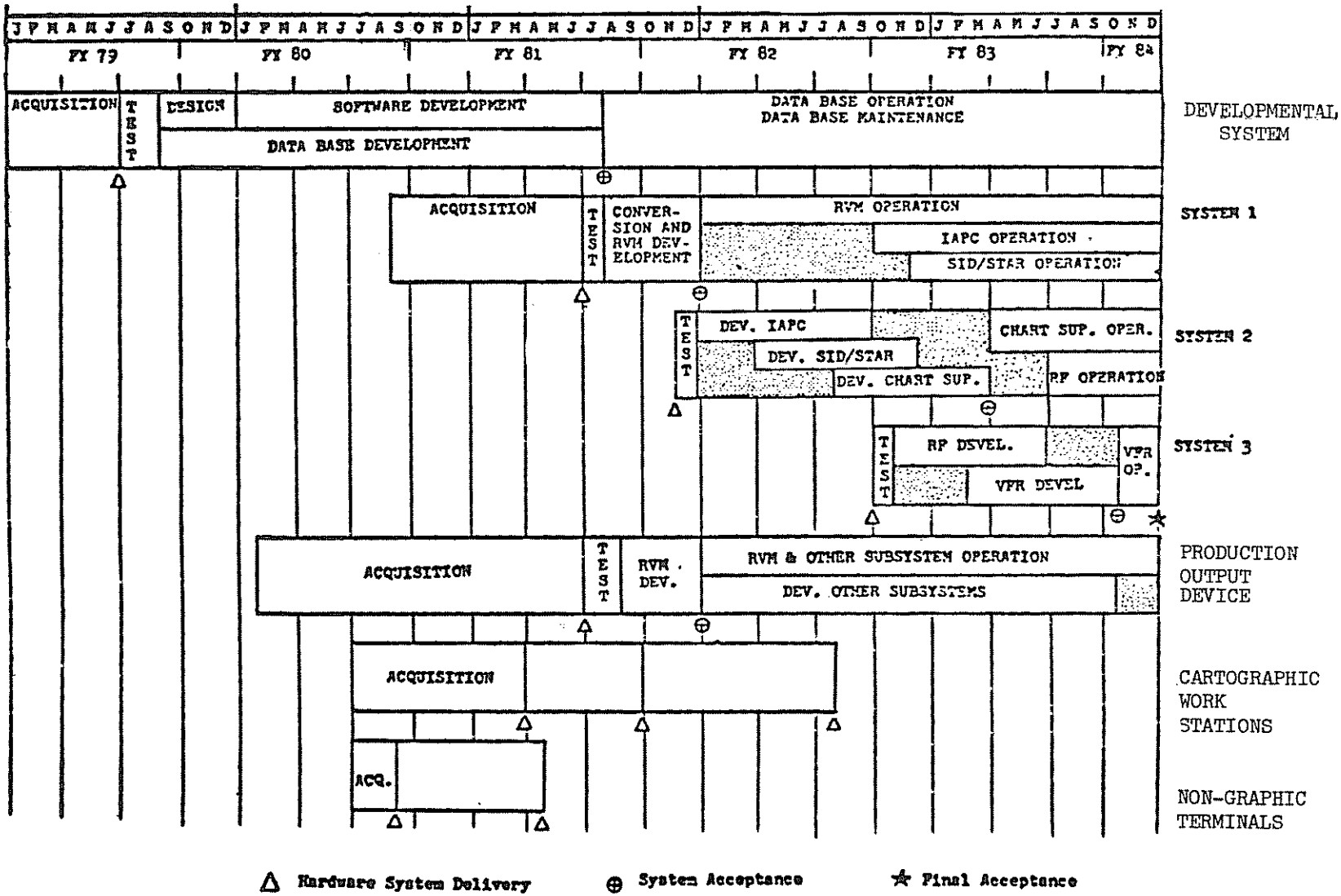


Figure 99. United States of America: system development plan

During 1981, the delivery and installation of the System 1 minicomputer of the final hardware configuration will be accomplished. After hardware testing and acceptance is complete, the previously developed system software will be converted to the new computer and development for the first application subsystem will be initiated. Thereafter, Systems 2 and 3 will be installed and utilized for development and operational use as shown. There is a rationale for shifting application subsystems, e.g., the Instrument Approach Procedure Chart (IAPC) subsystem, from System 2 to System 1, as operational status is achieved for each subsystem. This procedure will be used to eliminate the conflicts associated with performing continued software development and operational production operations on the same minicomputer configuration simultaneously.

The production output device or final plotter, cartographic work stations and non-graphic alphanumeric data terminals will be phased in as shown. The production output device will be a high-technology, ultra-high-resolution Computer Output Microfilm (COM) or Electron Beam Recorder (ERB) plotter. The cartographic work stations will include the interactive graphics display terminals with keyboards, joystick, light pens etc., to allow manipulation of the displayed image.

Progress to date

At this writing, the contractor has just completed the system concept document. The next major stages of activity will be a detailed system design and data base development. It is at this stage of system development that the specifics of hardware and software components will become defined. Subsequent papers regarding the development of this system will be provided in order to track the progress of the development of this major automated cartographic production system.

A PHOTOMECHANICAL METHOD OF BLACK-AND-WHITE IMAGE ENHANCEMENT*

Paper presented by the United States of America

On sait depuis longtemps, en cartographie, que le contraste ou la densité de l'image de base manquent d'homogénéité en raison des conditions atmosphériques locales, de l'angle des rayons solaires et de la différence existant entre les détails mêmes du terrain. Ces facteurs se traduisent par un large éventail de contrastes et de densités sur un même négatif ou une même série d'images. Jusqu'à présent, du fait de l'état des techniques, il n'était possible de reproduire les images qu'à un niveau donné de contraste (c'est-à-dire le compromis le plus heureux) pour l'ensemble du négatif. Les différences de densité importantes pouvaient être compensées au moyen des techniques d'impression bien connues Log-E-tronics[1].

Un procédé photomécanique de réglage automatique fin et localisé des contrastes aux fins des systèmes d'impression photographique a été mis au point et breveté. Ce procédé permet d'ajuster le contraste ainsi que la densité dans chaque zone particulière et d'imprimer les diverses zones avec le degré d'accentuation idéal pour les besoins de l'utilisateur aux fins d'une opération cartographique donnée. Cette opération peut consister en une fonction de corrélation automatique exigeant un rapport signal/bruit particulier ou en une tâche manuelle nécessitant des densités ou contrastes différents pour différentes fins. Il est ainsi possible d'obtenir un produit présentant la qualité idéale dans chacune des zones du négatif, qu'il s'agisse d'ombres, de forêts, de surfaces cultivées, d'un rivage, de montagnes, de cours d'eau, d'un voile nuageux, etc. On peut amener les zones de tonalité amoindrie aux degrés de contraste et de densité du terrain environnant. Cela vaut particulièrement pour les hautes latitudes nord ou sud sous lesquelles l'obliquité marquée des rayons solaires accentue fortement les ombres et les parties éclairées dans les régions montagneuses. Ces zones sombres ou illuminées peuvent être normalisés et harmonisées dans certaines limites. Cette technique d'impression permet également de normaliser les différences fondamentales de contraste et de densité entre certains détails de terrain (dont les facteurs de réflexion sont différents).

Le but de ce procédé photomécanique est de tirer pleinement parti des produits photosensibles existant dans le commerce et de tous autres produits susceptibles d'être mis au point qui font appel aux techniques de variation gamma tels que les produits Varigam de Dupont et Polycontrast d'Eastman Kodak. Il s'agit d'émulsions réagissant par divers degrés de contraste selon la couleur de la lumière utilisée pour les exposer, ce qui permet d'obtenir un large éventail de contrastes dans un même produit photographique. On peut également moduler l'intensité de la couleur choisie pour obtenir le niveau de densité souhaité. On peut obtenir un résultat optimal en faisant varier de façon sélective la couleur et l'intensité de la lumière d'exposition sur un même cliché, ce qui permet d'accentuer les zones faiblement contrastées et d'atténuer les zones à fort contraste (lorsqu'on le désire), ainsi que de régler la densité.

Des résultats comparables ont été obtenus dans le passé dans une mesure limitée, en procédant à des expositions partielles successives de différentes durées, au moyen de différents filtres de couleur. Les premiers essais d'automatisation de cette technique ont été effectués au début des années 50 par Dwin R. Craig, mais ils se sont soldés par un échec pour diverses raisons. On estime que le nouveau procédé photomécanique élimine les faiblesses de la technique précédente; le secret du microréglage automatisé des contrastes réside dans le système d'analyse utilisé dans ce procédé. Auparavant, les images originales étaient analysées simultanément à travers l'original et le support vierge. La pellicule ou le papier produisaient un effet de diffusion sur l'énergie lumineuse incidente, et il n'était pas possible de déterminer la qualité et le niveau réels du contraste fin des images figurant sur l'original. Si l'on ne connaît pas les caractéristiques réelles de l'image

*The original text of this paper, prepared by Michael J. Kelly, Defense Mapping Agency, appeared as document E/CONF.72/L.5. The complete English text is contained in United States Patent No. 4,145,709 (of 20 March 1979), which was awarded to the author.

[1]La mention d'un produit commercial ne signifie pas qu'il a la caution du Gouvernement des Etats-Unis.

originale, il n'est pas possible de déterminer les conditions d'exposition voulues pour obtenir un produit à contraste finement réglé. Une senseur chambre Vidicon ou autre capteur constitue le moyen d'analyse qui soumet les images originales à un prébalayage permettant de déterminer leur qualité réelle. Un tube à rayons cathodiques chromatiques effectue une lecture pour déterminer la couleur et l'intensité dans la couleur qui permettront d'obtenir l'effet souhaité lors du tirage photographique par contact.

On procède actuellement aux Engineer Topographic Laboratories (laboratoires topographiques du génie) de l'armée de terre des Etats-Unis d'Amérique, à des travaux de recherche-développement en vue de la construction de cette tireuse par contact à microréglage automatique des contrastes.

It has long been recognized in mapping that source imagery is not consistent in image constrast or density due to local atmospheric conditions, sun angles and the difference between ground features themselves. These factors render a multiplicity of contrast and density responses within an individual negative or set of images. Heretofore, because of the limitations of the existing state-of-the-art, imagery could only be reproduced at any one given level of contrast (i.e., the happy medium) for the overall negative. Large differences in density could be compensated for by the well known Log-E-tronics[2] printing techniques.

The Automatic Localized Micro-Contrast Control for Photographic Printing Systems is a photomechanical method that has been developed and patented. This method provides for the adjustment of the contrast as well as the density within each individual area and prints those areas at a level of enhancement which is ideally suited to the particular user's requirement for a specific cartographic operation. The cartographic operation can be an automatic correlation function requiring a specific signal-to-noise ratio or a manual task where different densities or contrast may be desired for the different tasks. A product can be produced with the ideal quality in every area of the negative for shadows, forests, culture, shoreline, mountains, streams, cloud haze etc. Diminished areas can be brought up to the contrast and density levels of the surrounding terrain. This is especially applicable for the critical northern or southern latitudes where sun angles are severe and cause dramatic shadows and highlights in the mountainous areas. Those shadow and highlight areas can be normalized and matched within limits. Basic contrast and density difference between different ground features (due to their different reflectance values) can also be normalized by this printing technology.

This photomechanical method is intended to take full advantage of commercially available photo-sensitive products and other such products that may be formulated which are based upon variable gamma technology such as the Dupont Varigam and Eastman Kodak Polycontrast products. These types of products consist of emulsions which are responsive in varying degrees of contrast depending upon the colour of the light used to expose them, thereby allowing for a wide range of contrast within a single photographic product. The intensity of the colour selected can also be modulated in order to control the density level as desired. The optimum advantage can be had if the colour and intensity of exposure light are varied selectively within a single frame, thereby augmenting areas of poor contrast and suppressing areas of high contrast (when desired) as well as controlling the density.

This has been accomplished to a limited degree in the past by successive partial exposures using different colour filters and exposure times. The first attempts to automate such a technique were started in the early 1950s by Dwin R. Craig, but his efforts were unsuccessful for various reasons. It is believed that this photomechanical method overcomes the weaknesses found in the prior art; the key to automated micro-contrast control lies in the sensing means of the invention. In the prior art the original imagery was sensed through the printing sandwich which consisted of the original and the raw stock. The film or paper had a diffusing effect upon incident light energy, and it was impossible to determine the true quality and level of the micro-contrast of the images in the original. Without knowing the true qualities of the original image, the proper exposure required to make a micro-contrast controlled copy cannot be determined. A Vidicon or similar sensor is used as the sensing means whereby the original images are prescanned so the true quality of the original images may be determined. A colour CRT is used in a playback mode to provide the colour and the intensity of the colour required to achieve the effect desired when making a contact photographic copy.

A research and development effort to build this automatic micro-contrast control contact printer is currently under way at the United States Army Engineer Topographic Laboratories (USAETL).

[2]Mention of a commercial product does not constitute endorsement by the United States Government.

PROCESS COLOUR PRINTING OF MAPS AND CHARTS*

Paper presented by the United States of America

RÉSUMÉ

Auparavant, l'impression lithographique traditionnelle des cartes se faisait à l'aide de négatifs ordinaires comportant des lignes et des fenêtres ouvertes, en préparant une plaque et en effectuant un passage sous presse pour chaque couleur caractéristique. L'encre de couleur utilisée pour chaque plaque d'impression et passage sous presse correspondait à la couleur souhaitée pour le détail à reproduire. Le nouveau procédé d'impression en couleurs (« Process Color Printing ») adopté par la Defense Mapping Agency (Service cartographique du Defense Department) utilise les mêmes négatifs ordinaires à lignes ou fenêtres ouvertes en combinaison avec quatre encres de couleur spécifiques pour reproduire toute la gamme des teintes requises. Les quatre encres de couleur spécifiques n'ont aucun lien avenc la teinte caractéristique du détail à reproduire. Le nouveau procédé utilise quatre couleurs de base — jaune, magenta (rouge), cyan (bleu) et noir — dans les combinaisons et les valeurs de ton voulues pour obtenir les teintes désirées; c'est-à-dire que le jaune et le cyan donnent le vert, le magenta et le jaune donnent l'orange ou le rouge, etc. Les diverses nuances, telles que le vert clair ou le rouge foncé, sont obtenues en interposant l'une de 10 trames à points normalisées par le Service cartographique devant le négatif à lignes ou fenêtres ouvertes correspondant à la couleur appropriée. L'interposition de trames à points devant le négatif d'une couleur réduit uniformément la quantité d'encre déposée sur la surface du papier, ce qui a pour effet d'éclaircir le tirage de l'image en cause. L'application d'une ou plusieurs des quatre couleurs de base dans telle ou telle des 10 densités d'encrage permet, grâce aux multiples combinaisons possibles, d'obtenir une gamme de teintes suffisamment étendue pour satisfaire les besoins des cartographes.

Le nouveau procédé d'impression en couleurs est utilisé depuis longtemps en imprimerie mais n'était pas appliqué aux cartes complexes comportant de nombreux détails en trait fin. C'est principalement en raison de la difficulté d'un repérage précis des couleurs de base (deux ou davantage) nécessaires pour obtenir les teintes désirées que ce procédé n'était pas utilisé pour les cartes. Un mauvais repérage pouvait rendre le produit final inutilisable. Les progrès techniques qui ont permis d'améliorer la capacité du matériel d'imprimerie de conserver un repérage précis, l'apparition de presses à plusieurs couleurs permettant une impression complète en un seul passage, l'amélioration de la stabilité dimensionnelle du papier, le contrôle des conditions atmosphériques dans les salles d'impression et l'amélioration de la formation des conducteurs de presse se sont combinés pour faire du nouveau procédé un moyen pratique de produire des cartes comportant cinq couleurs caractéristiques ou davantage.

Le principal avantage du nouveau procédé est l'économie de temps et d'argent. A titre d'exemple, le tirage, à 10 000 exemplaires, de nos grandes cartes en six couleurs demande environ 64 heures-homme et 35 heures d'horloge par le procédé traditionnel, c'est-à-dire avec un passage sous presse pour chaque couleur caractéristique. Par le nouveau procédé à quatre couleurs, il faut 47 heures-homme et 29 heures d'horloge, soit des économies respectives de 27 et 17 p. 100. De même, une carte en 8, 10 ou 12 couleurs obtenue en effectuant un passage sous presse pour chaque couleur caractéristique demandera respectivement 75, 92 ou 112 heures-homme et 38, 41 ou 48 heures d'horloge. Avec le nouveau procédé, il ne faut pas plus de temps pour produire des cartes en 8, 10 ou 12 couleurs que pour produire des cartes en six couleurs. En conséquence, les économies que permet de réaliser le nouveau procédé à quatre couleurs sont d'autant plus importantes que le nombre de couleurs caractéristiques de la carte est élevé. Dans l'exemple de la carte tirée à 10 000 exemplaires, l'économie réalisée avec le nouveau procédé dans le cas d'une carte en six couleurs est de 27 p. 100 sur les heures de travail et de 17 p. 100 sur les heures d'horloge. Pour une carte en 12 couleurs, l'économie réalisée passe à 58 p. 100 sur les heures de travail et à 40 p. 100 sur les heures d'horloge. Bien entendu, ces économies augmentent aussi en fonction du nombre d'exemplaires tirés.

Le Service cartographique a produit plusieurs catalogues essentiels pour l'adoption de cette technique. Ces publications sont les suivantes :

a) Catalogue normatif des trames d'impression; ce document présente des échantillons visuels ainsi que les caractéristiques techniques et données connexes

*The original text of this paper, prepared by Otto C. Stoessel, Defense Mapping Agency, appeared as document E/CONF.72/L.19.

relatifs aux trames d'impression normalisées qu'utilise le Service cartographique pour l'impression lithographique des cartes. Le catalogue comporte des sections séparées pour les trames normalisées à points, à lignes et à surfaces.

b) Catalogue normatif des couleurs d'impression; ce document contient une page échantillon de chacune des couleurs utilisées pour les différents matériels produits par le Service cartographique. Chaque page comporte, outre l'échantillon visuel de la couleur, des exemples d'utilisation de cette couleur dans les diverses épaisseurs de traits et de caractères ainsi que dans les 10 tons normalisés de tramage par points et les caractéristiques physiques de la couleur (luminosité, longueur d'onde dominante, facteurs de pureté et de réflexion), conformément aux normes de la Commission internationale de l'éclairage.

c) Catalogue normatif des couleurs obtenues par le nouveau procédé d'impression; ce document présente les teintes obtenues par les diverses combinaisons des quatre couleurs de base et des 10 trames à points normalisées du Service cartographique. Ce catalogue sert à déterminer le groupe de couleurs de base permettant d'obtenir la teinte désirée et fournit les données d'impression nécessaires pour reproduire la teinte choisie.

Process colour printing is the printing of maps and charts from standard line open-window negatives, using only four specific colour inks (yellow, magenta (red), cyan (blue) and black), which, in appropriate combination, achieves a reasonable facsimile of the desired colour. Thus, any map/chart can be printed from four plates/colours with the finished product appearing in the desired number of colours.

The dot screen consists of equal-sized dots, .002″ to .007″ in diameter, from 14,000 to 40,000 per square inch, which are equally spaced in parallel and perpendicular rows. Dot screens are used to print tones of a given colour ink. As the printing process deposits the ink uniformly on the paper surface, the appearance of tone is achieved by the percentage of area coverage of the printed dot screen.

Background

The Defense Mapping Agency (DMA) can trace its history with process printing of aeronautical charts to October of 1958 when the alternative of 4-colour process printing was established for emergency reprinting requirements. A technical paper was presented at the SHAPE Geographic Conference of 1958 which described our experimentation and development of the 4-colour process printing of aeronautical charts.

Four-colour process printing is combining tones of the basic process colours (yellow, magenta and cyan) in correct proportion with tones of the black to achieve a reasonable facsimile of any colour in the colour spectrum, thus, an indefinite number of colours can be achieved from four printing plate/colours.

In such process printing, which for our maps/charts is from line/open-window negatives, the exposure of a given feature/negative is required on as many of the 4-colour process plates and subsequent press runs as is necessary to achieve the desired colour. In certain brown colours, a given feature may be required on all four colour plates and press runs. To achieve the proper tone from each required process colour, dot screens are interposed between the feature negative and the printing plate for exposure onto the press plate. This multiple registration of the same feature detail in two or more process colours and the conversion of fine line/type details from solid line/type of the conventional method to multiple dot structures of the process printing method constitutes the basic quality deficiencies of the process, although in today's capabilities it may take a trained eye to detect this difference or quality loss.

Except as an emergency alternative, the process printing of chart products was not adopted in 1958, since this process colour method did not produce a chart at the same quality level that could be attained by the conventional method of one plate, one press run for each colour.

"Simulated" process printing

To achieve some of the economic advantages of 4-colour process colour printing and avoid the major quality deficiencies, a derivation of the process colour printing principle was employed in 1964 by a technique dubbed "simulated process printing". A technical paper was presented in March 1968 at the ACSM-ASP Conference describing use of this technique. This technique involves combining two or more conventional chart feature colours on given press runs to produce a feature in a third colour during the same press operation.

In adopting the simulated process printing technique, the conventional colours of critical fine line/type features were utilized to achieve other colours derived from proportioned combination of these critical feature colours. If the resultant colour(s) reasonably match non-critical feature colour requirements, a plate/press run is eliminated and the potential quality loss by misregistration of critical features is avoided. As an example, tints of drainage blue and city tint yellow were used to print a light green land relief feature. Of course, the use of non-process colours in the press run limits the colours which can be created and subsequently which can be matched. Many charts were produced in two or three fewer colours by the simulation process printing technique until September 1974 when four colour process printing in DMA was approved for maximum utilization. The "simulated" technique is still a valid option when 4-colour process is not acceptable and when retaining maximum qualities of fine line features is essential.

The simulated process printing technique reduction of one, two or three colours achieves a considerable savings when an 8-12 colour conventionally printed chart is reduced to 4-colour process printing. As an example, the labour savings on a typical chart of 10,000 quantity

when printed by process colour versus conventional 12-colour printing are 58 per cent. The production clock time is reduced by 40 per cent. For a more detailed explanation of the cost and time advantages, see table 1.

4-colour process printing

Reconsideration of the 4-colour process printing technique, for reasons of economy, and improvements in the "state-of-the-art", resulted in DMA adopting the process colour printing technique in September 1974. The process technique adopted was essentially of the same form as conceived in 1958. Improvements in materials (paper stability) equipment (close register 4- and 5-colour presses) and skilled personnel have significantly improved qualities over those which could be achieved in 1958; however, some loss in product quality is still to be expected. The use of a 4-colour press is essential for accomplishing the printing in one press pass and avoiding misregister of multiple press runs and paper movement.

The potential quality loss on certain products is real, except a map/chart user with an eye untrained in the printing process may not detect the loss caused by the process printing technique. The potential loss in quality is identified in three categories:

(*a*) *Sharpness of feature (resolution)*: caused when the two or more process colours of the same feature are imperfectly registered. In conventional printing each colour/feature is printed by a separate plate/press run, therefore, no misregister is possible;

(*b*) *Legibility/Clarity*: caused by the creation of feature/colours by two or more process colours composed of dot screens in a detailed congested area of the chart. In conventional printing, these features could be achieved with little or no dot screens, giving a less textured appearance and higher level of clarity;

(*c*) *Colour/match*: caused by the limitation of 10-dot screen tones which achieves a set of potential colours obtainable by combination of 10 tones and the 4 process colour inks. An actual colour desired may be between the 10 standard screen values. In conventional printing, the ink is made to any colour desired.

Many DMA map/chart products of 6 colours or more are now being produced by the 4-colour process technique. Having 5-colour presses, we have taken a critical feature in the chart adapted to the process printing technique, and printed it in the conventional colour, eliminating it from the 4-colour process printing technique and ensuring optimum quality; thus, a 5-colour job is printed one time through on a 5-colour press. The major United States Government map/chart producers have adopted the 4-colour process printing techniques as an integral part of their production operations.

TECHNICAL PROCEDURE

The final reproduction negatives required by our conventional printing method consist of hand engraved scribe coats for line work and open-window line negatives for the area tints. These are used to make one plate for each colour required, hence, the need for up to 12 or more plates for each chart, depending on the number of feature/colours required. To convert the conventional printing method to the 4-colour process method, there were two basic requirements; first, charts must be printed from existing negatives used in conventional printing; and second, screens used to achieve the tone intensity of the process colours should be limited to the 10 standard screens of the DMA Standard Printing Screen (SPS) system. The SPS system developed and adopted by DMA for its mapping, charting and geodesy requirements establishes a system of dot screens with visual tones of equal distant increments as viewed by an average observer. The system includes the full range of tints, from paper white (0 per cent tone) to solid colour (100 per cent tone). Table 2 is the DMA dot screen standards/tolerance table.

To use existing negatives, the previous conventionally printed copies were analyzed and the colour tones on these charts were compared with printed samples of process colours to approximate the existing tones. To iden-

TABLE 1. ECONOMIC AND PRODUCTION CLOCK-HOUR COMPARISON OF CONVENTIONAL *VERSUS* 4-COLOUR PROCESS PRINTING
(Based on chart size 42" x 58", 10,000 copies)

	Conventional printing		*4-colour process printing*			
					Savings (in percentage)	
	Man-hours	*Clock-hours*	*Man-hours*	*Clock-hours*	*Man-hours*	*Clock-hours*
6 colours						
Plate	24	24	23	23	27	17
Press	40	11	24	6		
TOTAL	64	35	47	29		
8 colours						
Plate	26	26	Same as above		37	24
Press	49	12				
TOTAL	75	38				
10 colours						
Plate	28	28	Same as above		49	29
Press	64	13				
TOTAL	92	41				
12 colours						
Plate	30	30	Same as above		58	40
Press	82	18				
TOTAL	112	48				

NOTE: DMA uses 5-colour process; aeronautical features are printed as a separate colour. Negatives can be photographically composited prior to platemaking.

TABLE 2. 120-LINE ROUND DOT SCREEN STANDARDS/TOLERANCES

Litho print screen per cent[a] name/number	*Film negative*		
	Dot diameter tolerance range	*Per cent tolerance range*	*Optical density tolerance range*
0			
	0.00136	2.1	1.68
4	0.00127 0.00145	1.8 2.4	1.74 1.62
	0.00199	4.5	1.35
7	0.00188 0.00210	4.0 5.0	1.40 1.30
	0.00277	8.7	1.06
12	0.00264 0.00290	7.9 9.5	1.10 1.02
	0.00375	15.9	0.80
21	0.00360 0.00390	14.7 17.2	0.83 0.76
	0.00465	24.5	0.61
31	0.00448 0.00482	22.7 26.3	0.64 0.58
	0.00542	33.2	0.48
42	0.00524 0.00560	31.1 35.5	0.51 0.45
	0.00616	42.9	0.37
54	0.00596 0.00636	40.2 45.8	0.39 0.34
	0.00629 [b]	55.2	0.26
67	0.00609 0.00649	58.0 52.4	0.24 0.28
	0.00523 [b]	69.1	0.16
79	0.00505 0.00541	71.2 66.9	0.15 0.17
	0.00388 [b]	83.0	0.08
91	0.00373 0.00403	84.3 81.6	0.07 0.09
100			

[a]Estimated percentage of printed area covered for screens having values as indicated in the columns to the right.

[b]Measurement is diameter of nonprint area.

tify and specify more effectively the approximate colour match, DMA has published the "Standard Printing Colour Catalog (Process)". This catalogue provides a listing and standards for colours used in the lithographic process colour printing of DMA maps/charts. Map 4 (in pocket) is a sample page from the catalogue. The colours presented are derived from the set of four process colour inks and the standard 10-dot screens printed in the various combinations necessary to obtain all required colours. The combination of process colours and dot screen percentages of tone are shown on the perimeter of each page.

After the exact screen angles and dot sizes (percentages) required to obtain the desired colours are identified, a specification can be prepared for making the process colour plates. The result is four press plates; magenta, cyan, yellow and black, which enabled production of charts using just four printing plates. Thus, we produced in four colours with only four press plates that which in conventional printing might have required up to twelve colours and twelve press plates to produce. (See table 3 and examples (maps 5 and 6 in pocket) of 4-colour process and conventional printing.) In 4-colour process printing, since all colours are derived from the same four basic process colours, products requiring different colours can be intermingled on the press run. The one colour, one plate concept of conventional printing could not mix such products. It is therefore possible to print two or more different products on the same four press plates in which each job, conventionally-printed, could have required as many as twelve press plates depending on the number of colours/features required.

TABLE 3. (*a*) 4-COLOUR PROCESS PRINTING SPECIFICATION

Feature	*Screen/Angle*	*Colour*
1		
Border/Culture	Solid	
Shaded relief (90° halftone)	54 per cent-240D-75°	
Contour/Values	54 per cent-240D-30°/60°	Black
Roads/Type	67 per cent-240D-30°/60°	
Boundary	31 per cent-120D-30°	
2		
Drainage	Solid	
Open water	21 per cent-120D-15°	
Inland water	54 per cent-120D-15°	
Grid	67 per cent-240D-30°/60°	
Glacier tint	7 per cent-120D-15°	
City tint	21 per cent-120D-75°	Cyan
Aeronautical	Solid	
Air space	42 per cent-120D-45°	
Vegetation (area pattern-42)	54 per cent-120D-75°	
Tint 0-250	12 per cent-120D-15°	
Tint 250-500	21 per cent-120D-15°	
Tint 500-1000	21 per cent-120D-15°	
3		
City tint	54 per cent-120D-45°	
Aeronautical	91 per cent-120D-75°	
Air space	21 per cent-120D-75°	
Roads/Type	Solid	
Boundary	31 per cent-120D-60°	Magenta
Tint 500-1000	4 per cent-120D-45°	
Tint 1000-2000	4 per cent-120D-30°	
Tint 2000-5000	7 per cent-120D-30°	
Tint 5000-9000	21 per cent-120D-30°	
Tint 9000-Max	31 per cent-120D-30°	

TABLE 3 (*continued*)

Feature	[a]Screen/Angle	Colour
4		
Roads/Type	Solid	
Boundary	31 per cent-120D-75°	
Vegetation (area pattern-42)	79 per cent-120D-30°	
Tint 0-250	21 per cent-120D-60°	
Tint 250-500	31 per cent-120D-75°	Yellow
Tint 500-1000	42 per cent-120D-75°	
Tint 1000-2000	12 per cent-120D-15°	
Tint 2000-5000	31 per cent-120D-60°	
Tint 5000-9000	31 per cent-120D-60°	
Tint 9000-Max.	42 per cent-120D-60°	

[a]*Screen description*:
21 per cent tone, 120-line dot screen, oriented at 60°
54 per cent tone, 240-line dot screen, oriented at 75°
67 per cent tone, 240-line dot screen, oriented at 30° and 60° (bi-angle screen)

Specification:
21 per cent-120D-60°
54 per cent-240D-75°
67 per cent-240D-30°/60°

(*b*) CONVENTIONAL PRINTING SPECIFICATION

1		
Border/Culture	Solid	Black
Contour/Values	54 per cent-240D-30°/60°	
2		
Shaded Relief (90° halftone)	Solid	Neutral gray
3		
Drainage	Solid	Blue
Open water	21 per cent-120D-60°	
Inland water	54 per cent-120D-45°	
Grid	67 per cent-240D-30°/60°	
Glacier tint	7 per cent-120D-60°	
4		
Roads/Type	Solid	Reddish brown
Boundary	54 per cent-120D-15°	
5		
Aeronautical	Solid	Reflex blue
Airspace	31 per cent-120D-60°	
6		
Vegetation (area pattern-42)	Solid	Green
7		
City tint	54 per cent-120D-45°	Purple
8		
Tint 0-250	54 per cent-120-D-60°	Light green
Tint 250-500	Solid	
Tint 500-1000	Solid	
9		
Tint 500-1000	31 per cent-120D-60°	Buff
Tint 1000-2000	31 per cent-120D-60°	
Tint 2000-5000	54 per cent-120D-60°	

TABLE 3 (*continued*)

Feature	[a]Screen/Angle	Colour
10		
Tint 5000-9000	31 per cent-120D-60°	Brown
Tint 9000-Max.	54 per cent-120D-60°	

[a]*Screen description*:
21 per cent tone, 120-line dot screen, oriented at 60°
67 per cent tone, 240-line dot screen, oriented at 30° and 60° (bi-angle screen)

Specification:
21 per cent-120D-60°
67 per cent-240D-30°/60°

ANALYSIS

Advantages and disadvantages of the 4-colour process printing of maps/charts as compared to one plate/one press run for each colour are as follows:

Advantages

(*a*) Reduction in lithographic plates and press runs with significant cost reductions;

(*b*) Reduction of clock/calendar time as product can be produced in one pass through a 4-colour press;

(*c*) Improved feature to feature registration quality as all can be registered and printed in one press pass.

Disadvantages

The disadvantages listed vary in significance depending on the nature of the features of the map/chart being printed as the "loss" quite often is of the just noticeable difference range not noticeable to a map/chart user untrained in the printing processes:

(*a*) Potential loss in fine line/type resolution when two or more process colours of the same feature are imperfectly registered;

(*b*) Potential loss in legibility/clarity by multiple dot structures in areas of congested details;

(*c*) Potential loss in precise colour match.

REFERENCES

Publications of the Defense Mapping Agency

"Standard printing screen system", ACIC technical report No. 72-1.
"Standard printing color identification system", ACIC technical report No. 72-2.
Standard Printing Screen Catalog.
Standard Printing Color Catalog.
Standard Printing Color Catalog (Process).

REPORT OF THE UNITED NATIONS GROUP OF EXPERTS ON GEOGRAPHICAL NAMES, ASIA, SOUTH-EAST DIVISION*

Paper presented by the Asia, South-East Division

RÉSUMÉ

La quatrième réunion du Groupe d'experts des Nations Unies sur les noms géographiques (Division de l'Asie du Sud-Est) a eu lieu à Kuala Lampur (Malaisie) du 14 au 18 avril 1977; elle a été la seule réunion tenue au niveau de la Division pendant la période considérée.

Des représentants de l'Indonésie, de la Malaisie, des Philippines et de la Thaïlande ont participé à la réunion, mais les autres pays membres de la Division, à savoir la Birmanie, le Kampuchea démocratique, la République démocratique populaire lao, Singapour, le Viet Nam et le Brunéi, étaient également invités.

The fourth meeting of the United Nations Group of Experts on Geographical Names, Asia, South-East Division, was held in Kuala Lampur, Malaysia, from 14 to 18 April 1977; it was the only Divisional Meeting during the period under review.

The Meeting was attended by delegates from Indonesia, Malaysia, the Philippines and Thailand although the other member states of the Division, namely Burma, Democratic Kampuchea, the Lao People's Democratic Republic, Singapore, Vietnam and Brunei were also invited.

PROJECTS REVIEWED AT THE MEETING

Map of South-East Asia (Political)

The third edition of this map, prepared and printed by the Directorate of National Mapping, Malaysia, was distributed to all delegates. It was agreed that the note "This map is not for public circulation" be amended by substituting "general" for "public" in the map. It was decided that this map, although specially prepared for the purpose of showing geographical names, should be called a "Political map" in line with international and standard usage.

Map of South-East Asia (Physical, including marine and submarine features)

The first edition in draft form of this map, prepared and printed by the Directorate of National Mapping, Malaysia, was distributed to the delegates. It was agreed that names shown in this map be confined to physical features, including important marine and submarine features. Only major place names are to be shown, each country indicating what place names it wishes to show. When symbols of marine and submarine features are required to be shown on the map, they would be in accordance with specifications of the International Hydrographic Organization.

Each member State was requested to study the draft map and to inform Malaysia by 31 July 1977 if it wished to make any additions or amendments to the map. It was also pointed out that each country try and indicate as many physical features as possible, including marine and submarine features.

The meeting decided that the note "This map is not for general circulation" be included on the map. It was also agreed to allot a number to each map.

Concise Gazetteer

The meeting was briefed on the various problems and difficulties that were encountered on the compilation of this Gazetteer. It was decided that all countries would review and compile a new list based on the third edition of the Political map. All names appearing in this map would be included in the list which also gives a description of the feature together with its geographical co-ordinates. For this purpose, as agreed in Bangkok in April 1976, if the feature was a point on the map, the geographic co-ordinates of the point would be shown, but if the feature was not a point on the map, then the geographic co-ordinates shown would refer approximately to the centre-point of the name. It was agreed that when the same name had been allotted to two different features, e.g. municipality and island, both names could appear on the listing but with the appropriate geographic description.

Regional Gazetteer

Malaysia had received lists from all member States concerned. This Gazetteer is under preparation by the Directorate of National Mapping, Malaysia.

Regional Atlas

At the Manila meeting in June 1976, Thailand agreed to put up the necessary specifications for the Regional Atlas. The meeting decided that the specifications would include the following:

(*a*) Designation: types of maps to be shown;

(*b*) Scale, projection and other geographical values;

(*c*) Sheetlines, general format and number of pages;

(*d*) Drawing specifications: number of colours, lettering, symbolization, marginal notes etc.;

(*e*) Size: easily handled book-dimensions.

Newsletter (GEONAMES)

The meeting urged member States to co-operate and to send articles and news items of general interest to the publisher (the Philippines). It was also noted that articles on notable personalities in this Divisional Group could also be included.

*The original text of this paper, prepared by the Directorate of National Mapping, Malaysia, appeared as document E/CONF. 72/L.91.

Course in toponymy

Indonesia has indicated that it would send two officials at government expense to Holland to gather facts and information on courses in toponymy. It was agreed that Malaysia, as the Divisional Representative, would write to the Secretary of the Cartographic Section of the United Nations to enquire about the provision of funds to obtain the services of suitable lecturers. One of the sources of funds could be the United Nations Educational, Scientific and Cultural Organization (UNESCO).

OTHER MATTERS

Exonyms

The meeting took note of the importance of resolutions 28 and 29 of the Second United Nations Conference on the Standardization of Geographical Names (London, 1972) and decided that each member country should compile a list of exonyms used in their country and send it to the Divisional Representative to be compiled into a publication for distribution to other member countries.

Names of features lying beyond a single sovereignty

For the time being, where more than one name exists for such features, those names would be shown on the maps and gazetteers. Each member country was requested to prepare a list of such names for discussion in due course with a view to standardization.

Non-participating member countries

The meeting expressed the hope that Burma, Democratic Kampuchea, the Lao People's Democratic Republic and Vietnam would participate in and support the activities of this Division by attending future meetings. It was also hoped that Singapore, which had participated in the first and second meetings, would continue to support the work of this Divisional Group by attending future meetings for the benefit of the region and to further the cause of mutual understanding and co-operation.

Although the above countries had been unable to attend this meeting, it was agreed to continue the past practice of sending them copies of reports of all meetings for their information. In addition, copies of *GEONAMES* would be sent to them by the Divisional Representative.

It was also noted that even though the Lao People's Democratic Republic and Vietnam did not attend the Divisional Group Meetings, they nevertheless had submitted geographical names of their countries for inclusion into the South-East Asia map.

PARTICIPATION

The Divisional Representative attended the seventh session of the United Nations Group of Experts on Geographical Names at Athens, Greece, on 16 August 1977.

The Divisional Representative had also attended the third United Nations Conference on the Standardization of Geographical Names, held in Athens from 17 August to 7 September 1977.

THE INTERNATIONAL CARTOGRAPHIC ASSOCIATION: INFORMATION PAPER*

Paper presented by the International Cartographic Association

RÉSUMÉ

L'Association cartographique internationale (ACI) a été créée en 1959 à Berne (Suisse) par 13 pays membres fondateurs, à l'initiative de la Suède, après des conférences préparatoires à Stockholm (1956), Chicago (1957) et Mayence (1958). La première assemblée générale a eu lieu à Paris en 1960 avec la participation de 25 pays membres.

Les objectifs de l'Association sont les suivants :

a) Promouvoir l'étude des problèmes cartographiques;

b) Organiser et coordonner la recherche en matière cartographique;

c) Diffuser les connaissances cartographiques;

d) Organiser des conférences, séminaires, expositions et autres rencontres professionnelles à l'échelon international.

L'ACI est une organisation non gouvernementale. En 1979, l'Association comptait 55 pays membres, chacun d'eux étant représenté dans l'Association par une organisation unique qui est en général la société ou le comité national de cartographie. Les particuliers ne peuvent être admis en tant que membres.

The International Cartographic Association (ICA) was established by 13 founder member countries in 1959 at Bern, Switzerland, upon Swedish initiative after preparatory conferences in Stockholm (1956), Chicago (1957) and Mainz (1958). The first General Assembly was held in Paris in 1960 with 25 member countries present.

The aims of the Association are:

(*a*) Advancement of the study of cartographic problems;

(*b*) Instigation and co-ordination of cartographic research;

(*c*) Dissemination of cartographic knowledge;

(*d*) Organization of international conferences, seminars, exhibitions and other professional gatherings.

*The original text of this paper, presented by D. D. McCormack, on behalf of F. J. Ormeling, International Cartographic Association, appeared as document E/CONF.72/L.95.

The ICA is a non-governmental organization. As of 1979 it has 55 member countries, (see annex I) each of them represented in the Association by a single organization, mostly by the national society or committee for cartography. Individuals cannot be admitted as members.

The ICA generally follows the definition of the word "Cartography" given in the *Multilingual Dictionary of Technical Terms,* which reads as follows:

Cartography is the totality of scientific, technical and artistic activities aiming at the production of maps and related presentations on the basis of data (field measurements, aerial photographs, satellite imagery, statistical material etc.) collected by other disciplines. Further, cartography includes the study of maps as scientific documents as well as their use. In this sense cartography is limited to "cartography proper", i.e. to data presentation up to the reproduction and printing of maps and charts: it will be understod that in the practical application of this definition, the gathering of primary data, field surveying and photogrammetry are excluded as are surveys carried out by other disciplines such as geology, statistics, demography etc.

The United Nations uses a much wider concept of cartography, dating from 1948, according to which it is the science of surveying and mapping and embraces all phases of mapping from data collection to data processing and data presentation, thus including surveying, aerial photography, topography, toponymy, photogrammetry and cartography proper.

The offices and organs of the Assocation are as follows:

(*a*) The General Assembly of delegates, which normally meets every four years, in which every member nation has the right of one vote. As a rule the General Assembly is held in conjunction with a technical conference;

(*b*) The Executive Committee consisting of a president, 5-7 vice-presidents and a secretary-treasurer, all elected by the General Assembly;

(*c*) The Office of the Secretary-Treasurer;

(*d*) The commissions and working groups established by the General Assembly for the execution or examination of important cartographic tasks. In principle the tenure of office of these commissions is limited to the time between two general assemblies (four years);

(*e*) The Publication Committee, responsible for the publication programme of the Association.

Annex II gives information on the various ICA commissions and working groups active between 1976 and 1980 and their terms of reference.

ICA conferences are held every second year. Annex III shows the successive conferences held since 1962 and the themes dealt with. Finally, ICA publications, available and in preparation, are listed in Annexes IV and V respectively.

Application for membership can be made by letter to the Secretary-Treasurer. Applications are subject to ratification by the General Assembly upon recommendation of the Executive Committee.

The annual subscription for the period 1976-1980 is graded into six categories. Member countries are free to select in which category they wish to be classified, the fee ranging from one to eight times $160.

The ICA has established working contacts with various international sister organizations such as ISP/FIG and IGU with which joint working groups on special subjects are in operation. Further, ICA co-operates with the United Nations Educational, Scientific and Cultural Organization (UNESCO) under contract for special projects in the field of education in cartography. For instance the "Multilingual Basic Manual on Cartography" is being prepared under UNESCO contract.

In 1976, ICA decided to establish a Third World Strategy. A seminar on computer-assisted cartography, presented by a teaching commando of ICA experts was held at Nairobi in November 1978. Similar seminars are planned in China and Indonesia.

Annex I

ICA MEMBER COUNTRIES (JULY 1979)*

Algeria
Australia
Austria
Belgium
Brazil
Bulgaria
Canada
Chile
Cuba
Czechoslovakia
Denmark
Dominican Republic
Finland
France
German Democratic Republic
Germany, Federal Republic of
Greece
Hong Kong
Hungary
India
Indonesia
Iran
Iraq
Ireland
Israel
Italy
Japan
Kenya
Luxembourg
Malaysia
Mexico
Morocco
Netherlands
New Zealand
Nigeria
Norway
Pakistan
Peru
Philippines
Poland
Portugal
South Africa
Spain
Sudan
Suriname
Sweden
Switzerland
Syrian Arab Republic
Thailand
Tunisia
Turkey
Union of Soviet Socialist Republics
United Kingdom of Great Britain and Northern Ireland
United States of America
Yugoslavia

Annex II

ICA COMMISSIONS AND THEIR TERMS OF REFERENCE (1976/80)

Education in cartography

Terms of reference:

Preparation of a multilingual basic manual for education in cartography for international use.

Multilingual dictionary

Terms of reference:

Preparation of a revised second edition of the *Multilingual Dictionary of Cartographic Terms*. The first edition was published in 1973.

Automation in cartography

Terms of reference:

(*a*) To organize an International Seminar in East Africa in 1978 in close co-operation with the Executive Committee, sponsored by UNESCO, on the possibilities and requirements of developing countries in computer-assisted cartography. The Seminar should concentrate upon problems related to the application of automated systems for natural resources inventories;

*China applied for membership in July 1979.

(*b*) To co-operate with experts of the International Society of Photogrammetry in an Inter-Association Working Group on Automation in Cartography.

Cartographic communication

Terms of reference:

(*a*) Preparation of a working model of cartographic communication and a list of research problems in this field;

(*b*) Compilation of a revised bibliography of publications on cartographic communication.

Cartographic technology

Terms of reference:

Preparation of publications on (*a*) Colour proofing systems; (*b*) Register systems and (*c*) Classification of cartographic techniques. To evaluate the techniques for the production of multi-coloured maps in small runs.

History of cartography

Terms of reference:

Compilation of a historical glossary of cartographic innovations and their diffusion prior to 1900.

Oceanic cartography

Terms of reference:

Preparation of a publication, containing a set of reference papers to serve as a guideline for oceanographers involved in thematic mapping.

Mapping of natural resources

Terms of reference:

To make recommendations regarding the international mapping of natural resources in close co-operation with UNESCO through the ICA administration.

Base maps for international thematic mapping

Terms of reference:

To make recommendations regarding the requirements of small-scale base maps to be used for international mapping of natural resources in close co-operation with UNESCO through the ICA administration, with special attention to matters such as scales, projections, base data, presentation and costs.

Joint ICA-IGU Working Group on Environmental Atlases

Terms of reference:

(*a*) To collect information and compile a documentation on environmental atlases and environmental maps incorporated in national, regional and urban atlases;

(*b*) To make a systematic analysis of these atlases and maps, in order to compare the themes presented and the techniques used;

(*c*) To establish a list of recommendations for the production and realization of environmental atlases, in connection with national and regional atlases;

(*d*) To publish the results of the research on the above-mentioned topics.

The tasks proposed at the initial state, are:

(*a*) To collect data on all atlases and maps dealing with the environment;

(*b*) To enquire into the precise meaning of "environmental map".

Publication Committee

Terms of reference:

(*a*) To set up a series of ICA publications;

(*b*) To function as the collection centre for manuscripts presented to the Association for publication;

(*c*) To function as an editorial board for these publications.

Annex III

ICA CONFERENCE THEMES, 1962-1978

1962—Frankfurt am Main	Generalization of maps Revision of maps Automated cartography
1964—London	Editorial problems of atlas making Production control of cartography Technical problems in thematic mapping Automation in cartography Technical problems on design and maintenance of topographic map series, air charts
1967—Amsterdam	Training of cartographers Thematic cartography Map and colour Atlas cartography Metacartography Automation in cartography Definition, classification and standardization of cartographic terms
1968—New Delhi	Education and training in cartography Automation in cartography Problems of map production in small quantities and frequent editions Maps of the future Generalization of map detail Mapping of developing countries Map revision Standardization of technical terms
1970—Stresa (Italy)	Cartography of mountainous areas Standardization of symbols in thematic cartography Cartography as means of expression and communication Synthesis of data in economic mapping Hydrographic charting/oceanographic cartography
1972—Montreal/Ottawa	Urban cartography Cadastral mapping Automated cartography Aeronautical and hydrographic charting Economics of cartography
1974—Madrid	Methods for increasing the graphic quality of computer derived maps Tourist cartography History of cartography Application of information derived from space programmes to cartography Advances in cartographic technology Urban cartography and data banks Innovations in aeronautical and oceanic cartography
1976—Moscow	Cartography as a service to public education Mapping of nature and natural resources for environmental protection Application of remote sensing in compiling thematic maps Cartographic education Communication in cartography Methods of map utilization for scientific research International collaboration in compilation of small-scale thematic world map series Development of cartography in the USSR
1978—Maryland	Map perception and design with special reference to map reading (colour, symbolism, tactual) Cartography in the developing nations Oceanic and coastal cartography with special reference to boundary demarcation, remote sensing, positional data, automated chart making Remote sensing with special reference to LANDSAT status, future plans, applications in aeronautical charting Automation in cartography with special reference to the user, digitizing and editing output systems, data bases, technological exchange
1980—Tokyo (planned)	Maps as a means of communication of information Utilization of maps for environmental assessment

	Map representation of cities (general and thematic maps)
	Application of new techniques developed in the related fields to mapping
	Marine resources and maps
	Modern requirements and experiences in training cartographers
1982—Warsaw (planned)	Theoretical and practical principles of cartography
	New sources of information in thematic mapping
	Thematic maps for regional and economic planning
	Contemporary school atlases
	History of thematic cartography

Annex IV

PUBLICATIONS OF THE INTERNATIONAL CARTOGRAPHIC ASSOCIATION AND RELATED PUBLICATIONS

(The following publications, if not otherwise indicated, are available from Rudolph Muller International Booksellers, P.O.B. 9016, Amsterdam, Netherlands.)

E. Meynan, comp. ICA bibliography 1956/1972. 132 p.

Adam Kerr and Annette Kordick, eds. Oceanic cartography. 136 p

L. van Zuylen and R. J. M. J. Bertrand, eds. Automation in cartography. 1975. 400 p.

Helen Wallis, ed. An historical glossary of map making to 1900: preliminary study. Copies for sale at Map Room, the British Library, London.

ICA Commission on Automation in Cartography, comp. Glossary of terms in automated cartography. 1976. 76 p. Copies available upon request. New edition in preparation.

Christopher Board. Bibliography of works on cartographic communication. 1976. Copies available upon request from C. Board, Department of Geography, London School of Economics.

ICA Commission on the Multilingual Dictionary, comp. Weisbaden, Federal Republic of Germany, Franz Steiner Verlag, 1973. 573 p. Second edition in preparation. The two editions contain 14 definitions and terms in, respectively, 5 and 9 different languages.

The international cartographic yearbook, vols. I-XIX (1961-1979). Bonn-Bad Godesberg, Kirschbaum Verlag. ca. 200 p. per volume. Volume XX in preparation.

Automation—new trends in cartography. Report of a seminar organized by the ICA Commission on Automation in Cartography. E. Csáti, ed. Budapest, 1973. Available upon request from the Institute of Surveying and Mapping, Budapest.

E. Csáti, comp. Multilingual explanatory dictionary of automation in cartography (MEDAC). Budapest, 1976. Contains 400-500 terms and definitions in 11 languages. Available upon order from the Institute of Survey and Mapping, Budapest.

Annex V

PUBLICATIONS IN PREPARATION

1. Multilingual Basic Manual on Cartography
2. Multilingual Dictionary of Technical Terms in Cartography (2nd edition)
3. Definition of Terms in Computer-assisted Cartography (3rd edition)
4. Bibliography of Works on Communication in Cartography (2nd edition)
5. Colour Proofing Systems
6. Registration Systems
7. Classification of Cartographic Techniques
8. Historical Glossary of Cartographic Innovations to 1900
9. Cartographic Guide for Oceanographers
10. Bibliography of Environmental Atlases
11. Bibliography of National and Regional Atlases
12. Proceedings of the Seminar on Computer Assisted Cartography, Nairobi, November 1977
13. Reader containing articles on mapping of natural resources
14. International Cartographic Yearbook, vol. XX (1980)

(c) *Cadastral surveying and urban mapping (including land information systems)*

LAND RESOURCE INFORMATION SYSTEMS FOR RURAL USES*

Paper presented by Australia

RÉSUMÉ

Les systèmes automatisés d'information sur les ressources foncières des régions rurales sont utilisés au Queensland depuis 1970. La nécessité d'utiliser ces systèmes s'est imposée en raison de différents facteurs mais surtout à cause du volume de renseignements rassemblés lors des levés pédologiques et topographiques et de la nécessité d'utiliser efficacement ces renseignements.

Avant 1970 et même encore aujourd'hui, les données rassemblées pendant les travaux d'évaluation des ressources foncières étaient interprétées et publiées sous forme de cartes et de rapports, mais une bonne partie des données fondamentales rassemblées n'y figuraient pas et n'étaient pas facilement accessibles aux fins d'interprétation ultérieure. En réalité, le volume même des données rassemblées restreignait leur exploitation au moyen des techniques manuelles classiques de tri et de classement.

Le coût de ces levés, dont le traitement du personnel constituait l'élément le plus important, était très élevé. Les masses de données y étaient rassemblées sur les sites des échantillons (avec des coordonnées) ou, pour les unités cartographiques, par un personnel expérimenté (agronomes, botanistes, pédologues, géologues, etc.). La mise au point des systèmes informatiques permet maintenant non seulement d'informatiser directement les nouvelles données mais aussi d'introduire en cas de besoin dans les systèmes les "anciennes" données fiables et précises.

*The original text of this paper, prepared by the Queensland Department of Primary Industries, appeared as document E/CONF 72/L.43.

Les systèmes informatiques mis au point au cours des huit dernières années visent ainsi à accroître l'efficacité de la collecte, du stockage, de la restitution et de l'utilisation des informations sur les ressources foncières.

Computer-based land information systems for rural use have been in use in Queensland since 1970. The need for these systems arose as a result of a number of different needs but primarily was associated with the amount of information being collected during soil and land surveys and the need to effectively use this information.

Prior to 1970 and even now, data collected during land resource surveys were interpreted and published as maps and reports, but much of the basic data collected was not reported or easily accessible for further interpretation. In fact the amount of data collected was a constraint on its use using conventional manual sorting and classification techniques.

The costs of these surveys were high with salaries being the most important component. In these surveys the masses of data were collected at sample sites (with co-ordinates) or for mapping units by experienced personnel (agriculturalists, botanists, soil scientists, geologists etc.). The development of information systems has meant that not only can new data be incorporated in information systems but reliable and accurate "old" data can also be incorporated should they be needed.

So the aims of information systems developed over the last eight years have been to improve the efficiency of collection, storage, retrieval and use of land resource data.

THE SYSTEMS USED

The Department of Primary Industries (DPI) in association with the Commonwealth Scientific and Industrial Research Organization (CSIRO) have developed a number of quite different systems since 1970. All of these have been designed for specific uses associated with projects being undertaken, but all have some general application. The systems have naturally developed with time, as both technology and knowledge have developed. Most of the projects have had considerable cost constraints so the systems used were not always the most developed systems, but they were the best within our financial constraints.

Regional resource assessment information systems

The work programme for which these systems have been developed is based on providing land resource and land-use maps and land management specifications for extension officers, farmers, graziers, producer organizations and planners. They provide basic inventories of the land types in an area, their attributes and suitability for a number of different uses.

At first the system relied on experienced personnel collecting site data throughout an area using computer compatible data forms to record information and then mapping the area into discrete mapping units using aerial photographs. The projects where this type of information was collected ranged from detailed studies on the Darling Downs with sample sites at 250-metre intervals to broad surveys based on sampling road traverses across landscapes in Western Queensland.

The characteristics of land are coded directly onto fixed format sheets using standard coding and this field information is then punched onto data cards and validated. The information is transferred to disk for use and to magnetic tape for long-term storage.

The output from the file can be retrieved in either coded or decoded form. It is possible to sort a great number of characteristics very quickly thus being able to print out very simple tables and distribution maps of plant species, soil types etc.

Classification on the data may be undertaken to develop lists of sites with certain land attributes which may make them suitable for particular uses, e.g., all the sites with soil deeper than 60 cm, slopes less than 5 per cent, phosphorous levels higher than 30 ppm and with soil texture heavier than clay loam could be identified and located on a distribution map.

However, this system initially did not cater for the recording of the map data so it was difficult to relate the site data to an area. This was not entirely satisfactory and as a result methods were developed to record map information in a manner which would allow it to be linked to the site data.

The technique which is just being implemented involved the identification of mapping units by centroid co-ordinates: a brief description of the mapping unit links this file with the site data file.

This system will allow the site information and mapping units to be sorted or classified thus printing out centroids which can be overlaid on the base map, thus indicating the distribution of a particular feature or classification in terms of an area as distinct from a point.

The advantage of this system is that it is cheap and easily operated. The disadvantage is that you don't end up with one completed map but have an overlay from which the thematic map can be drawn.

These systems have been used in the Western Queensland land-use studies, on soil surveys in the Burdekin and on the Darling Downs, and in limited versions they have been used for recording botanical information and soil analytical data. Their use is strongly dependent on the data being related to accurate grid co-ordinate information.

At present the mapping units associated with the *Atlas of Australian Soils* are being coded, using the centroid technique. Once this is done we will be able to relate the location of these units to the interpretative data collected by Agriculture Branch in their broad assessment of the agricultural lands of the state. In this study the suitability of each of the soil mapping units within shires were assessed in terms of their potential for dryland agriculture and pastures and their suitability for specific groups of crops and pastures.

Moreton system

The system used for the Moreton Regional Study was based on area data, not site data. All together 873 map-

ping units were initially delineated onto a photo mosaic of the region and were later transferred onto a cartographic map base. The map base was overlayed with a regular grid whose cell dimensions matched those of the line printer characters. This enabled the mapping unit boundaries to be manually digitized and stored in the computer by recording the cell locations corresponding to the boundary lines.

The 122 attributes of information recorded for each mapping unit could be easily sorted, classified and printed out on the line printer. In addition, an estimate of the area of each classified land unit could be determined.

The problems associated with the use of this system were that:

(*a*) The accuracy of the original boundary was lost due to the size of the grid;

(*b*) The overlay maps were of variable quality;

(*c*) Excessive amounts of time were involved in digitizing the map.

It was basically a very good system which could be improved.

Grid cell mapping system

This system was first used in the North Pine Catchment Study. In this approach, data were collected on grid cells of approximately 3.2 hectares. All together three attributes (soils, slope and timber cover) were recorded for each grid cell. One of the advantages of this system was that information on discrete units within the cell could be recorded together with the proportion of the cell it occupied. This avoided the problem of only the dominant feature being recorded.

Maps were prepared by selecting a range of specified characteristics and using the computer to classify or sort these characteristics thus indicating these areas as grid cells which could be overlaid as a map base.

As an example of how the information can be used for planning the delineation of areas susceptible to landslip is used. In this case the soil, timber cover and slope conditions which predispose the land to landslip were modelled and these attributes were recorded on the file. This information was used to generate a line printer map showing areas with a combination of the attributes. The area of each mapping unit is also calculated.

This system was further developed for use in the Upper Burdekin Basin where unit sizes of 20 sq km were used for broad regional assessment.

The main disadvantage of this system is that natural boundaries are not represented. However, at very large scales this is not limiting.

LANDSAT

The digital tapes associated with the LANDSAT programme form another information system which has been used for rural purposes. The information collected in each pass of the satellite relates to reflectance in a number of wavelength bands from an area on the ground (a pixel). These wavelengths, or signatures, for each pixel may sometimes be correlated with ground attributes such as bare ground, types of crops, pasture vigour, water, pasture biomass, land types, vegetation groups and the location of these specific attributes represented on visual display units (VDU) or line printers. At present we have only the capability to output data on line printers although VDU's are available in Australia. We have also been involved in land system mapping or interactive computers with VDU with the United States Geological Survey. One of the main problems associated with the use of this system has been the limited ground truth data.

AVAILABILITY

Wherever possible the information collected and stored in information systems is made available through reports. However, the additional material held in data banks by the DPI is generally readily available at the cost of generating the information, or at nil cost. This can be provided in hard copy as line printer form or as microfiche. The programs we use are run on the CSIRO systems so anyone with, or near, a CSIRO system can gain access provided the original generator of the data is aware of the request.

DEVELOPMENTS

At present the DPI is investigating means of aggregating individual data banks and indexing information already available on existing systems which could easily be recorded on current systems. These comments apply particularly to site data recorded by soil scientists, botanists, rural land-use planners, etc.

Input into the index would be based on co-ordinates with the type of information available at each site being shown.

At present a number of individual files are being aggregated. In most cases these have used uniform similar recording systems and the surveys are very similar. Even so, problems are expected due to individual bias as all the data input is not hard factual data but data requiring some form of interpretation.

One of the big advantages of land information systems for agriculturalists is that it allows experienced workers to collect large amounts of factual data that can be recorded and easily retrieved later so that new interpretations can be made on old but factual data as technology changes.

While the use of land information systems is increasing rapidly in agriculture many difficulties may be encountered associated with the use of centralized data banks, particularly those that relate to interpretive map boundaries.

REGIONAL LAND EVALUATION*

Paper presented by Australia

RÉSUMÉ

Au Queensland, les premiers levés relatifs aux ressources foncières ont été effectués par les géomètres du Lands Department (Département des affaires foncières) qui, dans le cadre de la préparation des plans de subdivision, ont décrit les sols et la végétation selon des techniques de classification simples. Plus tard, le Department of Agriculture and Stock (Département de l'agriculture et de l'élevage) d'alors, la Division of Soils (Division de pédologie) de la Commonwealth Scientific and Industrial Research Organization (CSIRO — Organisation de recherche scientifique et industrielle du Commonwealth) et le Bureau of Investigations ont effectué des enquêtes pédologiques pour des projets de développement particuliers. C'est seulement après la seconde guerre mondiale que la Division of Land Research and Regional Surveys (Division de recherches foncières et levés régionaux) de la CSIRO s'est occupée de levés de terrain au niveau régional. Il s'agissait essentiellement d'inventaires des caractéristiques physiques du terrain. Les enquêteurs ont introduit une notion appelée : cartographie des systèmes pédologiques. Ils ne se sont pas souciés outre mesure d'évaluer l'occupation des sols.

Les levés entrepris par le Department of Primary Industries (Département des industries primaires) visent à fournir des cartes des ressources foncières et de l'occupation des sols ainsi que des spécifications en matière de gestion des terres à l'intention des agents de vulgarisation, des agriculteurs, des éleveurs, des organisations de producteurs et des planificateurs. Les cartes s'accompagnent de recommandations techniques et de directives de gestion adaptées aux besoins de chaque type de sol et indiquent l'emplacement des zones où la production agricole pourrait être augmentée (avec la technologie connue) ainsi que les zones fragiles où il conviendrait de modifier la gestion des terres afin d'assurer la productivité et la stabilité économique à long terme. Elles fournissent sur les ressources les renseignements nécessaires pour la planification à l'échelon régional et au niveau de l'exploitation agricole et ont encore de nombreuses autres utilisations qui sont traitées dans le document.

L'exploitation des sols par l'homme dépend dans une très large mesure de la gestion, de la technique, des ressources financières et de la main-d'œuvre. Ces différents facteurs ne sont pas fixes dans l'espace mais varient dans le temps d'une manière qu'il est impossible de prévoir avec précision. Aussi la partie proprement pédologique de l'évaluation foncière n'est-elle pas une opération qui peut être effectuée une fois pour toutes, et elle doit être répétée lorsqu'interviennent des changements techniques importants. Alors qu'un inventaire foncier bien préparé n'exige pas les mêmes mises à jour, on estime nécessaire de mettre ces levés à jour lorsqu'une utilisation plus intensive des terres est envisagée. La principale raison en est que la plupart des levés exécutés au Queensland sont des levés de reconnaissance au 1/250 000 et ne sont donc pas des levés détaillés des ressources.

In Queensland the first land resource surveys were done by Lands Department surveyors, who during the course of preparing subdivision plans described soils and vegetation using simple classificatory techniques. Later the then Department of Agriculture and Stock, the Division of Soils of the Commonwealth Scientific and Industrial Research Organization (CSIRO) and the Bureau of Investigations conducted soil surveys for particular development projects. It was not until after the Second World War that the CSIRO Division of Land Research and Regional Surveys were involved in regional land surveys. These were mainly surveys of the physical land resources. They introduced a concept called land system mapping. Their surveys did not become too involved in land use assessment.

The studies that the Department of Primary Industries carries out aim at providing land resource and land-use maps and land management specifications for use by extension officers, farmers, graziers, producer organizations and planners. They tailor technical and management recommendations to suit the needs of each land type. They indicate the location of areas where agricultural production could be increased (under known technology) and the fragile areas where land management needs to be changed to ensure long-term productivity and economic stability. The resource information needed for regional and farm planning is provided. They have many other uses and these are covered later.

Man's use of land is very strongly dependent on management, technology, finance and labour. These are not fixed in space but time variable in a manner which is not predictable with great accuracy. For this reason the land assessment part of land evaluation is not something which can be done once for all time but an activity which must be repeated when significant technological changes occur. While a well-prepared land inventory is

*The original text of this paper, prepared by the Queensland Department of Primary Industries, appeared as document E/CONF.72/L.46.

not subject to the same updating it has been found necessary to update these studies when more intensive land uses are proposed. The main reason is that most of the studies conducted in Queensland have been reconnaissance studies at scales of 1:250,000 and as such are not detailed resource studies.

Land evaluation systems in use in Queensland

Methods of land evaluation in Queensland vary according to the objectives, the time available and the amount of prior knowledge about the land resource. Ideally, land evaluation surveys should concentrate on the collection and interpretation of as much data about individual pieces of land as is possible within these limiting factors. To avoid mixing details of different levels of survey I intend to deal with land resource evaluation methods used in the three major agricultural use zones. These are the grazing lands, the mixed cultivation/grazing lands and the intensively used agricultural lands.

The grazing lands

An inventory of rangeland ecosystems based on the concept of conducting "land system" surveys at a scale and of a type suitable for property management purposes has been found to be most suitable in these lands. The land system survey has the objective of describing, classifying and mapping the country including its surface geology, topography, soils and vegetation and of broadly assessing land use potentialities based on a consideration of these inherent land characteristics. A land system is described as an area or group of areas throughout which there is a recurring pattern of soil vegetation and topography. The method is based on the premise that each type of country appears on aerial photographs as a distinctive pattern hence the interpretation of aerial photographs is the basis of the approach. Land systems are basically descriptive and show the relationship between land units.

Land units are described in some detail containing descriptions and assessments of landform geology, soils vegetation and land utilization factors. This method of survey relies on having an integrated team comprising a botanist, a soil scientist and a land use man. Other specialists such as geologists and chemists are available when needed from time to time.

In reconnaissance surveys such as these where final map scales are 1:250,000 or larger considerable emphasis is placed on photo-interpretation as it is difficult in the areas being considered to visit all mapped areas. Most surveys of this nature rely on black and white aerial photography at a scale of 1:40,000 to 1:80,000. Colour photography makes photo-interpretation easier but is much more expensive and in most cases does not significantly increase accuracy. Imagery from the LANDSAT satellites is useful in grazing areas, not only to assist in the separation of land systems and land units, but also to monitor the condition of these once their spatial distribution and characteristics are known.

In this type of survey site sampling and air photo pattern checking is carried out at two levels. At the less detailed level vegetation, soil and landscape changes were described along continuous road traverses. Detailed site sampling is conducted on the basis of sampling limited length traverses across distinctive patterns. An understanding of the basic geomorphological process greatly facilitates sampling and description and is extremely useful to users.

The data collection, storage and retrieval techniques used were adopted to accumulate and process the large volume of resource information recorded. Land characteristics are recorded directly onto electronic data processing (EDP), field recording sheets to avoid errors in transcription. These data then form part of a computer data bank. The use of a computer-oriented information system improves job satisfaction by avoiding onerous jobs, increases accuracy, increases the amount of interpretation of collected data and reduces costs. Data maintained in the data bank are readily available for use by users.

From the quantitative and qualitative data collected on soil and vegetation it is possible to assess the land types and draw conclusions on how they react to use and how they will react to reclamation or management changes. The difficulty in grazing lands has been to derive meaningful assessments of stocking rates. A system of grazing capacity and drought grazing capacity assessment based on rating scales for soils, topography, hilliness, tree density, land condition and average annual rainfall has been used. A system based on fodder availability and palatability would be more reliable, but such data information is not available now.

Mixed cultivation/grazing lands

Most of the resource inventories in these lands are of the land system/land unit type or soil mapping unit type surveys. In these lands either the land unit or soil mapping unit have been assessed to determine land use suitability. Techniques used in these surveys basically follow the procedures covered in the grazing lands, the main differences being associated with scale, field sampling intensity and more emphasis on soil properties.

Map scale in these studies ranges from 1:50,000 to 1:250,000 with the more detailed mapping being required for the more intensively cultivated areas. The more detailed maps follow more intensive yield sampling and sometimes changes in sampling techniques. At the larger scales the normal methods of free sampling may be replaced with grid sampling. The sampling intensity increases dramatically with the larger scale. McDonald (1975) suggests site sampling at the rate of one sample per 12-25 hectares without air photo-interpretation or one per 40-75 hectares with air photograph interpretation for scales of 1:50,000 as against 1 per 50-100 hectares (without API) or 1 per 150-300 (with API). McDonald also summarized the details required in the different level surveys.

Currently in Queensland a modification of the eight class USDA land capability classification is being used to assess agricultural capability. This classification indicates under present levels of technology the limits of intensity of safe land use, the required management techniques to counter the limitations of the land and the hazards attached to the use of the land. This assessment does not give any details regarding yields. The more detailed studies presently under way in "key areas" aim at supplying more specific management requirements and yields of the different land types.

Intensively used agricultural lands

The assessment of soils for irrigation or special crops generally requires very intensive studies. The investiga-

tion of "key areas" to identify particular land attributes which influence yield or management practices also requires intensive survey but results from these studies should apply to a much wider area. These studies generally follow on from reconnaissance studies which indicate the most suitable areas for further study.

In irrigation studies in Queensland most decisions on land suitability are based on physical attributes of the land. At present a modified five-class USBR irrigation land capability classification is applied to soil mapping units. In these areas we lack the technology to back up the assessment of land for specific crops under irrigation.

Our sugar land studies which have been initiated to establish areas for expansion, for relocation of severely eroded assignments or for irrigation schemes generally follow a similar approach to "key area" studies, i.e., they identify the critical land attributes limiting cane-land production and necessarily take into account economic considerations. Individual factors such as soil depth, slope or drainage may be used to identify suitable land in some areas. They are usually preceded by detailed soil survey.

Other studies

Considerable use is made of particular land attribute studies such as vegetation maps, geological maps and current land use maps in our work, but it is felt that land surveys covering soil, vegetation, topography and geology are needed to develop land-use policy and management practices.

USES

Contributions that land resource surveys have made to the general welfare are greater than can be listed here. However, some of the most important uses, particularly those relevant to surveyors, can be covered.

Of prime importance is the fact that they indicate the distribution and extent of land types. They illustrate the problems of individual pieces of land (i.e., soil fertility, depth susceptibility to erosion etc.) and their desirable attributes (deep fertile soils, underground water etc.). They indicate the need for management practices (contour banks if the land is cultivated, drainage schemes, fertilizer application) and indicate suitability for crops, pastures, forestry etc. and the likelihood of hazards such as flooding and landslip.

In the grazing lands they have been used as the basis for:

(*a*) Preparing property management plans: this includes location of fences, dams, homesteads, yards etc. and the suitability of the lands for pasture improvement, fertilizer requirements etc.;

(*b*) Locating both property and main access roads;

(*c*) Property design: the size and mix of country on brigalow blocks were dependent on types of country;

(*d*) Location of reserves;

(*e*) Rural reconstruction;

(*f*) Development of research and extension programmes;

(*g*) Planning of opening of new lands, i.e., Brigalow Scheme;

(*h*) Property valuation;

(*i*) Property purchase;

(*j*) Animal management: poisonous plants, pasture value, mineral deficiencies.

Many of these uses apply to more intensive uses but they have also been used for:

(*a*) Providing information for land zoning through councils and other local authorities;

(*b*) Locating irrigation schemes;

(*c*) Indicating areas susceptible to landslip or soil salinity if certain management practices such as clearing are carried out;

(*d*) Planning irrigation layout and irrigation farm design;

(*e*) Relocating cane assignments.

AVAILABILITY

The reports prepared by the Division of Land Utilisation of the Department of Primary Industries on land resource studies are available to *bona fide* users, generally at no cost. Dyelines of many of the maps are available at small scales: these are only available to people actually working in the area. The Agricultural Chemistry Branch has published a number of soil maps covering small areas at Mareeba-Dimbulah, Emerald, Lower Burdekin, Bundaberg and Maryborough. They have also undertaken studies of the pineapple lands, Granite Belt vineyards and Brisbane airport.

REFERENCES

McDonald, R. C. (1975), "Soil survey in land evaluation", Agricultural Chemistry Branch technical report No. 6 (Department of Primary Industries).

Venz, B. (1977), "Land capability and land use studies in the sugar growing industry", Proceedings of the Queensland Society of Sugar Cane Technologists, 44th Annual Conference, Bundaberg.

APPLICATION OF ORTHOPHOTOMAPS IN THE DEVELOPMENT OF A VISUAL REGISTER OF LAND TITLE IN NEW SOUTH WALES*

Paper presented by Australia

RÉSUMÉ

Le document expose une méthode de production de plans cadastraux susceptibles d'être portés en surimpression sur des cartes topographiques pour servir de base à une étude de mise en valeur. Cette méthode convient dans les cas où les levés

*The original text of this paper, prepared by the Central Mapping Authority of New South Wales, appeared as document E/CONF.72/L.47.

cadastraux ont été établis indépendamment de la Central Mapping Authority (Service cartographique central) de la Nouvelle-Galles du Sud aux fins d'établir un grand nombre de cartes topocadastrales en un bref laps de temps, et l'on estime qu'elle est bien adaptée aux besoins des pays en développement.

New South Wales is not only the oldest state in Australia, but also the state with the largest population: 5.05 million. It follows that it also has the largest number of land parcels which cover an area of approximately 802,900 sq km or 310,000 sq miles. The land parcels currently comprise 2.25 million private properties and 63 thousand crown tenures. For over a hundred years the crown tenures have been illustrated on parish maps produced by the Department of Lands. The maps have served as a useful index so long as absolute fidelity was not required in the compilation process and the relationship to topography was relatively unimportant. During the past two decades, however, the need for a complete register of crown and freehold lands became a matter of considerable importance in state development, and the Central Mapping Authority was directed to produce such a series in conjunction with its basic topographical map series which were essential to virtually all forms of development involving land.

Ideal mathematical solution

For persons involved in the registration of land under the Torrens System there is little doubt that the ideal method of producing a visual index of the cadastre is to connect each land parcel by survey to the geodetic framework so that precise co-ordinates may be derived for the corners of individual parcels. If this were done it would be necessary only to punch the co-ordinates onto cards as input data for a suitably programmed computerized flat-bed plotter to plot the cadastral survey rapidly and precisely. Unfortunately, this "ideal" state of affairs did not and does not exist in New South Wales, as the overwhelming majority of cadastral surveys were and continue to be undertaken on local origins unrelated to the geodetic survey of the state. Plans are now in hand to implement legislation requiring such connections in the future, but even if such legislation were in force it is obvious that the survey connections for over two million existing properties would take a long time, perhaps many decades, to effect.

Cadastral map production using traverses

In order to make use of the mathematical data of the individual title surveys, the Central Mapping Authority has used the data to calculate traverses between corners subsequently connected to the geodetic system at intervals of 5 to 8 km. In this way, closures of the order of 7 m in 8 km were obtained from time to time. However, the data prepared in this manner were sufficient for only 20 rural cadastral map sheets covering 6500 sq km per year. In order to achieve cadastral coverage in a decade it was necessary for the output of cadastral mapping to match that of topographical mapping which then stood at 100 rural map sheets covering 108,000 sq km and 200 urban map sheets covering 1300 sq km per annum.

Cadastral adjustment experiments

The Central Mapping Authority is aware that if all the cadastral survey data, that is, the sides and bearings of each land parcel, were put into a mathematical adjustment similar to a photogrammetric block adjustment, it should be possible to derive co-ordinates for the corners of each parcel. Considerable experimentation has been done in this regard, particularly when it appeared that funds might be made available for the card punching of data relevant to metric conversion of survey plans. However, not only did the funds fail to materialize, but the experiments themselves were unsuccessful for the following reasons:

(*a*) Some of the old plans were illegible;

(*b*) Occasionally large errors existed, particularly in older surveys;

(*c*) There were several old surveys where only three sides of a rectangle had been measured while the fourth had been deduced incorrectly from a previous survey;

(*d*) Many properties were separated by road strips but no precise survey data for the road strip existed;

(*e*) There were few, if any, connections between properties on opposite sides of rivers.

Consequently, the Authority has accepted as impractical at this time purely mathematical solutions to the problem of cadastral mapping in New South Wales.

Orthophotos as a base for cadastral maps

During 1971/72, the Authority acquired two Zeiss-Jena Topocart machines and for the past eight years these machines have been operated on two and sometimes three shifts. The main output of the orthophoto machines is 1:4,000 orthophotos connected precisely to the geodetic system by ground survey and analytical aerial triangulation. Tests have shown that the detail on orthophotos is within 0.3 mm of their correct positions at 1:4,000. Orthophotomaps now cover all the cities and major towns of the state.

It is not infrequent for a single orthophotomap to depict over 2,000 houses. In New South Wales, most dwelling units are detached houses situated on land measuring approximately 20 x 40 m and very often three of the four sides are bounded by wooden split-pole fences, while the fourth side facing the street may be bounded by a low brick wall or a wire netting fence. Consequently, the orthophoto provides a precision base, true to scale, on which the majority of land parcels are clearly and visibly indicated by boundary fences or their shadows.

It is this information which the Authority has utilized to map some two million titles in a decade.

The orthophoto is printed down to a stable-base, scribe-cote material, such as Stabilene, and the sheet is then placed on a light table. The light table itself is capable of two different light intensities. Using the lower intensity the cartographer is able to see the orthophoto image clearly. He then takes a transparent copy of an available map of survey plans photographically reduced to 1:4,000, and, using the higher light intensity, places the copy under the orthophoto image. If the plan and the fences depicted on the orthophoto conform, as will normally be the case, it is merely necessary to scribe the four sides of the property, to commence the cadastral

map. In this way, well over half the land parcels are scribed in their correct ground position and visually verified against the orthophoto. Naturally some parcels which do not have clearly visible boundaries have to be plotted by measurement and scaling to parcels that have imaged clearly on the orthophoto. The procedure is known informally as the "let-in" process. While not as accurate as a mathematical solution, the let-in process is acknowledged as showing the following benefits.

Three hundred cadastral maps are produced each year, whereas the maximum output achieved with the same staff using mathematical procedures was 20 sheets per year. The average accuracy obtained is 0.5 mm at scale 1:4,000, and this accuracy is sufficient for:

(*a*) A visual land register;

(*b*) Land valuation;

(*c*) Town and country planning, transport, general engineering design and land-use studies.

A copy of each cadastral map is supplied to the Director of Land Titles, the Valuer General and all local government and service authorities in the area. The method is insufficiently accurate for many engineering purposes; however, orthophotomaps have been produced from time to time at scale 1:2,000 for engineering work and have been enlarged to 1:1,000 for use in the design of water and sewerage reticulation.

Production times

The format of each 1:4,000 map is 3 x 2.5 km, and an average town with a population of about 20,000 may be covered by, say, six sheets, that is an area of 6 x 7.5 km. Statistics have been compiled over the past six years of man-hours involved in the production of cadastral maps from orthophotomaps of urban areas.

The time necessary to effect the ground control survey, the orthophotos and 2-metre contouring has been found to be approximately 300 man-hours, while the time subsequently necessary to produce the cadastral map is approximately 290 man-hours. It is estimated that without the orthophoto the time necessary to plot the cadastral map would be more than twice as long, and the final result much less satisfactory from the point of view of over-all accuracy and relationship to topography.

Rural cadastral maps

In the rural areas the Central Mapping Authority has used similar methods to those described above for the production of cadastral maps. Where maps are required at scale 1:25,000 or 1:50,000, the Authority does not have the capacity to produce orthophotomaps and consequently most production at these scales is in the form of line mapping. However, the line maps are printed down on stable-base scribe-cote material, and numerous rural properties, averaging 20 hectares in extent, are compiled by a let-in process identical to that described for 1:4,000 mapping. The time required to produce each rural cadastral map is approximately 180 man-hours. The western half of New South Wales comprises semi-desert scrub land suitable only for grazing, and in these areas a viable pastoral unit runs into many thousands of hectares. The whole of the Western Division of New South Wales has been covered with 1:100,000 orthophotomaps produced by the Commonwealth Department of National Development, Division of National Mapping. These 1:100,000 orthophotomaps are used in the identical manner to 1:4,000 orthophotomaps, to produce cadastral maps of the pastoral holdings by the let-in process. In this case, at least half the boundary lines can be located on the orthophoto from the image of lines cut through the scrub for boundary fencing, while the balance of the information is plotted by scaling.

CONCLUSION

By adopting the pragmatic approach of "letting-in" survey information into a precisely controlled orthophotomap, the Central Mapping Authority has evolved a speedy and effective method of producing cadastral compilations entirely adequate for the needs of most users. Under existing circumstances no other method could have produced cadastral maps of two million properties in so short a time.

It is submitted that the method outlined above will more than adequately meet the needs of developing nations faced with the urgent problems of land management and development.

CADASTRAL MAPPING, QUEENSLAND*

Paper presented by Australia

RÉSUMÉ

Le document donne un bref aperçu de la façon dont l'établissement des levés cadastraux a évolué au Queensland, depuis la proclamation du Queensland en tant que colonie. Il décrit le système de numérotation cadastrale actuellement en activité, expose deux principes importants pour l'établissement des levés, et indique les types de cartes produites jusqu'au milieu des années 60. Le document donne ensuite des détails sur les changements apportés au quadrillage cartographique en Australie, sur les types de cartes actuels et sur les méthodes de préparation des cartes; pour conclure, les perspectives d'avenir sont brièvement examinées.

*The original text of this paper, prepared by the Department of Mapping and Surveying, appeared as document E/CONF.72/L.51.

In 1859 the colony of Queensland was proclaimed. The initial population was 23,000 and the capital, Brisbane, on the Brisbane River in the south-east corner of the new territory, was the centre of development.

By 1900 the various colonies in the continent had progressed to the stage where some sort of federation was a logical step and accordingly Queensland, together with the other colonies, became states of the Commonwealth of Australia.

Early development first centred on shipping which serviced settlements along the 5,200 km coastline, and then on pastoralists who braved isolation and hardship in an unhospitable inland. Gradually railways provided communications along the coast of the state and eventually lines began to penetrate the western areas.

Queensland's area is 1,727,200 sq km and the state is divided by a relatively low series of ranges which run north-south and stretch along the whole east coast of the continent. To the east of this range, termed the Great Dividing Range, are fertile coastal areas supporting most of the state's population, and to the west stretch immense plains providing grass for millions of sheep and cattle, despite the moderate to arid climatic conditions that exist in the inland.

Land tenure

With such a diversity of conditions coupled with the size of the state, the recording of land ownership and the provision of appropriate maps has been a challenge to the Department of Mapping and Surveying throughout 120 years of map production.

As settlement expanded, a need arose to correlate land tenure and ownership information. As a result, the state was divided into irregularly shaped "counties", bounded in the main by geographical features and encompassing areas in the order of 6,000 sq km. However, as development intensified, the counties had to be divided into smaller administrative "parishes". The parishes were also bounded by geographical features, where possible. However, projected lines were used in featureless country, particularly in the vast western plains.

The task of recording ownership began with some tentative excursions into various forms of numbering systems; however, two major types of tenure descriptions evolved, and are still in use today.

The first description covered town residential blocks which were called "allotments" of a "section" of a "town". All other parcels of land sold or leased were described as "portions" of a "parish" of a "county". As in every procedure there are exceptions; possibly the major one in Queensland's system is the practice of assigning names to the huge western cattle properties, for example "Durham Downs Holding". These properties or stations, as they are often termed, embrace many parishes and commonly have areas of 100 sq km.

As Crown land was sold and became freehold the administration of the subdivision passed to the Titles Office which initiated a numbering system to record subdivision of Portions and Allotments. The first divisions of a parcel of freehold land were called "subdivisions", the next, "resubdivisions", and the following, "subdivisions", and so on. So subdivided freehold land became "subs." of "resubs." of "subs." of a "portion" etc. As can be imagined, this worked well in the early stages of development but as time went by the complexity of description became a challenge to interpret.

As a result, in 1966, the Queensland Titles Office changed from one extreme to another by abandoning subs. and resubs. and simply naming newly surveyed blocks of land "Lots on Registered Plan '123456' ", i.e., Lot 1 on R.P. 123456.

So it is that, apart from a large legacy of subs. and resubs., all present descriptions are portions, allotments or lots.

It should be noted that 80 per cent of the state is still occupied under lease from the Crown and even with a continuing trend to freehold, there will be large areas of Crown leasehold land for many years to come.

Surveying

Turning to the technical side of land subdivision, in 1896 a far-sighted Surveyor General foresaw the need to avoid surveys being effected that were not connected to original marks. He foresaw the difficulties in reinstatement of survey marks when all traces of the original work were destroyed and he reasoned that an integrated system in which all surveys were connected to other surveys would provide the means of reinstatement which would otherwise be well nigh impossible.

An even more important decision was to ensure that not only would surveys be connected to each other but that their azimuths would be interrelated. To achieve this goal regions were established in which the azimuths of all surveys would be related to a common arbitrary north. The previously mentioned counties were used as a basis for this standardization, and the north adopted in each county was selected to approximate the magnetic north in the area. Accuracy was maintained by sun and star observations which were used to calculate meridian convergence, thus ensuring the surveys' correct relationship to the adopted north. This system of azimuth control became known as county arbitrary meridian or CAM.

These two decisions, made long ago, have been a tremendous asset to mapping in the state, for it has given cartographers over the years the means of producing reliable and accurate maps.

Mapping

The basis of Queensland's present mapping systems began to crystallize in the early 1900s as development began to spread throughout the entire state. It was clear that, due to the vast size of the state, a wide range of cadastral maps would be required to provide adequate administrative coverage over such a wide variation of development and population density.

During the 1920s a policy on scales and procedures was formulated and the general principles evolved then have proved so successful that they are still fundamental today in the Department's approach to, and the public's acceptance of, cadastral maps.

The types of maps and scales used until the middle 1960s were:

(*a*) A sheet series at four miles to an inch which covered the state with the exception of the coastal strip;

(*b*) Maps at two miles to an inch which provided coverage over the eastern half of the state;

(*c*) A series of parish maps, produced to provide maps for the more populated areas of the state. These were published at forty chains to an inch and are on an "island" format to suit the irregular shape of the parishes. As these maps cover the state's most developed areas they were, and still are, a very widely used series. About 1,100 were published;

(*d*) Town maps, the largest scale maps produced. These are at scales ranging from two chains to eight chains to an inch, depending on the size of the town and the complexity of the cadastral information.

It has always been the policy of the Department of Mapping and Surveying to show on maps as much information as economically possible; i.e. the state's cadastral maps show land description, lease number, area, survey plan catalogue number and, in the case of freehold land, subdivision numbers and areas. Limited topographic information is depicted in the form of selected creeks and mountain ranges.

The Department has always attempted to present the map user with a product that is informative, as complete as possible and easy to read. The time taken to produce such a map reduces the time the public and private sectors would otherwise spend in searching information at the State's main tenure recording Departments.

About 1960, changes were beginning to influence mapping procedures. Until this date all maps had been prepared on tracing linen and "written up" by the compiling draftsman. Co-ordinates calculated from survey plans controlled the maps, but as plots were prepared on paper, then traced to linen, accuracy was difficult to maintain.

With the introduction of stable based drafting film, accuracy increased dramatically and this, coupled with the use of computers to provide plotting control co-ordinates, provided accuracies not previously possible. Because the times necessitated the use of more juniors and hence less trained staff, hand lettering gave way to the use of photographically produced type.

Until 1966 there was only limited standardization of map preparation in Australia. There was a need for the national co-ordination of trigonometrical networks throughout the country.

These anomalies were resolved in 1966 when all geodetic surveys in Australia and New Guinea were recomputed and adjusted on the Australian Geodetic Datum, providing an homogeneous system of co-ordinates for geodetic work throughout the continent. The Universal Transverse Mercator projection was used as a base for the Australian Map Grid (AMG) and forms the origin of an integrated system of maps based on ½° x ½° sheets at a scale of 1:100,000. To provide larger scales, these areas were quartered to provide 1:50,000 sheets and so on up to a scale of 1:2,500. The numbering system follows the division of the 1:100,000 areas, i.e. 9543 for a 1:100,000 area, 9543 14 for a 1:25,000 within the area, and so on to 9543 14243 for a 1:2,500 map.

The provision of AMG and the need to begin the metrication of mapping required the Department to adopt the national system. It was resolved that maps of all scales would be compiled on the sheet system and, as resources permitted, existing "island" format maps would also be converted.

During the last decade, the Department of Mapping and Surveying has embarked on a topographic mapping programme. An important by-product of this has been the use of photogrammetric material as a base for cadastral plotting. This has proved of immense value in the preparation of cadastral maps and has eliminated the problem encountered in co-ordinate calculations from cadastral surveys where one erroneously surveyed line will corrupt an entire close thus distributing the error through the entire map.

To extend the Department's photogrammetric capabilities, a Zeiss GZ1 orthophoto projector was purchased in 1973. Since then, the Department of Mapping and Surveying has been heavily committed to orthophoto map production at scales of 1:2,500 and 1:10,000, and is now entering the field of 1:25,000 orthophoto mapping. As with the photogrammetric plot, the orthophoto has proved an ideal base for cadastral map plots, resulting in these two mapping bases forming the foundation for all new work and in the conversion of the old series to the sheet system.

CURRENT MAPPING

In 1976 the Department was reorganized and, in the Cartographic Division, five compiling sections were established, each with 30 officers. These sections are responsible for the production and revision of the following map classifications.

Compiling 1 A 1:250,000 series, replacing the old four-mile maps and covering the state west of 145°. Maps at 1:100,000 which cover all regions east of 145°. Numerous state maps depicting major administrative boundaries.

Compiling 2 Preparation of 1:25,000 and 1:50,000 series to replace the "island shape" and ageing parish maps. Where 1:25,000 sheets cannot be prepared as standard maps due to lack of map control, provisional sheets are being prepared as an interim measure.

Compiling 3 This section is engaged on topographic work and is responsible for maps at a scale of 1:25,000, 1:10,000 and orthophoto maps at 1:25,000 and 1:2,500.

Compiling 4 This section prepares and maintains 1:10,000 cadastral maps which are in good demand, and cover the state's areas of open urban and closely settled rural areas. Orthophoto maps at 1:10,000 are also prepared in conjunction with the cadastral maps.

Compiling 5 Previously drawn town maps of all cities and towns are maintained, and the lengthy process of converting and upgrading these maps to the sheet format is a continuing task. All new "town map" compilation is at a scale of 1:2,500 and production is based on orthophotos.

SOME COMPILATION DETAILS

All new maps are now prepared in overlay form and a three position punch registration system ensures perfect registration. The Department of Mapping and Surveying sees great flexibility in this system as it allows the combining of various forms of information. As an example, the Department publishes 1:2,500 orthophoto maps with one-metre contours and the same contour overlay is used to produce a 1:2,500 cadastral map with contours.

Both scribing and ink type pens are used for map line work, scribing being favoured for smaller scales while ink is found convenient for larger scale maps.

For each cadastral map scale, the Department produces a comprehensive manual that covers all aspects of map compilation. The manuals are provided to individual officers of each mapping section.

The Department of Mapping and Surveying has recently acquired an "Editwriter" type-set instrument which supersedes two Monotype and one Hadego machine. The Editwriter is computer-controlled and possesses a VDU for editing and floppy disc memory storage unit. It is proving effective in supplying type which is processed as "strip film" or "dry transfer type", depending on the requirements of differing map types.

To provide experience in all fields of the Department's activities, a staff rotation scheme operates for all officers below a specific classification. A two-year period, with variations to suit circumstances, is the average time spent in each section, and while problems do arise when an efficient officer is transferred, the over-all effect is beneficial for the Department.

There are about 4,300 maps published by the Department, and in the order of 125,000 lithographs are sold each year. All cadastral maps are revised at approximately five-year intervals and many parish and town maps have survived this process for fifty years and are still good for a revision or two as they await conversion to the national sheet system.

THE FUTURE

The Department of Mapping and Surveying considers, along with most cartographic organizations, that for economic and technological reasons the future lies in some form of computerization. This is the only way information can be manipulated to provide not only the traditional map, albeit in new forms, but also new means of data presentation.

To pursue these goals the Department has acquired an Interactive Graphics Unit consisting of computer, graphics display, disc storage and flat bed plotter. This equipment is seen as the embryo of future systems which will allow expansion in the area of automated mapping and data banks.

Cadastral maps have had a long tradition of providing users with a reliable picture of the state's cadastral systems, and the Department of Mapping and Surveying has confidence in the future role they can play in the development of Queensland.

APPLICATION OF COMPUTER TECHNOLOGY IN THE PROCESSING OF CADASTRAL SURVEYING AND MAPPING DATA*

Paper presented by France

RÉSUMÉ

L'Institut géographique national a acquis au cours des dernières années une bonne expérience dans les domaines de la cartographie numérique à grande échelle et la gestion des banques de données cartographiques.

En fonction des résultats obtenus et des besoins exprimés, un schéma de système cartographique à buts multiples est présenté qui pourrait convenir soit à un pays développé dans lequel l'harmonisation et la mise à jour de la documentation cartographique et cadastrale seraient envisagées dans le cadre d'un système intégré, soit à des pays ne possédant pas encore de documentation à grande échelle mais dont le développement justifierait cet investissement.

L'accent est mis sur la nécessité de mettre en œuvre un système à la fois simple et souple, en évitant les matériels trop sophistiqués et en limitant l'utilisation de l'informatique à des applications raisonnables.

La saisie des données sur appareil de restitution et sur table à numériser ainsi que les traitements des fichiers sont décrits en détail.

Des méthodes originales de traitement des données pour l'obtention des plans parcellaires cadastraux sont développées.

Developments in computer technology during the last twenty years have enabled cartographic and cadastral services in various countries to experiment with automatic methods of data acquisition, processing and display which, in order to justify the large investments involved, can only be planned as part of integrated systems where the basic data will be used for many different purposes and will be available to a large number of present and future users.

Obviously, one cannot propose such systems to all countries, and taking into account such factors as their degree of development, amount and nature of the data to be processed, available trained personnel and financial resources, it is sometimes wiser to use conventional methods, which are easier to apply and do not necessitate heavy investment.

The method discussed below is applicable in a country which has been producing cadastral plans for quite some time and has medium-scale basic mapping linked with a very accurate geodetic network and plans to build up an integrated digital system as part of a cadastral renovation project associated with the production of large-scale basic maps. It can also be applied in a developing country where there is no existing large-scale or cadastral mapping, so long as one first establishes a homogeneous accurate geodetic network without which the digitized position data may have to be readjusted at a later date.

*The original text of this paper, prepared by D Cremont, Institut géographique national, appeared as document E/CONF.72/L.62.

The development of these procedures will require, if not the centralization of resources, at least an excellent co-ordination between all the services concerned and all possible users.

General observations

The structure of the data acquisition and processing chain should be independent of the accuracy and scale of the cartographic documents that will be produced, at least where the 1:500-1:5,000 scale-range is concerned. Only the characteristics of the aerial photography, field surveys, digitizing procedure and the scale of intermediate documents should be adapted to the aims of the various operations.

In a developed country where agriculture and industry are well balanced, and where the average plot area is about one acre, the following basic scheme might be adopted:

(*a*) General maps at the 1:5,000 scale except for mountainous and desert zones with low population densities and few industries;

(*b*) Cadastral plans at the 1:2,000 scale in agricultural zones;

(*c*) Maps at the 1:2,000 scale and cadastral plans at the 1:1,000 scale in suburban zones;

(*d*) Maps at the 1:1,000 scale and cadastral plans at the 1:500 scale in dense urban zones.

If the different cadastral plans and topographic maps are sufficiently accurate and complete so as to qualify them as "regular" maps, then by-products at scales 2 or 2.5 times larger could still be useful in many cases.

Some basic principles must, however, be borne in mind:

A priori it seems preferable to dissociate the graphic data from the non-graphic data and to store them in separate data-bank files which can then be linked via various identification codes such as:

(*a*) Cadastral parcel numbers;

(*b*) Building postal addresses;

(*c*) Code numbers of geographic, statistical or administrative sections etc.

In this way each file can be managed separately in a flexible modular structure so that it will always be possible to add or modify the information and the relations between data.

When interrogating the data bank the references may be non-graphic data giving access to a group of position data. Inversely, the reference may be a well-defined zone in which statistical research concerning a particular theme is being undertaken; in this case the output will be a list of non-graphic data and, if necessary, a drawing of all the details concerned.

In such a structure the users will be obliged to comply with a certain number of rules particularly when formulating their questions; this may be considered as a drawback by some of them. However, this structure has the great advantage of being perfectly organized, so making it possible at any moment to introduce new storage levels, improve management programmes and gradually increase the data bank loading.

It should be noted that at the commencement of such large projects, it is impossible to foresee future main developments. Consequently, the main concern must be the organization of the data and the flexibility of the system, in spite of any criticisms which may be made.

Figure 100 gives a general idea of the organization of data collection and processing both for establishing a data bank as well as up-dating it. This organization, which is quite conventional, comprises the following seven different stages:

1. Data collection (stereoplotters, existing files of position or non-graphic data, digitizing tables etc.);
2. First graphic processing (file structuring, automatic checking, line smoothing etc.);
3. Production of graphic documents for the following stage;
4. Investigation, inspection, identification, adding information, field completion etc.;
5. Integration of the complementary data obtained during the preceding stage into the files, correction of faults and errors, linkage of graphic data to non-graphic data using identification codes etc.;
6. Data processing and establishment of the data bank using management and utility programmes for the applications;
7. Output: final drawing on precise drafting tables or with scanning plotters, orthophotographs from digital terrain models, graphic files for external users, non-graphic data files for all purposes (cadastral listings, statistical analysis, administrative documentation, environmental studies, etc.), digital terrain models and special drafting, such as urban perspectives etc.

The same procedures can be used for up-dating maps and files. After investigation or field completion one may need to use a stereoplotter or digitizing table once again particularly when there are numerous changes; the new data must then be processed in the manner described above.

Compilation of non-graphic data takes place at the same time as the field completion owing to the fact that in many cases the information is collected on site. This is particularly true for cadastral information obtained from land-owners, farmers and occupants of parcels and buildings. For this reason these activities are linked with graphical field completion.

The seventh stage concerns products which may be final ones or intermediate research results from which additional information can be processed. These results can then be fed back into the central computer when interactive procedures are available.

Data collection

Methods

The following three methods are in general use for data collection:

(*a*) Photogrammetric surveys;

(*b*) Conventional field surveys;

(*c*) Digitizing existing maps and documents.

It is no longer necessary to mention the advantages and capabilities of photogrammetry, but it will be useful to stress certain points:

(*a*) Stereocomparators or first-order analytical stereoplotters with bundle adjustment programs, when carrying out aerial triangulation, give standard deviations of 5 microns on the photoplate. This makes it possible to use this method for increasing the geodetic network density and, in particular, to obtain complementary control points for conventional surveying;

(*b*) Digital stereoplotting avoids the reduction in accuracy which occurs in graphical plotting between the stereomodel, the compilation base and the final drafting and can amount to 0.5 mm in certain cases;

(*c*) Photogrammetry is quite suitable for large-scale mapping which, at one time, was not generally accepted. With first order analog stereoplotters standard deviations of 10 microns at the photoplate level can be obtained if the features are clearly defined. This accuracy, which can be improved using analytical stereoplotters and plate grids, is preserved until the last stage of the procedure when digitizing on magnetic tape;

(*d*) Photogrammetry guarantees a homogeneity which cannot be obtained with conventional field surveying. This exceptional quality makes it possible to use a ground control network with an accuracy of the same order of magnitude as that of the detail survey.

In general, when one wishes to set up a land information system, the photogrammetric survey must be completed in the field. For this purpose it is necessary to give the surveyor a sufficiently detailed compilation base in order to reduce the field survey to simple length measurements with a tape. If there are not enough well-defined natural points in the area, it will be necessary, before the aerial photography, to set up a pretargeted network for the complementary field survey.

If maps and documents with satisfactory quality are available, they could be digitized. A digitizing table linked to an interface and a magnetic tape recorder can then be used.

However, it should be noted that:

(*a*) The standard deviation for the digitization of a graphic document, notwithstanding its quality, is of the order of 0.3 mm at the document scale, so long as the deformations of the support document are isotropic;

(*b*) If the document to be digitized requires a large amount of up-dating, it is often less expensive and more accurate to renew it, in particular, using digital photogrammetry;

(*c*) The digitization of existing maps is only economic if the density of the details is not large or if the information they contain cannot easily be collected by other means, e.g. buried networks, old plot boundaries etc.

In most cases, photogrammetric surveys, direct surveys and document digitization are used together. The difficulty is to select one of them to meet the specific conditions encountered and also to co-ordinate all three methods.

Digitization on the stereoplotter

At the IGN-F the stereoplotters are first order ones such as (*a*) Wild A 10 or (*b*) Zeiss Planimat D 2, respectively equipped with the following interfaces and magnetic tape recorders:

(*a*) EK 22 and Digidata;

(*b*) Ecomat 12 and Pertec.

In addition each instrument is equipped with a co-ordinatograph on which the plotted lines are drawn; the resulting document is only used at this stage to organize the stereoplotting, break it down into meshes and obtain a record of the progress made.

The ratio between the stereomodel scale and that of the photograph is generally about 2.

Data collection can be carried out point by point or automatically either with recordings at pre-established time intervals or for given x, y, or $x + y$ displacements. A foot-pedal simultaneously controls the co-ordinate recording on magnetic tape and the drawing on the adjacent table.

This configuration results from the conversion to digital cartography of an instrument designed for conventional mapping. The following other systems exist:

(*a*) Several stereoplotters connected to the same computer via an interface;

(*b*) Use of an interactive console at the stereoplotting stage for error correction;

(*c*) Replacement of the co-ordinatograph by a device for displaying the lines already plotted (anaplot, screen) etc.

Selecting a system obviously depends on the equipment already purchased and the available finance, but one must also consider the staff diverted to this task, their habits and qualifications.

It appears difficult to completely avoid off-line inspection even if an interactive console is added to the data collection system. In addition, one should not increase the number of plotting operations, otherwise the productivity will decrease considerably.

Analytical stereoplotters should be more suitable for digital plotting than analog ones because certain recording control functions can be carried out by computer, and a screen along with an alphanumeric console facilitate the exchange of instructions. Finally, they have the great advantage of being independent and perfectly integrated units.

Although all possibilities remain open, two scale ranges are often used because they correspond to the most frequent needs arising with multi-purpose large-scale maps:

(*a*) 1:14,500 photographs:
Regular maps at 1:10,000, 1:5,000, 1:2,000
By-product at the 1:1,000 scale

(*b*) 1:6,000 photographs:
Regular maps at 1:5,000, 1:2,000, 1:1,000
By-products at the 1:500 scale

To this range one might add

(*c*) 1:3,500 photographs:
Regular maps at the 1:500 scale

The photographs used are often on panchromatic emulsion, but colour emulsions could be used to make the identification of planimetric details easier.

The order in which the data are digitized has no effect on the processing; nevertheless, it is convenient to adopt the following procedure:

(*a*) Reference points;

(*b*) Roads, railways, drainage network etc., and in general any line which forms a mesh boundary;

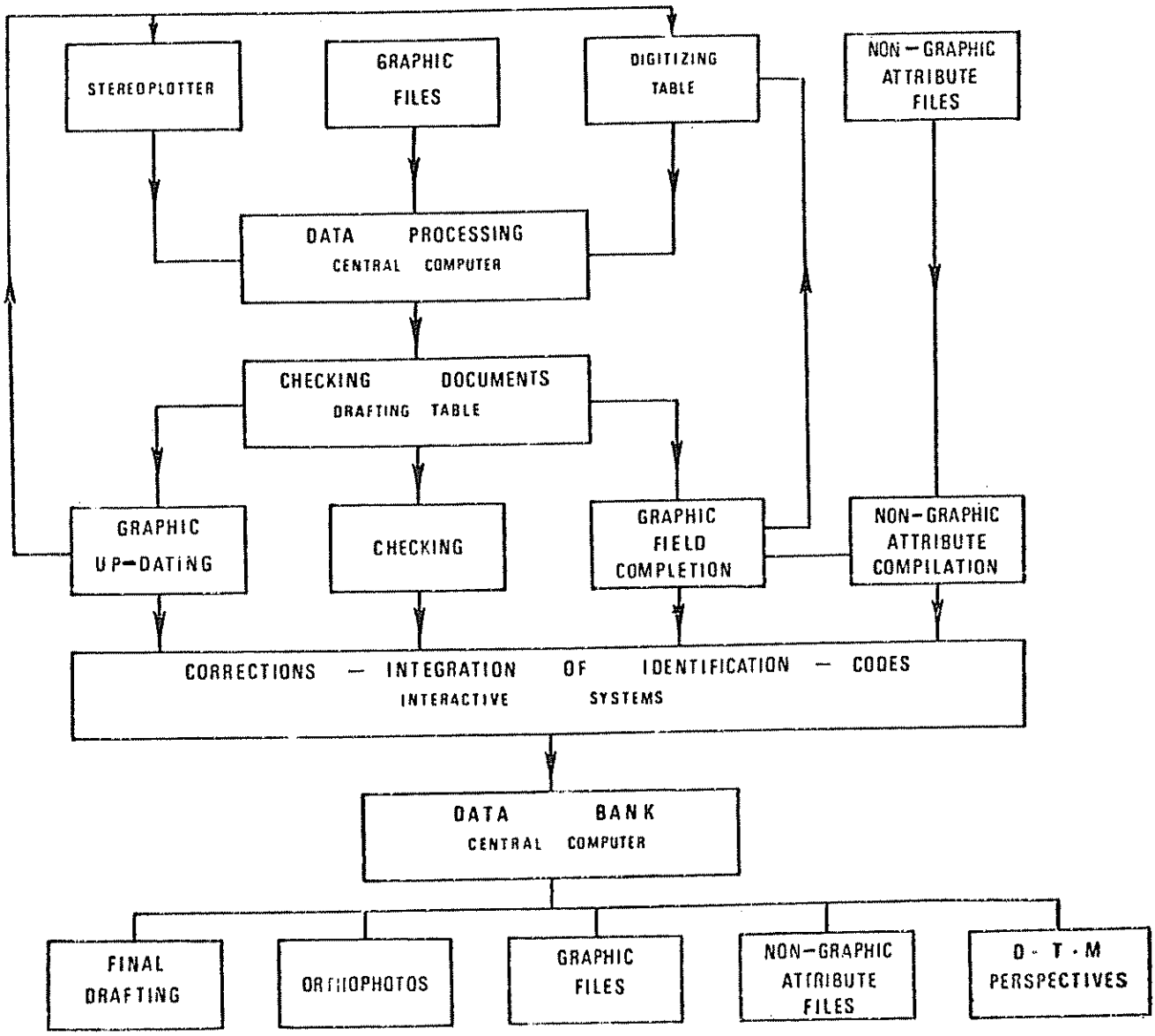


Figure 100. France: general structure of data collection

(*c*) In each mesh, secondary roads, buildings, vegetation etc., finishing each theme before passing to the next one;

(*d*) Spot heights linked to planimetric features;

(*e*) Contours;

(*f*) Spot heights related to the relief (knoll, col, talweg, depression etc.);

(*g*) Reference points.

Recording management: NUMERIS file (figure 101)

The management must be the same both for digitization with stereoplotters and the processing of old documents on digitizing tables.

In general, a single magnetic tape with a capacity of about 11.5 million bytes (1,200 feet with 800 bits per inch (bpi)) is used for one stereomodel or one map sheet.

A stereomodel comprises between 10,000 and 300,000 points, i.e. from 50,000 to 4 million bytes divided into several digitization sequences (5 to 20) each constituting a distinct file.

As the capacities of the buffers in the recording devices are multiples of 16, i.e. 512 and 1,024 bytes respectively for the Digidata and Pertec equipment, each recording block contains 512 bytes (2/3 inch). An interval of the same length separates each block.

The aerial triangulation pass-point co-ordinates (6-15) or the map reference points (corners or grid intersections) are recorded ahead. The code number 99 is written first to distinguish them from the feature co-ordinates, and they are followed by a four-digit number corresponding to the general repertory or ground co-ordinate file of those points.

Each point is defined by a set of 3 co-ordinates (X and Y in hundredths of a millimeter in the model space, Z in metres, decimetres or centimetres in the ground space) and one code-number which makes it possible to identify their nature.

The length of the recording is constant and equal to 16 bytes for one set of point co-ordinates and for the identification codes.

One co-ordinate record consists of 5 bytes for X, 5 bytes for Y, 1 interval byte and then 5 bytes for Z (figure 101).

The identification code for a reference point consists of:

(*a*) 2 bytes (99) to indicate that it is a reference point;

(*b*) 2 bytes available for other purposes;

(*c*) 4 bytes for the number of the point;

(*d*) 3 bytes available for other purposes;

(*e*) 5 bytes for the incremental numbering of the points.

The identification code of the digitized detail points is somewhat different and consists of:

(*a*) 1 byte (8 or 9) indicating that it is either a relief-point (spot height or contour point) or a planimetric point; this number is used to identify possible errors;

(*b*) 1 byte for confirmation or erasure (validation);

(*c*) 1 byte indicating the position of the object with respect to the index movement during digitizing (road on the right or on the left);

(*d*) 1 byte indicating whether the digitized line is a closed polygon or not;

(*e*) 1 byte showing whether the digitized line is a property boundary or not;

(*f*) 3 bytes for the nature of the feature;

(*g*) 3 bytes in reserve for later applications;

(*h*) 5 bytes for the numbering of the points. The counter is turned back to zero at the end of each file and, in particular, at the end of each working sequence.

In practice, the code number is recorded only at the end of a set of points defining a feature (line, contour, etc.) in order to indicate the end of the record. In general, 42 code numbers are sufficient when plotting for distinguishing the different features on aerial photographs, so it has been possible to construct special keyboards on which each of the 42 keys corresponds to a distinct feature and automatically activates the writing of that code number on the magnetic tape.

For each digitizing sequence, which ends with a tape-mark and whose length corresponds to about three hours of data acquisition, there is an index card on which the following information is given:

(*a*) Numbers of the aerial triangulation points;

(*b*) Co-ordinates of the 6 reference points read on the plotting counters;

(*c*) Absolute orientation calculations and scaling of the stereomodels;

(*d*) Discrepancies between the different reference point co-ordinates observed during the stereoplotting;

(*e*) Counter readings;

(*f*) Summary description of the different files (contours, buildings etc.);

(*g*) Information concerning anomalies, difficulties etc.

DATA PROCESSING (FIRST STAGE)

The data acquired with stereoplotters or digitizing tables as well as those coming from existing files are next processed in a central computer and modified before being integrated in the data base (see figure 102).

This data base comprises:

(*a*) FIGEST management disk file, permanent during all the operations in a given zone containing:

(i) General information about the zone;

(ii) All networks (geodetic points, aerial triangulation pass-points, bench-marks etc.);

(iii) Storage addresses of the data concerning single collection units, e.g. map sheets or stereo-minutes;

(*b*) Disk file of the symbols on maps at the 1:200, 1:500, 1:1,000, 1:2,000, 1:5,000 and 1:10,000 scales;

(*c*) Disk file containing the X and Y co-ordinates of the sheet corners of the 1:10,000-scale maps in a normal sheet line system, the alphabet program as well as the standard theme program, e.g. roads, buildings etc.;

(*d*) Non-graphic data file (empty during the first stage of operations);

(*e*) Special disk file at three levels;

(i) Objects, parcels, sections etc. (OBJECTS file);

(ii) Segment identification code (FIDENT file);

(iii) Point co-ordinates (FIPOINT file);

NUMERIS FILE

Xa in 1/100 mm					Ya in 1/1 0 mm						7 (field value)				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ø to 7	Figures from Ø to 9				Figures from Ø to 9					Ø	Figures from Ø to 9				

STRUCTURE OF CONTROL POINT CODE RECORDING (II)

SPECIAL CODE				Point number							Counter				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
9	9	Ø	Ø	Figures from Ø to 9				Ø	Ø	Ø	Figures from Ø to 9				

STRUCTURE OF IDENTIFYING CODE RECORDING (III)

Cat.	Del.	left right	Shut Open	Plot.	Nature Code						Counter				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
8 or 9	Ø or 1	Ø or 1	Ø or 1	Ø or 1	Fig. from Ø to 9			Ø	Ø	Ø	Figures from Ø to 9				

BLOCK STRUCTURE (512 octets)

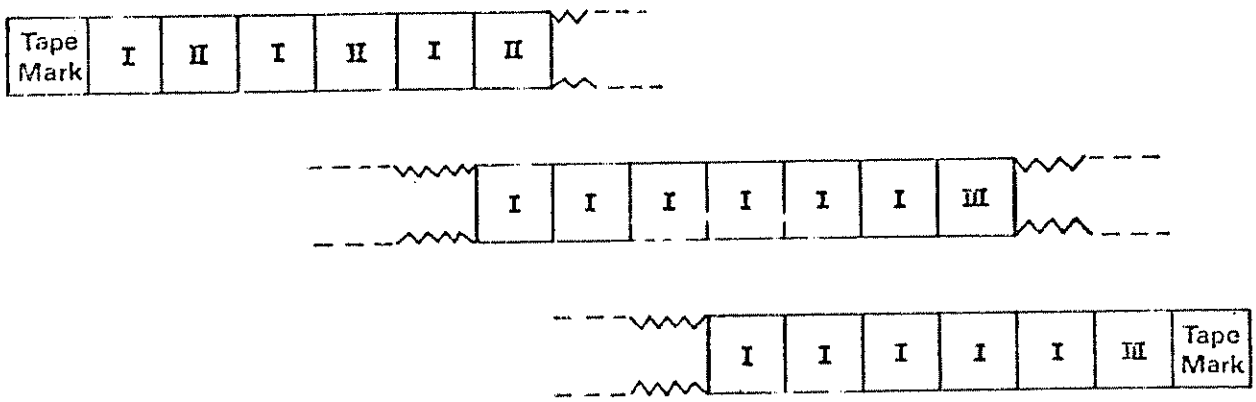


Figure 101. France: structures of recording

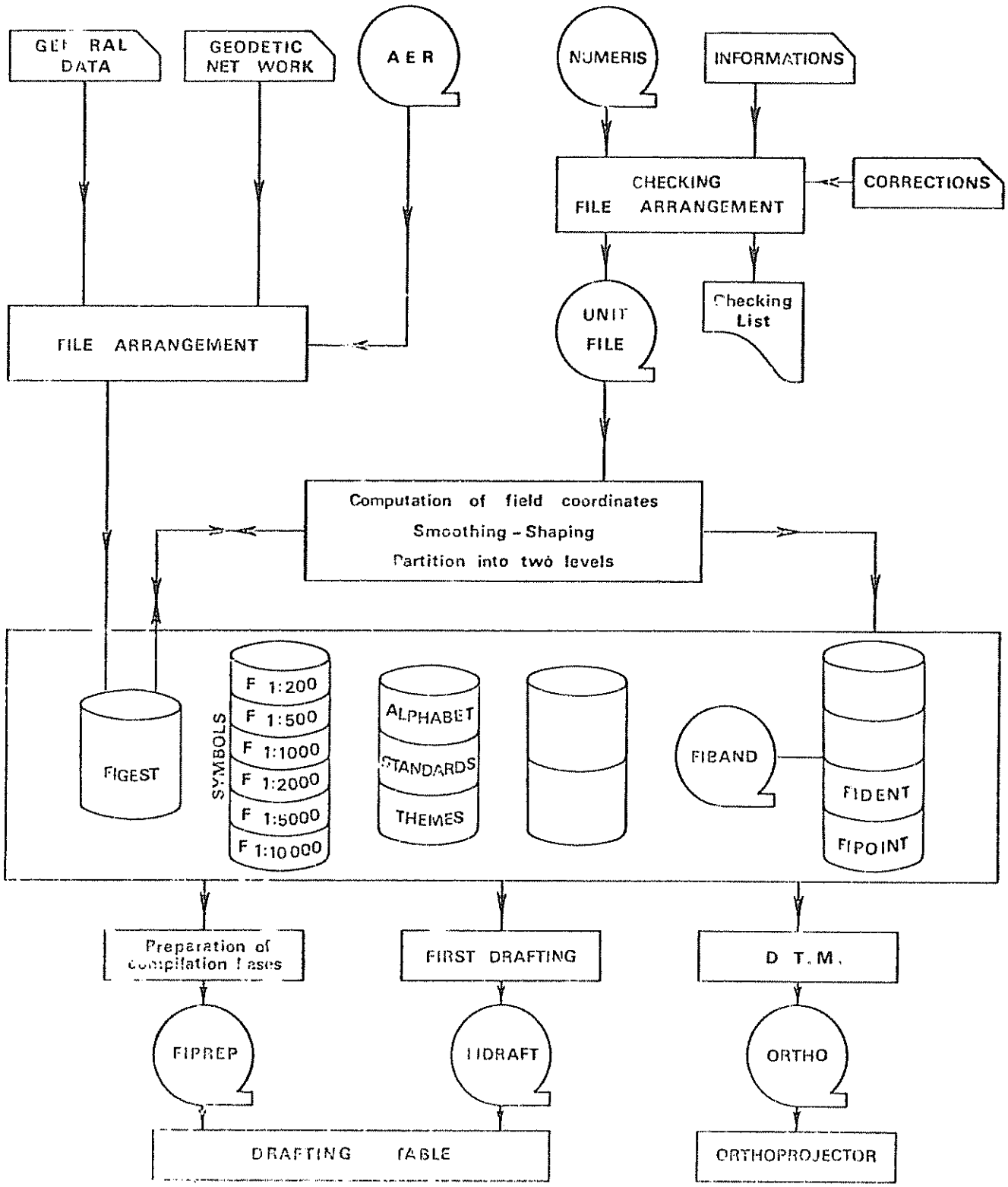


Figure 102. France: preliminary data processing

(During the preliminary data processing the FIDENT and FIPOINT files are the only ones to be loaded.);

(*f*) Group of magnetic tapes forming the FIBAND file in which data from the disks are stored after use.

FIGEST file

The FIGEST file is loaded, either with a special program which classifies external information such as:

(*a*) General information about the zone;

(*b*) Co-ordinates of geodetic points and bench-marks;

(*c*) Co-ordinates of aerial triangulation points;

or with the general data processing program after obtaining information from FIGEST for the calculations.

The FIGEST file is an index sequential file consisting of sets of 508-byte recordings. The first five sets are devoted to general information about the zone, and the following sets contain special information about each collection unit (stereomodel or map sheet).

The detailed general data are as follows:

(*a*) Number of aerial photography missions covering the zone;

(*b*) Reference numbers of those missions;

(*c*) Dates of aerial photography;

(*d*) Focal lengths of cameras used;

(*e*) Serial numbers of cameras used;

(*f*) Free text of 160 bytes;

(*g*) Total number and serial numbers of map sheets covering the zone;

(*h*) X and Y parameters (km) for translation of the entire zone (X and Y zone co-ordinates are given with respect to the zone barycenter);

(*i*) Number of reserved records (8,160 bytes each) for each collection unit in the FIDENT file;

(*j*) First FIDENT record address;

(*k*) Address of the first FIDENT free spot;

(*l*) Address of the end of the FIDENT file;

(*m*) Number of reserved records (8,160 bytes each) for each collection unit in the FIPOINT file;

(*n*) First FIPOINT record address;

(*o*) Address of the first FIPOINT free spot;

(*p*) Address of the end of the FIPOINT file;

(*q*) Number of aerial triangulation blocks in the entire zone;

(*r*) Serial numbers of those blocks;

(*s*) Serial numbers of stored tapes, i.e. containing at least one stereomodel;

(*t*) Serial numbers of reserved tapes for storage;

(*u*) Number of stored files in each tape;

(*v*) Length, in feet, already used on the last tape;

(*w*) Length, in feet, of the storage tapes;

(*x*) Their density (800 bpi, 1,600 bpi etc.);

(*y*) Name of zone;

(*z*) Variable indicating the last significant figure of the co-ordinates;

(*aa*) Last recording (in condensed form);

(*bb*) Listing of the useful codes for the first drafting.

The detailed special data for a given collection unit (stereomodel or map sheet) are as follows:

(*a*) Number of the collection unit;

(*b*) Size in decimeters (or double decimeters) of its emprise (rectangle with sides parallel to the co-ordinate grid covering the collection unit);

(*c*) Parameters of the required translation for transforming zone co-ordinates into field co-ordinates;

(*d*) Number of collection unit points in the FIPOINT file;

(*e*) Address of the first record in the FIPOINT file (0 if the collection unit is not on the disk);

(*f*) Address of the last record in the FIPOINT file including extensions (0 if the collection unit is not on the disk);

(*g*) Number of identification codes for the collection unit in the FIDENT file;

(*h*) Address of first record in the FIDENT file (0 if the collection unit is not on the disk);

(*i*) Address of the last record in the FIDENT file, including extensions (0 if the collection unit is not on the disk);

(*j*) Serial number of tape on which the collection unit is stored;

(*k*) Rank of the file on the storage tape;

(*l*) Number of geodetic points;

(*m*) Geodetic point co-ordinates;

(*n*) Number of bench-marks;

(*o*) Bench-mark co-ordinates;

(*p*) Number of ground control points;

(*q*) Co-ordinates of the ground control points;

(*r*) Special progress code:

(i) O if the collection unit has not yet been processed;

(ii) A if the two-level file exists;

(iii) B if the first drafting has been carried out;

(iv) C if corrections have been made;

(v) D if the given collection unit is stored on magnetic tape;

(*s*) Serial number of the version;

(*t*) Date of the last version (year, month, day).

FIDENT and FIPOINT files

Digitized data are first read with a special program which

(*a*) Reveals certain recording mistakes and corrects them either automatically or with instructions on punched cards;

(*b*) Regroups all the data sequences concerning a given collection unit on the same magnetic tape.

This program lists general information which is then compared with the index card produced at the time of data collection, so as to check that the

(*a*) Control points have been introduced;

(*b*) Machine system co-ordinates have been correctly recorded;

(*c*) Serial numbers of the ground control points have been correctly written;

(*d*) Record numbers for each file agree.

These checked data are then processed with the general input program before being introduced into the

data base. The main functions of that program are as follows:

1. Take from FIGEST the data required for current processing, e.g. field co-ordinates etc., and to up-date FIGEST.
2. Erase redundant ground control points.
3. Compute linear transformation parameters using the formula
$$X = a_1x + b_1y + c_1$$
$$Y = a_2x + b_2y + c_2$$
in order to convert the machine co-ordinates x, y, into field co-ordinates X, Y, with reference to the general projection system.
4. Erase redundant detail points (Δx and $\Delta y \leqslant 4{,}100$ mm) and excess points inside a line (direction changes $\leqslant 6/100$ mm).
5. Check line closure within a given tolerance, which varies according to the nature of the details, and reveal anomalies.
6. Modify slightly building shapes to make them rectangular (within limits).
7. Compute centre co-ordinates, radius and sometimes circumference points.
8. Transform detail co-ordinates $(x, y) \rightarrow (X, Y)$ using the parameters defined in 3, above.
9. Separate identifiers and co-ordinates in order to create the two-level FIDENT and FIPOINT file.

FIDENT is the element identifier file. Each identifier associates with the NUMERIS code information which makes it possible to retrieve the point co-ordinates of a given element in FIPOINT.

The FIDENT file structure is as follows:

Category code (planimetry or relief)	1 byte
Validation code	1 byte
Closing code	1 byte
Direction code	1 byte
Entity code	3 bytes
Auxiliary code (contours)	5 bytes
Element emprise (max. and min. X and Y)	8 bytes
X and Y of the element first point	4 bytes
X and Y of the element last point	4 bytes
Serial number of FIPOINT block	2 bytes
Element rank in FIPOINT block	2 bytes
Number of points in the element	2 bytes
Element linkage	2 bytes
Error code	1 byte
Drafting code	2 bytes
Correction code	1 byte
TOTAL	40 bytes

Each record in the FIDENT file consists of 204 identifiers of 40 bytes each, i.e. 8,160 bytes.

The first two identifiers do not correspond to any point; they are used to supply information about the collection unit (stereomodel or map sheet) and the working zone information which can also be found in the FIGEST file.

The FIPOINT file is divided into blocks of 1,360 points of 6 bytes. The sets of X, Y, Z, co-ordinates are recorded one after the other; X, Y are given with respect to the barycenter of the collection unit in order to condense them. When it becomes necessary to know the field co-ordinates of these points two translations have to be made:

(*a*) One translation related to the collection unit;

(*b*) One translation related to the working zone.

This arrangement of two separate files, FIDENT and FIPOINT, has the great advantage of being useful for searches, selection by theme, sorting and elimination on identifiers only, the ranks of the latter being known in the files as well.

PRELIMINARY DRAFTING

When the FIGEST, FIDENT and FIPOINT files have been built up, special programs produce output on magnetic tape which in turn drive automatic drafting tables.

Consequently one can produce:

(*a*) Projection grids with linking drafting strips when the stereoplotting of adjacent models is planned;

(*b*) Drafts with symbols which can be used as provisional documents;

(*c*) Drafts without symbols but with supplementary data, e.g. identification codes, element ranks etc., for field completion and checking;

(*d*) Digital terrain models either in the form of contours or profiles which can be used for

(i) Surface and volume calculations;
(ii) Special processing, e.g. perspectives etc.;
(iii) Driving orthoprojectors.

When the graphic output is used for up-dating, checking or field completion, the drawings must be produced on stable bases with drafting tables which are accurate enough to comply with the required specifications.

In addition, as the supplementary elements have to be manually drawn on those bases and then digitized, it is best to select a scale that is sufficiently large so that the inevitable graphic errors do not reduce the accuracy of the original digital file.

For example if digital file accuracy is given by a standard deviation of 0.20 m, it is best that the auxiliary checking and compilation document should be at a scale greater or equal to 1:1,000 and preferably at 1:500.

CHECKING, UP-DATING AND FIELD COMPLETION

The first three operations (digitizing, preliminary data processing, graphic output) lead to the production of a basic topographic file which is going to be checked and corrected and/or completed by topographic and non-graphic data.

Four different applications are discussed, as examples, below; many others could be considered but the procedures would be quite similar.

Checking of drafting files

A first inspection of the recorded data, carried out with the general program, was described in the section on FIDENT/FIPOINT files, above. It is best to make sure that no coding errors have arisen and that nothing has been omitted.

Consequently, the check drafting should be very carefully examined and, if necessary, compared with existing documents, such as photographs, old topographic and cadastral maps etc. The items to be suppressed should be indicated in yellow and the code number corrections in blue.

Certain details may have been omitted; if they can be introduced without making topographic or photogram-

metric measurements, e.g. administrative boundaries, public buildings etc., they should be indicated in red.

Place names can also be introduced at this stage, using existing documents.

Field completion

Field completion is necessary in many cases, particularly when earlier cartographic documents are not available or when a cadastral plan has to be produced.

In the latter case, the field completion would be carried out in conjunction with a cadastral enquiry during which the property boundaries would be identified and non-graphic data, such as landowners' names and addresses, nature and type of ground, use, rights of way etc., would be collected.

The boundaries would be transferred to the provisional document using ground measurements starting either from digitized features or the pretargeted points of the supplementary network, whose co-ordinates would have already been computed during the analytical aerial triangulation procedure.

In urban zones simple tape measurements are generally sufficient if well-defined superstructure lines e.g., roof edges, are carefully and systematically plotted.

Each parcel would then be given a provisional serial number which would appear both on the cadastral plan and ahead of the non-graphic data file, so playing the role of a linkage identifier.

Place names as well as all the information which should be included in the multi-purpose file would be noted, e.g. postal addresses, data concerning the water, gas and electricity utilities.

On completion of the field-work the new lines would have to be digitized, which brings us back to initial data acquisition again. The new data would be processed with the general program, and then integrated into FIDENT/FIPOINT files.

If there are few extra data to be digitized, that operation could best be carried out with the interactive system during the correction operations.

File up-dating

A preliminary investigation of earlier maps should be undertaken either by comparing them with recent aerial photographs or by referring to other kinds of information, e.g. plans, lists, specific maps, sketches etc.

The next stage of the up-dating operations makes use of all available resources but, unfortunately, no universal method is available. Even if it is only necessary to make a few minor changes or if the complete renewal of a zone is required one may have to:

(*a*) Carry out field measurements;

(*b*) Use orthophotographs;

(*c*) Integrate plans from specific projects;

(*d*) Carry out additional stereoplotting etc.

In all cases one is forced to produce a new preliminary document and/or a new file that have to be processed using an interactive system.

Integration of public utility plans

As for the production of cadastral plans, the graphic document produced with the digital file will serve as the basis for the integration of public utility plans, e.g. sewerage, water, gas and electricity.

Two different cases may arise:

(*a*) No documents are available;

(*b*) Plans or sketches are available, generally at very large scales, e.g. 1:100, 1:200, 1:500, for each street section without any reference to the basic geodetic network.

In the first case, it is obvious that except for elements visible on the ground or on aerial photographs, such as hydrants and manholes, and those that could be pretargeted where necessary, all the buried details will have to be surveyed during the repair or renewal of the networks.

In the second case, the more general one, two methods can be used:

(*a*) Direct digitizing of existing very large-scale plans after the identification of reference points marked both on the preliminary drafting and on those plans;

(*b*) Mounting of the existing plans on graphic output at the same scale and digitizing with respect to the file reference points.

The first method can be used when good quality updated utility plans are available.

The second method, more often used, is employed when the accuracy and quality of the very large-scale plans are uncertain and not homogeneous.

Depending on the nature of the utility networks, the features and the data concerning them can be very varied. Consequently, it will be wise to proceed as with the cadastral survey, i.e. give a serial number to each item or buried detail which will act as an identifier linking the graphic and non-graphic files.

Mention was made above (under "Field completion") of the problem of building up a land registry. Here, one should note that a special case of setting up a digital cadastral file can arise when one has to use an old graphical cadastre established and maintained in a local system by procedures which guaranteed neither good relative accuracy nor homogeneity.

The method to be applied in such cases would be similar to that of the integration of non-uniform plans by graphical or digital methods used for public utility networks.

INTERACTIVE SYSTEM

The establishment, use and management of an integrated land information system implies the use of an interactive system, which could include:

Storage unit or terminal giving access to a central data base;

One or several magnetic tape decks;

Computer;

Digitizing table;

Interactive graphic display unit;

Hard-copy device.

In the general procedure described in this paper the functions of the interactive system would be as follows:

Suppression

(*a*) Partial or total suppression of elements (points, lines);

(*b*) Suppression of entire zones inside circumferences.

Creation

(*a*) New elements;

(*b*) Geometric shapes (rectangles, circles, curves);

(*c*) Code numbers;

(*d*) Texts (place names).

Modifications

(*a*) Line-element smoothing;

(*b*) Line translation;

(*c*) Fusion of various parts of an element;

(*d*) Displacement of points (detail point or spot height);

(*e*) Changing one or more digits in code numbers;

(*f*) Partial or total duplication of elements.

Computations

(*a*) Areas, lengths, volumes;

(*b*) Co-ordinate conversion, i.e. from digitizing table to geodetic system;

(*c*) Adaptation (translation, rotation, similarity etc.).

In addition, all these basic functions can be combined.

In practice the following operations take place successively.

1. The file on magnetic tape is transferred to the working disk of the interactive system computer, and data are distributed into levels according to theme or sets of entity codes, such as roads, railways and buildings.

2. The graphic document is placed on the digitizing table and a few reference points, e.g. sheet corners, grid intersections, characteristic points of the drawing etc., are digitized to ensure the file/graphic document correspondence. Co-ordinates can also be introduced via the keyboard.

3. The level of data to be corrected or completed is called into the disk working zone.

4. The element to be processed is called either by its number or any one of its points. If it is an element processed recently it will have been retained in the memory. One can display on the screen either a sub-file or all the data contained in the disk working zone provided that a distribution by theme has already been carried out.

5. Application of processing functions. These can be carried out using the

(*a*) Digitizing table cursor;

(*b*) Alphanumeric keyboard.

Operations are facilitated by immediate display of results on the screen; windows with enlargement coefficients up to 100 give clear displays for accurate checking.

Several functions can be applied one after the other to the same element using the address kept in the central computer memory.

Deletion from displays as well as numerous other functions can be commanded directly from the digitizing table cursor using a "menu" board.

6. The entire corrected or modified level is then transferred to the corresponding sub-file and at the end of all the operations all the sub-files are regrouped again into a single file.

7. The data contained in the working disk are transferred on to magnetic tape in a form similar to that of the original tape. If the interactive system is connected to a central terminal, the corrected data can be sent directly for processing and then they replace the earlier data in the FIDENT and FIPOINT files.

In general, interactive system performance depends on:

(*a*) Convenience of the controls (cursor, keyboard menu board);

(*b*) Speed of data retrieval and the application of functions;

(*c*) Permanence of correction functions.

Digitization errors diminish rapidly after a few months training. Generally, inspection reveals photographic identification errors which would not be avoided by linking interactive systems to stereoplotters. Omissions and manipulation errors are very rare and after one year's experience digitizing is perfect. Consequently a simple system with a limited number of controls at the stereoplotting level are preferred by the Institut géographique national of France.

FINAL DATA PROCESSING

The interactive system is generally used to make corrections and modifications to the basic files but it can also be used to introduce the identifiers which act as links between the position and non-graphic data files (see figure 103).

Nevertheless, it would be more economical to use either a less accurate digitizer or to list the code numbers which must appear on the final drafting.

Different procedures are then applied to the data resulting in the constitution of the final files.

A particular case is that of the production of cadastral files.

It was stated above that after either digitizing existing topographic plans or stereoplotting, a basic document is obtained on which parcel boundaries can be drawn. These parcel boundaries could be:

(*a*) Topographic elements from the original file;

(*b*) Lines plotted on the basic document from direct field measurements;

(*c*) Lines taken from old cadastral plans after adjustment.

During successive digitizations, the apexes of the parcel polygons are generally digitized several times. These different sets of co-ordinates vary slightly from each other in a tolerance range depending on the document scale and the digitization accuracy.

These co-ordinates are unified using a special program which, at each apex, seeks points within a given radius, analyses them, calculates the barycenter of those retained, and substitutes the X and Y values of that barycenter for the file co-ordinates.

As the parcels are then correctly closed one can draw them; this task is carried out with a special program which, starting from the origin, follows the line to the next apex and traces all the segments beginning there.

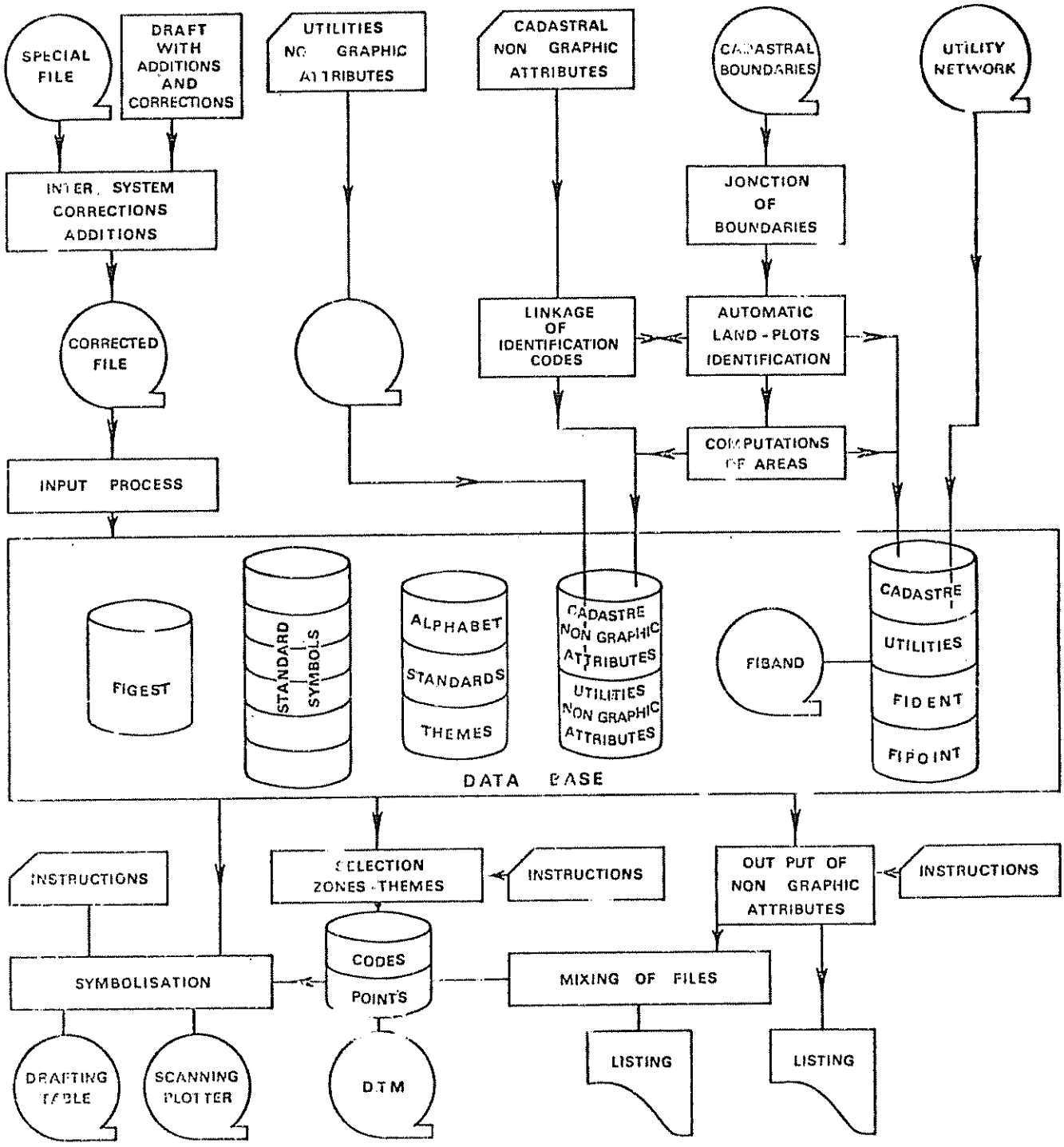


Figure 103. France: final data processing

The angles formed by those segments with the first one are computed and, step by step, the sides of the first parcel are drawn. A temporary serial number is then given automatically to this parcel and the process is applied once more, for example to the first temporarily abandoned segment, the identifier of which has nevertheless remained in the memory.

Reiteration of this procedure would define sections limited by roads and railways and sometimes administrative boundaries, rivers and streams. Thus, it would be possible to build up the third level of the file with an object/parcel serial number associated with the addresses of the FIDENT identifiers to which the FIPOINT element co-ordinates correspond.

The emprise of the parcel would also be determined similar to those for the zone and the collection unit.

This method makes it possible not only to reduce considerably the identification operations, but also to avoid all co-ordinate redundancy.

Serial numbers given to the parcels by program would be listed with the corresponding numbers given during the field enquiry which are written ahead of the non-graphic index cards.

Acreages and, if necessary, the lengths of parcel sides are computed by other special programs and these data are generally stored in the non-graphic data file.

Junction co-ordinates in utility networks can also be unified in the same way.

These network apexes can be taken as objects themselves, e.g. geodetic monuments can be erected to mark parcel boundaries, manholes are usually situated at pipe junctions etc.

At the end of this supplementary data processing the data base will consist of all the files required for further applications.

USE OF THE DATA BASE

The data base described in this report can supply:

(*a*) Files required for automatic machine drafting (magnetic tapes);

(*b*) Digital files for computations (DTM);

(*c*) Listings of non-graphic data and/or co-ordinates.

Mapping

In general, for driving automatic drafting machines, the following instructions have to be given:

(*a*) Boundaries of the zone to be mapped (standard sheet in the general mapping system or special area);

(*b*) Projection system (conversions are not often required for large-scale mapping);

(*c*) Themes (roads, buildings etc.);

(*d*) Map scale;

(*e*) Symbols to be used.

In accordance with these instructions, programs take the required data from the standard files. If the specifications of the map to be produced are not contained in the standard files they can be introduced with punched cards.

A special disk file is then created to which are transferred FIDENT and FIPOINT data concerning the given zone and the special themes. A new magnetic tape contains not only the co-ordinates of the features to be drawn but also the symbols to be applied, i.e., instructions for the drafting machines.

Listings

A special program extracts from the non-graphic data files the information received, combines them, if needed, with the co-ordinates extracted beforehand from the position data files and supplies the required listings. By this method one can obtain cadastral data, e.g. listing of parcels in a given section or belonging to a given landowner, specific information concerning a given parcel, including its area, apex co-ordinates, side lengths etc.

Numerous other applications can be developed for this system in order to meet special requirements.

CONCLUSION

The system configuration described in this report does not claim to solve all urban planning problems which may arise, but it is hoped that it constitutes a solid basis because of its simple structure. With current technology it seems best to moderate one's ambitions and not exceed a certain limit of application beyond which system complexity outweighs the benefit of data processing.

REFERENCES

G. Konecny, "Data acquisition for land information systems" (1978).

J. Denegre, "Acquisition et contrôle des données par photogrammétrie numérique à grande échelle", *Photogrammetria*, March 1977.

E. Dorrer, "Software aspects in desk-top computer-assisted stereoplotting", *Photogrammetria*, March 1977.

S. E. Masry, "Photogrammetric digitizing and editing under computer control", *Photogrammetric Record*, April 1973.

J. M. Karzycki, "An integrated digital mapping system", *The Canadian Surveyor*, December 1978.

D. Rhind, "Towards universal, intelligent and usable automated cartographic systems".

R. J. Gibson, "The production of 1:10,000 scale mapping from a large scale data base", ICA Commission III, April 1975.

M. Thompsom, "Automation in photogrammetry", SIP Commission IV, Helsinki, 1976.

E. Mikhail, "Recent developments and applications", SIP Commission IV, Helsinki, 1976.

DEVELOPMENT OF A REAL-ESTATE ORIENTED INFORMATION SYSTEM IN RURAL AND URBAN AREAS*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

Un système d'information sur la propriété foncière dans les zones rurales et les zones urbaines fournirait de précieux renseignements aux politiciens, aux administrations et aux responsables de l'économie, tout en permettant de rationaliser la planification. Pour mettre sur pied un tel système, il est indispensable de faire appel à la géodésie, qui fournira le cadre spatial des données techniques, juridiques et économiques introduites dans le système. S'il existe déjà un cadastre pour telle ou telle région, on pourra en tirer les éléments fondamentaux nécessaires à la mise en place d'une base de données sur la propriété foncière. Les systèmes de traitement utilisés à cette fin devront être suffisamment souples pour permettre différents arrangements des données foncières proprement dites et des autres catégories de données qui seront introduites dans le système. Il importe, avant de se lancer dans l'élaboration d'un pareil système, de faire l'inventaire des données existantes. Il faut s'assurer en particulier qu'il existe un système géodésique offrant les données de base nécessaires à l'élaboration d'un système d'information; il faudra sinon remédier à cette lacune au fur et à mesure de la mise en place du système d'information sur la propriété foncière, en veillant à ce que le canevas géodésique soit établi en commençant par la triangulation de premier ordre. Le système conçu en République fédérale d'Allemagne fournira des données sur la propriété foncière intéressant aussi bien les juristes et les administrateurs que les statisticiens et les économistes, et il répondra, dans une large mesure, à ce qu'on peut attendre d'un système moderne d'information sur l'occupation des sols.

A modern real-estate oriented information system in both rural and urban areas is, at the present time, a requirement for the needs of law, administration, planning, statistics and the economy. All useful spatially related, attributive data should be acquired systematically and made available as an aid to development and the planning of better infrastructure.

THE PROPERTY CADASTRE AS THE BASIS OF A REAL-ESTATE ORIENTED INFORMATION SYSTEM

Content, purpose and maintenance

When developing such a system, it is necessary to have regard for the already existing one. Also, such development is performed in several phases. In the Federal Republic of Germany, the existing property cadastre forms, among other considerations, the basis for a real-estate oriented information system. The property cadastre is a public register, describing and recording all real estate, rights analogous to property rights, and buildings (immovables) as required in legal dealings, administration and the economy. It is the only complete compilation of all real estate.

The property cadastre consists partly of a survey and map—the property map—and partly of descriptive matter. The property map represents the various kinds of real estate in their relative position on maps (*Rahmenkarten*, maps showing details up to the sheet margin, or *Inselkarten*, maps showing only an isolated region, as transparent topographic bases), reduced-scale drawings and indexes. It shows, in addition to the real estate (parcels, boundaries, position, buildings, nature of use and productivity), topographic features and, partly, terrain forms. The descriptive part of the conventional property cadastre contains the schedule of real estate condition according to certain important real characteristics and records a series of legal classifications. This part comprises the parcel register, the land-tax register, the list of names of owners, and the alphabetical list of owners. The results of the official valuation of land made by the tax office are recorded in the parcel register and on the overlay valuation tracings accompanying the cadastral maps.

The establishment and maintenance of the property cadastre is the responsibility of the *Länder* (provinces) of the Federal Republic of Germany.

Development phases

At the beginning of the nineteenth century, the cadastre was first established for tax purposes only. By the turn of the century, with the introduction of the property registers, this cadastre became the official index of real estate (property cadastre). Following the requirements of administration, economy and planning, the property cadastre evolved to the present multipurpose cadastre.

The property cadastre compiles real estate in respect of facts, while the property register compiles it with regard to legal aspects. The property cadastre and the property register must permanently be kept in accord. In the same way, a data exchange takes place between the cadastral survey office and the tax office. For the time being, expansive mutual information procedures between the offices are necessary for this purpose.

Conventional maintenance of the land tax register corresponds to bureaucratic techniques of the thirties, and, in part, is even older.

In the Federal Republic of Germany, a transition to electronic data processing (EDP) in cadastre and survey-

*The original text of this paper, prepared by Karl-Heinz Bastian, Landesvermessungsamt, Rhineland-Palatinate, appeared as document E/CONF.72/L.76.

ing was started in the middle of the 1950s. According to EDP techniques, the punched card—in the beginning the handpunched card—was used as storage medium. In 1964, with the so-called second generation of the EDP systems, the automated cadastre with tape storage was developed. Since 1972, the large-capacity storage techniques of the third computer generation has been employed in the newly developed program system land tax register EDP. The *Länder* of the Federal Republic of Germany are, at present, converting the data of the land tax register to this automatic maintenance. The procedures are not uniform among the federal *Länder*.

EDP in the maintenance of the land tax register using the program systems ELIKA/FOLIKA

The program system for the acquisition of the property cadastre (ELIKA) was developed and is maintained by the federal *Land* Hesse, and the program system for updating and use of the property cadastre (FOLIKA) by the federal *Land* Rhineland-Palatinate. In Rhineland-Palatinate ELIKA and FOLIKA have been successfully used since 1977.

The property cadastre is converted according to local areas. The preliminary works are decentrally executed at the cadastral survey offices and comprise:

(*a*) Field check: acquisition of the actual types of use;

(*b*) Coding of the types of use according to a list of types of use;

(*c*) EDP-compatible editing of cadastral information.

The parcel data are acquired from the cadastral compilation by means of element typewriters in legible print-out by the land valuation bureaus at certain cadastral survey offices for the entire *Land* Rhineland-Palatinate. The further processing is centrally performed by the computation centre of the Land Survey Office. The legible print-out documents are converted on a character reader to a magnetic store. Next, processing according to the program system ELIKA is performed. The compiled data are partly automatically, partly visually checked. After correction, the error-free data are stored in the central data memory. New cadastral compilations are printed out:

(*a*) Owner sheet;

(*b*) Parcel sheet;

(*c*) Parcel list;

(*d*) Name sheet;

(*e*) Index sheet as contents for owner and parcel sheets;

(*f*) Statistical classifications according to types of use, main summaries of real estate and ground classifications for the tax office.

The machine printout is used as cadastre in the legal sense.

The prepared data are updated and used via the program system FOLIKA. The cadastral survey offices transfer the revision documents to legible print-out documents, readable by machine, which are then processed centrally by the Land Survey Office. The error detection and necessary validity checks being made, the data files are corrected. Then the modifications of the new indexes, of the references to modifications and of the revision indexes are automatically printed out for help when sorting in. The documents are sent to the local cadastral survey office for sorting in the new sheets and sorting out and destroying the outdated sheets. The formation history of the parcels can now be traced back only through the reference number to modification, printed out for each parcel.

The land registry and tax offices receive second prints of the files such as are necessary for their purposes. The communities may obtain a second cadastre on demand. Modifications that occur are made known to these offices by sending over sheets newly prepared. The cadastral survey offices prepare smaller extracts from the cadastral compilations by copying the respective sheets, while larger extracts are made by the central data processing system. Data teleprocessing is planned for a later time.

THE AUTOMATED PROPERTY CADASTRE AS THE BASIS FOR THE REAL ESTATE DATA BASE

The real estate data base

In order to reach decisions in politics and administration, comprehensive information systems are required on the basis of real estate data bases. A real estate data base constitutes a collection of real-estate oriented data of real, legal and administrative nature comprising total ground areas and kept current by continous updating. Such a real estate data base must be conceived so that it serves as an information system as well as for rationalization.

The Working Committee of the Survey Administrations of the *Länder* of the Federal Republic of Germany decided in 1973 to maintain the automated property cadastre as a basis for the real estate data base in the manner described in theoretical concept. This concept is co-operatively prepared by representatives of the cadastre, property register, tax office and local survey administrations. Furthermore, a logical data structure for the automated land tax register was elaborated. The elaboration of a theoretical concept for the automation of the results of cadastral surveying and calculations and of parcel map series was also decided upon.

The real estate data base is an automated information system, in which real-estate oriented data are compiled in an orderly manner. The real estate data base to be maintained interdisciplinarily is linked with other data bases to form an over-all information system. This system can be compared in its functions with a huge gear unit, a system of meshed gear wheels (figure 104). In order to avoid double work, transmission errors and updating delays, the data are stored in poor redundancy. This does not change anything in the competences of the institutions involved. The access to the individual data is performed via mutual logic elements.

Input to the real estate data base is provided by the following agencies:

(*a*) The property cadastre with real data (position, area, use, buildings, boundaries, co-ordinates, topographic features and terrain form);

(*b*) Land registry with private law information (property, charges, restrictions);

(*c*) Tax office with economic information, as real estate value, building value, ratable value (valuation of land);

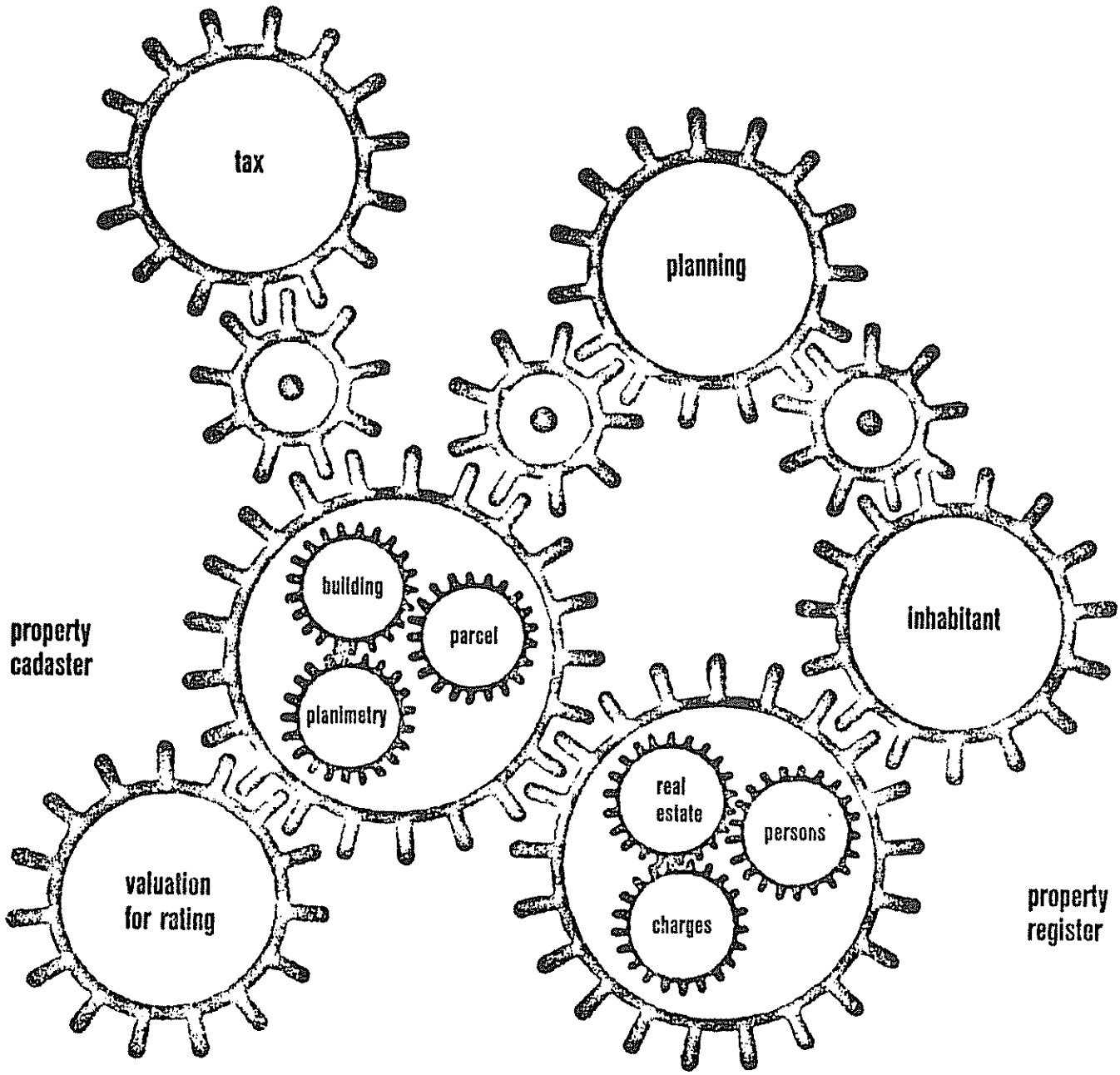


Figure 104. Federal Republic of Germany: model of linking

(*d*) Building and planning offices with information under public and planning law (e.g., public charges, legal classifications and development planning).

Links can be provided with data of roads, circuits, forest, statistics, protection of landscape, land regulation, remote sensing, geophysics.

The parcel, as smallest entry unit of the cadastre, is the reference unit of the real estate data base. For this purpose real-estate oriented data are available in the description part and in the results of cadastral surveying and computation of the property cadastre. The data are continuously updated. The reference to the property register exists via the parcel. Thus, the property cadastre forms the basis for the real estate data base.

Each information processing operation comprises the following steps:

(*a*) *Acquisition*. Acquisition makes data available;

(*b*) *Transmission*. Transmission is the data transport between station and receiver (objective: data teletransmission system);

(*c*) *Storage*. Storage is linked with all other steps (temporary or long-term storage);

(*d*) *Processing*. Processing can be divided into pre-processing and central processing phases.

Pre-processing can be performed by decentralized data stations in order to relieve large capacity systems. These systems are especially appropriate for acquiring and checking input data obtained in the field, and for updating and using decentrally stored data. Complex geodetic computations, however, computing intensive tasks with integrated program systems and larger main storage and peripheral requirements, remain for the large-capacity computers.

The automated property cadastre comprises, according to the former division, a survey and map part and a descriptive part.

The automated property map

With respect to content and volume, the automated property map comprises the cadastral survey and parcel map series. It consists of three data files:

(*a*) *The planimetric data file.* This is the central data file of the automated property map, and it provides the link with the automated land tax register. In this data file is stored all information on the graphic representation of the content of the parcel map series and other map series derived therefrom, on the basis of planimetric co-ordinates and heights. The map series should be extended, especially with respect to topography, in order to satisfy the requirements made for town maps and for making available basic data for topographic cartography. The planimetric objects to be represented are compiled in a feature code catalogue;

(*b*) *Point data file.* The point data file comprises all points of the survey control station net (planimetric, altimetric and gravity points), the numbered cadastral points (survey, boundary and building points, topographic points), and other points, with their co-ordinates, heights if necessary. The point data file is an advancement of the prevalent co-ordinate data file, containing, at least, the point number and the co-ordinates. In some program systems additional information is possible, as administrative allocation, type of marking, accuracy, year of survey and computation;

(*c*) *Data file of the measuring elements.* It should contain the measured quantities for the computation of the planimetric co-ordinates and heights.

The results of cadastral surveying and calculation and the parcel map series can first be acquired by digitizing the parcel maps, taking over already co-ordinated points, by numerical evaluation of the survey documents and by cadastral resurvey. The updating should be performed using the graphic interactive procedure. An application program is planned.

Additional programs are made available for the administration of requests, pre-processing of the measuring elements, interactive graphic processing and graphic presentation. The peripheral large capacity store of the EDP-system is defined as a property map in the legal sense.

The renewal of the parcel map series is tested as a prephase of the automated property map, using the interactive graphic system. A large part of the parcel maps now in use dates back to a time when the cadastre was started. Often, these maps can no longer satisfy present requirements. Thus, they must be renewed. With the renewal are always combined extensive computation and mapping works which—manually performed—require much expenditure in work and time. Thus, the interactive graphic system is well suited to this work. The process of parcel map renewal using an interactive system is shown in figure 105.

When using the interactive graphic system each image can be divided into up to 31 levels. Levels having functions of transparencies can, alternatively, be activated and represented, individually or in any combination (figure 106).

The interactive graphic system is used as a universal working place for the interactive graphic processing within the scope of the over-all system of the automatic property map for:

(*a*) Taking over planimetric objects and editing for interactive graphic processing;

(*b*) Identifying, modifying and erasing outdated features as well as adding new planimetric objects;

(*c*) On-line digitizing and the on-line error correction;

(*d*) Performance of computations of co-ordinates, surfaces, laying out in interactive mode;

(*e*) Editing of the graphic output—oriented to the level or symbol, dependent on or independent of the instrument.

The automated land tax register

The automated land tax register describes the real estate according to its most important real characteristics. This register has to store the information, so far comprised by the cadastral books, in a manner satisfying the objectives of the real estate data base. It is divided into the following data groups:

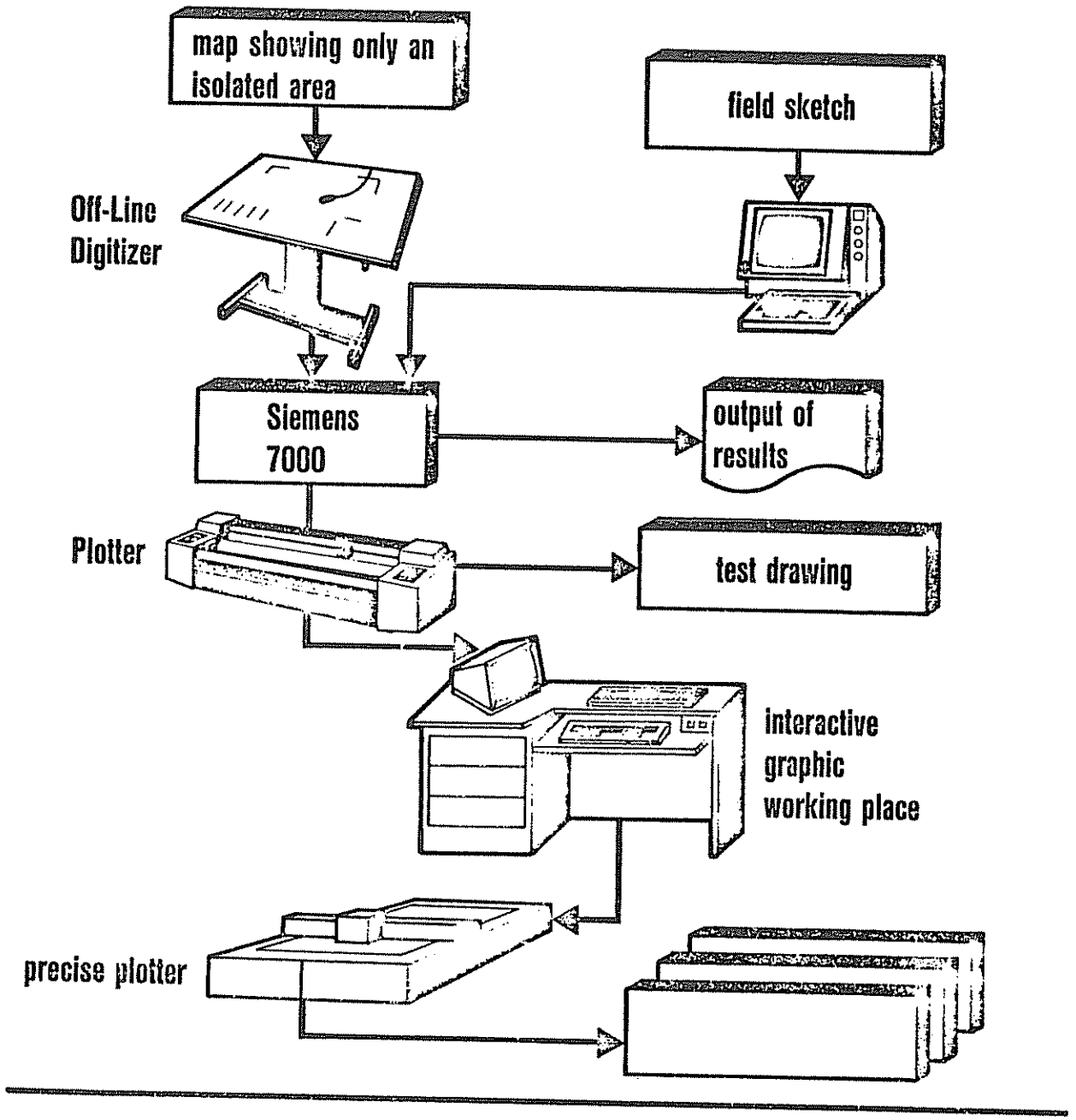


Figure 105. Federal Republic of Germany: process of parcel map renewal in the interactive graphic system (IGS)

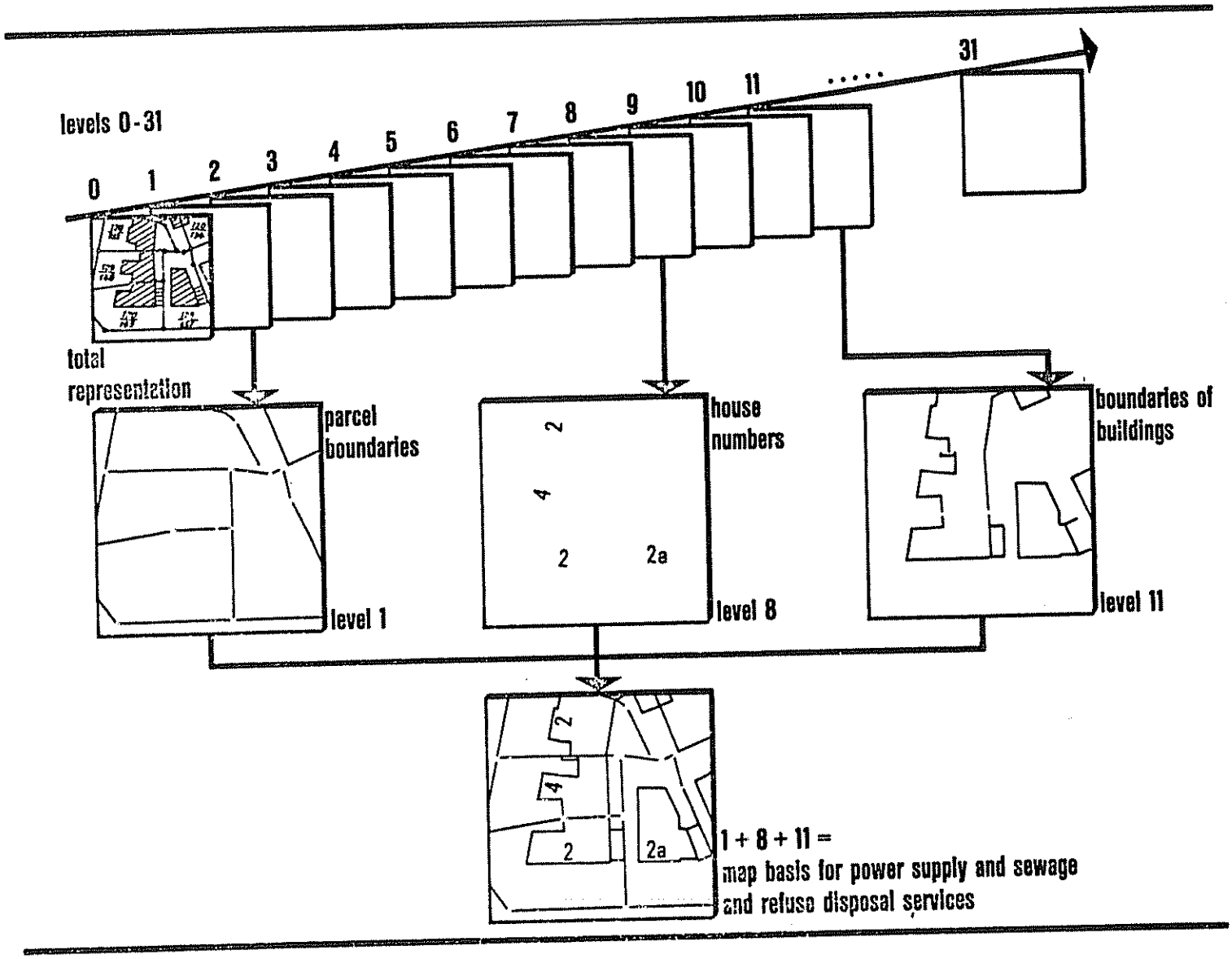


Figure 106. Federal Republic of Germany: application of level representation

(*a*) The parcel data file: this comprises the parcel header (classifying characteristic), surface, place name, real use, legal classification (ground property, land and forest property, road surfaces, water surfaces, forest surfaces), valuation of land, place of entry in the property register, additional information on the position (parcel co-ordinates, parcel map, reduced scale drawing, block of building, community), other information of descriptive nature (reorganization of land holdings, abutter note, building charges, restraints on disposal, references to the parcel), administrative attribution, references to formation and updating, parcel history;

(*b*) Local area and community data file;

(*c*) Building data file;

(*d*) Data file entry;

(*e*) Data file owner/persons holding the hereditary right to erect buildings on the land of another.

The data of the automated land tax register are linked so that double compilation of information, occurring at former times in the cadastral books, is cancelled.

The land tax register in the legal sense is the peripheral large-capacity computer of the EDP-system. The date for taking over the data into the cadastre is thus that of storage of the data in the peripheral large capacity store and not that of data input or data processing.

The cadastral survey office should obtain direct access to the real estate data bank by way of data teleprocessing. The land tax register is maintained through display units. A continuous paper compilation is superfluous (cadastre without paper). The stored data can be retrieved via search arguments parcel headers, property register headers and name headers, and can be output in different format types (inventory sheet, parcel list, name list and road list).

The automated land tax register can be used for the following purposes:

(*a*) Extracts from the land tax register;

(*b*) Access by means of display units via search arguments;

(*c*) Evaluation according to data elements in list format.

Integrated data processing of property cadastre and property register is planned and being developed, above all, to avoid double maintenance and double updating of data. In the regular data exchange, first the tax offices should participate for the purpose of ratable valuation, as well as the communities, both by linking. Later, further linking possibilities with other institutions will be possible.

Conclusion

Finally, a cost-benefit consideration is presented for the projected real estate data base. The special benefits for all participating agencies are listed below:

Benefits at the working place;

Improvement of the existing system;

Integration of all infrastructure variants;

Avoidance of multiple data;

Improvement of use;

Improvement of the organizational process;

Lowering of working and processing times;

Increase of efficiency;

Space saving archives;

Reduced conversion times;

Qualitative improvement;

Cost saving by automated procedures.

In the Federal Republic of Germany, the automated land tax register will be realized first, while the automated property map, for the time being, can be realized only in part.

In the introduction of the procedure it would be of no advantage if the trained personnel were to be changed quickly, wherefore, of course, neither of the systems should be changed. The development of the concept should be planned for a foreseeable period of time, and the programs should be developed independently of the system.

In conclusion, it should be mentioned that the Federal Republic of Germany has paid so far 50 million deutsche mark for the development of the automated land tax register, property map and property register. A single federal *Land* cannot afford these costs; for this reason the work was distributed among different *Länder*. Owing to the high cost, central upkeep of the system is planned for later on, and this is at present a subject of discussion between the respective *Länder*.

If the real estate data base, as demonstrated above, is realized in all fields, the multi-purpose cadastre so far in use will be advanced to an almost country-wide information system.

REPORT ON CADASTRAL MAPPING IN INDONESIA*

Paper presented by Indonesia

RÉSUMÉ

C'est au Gouvernement indonésien que revient la responsabilité de réglementer l'occupation des sols de telle sorte que le territoire national soit utilisé au mieux des intérêts tant individuels que collectifs de la population.

Le cadastre a pour objet de déterminer les limites des parcelles de terrain et de réaliser des plans établissant les titres de propriété, ainsi que de fournir des informations et de retrouver les limites des parcelles si des différends surgissent. On utilisait autrefois les méthodes de levés sur le terrain et on les utilise toujours dans les zones cadastrales du premier ordre pour calculer les coordonnées des bornes de délimitation par cheminement détaillé à partir de points de canevas de haute précision.

*The original text of this paper, prepared by Bambang Triono, appeared as document E/CONF.72/L.112.

Dans les zones rurales, en Indonésie, la méthode photogrammétrique, c'est-à-dire l'utilisation de photocartes redressées, est maintenant largement utilisée pour établir les plans cadastraux.

Le document a pour objet de décrire :

a) Les méthodes de détermination des limites des parcelles de terrain;

b) Les méthodes permettant de déterminer à nouveau les limites des parcelles quand on en a perdu la trace ou quand des différends surviennent en matière de délimitation;

c) La délivrance de titres de propriété officiels avec « lettre de mesure ».

Pour toutes les activités mentionnées ci-dessus, l'Indonésie utilise maintenant la méthode du redressement photogrammétrique.

Land in Indonesia is becoming scarce. Although family planning has been introduced, population is increasing at a great rate. People need houses, schools, food markets, shopping centres, rice-fields, recreation areas and all other community facilities. Therefore, planning for the future plays an important role in administration. A proper cadastral system, complete with maps and land records, will greatly assist this planning and make more efficient the work of government bodies concerned with land and land-use.

It is the responsibility of Government to regulate use of land in such a way that all land, throughout the national territory, will be used for the maximum benefit of the people, individually and collectively.

The objective of cadastral mapping is to locate boundaries of land parcels and produce plans or plots to establish ownership, and also to provide information and relocate boundaries if and when disputes arise. Formerly, terrestrial methods of surveying were used, and are still used in first-order cadastral areas, to compute the co-ordinates of the monument boundaries by detailed traversing from high-order control.

In rural areas in Indonesia, the photogrammetric method, namely the use of rectified photo-maps, is now being widely used to establish cadastral maps. The objectives of this short paper are to describe:

(*a*) Methods of determining boundaries of land parcels;

(*b*) Methods of relocating lost boundaries or settling disputes concerning boundaries;

(*c*) Issuing of certificates as proof of ownership to landowners, complete with "letter of measurement".

All the above-mentioned actions are carried out by the photogrammetric rectification method.

Cadastral maps are a tool for completing a proper land register. Land registration was formerly done, during the Netherlands administration, by a small number of land-surveyors and had the sole purpose of protecting and safeguarding colonial interests. In 1960 the Government of Indonesia announced the Agrarian Law (Act No. 5, 1960) which outlined basic regulations governing agrarian affairs. Under this act, the volume of work in land registration increased enormously with a total of ±65,000 villages to be registered and a total area of 1,200,000 sq km to be mapped. If the conventional method of cadastral surveying, as done during the former administration, were still used to cover this gigantic area, it would take 200 years to finish.

CADASTRAL PROBLEMS

It was intended in Act 5, 1960, that land registration should be carried out simply, in a way easily understood and with low cadastral fees, so that the people would realize the advantages of land registration and feel the protection and safeguards offered them by the Government.

The decisions that the Indonesian Government had to face were:

(*a*) Which administrative system was to be used to issue certificates?

(*b*) What technical system was to be used to produce cadastral maps, in quantity as well as in quality?

The first problem is mostly legal and is concerned with the location of the parcels.

The second and major problem involves provision of cadastral maps within the shortest possible time.

PHOTOGRAMMETRY APPLIED TO CADASTRAL MAPPING

The solution for both problems was to apply aerial photography, namely photogrammetry, to speed up mass production of cadastral maps. This method was deemed particularly suitable for open areas such as rice-fields, cultivated villages, plantations, and even city areas where, as land prices are not too high, the rectification method could be used to fulfil the purpose so that people could be given a certificate as proof of ownership at a price they could afford. In this certificate, a copy of the cadastral map showing the parcel on scale 1:1,000 is obligatory; it is enclosed together with the legal sheet showing the name of the owner, the status of rights of land, and notation as to whether or not it is encumbranced.

The rectification method has the following procedure:

(*a*) Pre-marketing before aerial photography (for adjustment purposes), photo-scale 1:5,000;

(*b*) Strip adjustment, now using block adjustment with Pat-M program;

(*c*) Rectification, photomaps scale 1:1,000;

(*d*) Identification, that is, going to the fields and checking all the boundaries of the parcels and recording the names of the owners, the status of rights etc.;

(*e*) Announcement to the entire village community that the Government will issue the certificates to the landowners;

(*f*) After announcement, a passage of 2 (two) months; if nobody protests or makes claim on the boundaries of the parcels or the legal status of the parcels, certificates will be issued.

To increase the accuracy of the rectification method, the Cadastral Service has built up its field equipment, e.g. electronic distance measurement (EDM) instruments and one-second theodolites, and has aimed at high accuracy in traversing and computing through computers. A block adjustment with Pat-M program is now used.

Another method of measuring distances rectangular to each other on the aerial photos and through adjustment is by seeking on each photo four points known and suitable for rectification. This rectification method is to ascertain the relative position of each parcel in relation to the surrounding and neighbouring parcels. Such relative positioning is sufficient to list the parcel for the "first registration" in the cadastral records.

For on-going requirements due to transfer of land, the length of each side of the parcel has to be measured by tape or EDM equipment to upgrade accuracy.

With this rectification method, during the First and Second Five-year Plans (Pelita) an increase of 15 per cent was achieved: a total of 761,283 hectares.

Cartography for cadastral purposes

Although a photomap is sufficient to locate a parcel within a district, still, a line-map is required. The line-maps (1.00 × 0.70 m in size, government regulation No. 10, 1961) are the basic maps. A copy of each parcel on the basic map, in which the boundaries are coloured yellow along the boundary-lines, becomes the "letter of measurement" to be attached to the certificate. The line-maps on kodatrace are made by hand, by tracing from the photomaps placed on a light table.

Conventional cartographic mapping techniques are being developed as various tools for production, such as scribing techniques, reproduction using reproduction-cameras (e.g. Klimach Super Othohorika), and photo type-setting machines.

Relocation of boundaries

In cadastral survey projects it is often necessary to relocate the boundaries if these boundaries are lost owing to flood or natural disasters. Although this rectification method is not too high in accuracy in comparison with other methods—the accuracy of this method is 1/500 lineal (1 m for a length of 500 m)—still, lost boundaries can be traced back and be recognized by the people as the boundaries of their parcels. The normal procedure of restoring boundaries is to make a traverse from the nearest relocated photo-point (to be used for adjustments) and establish the boundaries by either single or double proportion.

An alternative method is to use plotting instruments and stereoscopic viewing, using the photo-pair where the boundaries of parcels are lost and tracing those lost boundaries by the still existing boundaries of parcels that are present on the field.

Using the existing photomap and the above-mentioned method to relocate lost boundaries has proved that people in the villages realize that land disputes have to be solved by give and take (we called this *gotong-royong*, that is, solving the problems peacefully with mutual understanding).

Certificate as a strong evidence of ownership

The end product of a cadastral service is to issue a certificate and hand this over to the owner as proof of ownership. However, as a public service, it not only issues certificates but also acts as an information service concerning land.

As mentioned above, the certificate consists of two parts, namely, the legal part and the technical part.

The legal part is achieved through identification of the land, the public announcement and the inspection of the documents of the landowner. The technical part, after mapping, concerns the location of the boundaries of the land as known to all the neighbours.

The advantages in having a certificate are already known to the people, namely:

(*a*) It gives the owner full security of ownership;

(*b*) It minimizes the possibility of disputes, legal as well as technical;

(*c*) It enables transactions of land (it is obligatory to have a certificate for transactions completed in front of a land deed official);

(*d*) It enables the owner to obtain a mortgage, especially for farmers to obtain agricultural credits (it is obligatory to have a certificate for mortgage and credit).

Conclusion

Cadastral mapping, as part of the task of establishing official land registration in Indonesia, is carried out by the Directorate of Land Registration within the Directorate General of Agrarian Affairs, Department of Interior, based on Act 5, 1960, and government regulation No. 10/1961. Since cadastral mapping by the conventional method would take 200 years to complete, this rectification method, which is to be used in open areas such as rice-fields, cultivated villages, plantation and transmigration projects, is a solution to the problem of speeding up the production of cadastral maps, in the hope that by the year 2000 cadastral maps covering ± 35,000 villages will be completed.

A SYSTEM PROVIDING ACCESS TO NATIONAL SURVEY DATA*

Paper presented by Japan

RÉSUMÉ

L'Institut cartographique japonais est chargé du stockage de nombreux types de données, documents et dossiers relatifs aux levés, tels que résultats des levés de base, cartes et photographies aériennes. Il y a une grande quantité de données, recueillies depuis plus d'un siècle et remontant jusqu'à l'ère du Meiji, et cette quantité a récemment augmenté rapidement avec l'adjonction de données sur la propriété foncière.

Il y a d'autre part sur le plan social une demande pour ces données, qui trouvent des applications pratiques dans la planification du développement, les activités administratives et les travaux de recherche concernant de nombreux domaines, et la cadence d'utilisation s'accroît d'année en année.

Pour faire face à cette situation, il est nécessaire de réformer l'actuel système de gestion et de service, qui s'appuie sur des archives sous forme de registres, et d'introduire un nouveau système de service informatisé qui permette de gérer efficacement les données et de les rendre accessibles au public.

L'Institut a travaillé à l'élaboration d'un nouveau système qui permet de classer automatiquement une très grande quantité de données de toutes sortes, de les réviser et de les tenir à jour ainsi que de répondre aux demandes des usagers en leur fournissant les informations les plus récentes. Le nouveau système, qui est maintenant presque opérationnel, est décrit brièvement dans ce document.

The Geographical Survey Institute (GSI) has the custody of many kinds of data, records and materials connected with survey, such as the results of basic surveys, maps and aerial photographs. There is a large volume of material, collected for more than a hundred years and extending back to the Meiji period, which has recently been increasing rapidly as data showing the properties of land.

There is now a social demand for these data, which are put to practical use in development planning, administrative activities and research works in many fields, and the frequency of utilization is increasing year by year.

In order to cope with this situation, it is necessary to reform the existing management and service system, which consists of files in book form, and to introduce a new computerized service system that can efficiently manage the data and make them accessible for public use.

The GSI has been working towards a new system by which a very large amount of many kinds of data can be automatically filed, revised and maintained and the Institute can respond to requests from users by offering the latest information. The new system, which is now almost established, is described briefly in this paper.

KINDS OF DATA

The kinds of data stored in this system at present are the following:

(*a*) *Control points*. Triangulation stations, benchmarks, traverse stations and other data of survey of about 120,000 points;

(*b*) *Aerial photographs*. Colour and monochromatic photograph prints of about 780,000 copies; original films of 7,000 rolls;

(*c*) *Geographical names*. Names authorized by local governments, district names and others: about 200,000 items;

(*d*) *Digital national land information*. Ground elevation; land form; geology; situations of land-use etc. of about 7,700,000 grid points.

OUTLINE OF THE SYSTEM

The new system is operated from a terminal in the office of the Source Material Division, Map Management Department of the GSI in Tsukuba Academic City and is connected on-line with the central computer in the same building. Revision and retrieval of data on magnetic tape can be done at the terminal. The constitution of the system is shown in figure 107.

Users receive data by putting instructions into the system, using the keyboard of the Chinese-character display system. Information on survey results is searched for on the disk file and, when found, is ordinarily shown either on the graphic display unit as figures, or on the Chinese-character display unit as words; and, if necessary, hard copies can be obtained from the Chinese-character printer. Moreover, so-called analog data, such as maps showing the distribution of control points, pictorial displays including bird's-eye views, or digital maps, can be drafted automatically using the *X-Y* plotter by operations on the digital data recorded on the magnetic tapes or disks. However, the most valuable facility of this system is provision of information by using the digitizer unit, as discussed below.

For information about any area, the relevant topographic map is laid on the board of the digitizer and the boundary of the area of interest is traced out with the cursor. The *X-Y* co-ordinates of each point on the boundary are transmitted to the computer and the data for the enclosed area are proposed according to the user's request. Subsequently, the desired information is shown on a terminal unit, such as the graphic display.

*The original text of this paper, prepared by the Map Management Department, Geographical Survey Institute (GSI), appeared as document E/CONF.72/L.22.

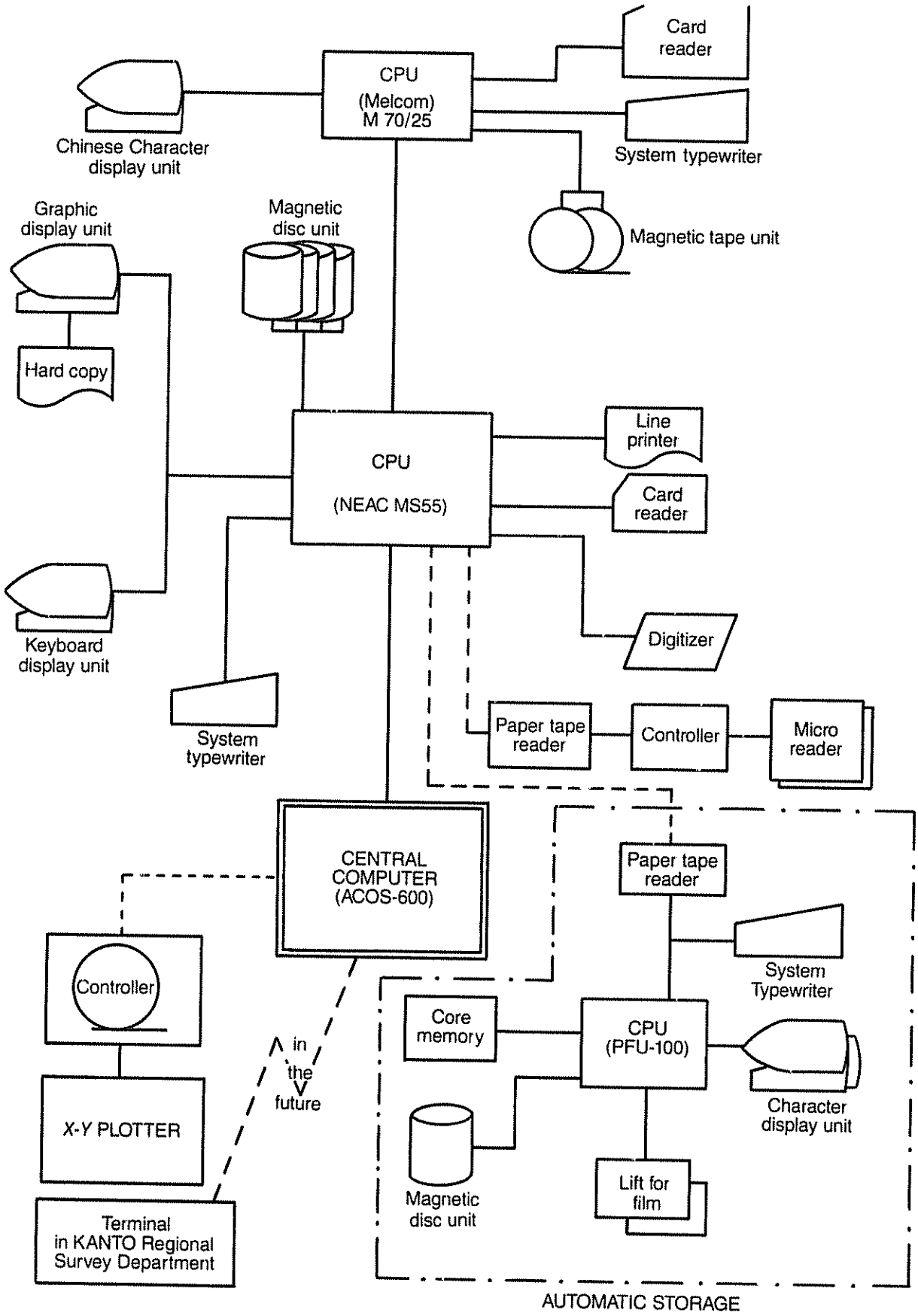


Figure 107. Japan: system providing access to national survey data

On the board of the digitizer, there is a "menu" sheet on which there are characters and commands that can serve as a system typewriter. By pointing to characters and commands with the cursor, users can get the required information directly.

It is proposed that, in the future, the same system will be set up in the office of the KANTO Regional Survey Department for the convenience of users in Tokyo.

PROCESS OF RETRIEVAL

Control point data

All data from geodetic surveys, which amount to about 120,000 points, have been filed on magnetic tapes, and they are constantly revised with the incorporation of new data. When a user makes an application for use of data, the instruction is input for information retrieval on a system typewriter or digitizer and a display is obtained on a CRT and a hard copy from a line printer. This copy includes a written estimate of the fee, a record of the application for use of the system and list of data as requested.

To retrieve information about control points for a particular area, the area may be indicated in various ways for such units for inspection as follows:

(*a*) *The national standard grid*: to retrieve data in a grid rectangle which is designated by a mesh code;

(*b*) *The control point*: to retrieve data by designating the code of a control point;

(*c*) *A sheet of topographic map*: to retrieve data on a sheet of 1:50,000 map which is designated by a map code;

(*d*) *An area on a topographic map*: to retrieve data in a fixed area which is designated on a map with a digitizer;

(*e*) *A local government boundary*: to retrieve data in an administration area which is designated by an administration code.

A map of control points can be output by *X-Y* plotter automatically from digital data held on magnetic tape. Microfiche records contain "descriptions of geodetic stations", in which the location of each control point is registered in detail. From these, output in hard copy by automatic retrieval can be obtained.

Aerial photographs

Concerning the library of colour and monochromatic aerial photographs, which amounts to 780,000 copies, the photographic conditions, such as camera situation, date of photography and filter, are recorded on magnetic tapes. If a user wishes to make a print from an original film, the line printer output contains, in addition to a copy of his written application and the written estimate of the fee, a certificate of borrowing of film and a written permission for reprinting the film. Original films amounting to 7,000 rolls are stored in an adjacent automatic storage. By setting paper tape on a tape reader, selection and withdrawal of an original film from storage is done automatically. The acceptance and return to storage of the film can also be done automatically. A record of the film stock is kept by computer.

The information required for film or photograph retrieval includes the year of photograph and the area, or, as in the case of control point retrieval, the mesh code, the map code, an area delineated on a topographic map or a local government boundary.

Geographical names

Geographical names, which amount to a great number, are now being standardized. For the time being, data referring to names authorized by local governments, regional names, and physical names such as mountains, rivers, lakes and islands are filed on magnetic tapes. Altogether, 200,000 names are filed. A list of geographical names that satisfy any rule may be output on the Chinese-character printer. They can be retrieved according to pronunciation, spelling or location by mesh code, map code, area delineated on a topographic map or local government boundary.

Digital national land information

Various kinds of digital data on the land have been determined at the intersections of a grid and have been filed on magnetic tapes. They include land form, surface geology, soil, rivers, situations of land-use, local government boundaries, legally designated zones, roads and railways. These data can be matched with other data in the computer to produce new data which are very useful for various analyses of the condition of the land. Such data are used mainly for national and regional land-use planning, not only by national and local governmental organizations but also by many public organizations, or for research work in universities.

THE MEXICAN EXPERIENCE IN THE ESTABLISHMENT OF A GEOGRAPHIC INFORMATION SYSTEM*

Paper presented by Mexico

RÉSUMÉ

Le Mexique procède actuellement à la mise en place d'un système d'information géographique qui fournira une couverture cartographique du pays aux échelles des 1/5 000 000, 1/2 000 000, 1/1 000 000, 1/250 000, 1/50 000, 1/20 000 et 1/10 000, et dans les domaines suivants : topographie, géologie, hydrologie, occupation des sols, pédologie, possibilités d'utilisation des sols et tourisme.

*The original text of this paper, presented by Jorge F. Vaca H., Angel Garcia Amaro and Carlos Salman G., Dirección General de Estudies del Territorio Nacional, appeared as document E/CONF.72/L.90.

L'organisme chargé de la mise en place de ce système est la Dirección General de Estudios del Territorio Nacional (Direction générale de l'étude du territoire national), qui est le service cartographique national prévu dans le cadre de la coordination générale du Système national d'information.

Ce service, fondé en 1968 par une dizaine de personnes, constitue, actuellement, après 11 années d'activité, un organisme comptant 2 200 employés et fonctionnant efficacement. Parmi ses principales réalisations, on peut citer :

Couverture photographique en noir et blanc sur 1 800 000 km² du 1/50 000 au 1/80 000 pour l'établissement de cartes topographiques, et sur 1 000 000 km² du 1/25 000 au 1/35 000 (dont 65 p. 100 en couleurs) pour l'établissement de cartes des ressources.

Aérotriangulation de 180 blocs avec une moyenne de 350 modèles par bloc.

Préparation stéréographique de 1 750 cartes topographiques au 1/50 000.

Etablissement de plus de 2 500 cartes des ressources (géologie, occupation des sols, pédologie et possibilités d'utilisation des sols).

Quelques expériences réalisées par le service sont examinées dans le document, dans l'espoir qu'elles pourront être utiles à des pays qui, comme le Mexique, souhaitent utiliser leurs ressources de façon plus rationnelle.

The General Coordination of the National Information System is a government organization charged with co-ordinating the accumulation, processing and distribution of information produced by the federal Government. The Coordination comprises several institutions, among them the General Directorate of Statistics and the General Directorate of National Territorial Studies (DETENAL).

DETENAL's objectives are to implement, develop and maintain the national geographic information system. Its main activities are:

(*a*) Cartographic production, which involves geodesy, aerial photography and topographic and resources mapping;

(*b*) Analysis and correlation of geographical and socio-economic information with the aim of providing useful indicators for the decision-making process of government agencies, private companies, professionals and private citizens.

The policy of the agency has evolved from the concept of a single-scale resources inventory to a more systematic approach of establishing several information subsystems related to geodesy, aerial photography, topographic cartography and resources mapping.

Origins and evolution of the National Mapping Agency

Since the early 1960s, several professional groups in Mexico have been increasingly concerned about the need for an efficient, integrated resources inventory of the country. In the period between 1961 and 1968, the objectives and functions of an agency that could handle this task were analysed, delineated and submitted to several ministries.

In October 1968 the project was realized with the establishment of a National Mapping Agency within the ministry of the presidency, CETENAP (Comisión de Estudios del Territorio Nacional y Planeación). It had two departments, as shown in figure 108.

The staff at first consisted of only about 20 people. That situation has dramatically changed with the years, as can be seen in figure 109.

In order to be able to handle this "demographic explosion", the structure of this agency has been changed several times. Without being exhaustive, the organizational structure of those years, such as is important for the understanding of the agency evolution, is described below.

Figure 110 shows the agency structure in 1973. By 1976 the agency had grown to 20 departments, as shown in figure 111. Figure 112 shows the present structure of DETENAL.

In 1970, the name CETENAP was changed to CETENAL. In 1977, CETENAL was renamed DETENAL, and the agency was incorporated in the General Coordination of the National Information System.

Turning back to 1968, the main actions in organizing the agency were:

(*a*) *Scale selection for basic mapping.* With the end in view of covering the most urgent information needs for national development, a Consultative Committee was established, made up of representatives of all the government ministries, to assist in major decisions. The Committee decided that the best scale for the basic maps would be 1:50,000 because of its advantages in relation to the quantity of semantic information contained and to the metric quality of the product;

(*b*) *Establishment of regional mapping priorities.* The problem was solved by giving each ministry representative a small-scale map of Mexico on which they outlined the region where their respective ministries had interest. Afterwards, superimposing all the maps, DETENAL decided to begin with the region where the interests of most ministries coincided, this being the central portion of the country.

Among the decisions taken in that period, the most important were:

(*a*) Photogrammetric operators, photo-interpreters for resources mapping, laboratory technicians and other kinds of personnel required were to be trained at DETENAL (in-house training base);

(*b*) The country was to be divided into 83 zones, as shown in figure 113, and all flights and ground control were planned according to these zones. Generally, most of the zones were divided into blocks for aerial triangulation purposes;

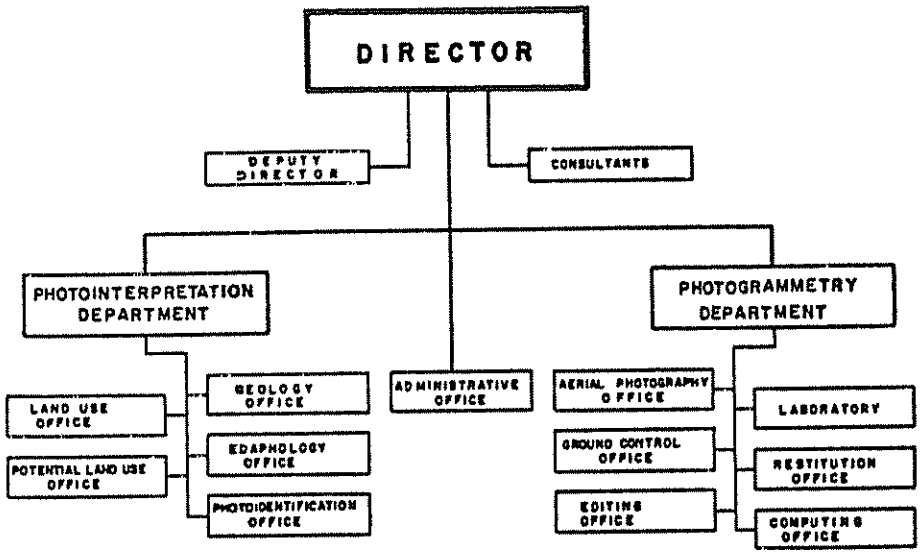


Figure 108. Mexico: DETENAL in 1968

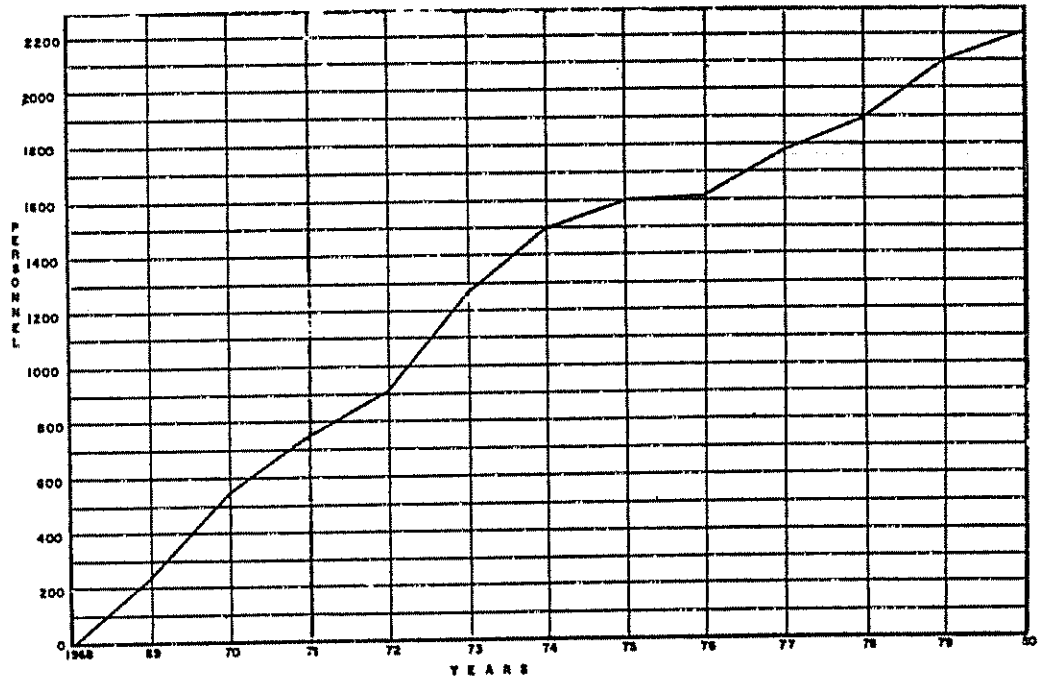


Figure 109. Mexico: number of personnel in DETENAL between 1968 and 1980

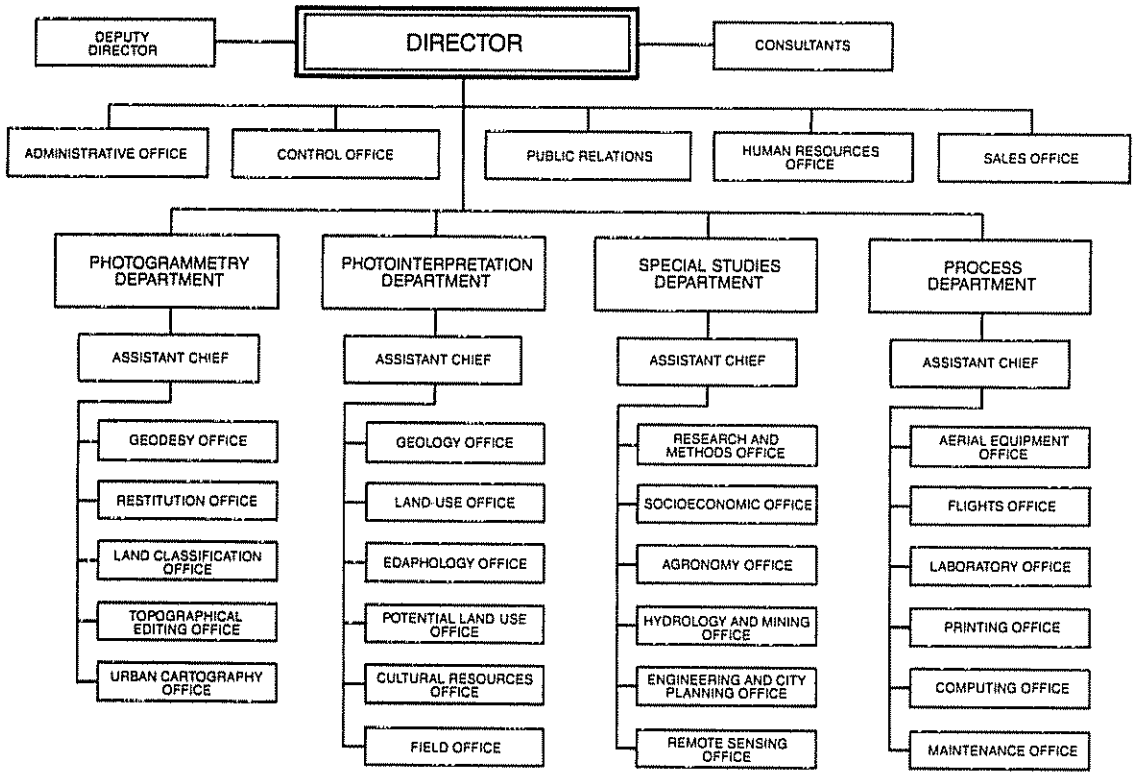


Figure 110. Mexico: DETENAL in 1973

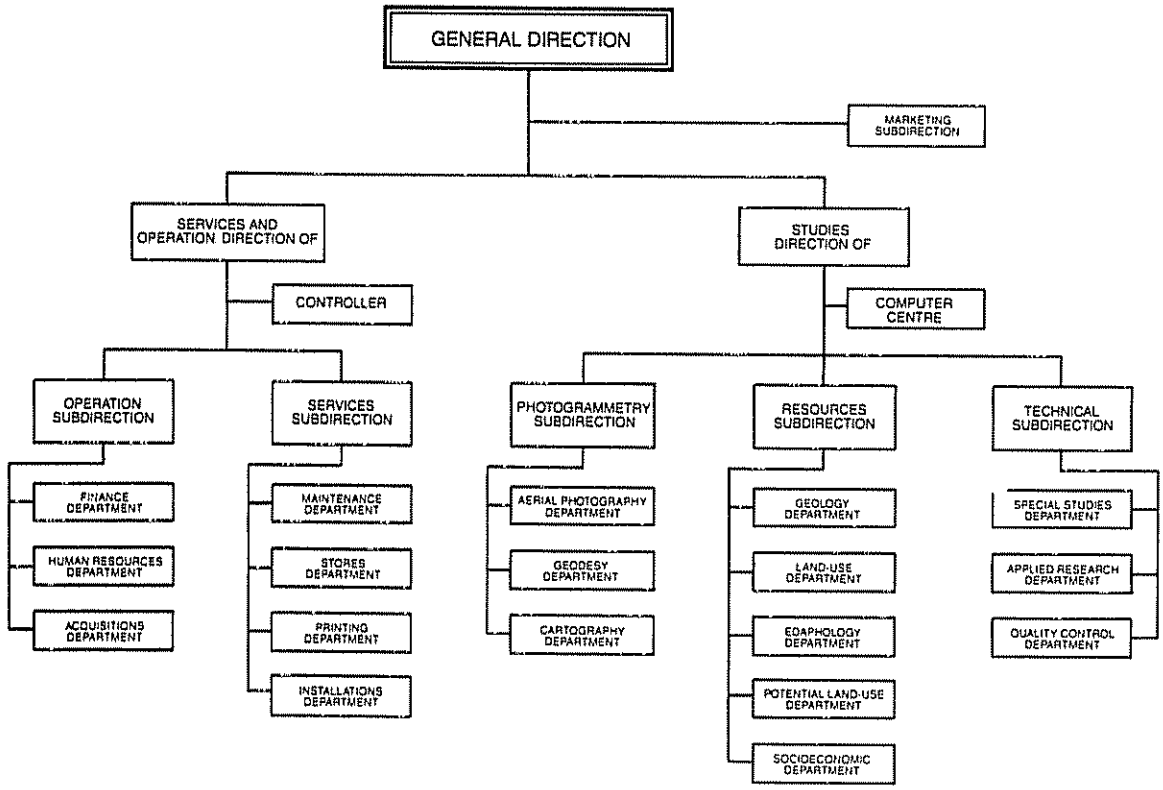


Figure 111. Mexico: DETENAL in 1976

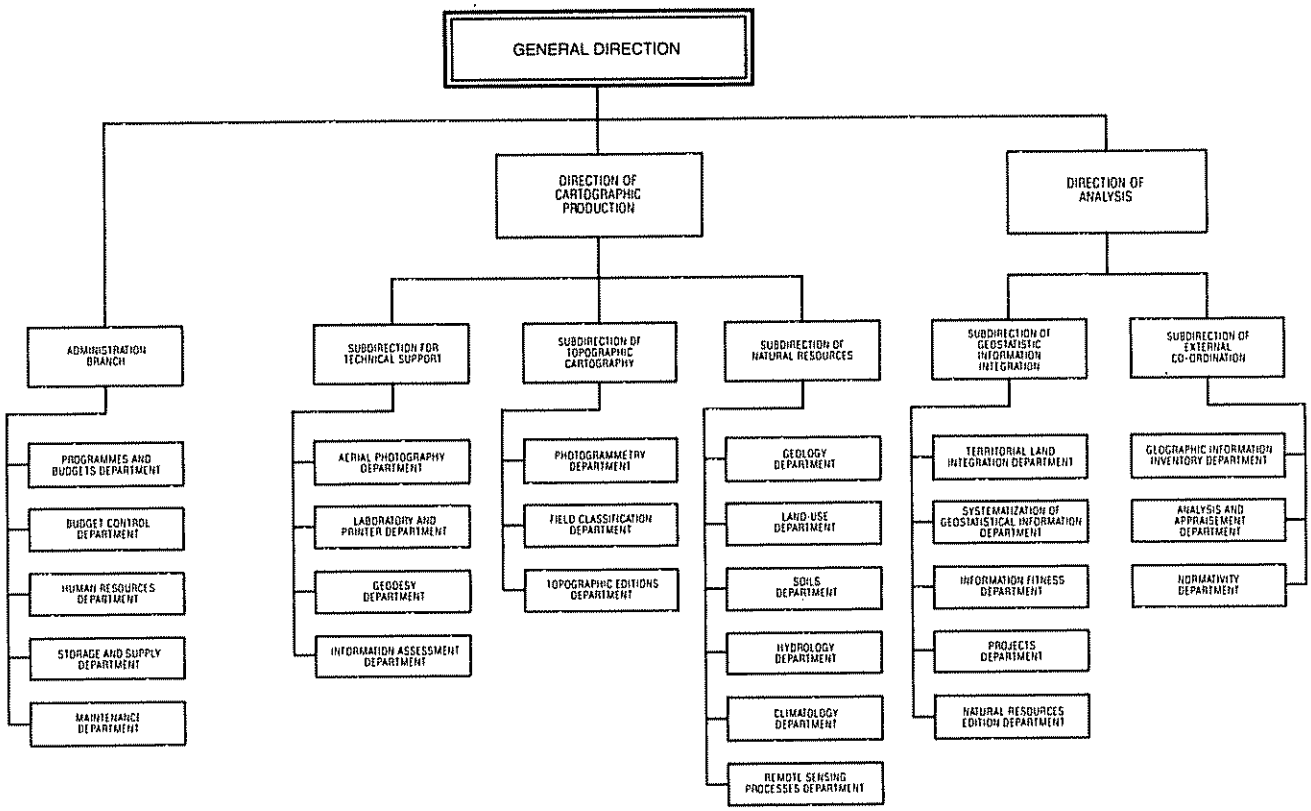


Figure 112. Mexico: DETENAL in 1980

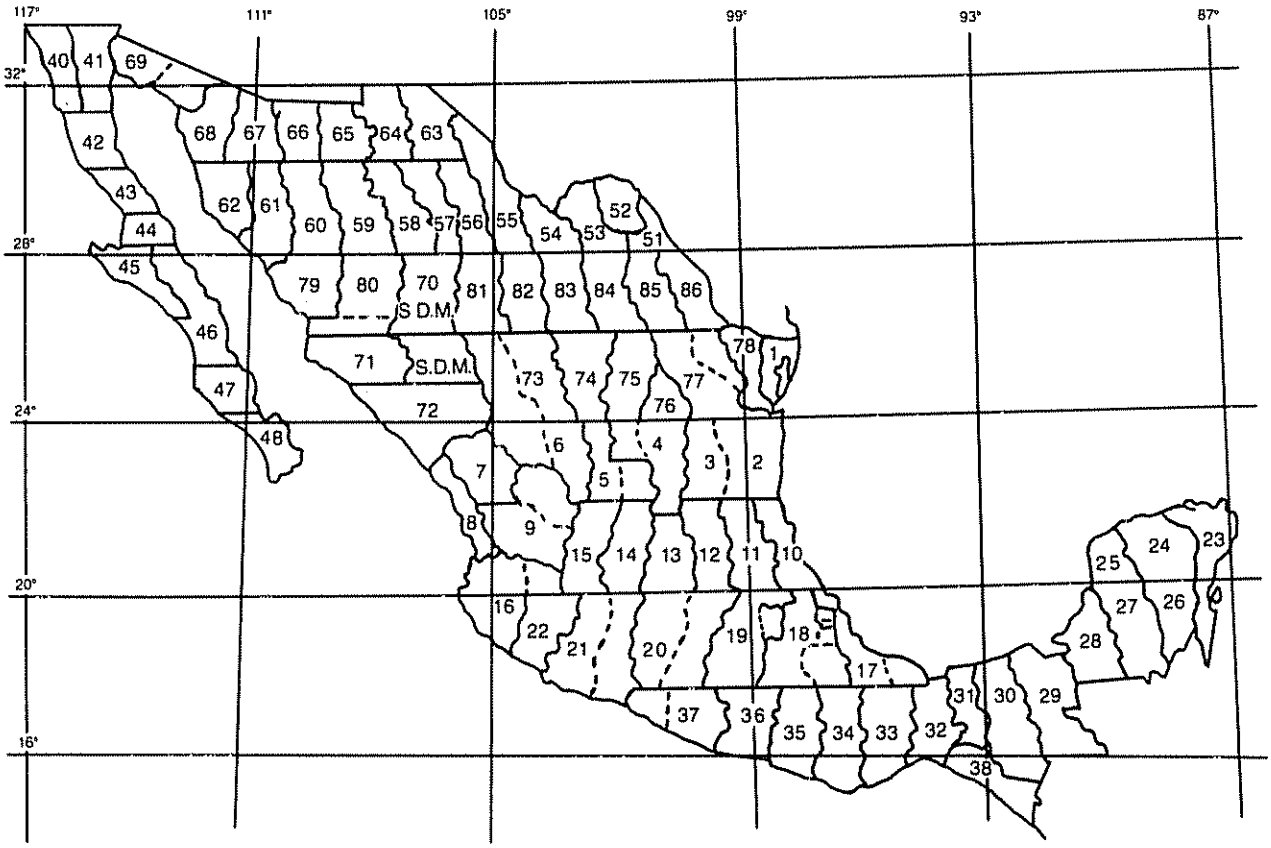


Figure 113. Mexico: division of working zones

(*c*) DETENAL was to be responsible for handling the complete process independently, from aerial photography and geodesy, through photogrammetry and photo-interpretation and up to the printing of the maps;

(*d*) All the information produced by DETENAL was to be available to the public, in such a way that the cartographic development of the country was advanced, and the proper use of the maps was ensured.

METHODOLOGICAL DEVELOPMENT AND CARTOGRAPHIC PRODUCTION

This section will take up the two main fields of DETENAL's techniques: photogrammetry and photo-interpretation. In the first case, the development of aerial triangulation and stereo compilation techniques will be described, and in the second, the integrated approach to resources mapping.

Development of aerial triangulation

A detailed description of the evolution of aerial triangulation techniques at DETENAL can be found in a paper presented to the XIII Congress of the International Society of Photogrammetry, held in Helsinki in 1976. Here, only some of the more relevant aspects are pointed out.

The Aerial Triangulation Section of DETENAL has developed in three main steps:

(*a*) Aeropolygon, from 1969 to 1971;

(*b*) Independent models, from 1972 to 1973;

(*c*) Analytical method, since 1973.

In all cases the method used has been polynomial block adjustment. It was decided to start with the aeropolygon method because it helps to train operators: as is known, the residuals in the instrumental connection of the models provide an immedite quality check on relative orientation, and this fact makes the operator conscious of the importance of relative orientation in the final result.

In the second step, in 1972, the method was changed to that of independent models because of its advantages relative to the aeropolygon method in accuracy, versatility and simplicity. Also in 1972, a stereocomparator STK-1 was bought, because it was considered convenient to use a smaller scale where possible (1:70,000 and 1:90,000 in flat areas), and for this purpose, owing to the flight capabilities, it was necessary to use super-wide-angle photography, which cannot be handled in the A-7, at least in the analogic mode of operation.

At the beginning of 1973, it was possible to go into analytical aerial triangulation procedures. DETENAL personnel expected to have a very high production rate with the STK-1 in comparison with the A-7, but it was only about 20 to 25 per cent higher (about 10 models per shift). In considering the reasons for this poor increase, it was concluded that the system of keeping only one operator on each shift was not satisfactory because his performance was impaired owing to monoactivity. This fact is clearly understandable from the physiological and psychological point of view. On the other hand, it was intended to enrich the operators' experience by having them enrol in the complete process, and not only in the instrumental part.

The solution tried (and it has given the best results) was to set up an operation mode of only 3½ hours on the instrument per operator (i.e. one half shift). After 3½ hours, the operator is replaced by another who has been working on a different activity, i.e., preparing photographs, checking computer results or preparing data checks. With this mode of operation, the production rate increased in a notable way, as is shown in figure 114, where the results of different operational methods are reported.

DEVELOPMENT OF STEREO COMPILATION TECHNIQUES

Direct scribing of contours in photogrammetric instruments

When the stereocompilation process started, DETENAL faced two facts: on the one hand, lack of experience of the operators, and on the other, the urgency of the information.

As is well known, the normal time difference between a photographic mission and the final printing of the map is from three to four years. In addition, the editing of altimetric information in some map sheets of mountainous regions takes from five to eight months. Also, during editing of contours a certain smoothing of the lines is made which decreases the quality of the cartographic representation.

For all these reasons, it was attempted to implement direct scribing of contours on the plotters, which might afford the system a considerable saving of money and time and also increase the quality of the altimetric information on the map.

The main problems were:

(*a*) Operators' resistance to the change: even if it could not be said that too strong a resistance to the change prevailed among the operators, since most of them were young people with a good disposition towards innovations, it was still necessary to demonstrate the advantages of the method and the importance of this step in the whole information production system. The solution adopted was to set up an experimental team with two operators, in such a way that they could evaluate the convenience of the method. The facts that convinced them were the superior quality and cleanliness of the contour lines they could obtain, and also that with direct scribing, some of the most problematic parts of compilation were diminished or eliminated, for instance, the sharpening of pencil points or the inking problem, and, especially, erasing;

(*b*) Procuring of scribing needles: this is perhaps the most difficult problem of the method. To overcome it, some of the available needles on the market were tried. They are made of steel and were not in any way satisfactory. In this situation, it was decided to produce the appropriate scribing needles, according to DETENAL needs, that is, scribing needles of two calibres: one for the normal contours (0.05 mm width) and the other for the index contours (0.15 mm). A production process that is fast, economic and accurate was implemented in the Restitution Office, using sapphire as basic material;

(*c*) Correction of mistakes in the plotting: the most usual mistakes in the plotting are contours that touch each other, errors in contour continuity of consecutive models and mistakes during plotting (erroneous following of the relief).

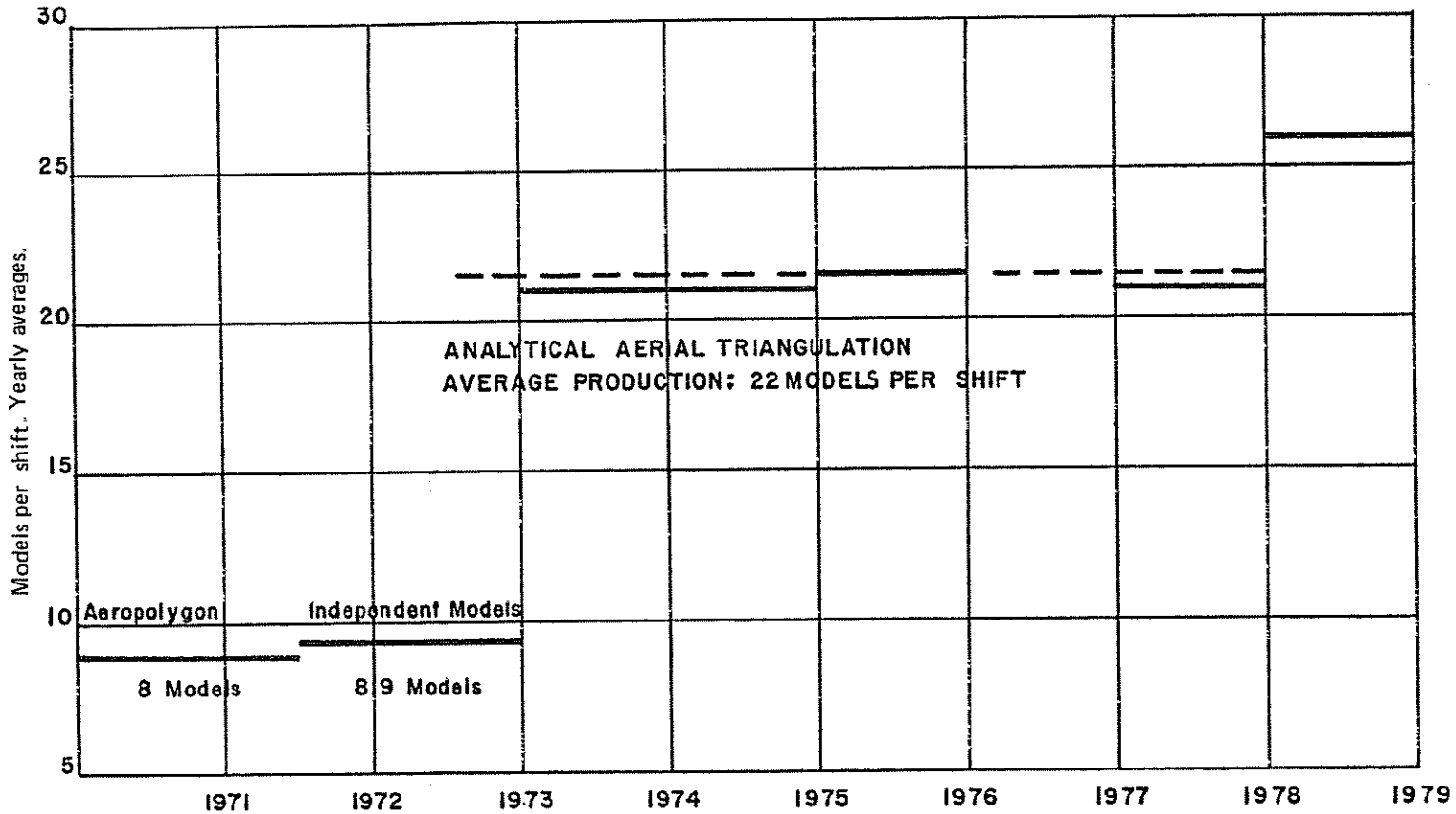


Figure 114. Mexico: aerial triangulation production rates per shift

The possibility of correcting such mistakes was thought to be very difficult, but as a matter of fact it is not, for two main reasons: the availability of the emulsion which forms the stabilene film and the cleanliness of the direct scribing method as compared with traditional plotting with ink or pencil.

In general, it can be said that direct scribing of contours increased considerably the quality of relief representation, and it saved about four months, on an average, in the production time per sheet. Perhaps the most important advantages were that it made possible the production of a provisional edition of the maps with very good quality.

Provisional edition of the 1:50,000 topographic map

The production of the provisional edition was possible thanks to the high quality obtained in the relief representation directly on the plotters. Taking into account that only 900 maps have been printed out of the 1,200 available in provisional edition, the importance of this solution is clearly understood to a country with urgent requirements for cartographic information.

The provisional edition is made by adding, in one positive, the planimetric and altimetric originals and the sheet that contains the grid and graticule. On the planimetric original the geographical names of some relevant details are placed.

The provisional edition has had very good acceptance among map users. The flow diagram production process of figure 115 shows where the provisional edition fits.

PRODUCTION RATES

The production rates per operator are shown in figure 116. It is important to point out that about 70 per cent of the terrain is mountainous area where the density of the altimetric information is quite high.

During the first three years (1969-1971) the system of payment was by task work contract, so that the operator's salary was in direct relation to production. Since 1973 the system has changed, and the operators are now employees of DETENAL with a fixed salary, so that it is possible to incorporate them into the social security facilities provided to people working for the Government.

An overall view of the total annual production in different aspects is given in figure 117.

PHOTO-INTERPRETATION

Integrated approach to resources mapping

The decision to produce simultaneously the geology, land use, soils and potential land-use maps of Mexico (1:50,000 scale) was at the same time a challenge and an advantageous opportunity: in the first place, because of the extent of the territory (2,000,000 sq km), and secondly, mainly because producing these maps consecutively allowed each to be enriched with the information contained on the preceding one.

The production process flow chart of the resources mapping at DETENAL is shown in figure 118. As can be seen, the geological map is produced only after the topographic base is available; only afterwards is the land-use map produced. The soils map is produced taking advantage of the information contained on the geological and land-use maps, complementing the specific and specialized procedure for soils mapping. In the same way, the potential land-use map is elaborated by integrating the data contained on all the preceding ones by means of a joint analysis, and of course with additional photo-interpretation and field verification.

MANAGEMENT

In this section management policies will be described in relation to:

(*a*) Selection and training of personnel in photogrammetry and photo-interpretation;

(*b*) Map distribution.

Selection and training of photogrammetric personnel

As mentioned above, one of the most difficult problems to solve when DETENAL started was the lack of trained personnel in photogrammetry and photo-interpretation. A complete programme for training had to be set up. In order to increase the possibilities of success in this vital step, very good care was taken in the selection of the people that had to be trained. The following requirements had to be fulfilled (and are still in effect) for each applicant to the preparatory course:

(*a*) In educational background, at least of university entrance level; students of engineering sciences are preferred over those of other specialities;

(*b*) Satisfactory passing of ophthalmological examination, with emphasis on stereoscopic vision;

(*c*) Successful passing of a psychotechnic examination.

After a sufficient number of applicants for a group (about 8-10 people) have succeeded in the battery of tests, DETENAL offers them a fellowship (at about half the normal operator's salary) for three months with the objective of following a course in basic photogrammetry and operation of instruments.

The course is composed in two main frames:

Theoretical background

Different kinds of projections: parallel, central, orthogonal;

Aerial photography;

Bundle of perspective rays;

Photographic flight project: cameras, plans, overlaps, number of photographs, number of strips etc.;

The photogrammetric model;

Empirical relative orientation procedures;

Absolute orientation;

Principles of photogrammetric instruments;

Complementary lectures:

(*a*) DETENAL objectives and perspectives;

(*b*) Aerial triangulation;

(*c*) Topographic mapping systems;

(*d*) Human relationships.

Practical exercises

Preparation of photographs for aerial triangulation;

Readings of photogrammetric heights in different instruments (A-7—Santoni II C);

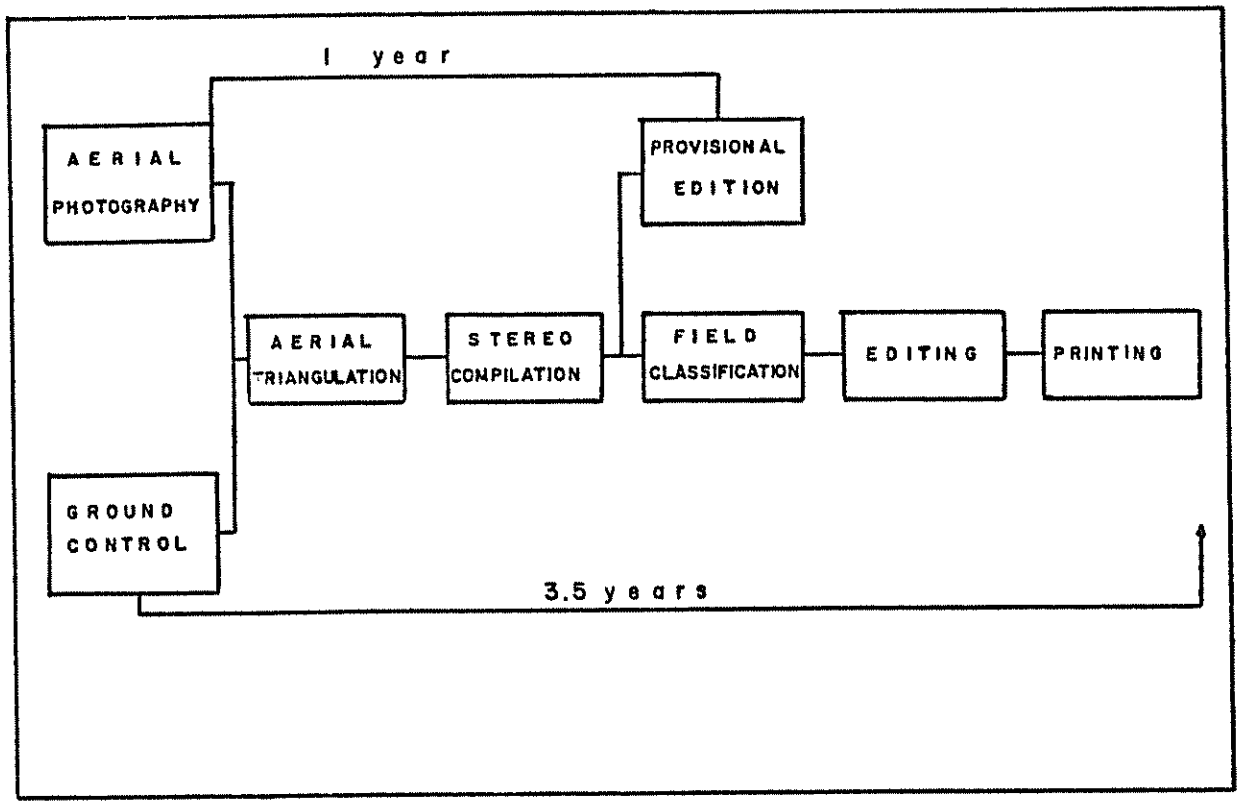


Figure 115. Mexico: flow diagram of the 1:50,000 topographic map proceeding

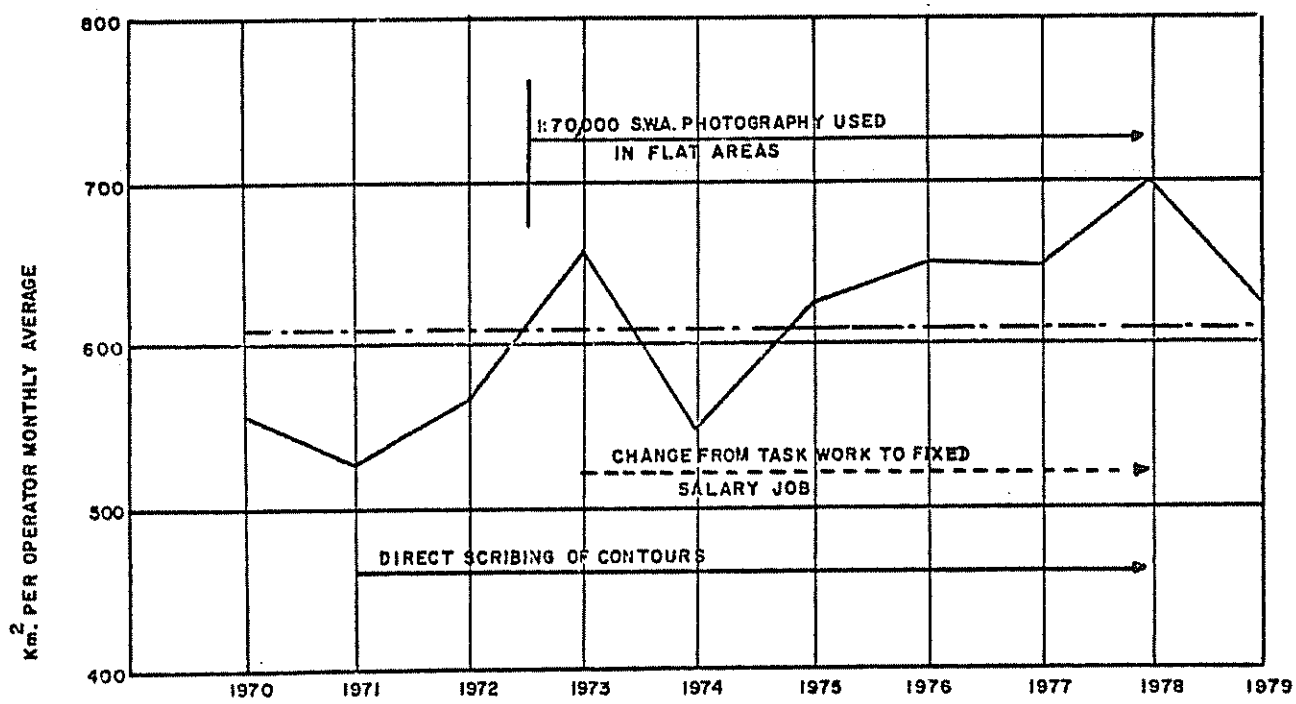


Figure 116. Mexico: production rates per operator per month

Scale ACTIVITY	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Topographic mapping (1:50,000)										
Aerial triangulation	192	200	180	128	170	195	160	180	140	200
Stereo compilation (map sheets)	90	136	240	194	183	176	187	173	134	240
Field classification (map sheets)		400		113	215	150	158	131	20	138
Editing (map sheets)		60	163	155	255	148	160	146	41	60
Resources mapping (1:50,000)										
Geology		31	99	106	127	85	112	142	80	4
Land-use		30	106	82	97	62	95	80	64	18
Soils		33	93	73	109	51	91	89	67	53
Potential land-use		31	61	96	80	35	85	63	59	5
1:250,000										
Topographic							2	10	7	19
Geology									1	6
Hydrology									2	2
Land-use									2	9
1:1,000,000										
Tourist							2	2	3	2
Topographic										2
Land-use										1

Figure 117. Mexico: total annual production

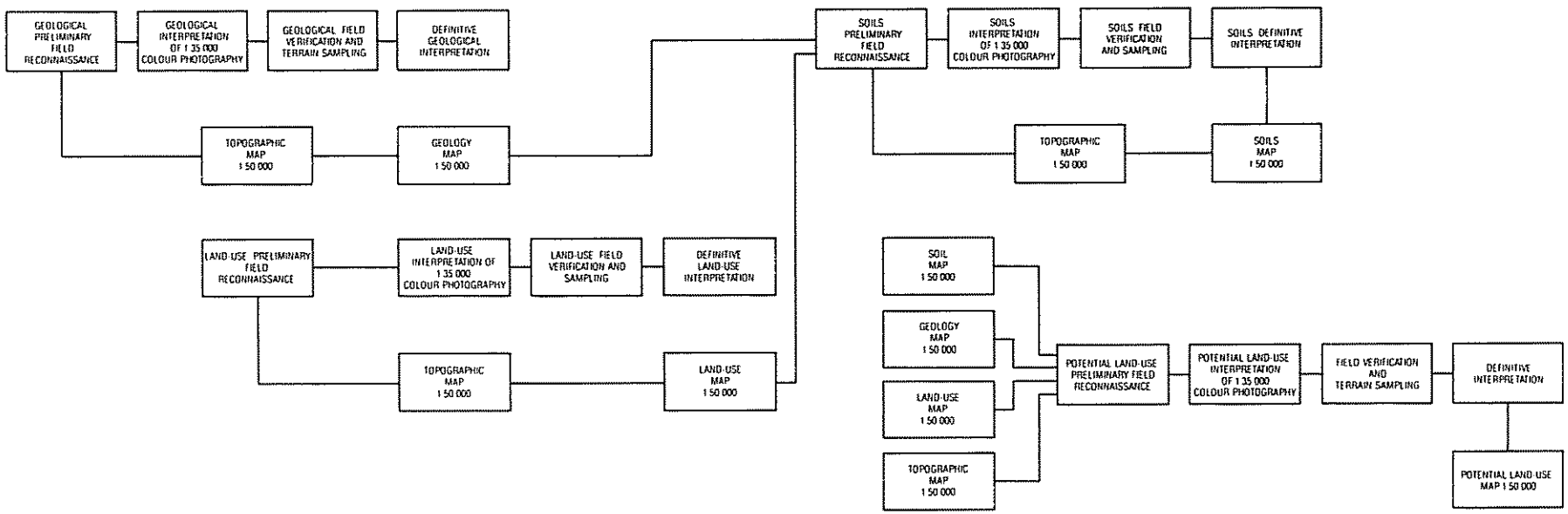


Figure 118. Mexico: flow chart of resources mapping

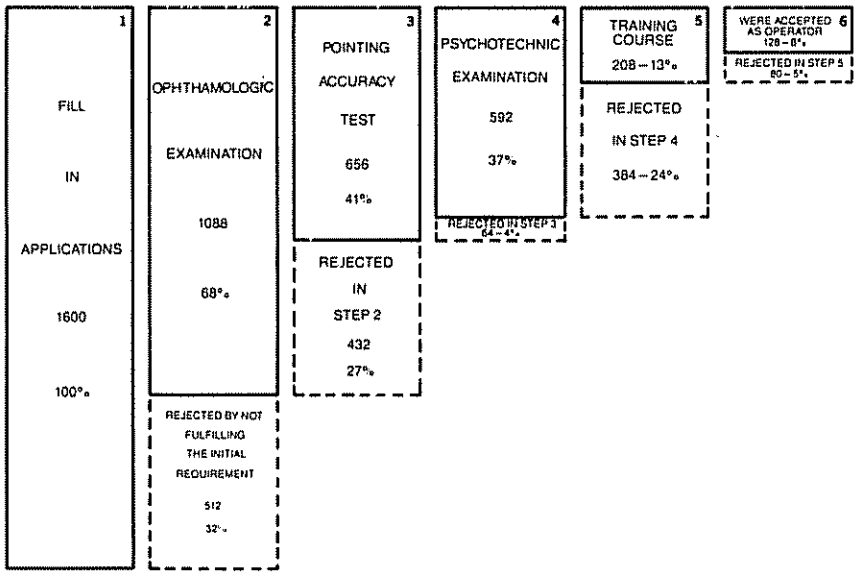


Figure 119. Mexico: training of photogrammetric personnel; fellowship statistics

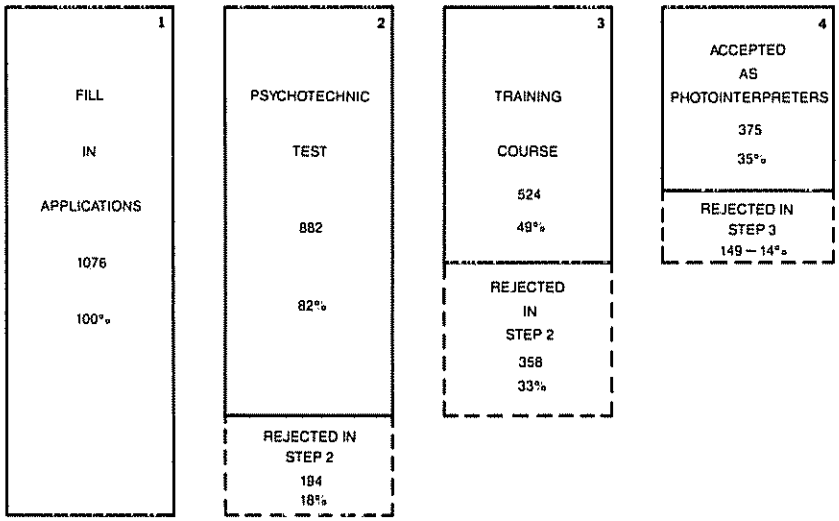


Figure 120. Mexico: training statistics of photo-interpreter personnel

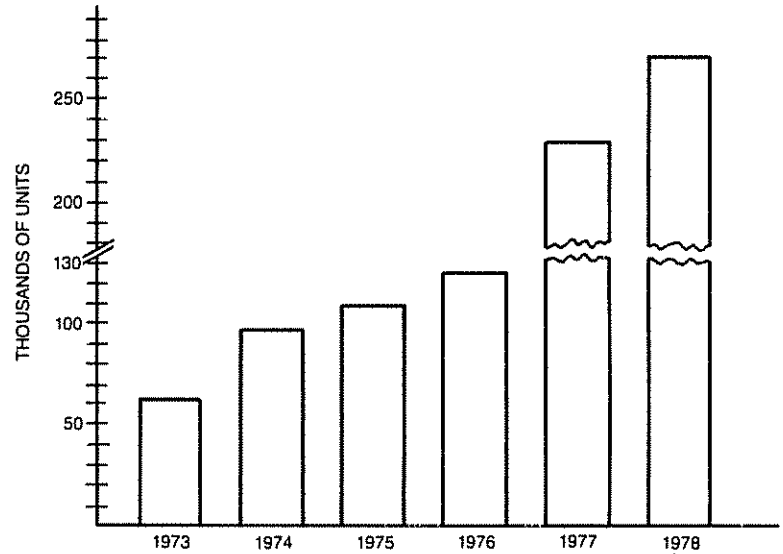


Figure 121. Mexico: DETENAL cartographic material sales for the period 1973-1978

Exercises in plotting:

(*a*) Contour lines;

(*b*) Planimetric details;

Exercises in empirical relative orientation;

Exercises in absolute orientation;

Exercises in compilation of topographic maps.

At the end of the fellowship period about 40 per cent of the fellows would have been eliminated for several reasons. In order to give an idea of the degree of rigorousness of the selection process, figure 119 shows the statistics of the process over five years.

As can be seen in the diagram, only 8 per cent of the people that fill in an application are accepted as operators in the Plotting Section. From here the best elements in relation to pointing accuracy will be chosen for the Aerial Triangulation Section.

The people working in photogrammetric tasks at DETENAL have passed the described training process, and the flow of personnel in the Restitution Office has not been interrupted, although the number of people in the office remains almost the same owing to the fact that a certain percentage of operators leave the job after four or five years; this is understandable, because most of them have in the meantime finished their college studies. This fact is accepted and even believed to be an advantage, permitting satisfactory production indexes to be reached and maintained.

Selection and training of photo-interpretation personnel

At the beginning of DETENAL activities, only 5 people out of the approximately 20 founders had experience as photo-interpreters, so the first production of DETENAL had to be not of maps, but of trained people. The magnitude of the task that was faced can be figured out if we think of producing 1:50,000 geological, soils, land-use and potential land-use maps of 2,000,000 sq km.

In order to solve this lack of skilled people, a selection and training programme was established with the following steps:

Selection of candidates;

Psychological examination;

Training.

The applicants to the training must fulfil the following requirements:

(*a*) Bachelor of Science degree in the specific field in which they will work, for instance, geology, biology, forestry etc.;

(*b*) Passing of an examination in stereoscopic vision.

With these qualifications, they submit to a psychological test, and those who succeed are able to go into the training phase, which is divided into the following steps:

Integration of the group;

Training in the specific field;

Training in photointerpretation;

Field training;

Methodological training;

Final assessment.

The statistics for a group of about 1,000 applicants to the position of photo-interpreter are shown in figure 120.

Map distribution

One lesson learned over time is that possibly the most difficult task for a cartographic agency is not so much the map production as getting the map used properly, especially in developing countries where a solid cartographic culture does not exist. The problem is a sort of vicious circle: in the past there were no maps, so decisions had to be taken on the basis of the best information available, in many instances poor information; now more regions are covered by good topographic and resource maps, but the people are not prepared to use them.

In order to solve the difficulty, DETENAL has followed a policy of an unlimited distribution of maps, encouraging the establishment of map libraries in all professional and preparatory schools. Also, in the 31 states that form the country, the local governments have been provided with a series of all maps available that cover their respective territories.

In addition, in the first years of DETENAL, the pricing policy was such that the maps were almost free of charge. Nowadays cartographic material is free of charge for governmental institutions. The sales of cartographic products on map sheets for the 1973-1978 period are shown in figure 121.

FUTURE TRENDS

The strategy in DETENAL for the near future is based on the establishment of a National Cartographic System, flexible and powerful enough to provide information at the scales and covering the subjects that the country requires for planning and programming its development.

In topographic mapping, the system will be completed at 1:250,000, and at smaller scales in 1982; and in that year there will also be available a complete coverage of the 1:50,000 topomap in a provisional edition.

After 1982, the updating process will start, and at the same time production of 1:20,000 photomaps will be increased, using a multi-purpose project of aerial photography coverage at 1:80,000. That scale could be used for updating the 1:50,000 topomap, for producing the 1:20,000 photomaps and for resources mapping at 1:250,000.

In resources mapping the strategy is to complete first the 1:1,000,000 and 1:250,000 scales, and then finish the 1:50,000 project.

More attention is being paid to the use of data collected from other sensors different from the traditional aerial photographs, especially electromagnetic sensors, in order to implement a system of crops forecasting and a speeding up of the resources mapping production.

In this decade, one of the main objectives is to take an inventory of the specialized cartographic projects of other federal agencies, as a means of rationalizing the production processes and giving them consistent specifications so that the limited resources available may be used more efficiently.

Last, but not least, it should be mentioned that the unlimited distribution policy will continue, as only by affording every user the same chance to obtain precise, complete and opportune geographical information can DETENAL collaborate in the construction of a country enjoying greater social justice.

APPLICATION OF PHOTOGRAMMETRY TO CADASTRAL SURVEYS AND TO LAND MANAGEMENT IN GENERAL*

Paper presented by the Netherlands

RÉSUMÉ

L'auteur recommande aux pays qui n'ont pas encore commencé à établir systématiquement des plans cadastraux, et ou les délimitations cadastrales sont principalement formées par des caractéristiques topographiques telles que haies, fossés, diguettes de rizière, etc., d'utiliser la méthode des photocartes au cours de la phase initiale.

Ces photocartes peuvent servir à de multiples fins : 1) elles constituent une bonne base pour l'établissement d'un cadastre permettant de déterminer l'assiette de l'impôt foncier; 2) elles fournissent un canevas idéal pour l'assemblage des éléments d'un cadastre juridique; et 3) elles constituent des cartes parfaites pour l'administration foncière et la planification régionale en général.

Toutefois, dans le cas du cadastre juridique, on n'utilise pas ces photocartes comme documents de base, mais seulement comme canevas d'assemblage. Les véritables documents de base de ce cadastre sont les agrandissements photographiques qui ont servi sur le terrain à identifier les délimitations cadastrales. On trouve indiquées sur ces agrandissements toutes les données concernant l'identification, y compris les données complémentaires relatives aux levés sur le terrain. Pour ce dernier usage, il serait préférable d'utiliser, aux fins d'identification sur le terrain, des copies des photocartes plutôt que des agrandissements photographiques non redressés.

Lorsque surgit un différend et que les délimitations doivent être juridiquement reconstituées sur le terrain — il faut espérer que cela ne sera nécessaire que dans un très petit nombre de cas —, on doit recourir aux agrandissements annotés sur le terrain et à la photographie aérienne originale. Lorsque l'échelle de la photographie a été choisie de telle sorte qu'on puisse tenir compte des erreurs inévitables dues à « l'idéalisation » des caractéristiques topographiques qui forment les délimitations cadastrales, on peut alors obtenir les données nécessaires à la reconstitution sur le terrain avec la plus grande précision possible dans des conditions d'économie acceptables. On peut y parvenir en recourant soit à la stéréorestitution numérique, soit à la stéréorestitution graphique à grande échelle, à partir de la photographie originale. Toutefois, il ne convient d'utiliser de tels procédés que lorsque cela est réellement nécessaire, car ils sont coûteux et demandent beaucoup de temps.

In many countries of Asia, but also in the Netherlands, the cadastral boundaries are formed by visible features such as hedges, ditches, fences, walls etc.

Experience in the Netherlands has shown that the idealization "errors" of these boundaries in an aerial survey are of the same order as those in a field survey. Expressed in errors in distances, relative to reference points, the standard errors due to idealization may be of the order of: 2-10 cm for walls, 5-25 cm for hedges, 10-40 cm for ditches, etc. (see figure 122).

Now, it would be the height of folly to crawl under a hedge, materialize the idealization of the hedge with wooden pegs and next measure the positions of these wooden pegs, relative to the measuring frame-work, with one-centimetre precision! It is clear that a repetition of the idealization would produce positions of wooden pegs which might have random shifts of several centimetres (or decimetres, depending on the width and the symmetry of the hedge) in the direction perpendicular to that of the boundary itself, as compared with the first series of pegs.

Therefore, for obvious economic reasons, the accuracy specifications for boundary survey in the Netherlands simply read: "The measuring accuracy of the boundary survey need not be significantly better than the accuracy of the idealization". This applies equally to field and photogrammetric survey of the boundaries.

Assume that there is an area in which the cadastral boundaries are mostly features with

$$(\sigma_d)\ \text{idealization} = 20\ \text{cm}.$$

NUMERICAL STEREO-RESTITUTION

If numerical stereo-restitution on an analog instrument is considered for the boundary survey, then the distance-measuring accuracy of this procedure may be assumed to be

$$(\sigma_d)\ \text{num. rest.} = 17.5\ \text{microns}\ (\mu).$$

This is a conservative estimate based on European experiments of 1964 (OEEPE publication No. 4).

Accepting a 1:1 ratio between measuring accuracy and accuracy of idealization, the photo-scale to be used can now be computed from

$$17.5\ \mu = 20\ \text{cm} \longrightarrow 1{:}11{,}500$$

and the eventual accuracy of the distances is then

$$\sigma_d = \sqrt{20^2 + 20^2} = 28\ \text{cm}$$

*The original text of this paper, prepared by J. Visser, International Institute for Aerial Survey and Earth Studies, appeared as documents E/CONF.72/L.55 and Add.1.

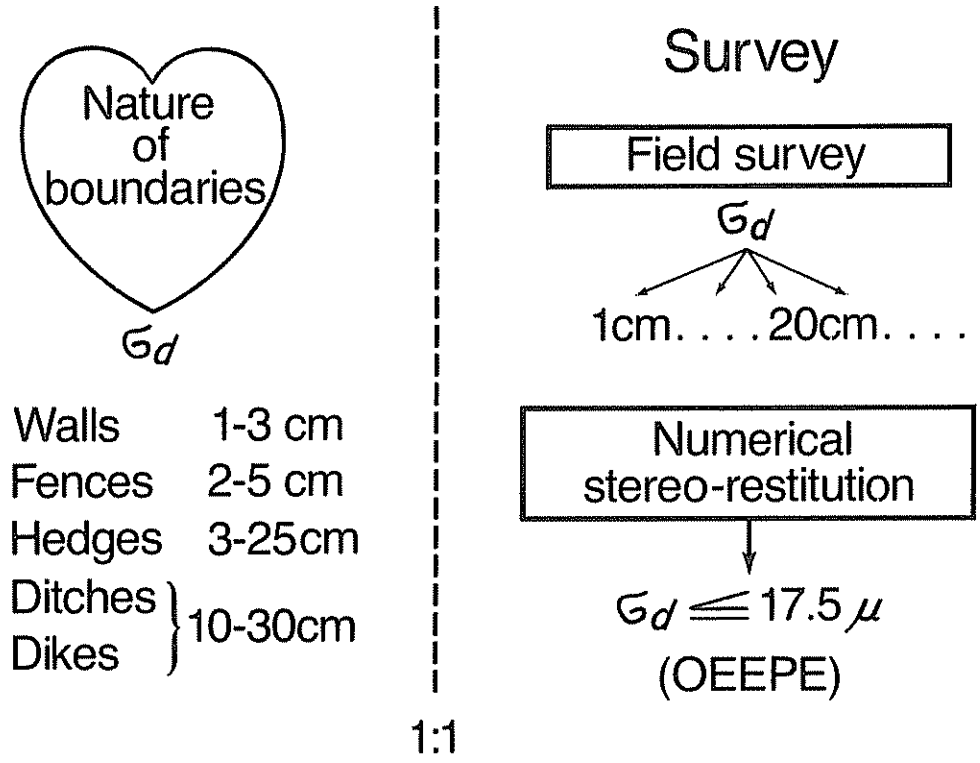


Figure 122. Netherlands: accuracy specifications for boundaries

Graphical stereo-restitution

If, in the case above, graphical stereo-restitution is considered instead of numerical stereo-restitution (because the former is simpler and cheaper), then accuracy is lost due to graphical plotting (σ_d = 0.15 mm at the scale of the map) and due to the scaling-off of the distances from the map (σ_d = 0.10 mm at map scale).

The final accuracy of the distances, in the case of a map scale of 1:2,500, is then

$$\sigma_d = \sqrt{20^2 + 20^2 + (37.5)^2 + 25^2} = 53 \text{ cm}$$

For graphical stereo-restitution at a scale of 1:2,500, from aerial photography at 1:10,000—1:12,500 of rural areas (cadastral details plus general topography), a production (pencil plot only) of 2.5-10 ha per instrument-hour may be expected, depending on the density of the planimetric details to be plotted. Average production: 5 ha/hr; per stereo-model, consequently, some 40 instrument hours are required for the pencil plot only. If, therefore, in a certain country, it is desired to map in this way about 5,000 sq km annually, then 35 stereo-instruments are required provided the work is carried out with two shifts per day on each instrument.

Mixed graphical and numerical stereo-restitution

In order to extract, at least for the cadastral boundaries, the highest possible accuracy from the aerial photographs (σ_d = 28 cm in our example above), one could, simultaneously with the graphical plotting of the cadastral boundaries, record the model co-ordinates of the plotted boundary points. Productivity at the stereo-instrument will not be significantly lower than for graphical restitution, though, for easy reference, the recorded model co-ordinates should be coded at the instrument.

For the numerical restitution, a device for automatic digital recording and a calculator—preferably an electronic computer—are necessities. In the case of cadastral boundaries formed chiefly of topographic features, the main product will be a long list of transformed co-ordinates. The procedure leads, of course, to a confrontation with problems of mass data-processing, inspection, filing and administration.

Recommended procedure

Usually, the purpose of a cadastral survey is, in the first place, to fix the boundaries of a property for the legal protection of ownership and other rights of the land, and, in the second place, to have a basis for taxation.

With regard to the legal aspect, a real geometrical survey of these boundaries would not be necessary if no changes in the boundaries were expected in the future. All that would be necessary would be a good description of the boundaries and, for this, a near-vertical photograph is ideal if most of the boundaries are visible, i.e. when they consist of topographic features. Non-visible boundary points may be signalized before the photographic flight, or else they require a local field completion survey in which the non-visible points are fixed relative to photo-identifiable terrain points.

Definition of boundaries in the terrain

Cadastral boundaries must first be defined in the terrain. A formal (i.e. legal) definition of the boundaries requires discussion with, and the agreement of, landowners in the field and may thus be very time-consuming. The visible boundaries have to be annotated on the photographs (preferably enlargements of the original photography), for instance by a series of pricked points, and be described in words on accompanying documents on which the complementary field survey observations are also entered.

Annotated photographs, plus accompanying documents, should have an official legal status.

The definition of boundaries in the field may be very time-consuming, but this is unavoidable. Not really unavoidable, however, is the execution of a consecutive high-precision photogrammetric restitution, although that is customary in The Federal Republic of Germany, the Netherlands and Switzerland.

High-precision photogrammetric restitution for reconstruction of boundaries

Apart from sub-divisions (which require a local field survey similar to that required for non-visible boundary points), only a small percentage of existing boundaries ever change (or disappear) and lead to boundary disputes which require reconstruction of the original boundaries in the field.

There will thus be relatively few requests for reconstruction surveys, and these are usually confined to areas where some special development is being carried out or planned. Unless high-precision photogrammetric restitution is required for other purposes, therefore, it would be uneconomic to begin immediately to carry out such a high-precision restitution of all the areas covered by aerial photography. It would be better to do this only when really necessary, i.e. when boundary disputes arise. Provided that, at that moment, there are some sharp image points which can still be clearly identified in the terrain (or, better, when a grid of monumented and signalized reference points has been prepared before the photo flight, see below), a high-precision photogrammetric restitution can be executed any time.

For reconstruction of boundaries which have disappeared, only some distances between some reference points, together with some relative heights, would have to be observed in the field in order to be able to absolutely orientate one, or more, stereo model(s). By means of a high-precision photogrammetric restitution (either a numerical stereo-restitution or a large-scale graphical restitution) of the reference points, together with points of the vanished boundary, the necessary data can then be collected for accurate reconstruction of the boundary in the field (the accuracy obtainable depends, of course, on the photo-scale chosen).

An "intermediate" map product

Although for legal protection, high-precision photogrammetric restitution from the very beginning is thus unnecessary, there will nevertheless be a need for some sort of map. This derives from a threefold circumstance:

(*a*) The need for cadastral index plans, i.e. comprehensive cadastral maps showing all parcels in an area rather than specific details about individual parcels (the latter being available from the annotated photographs plus accompanying documents);

(*b*) The need for maps for taxation purposes;

(*c*) The need for base maps for general land administration including the planning of development projects.

These needs can be fulfilled by an orthophoto map.

Having, as in our example, a photo-scale of 1:11,500 and assuming non-flat terrain, an economic proposition might be to produce orthophoto maps at 1:5,000 using the differential rectification method. Orthophoto producing equipment would then be necessary. Today on the commercial market a variety of this equipment exists, of different makes and with different potentials. There is no doubt that the present assortment will be extended in the near future with more defined and economical systems. Making, for the time being, a conservative choice of an on-line orthophoto producing system in the form of a topographic plotter with orthophoto attachment, such as the Galileo Santoni SIIc or the Zeiss Jena Topocart, one can state that such a system requires the investment of 1.4 times the cost of a precision plotter. The productivity of orthophoto mapping at 1:5,000 is high: only about 4 to 5 instrument hours are required per stereo model as compared to some 40 hours for graphical stereo-restitution at 1:2,500; see above.

In order to map, in this way, some 5,000 sq km annually, only 4 to 5 orthophoto-producing instruments would be necessary (as against 35 precision plotters—see above). The accuracy obtainable with photomaps is a "graphical" accuracy: $\sigma_d \approx 0.3$ mm on the map, thus about 1.5 metre on the ground on a 1:5,000 map.

If contours are required, overprinted on the orthophoto maps, contours at 2-metre intervals can be easily extracted from the 1:11,500 photography, whenever needed.

If the ground is sufficiently flat (i.e. when, per photograph, elevation differences with respect to a mean horizontal datum plane do not surpass ± 3 metres), photomaps at 1:5,000 may be produced by conventional rectification. For this a rectifier is needed. The cost of such an instrument is about two thirds that of a precision plotter. For the production of photomaps at 1:5,000 by conventional rectification of 1:11,500 photography, covering an area of 5,000 sq km annually, only one rectifier is necessary.

Aerial triangulation

For photomapping at 1:5,000, in our example, from 1:11,500 photography, the required control can be obtained most economically by aerial triangulation (figure 123). Through this triangulation also the ground co-ordinates of a grid of reference points (sharply identifiable permanent objects, or pre-signalized monumented points) can be determined. These reference points are needed for the field completion and field revision surveys. The intervals between the reference points should be chosen according to the methods and equipment envisaged for the field completion and revision. The intervals may thus range from 200 to 2,000 metres.

Aerial triangulation and subsequent block adjustment do not affect the high relative accuracy within each stereo model, and even improve the relative accuracy of neighbouring models, as compared to the use of full ground control for each stereo model.

Annotated photomaps

Rectification—either conventional rectification in the case of flat terrain, or differential rectification in the case of non-flat terrain—is usually employed using diapositives (on glass or film) in the rectifying instrument, so that the first product is usually an orthophoto negative, normally on film. Next, these orthophoto negatives must be assembled to form photomap sheets.

From the assembly of orthophoto negatives, photomap sheets can be produced (in the form of dyeline copies, bromide copies, or off-set printed copies), annotated with grid, names, contours and spot heights, and—if required—with soil type or vegetation strata lines etc., by following cartographic procedures such as those described in the ITC lecture notes on cartography by L. van Zuylen and J. Shearer, or by F. Urban of the Central Mapping Authority, Australia, in a paper, "Large-scale mapping in New South Wales", presented to the Seventh United Nations Regional Cartographic Conference for Asia and the Far East, held in Tokyo in October 1973.

When the definition of the cadastral boundaries in the terrain (see above) has been done by annotation on enlargements of the original photography, the photomaps can easily be annotated with these boundaries in the following way. A contact copy of the ortho-negative assembly is made onto a scribing sheet coated with a photographic emulsion (e.g. Stabilene Contone by Keuffel and Esser). When the scale of the enlargements is about equal to that of the photomap, a simple mirror stereoscope such as the ITC Stereoscan can be used for the transfer of cadastral boundaries to the photomap; otherwise a mirror stereoscope with differential optical enlargement is needed.

The cadastral boundaries can next be scribed into the coated scribing sheet. By successive photography of the ortho-negative assembly and the scribed sheet, using the proper means of registration, the cadastral boundaries will appear on the resulting positive orthophoto in black. From this scribed sheet conventional line maps of the cadastral situation can also be produced by offset printing, if desired. It should be noted here that the line plotting is done from the orthophoto and is thus not dependent on an expensive photogrammetric plotter.

Instead of carrying out the field definition of the cadastral boundaries by annotation on simple enlargements of the original photography, however, it is recommended to produce photomaps first and use these for the definition in the field. This has the significant advantage that any gross errors in the definition of cadastral boundaries (which may occur, for instance, when there are several almost parallel features close together, only one of which represents a cadastral boundary) can be checked by simple measurements on the photomap. Moreover, invisible boundary points can be plotted directly onto the photomap from the complementary field survey observations, also providing a direct check.

Choice of photo scale and camera type

As mentioned above, for the choice of the scale of the aerial photography the economic criterion that the accuracy of the boundary survey need not be much better than the accuracy of idealization may be used.

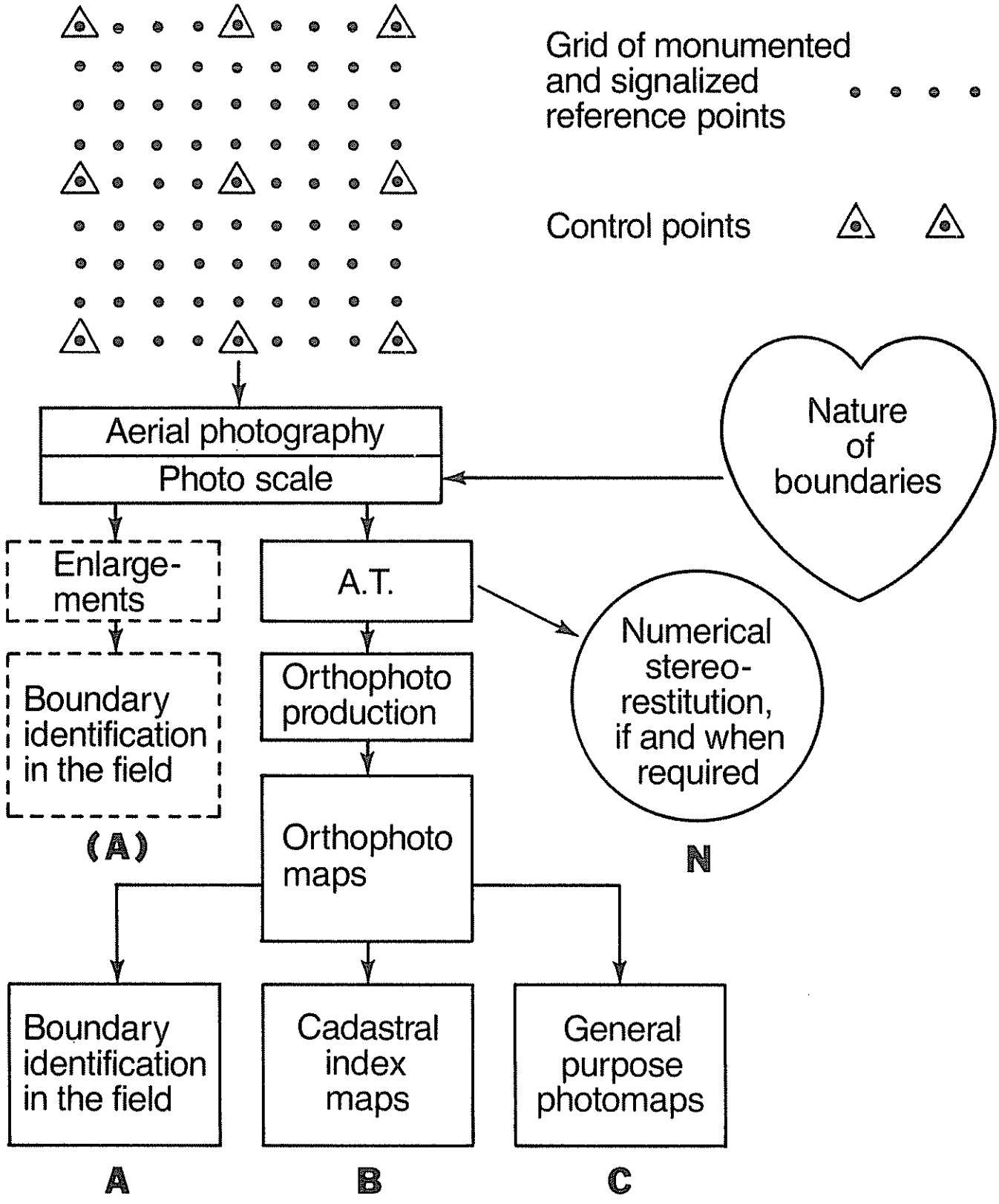


Figure 123. Netherlands: flow diagram

If, in a certain region, idealization errors in the definition of boundaries are of the order of 20 cm, as in our above example, then when accepting a ratio 1:1 between survey accuracy and errors in idealization, a photo-scale of 1:11,500 is found from the condition that 17.5 μ at photo-scale = 20 cm on the ground.

If a reconstruction of a disputed boundary is required, then, by applying numerical stereo-restitution from the 1:11,500 photography, the boundary can be re-established in the terrain with an accuracy of $20\sqrt{2}$ = 28 cm (neglecting here the errors in the stake-out of distances and/or angles as computed from the transformed model co-ordinates; the stake-out will in any case be executed with special care).

Regarding camera type: a narrow-angle camera, with 30-cm focal distance, has the advantage that all radial displacements of objects standing above the ground, and all errors due to ground height differences within the unit area of rectification (i.e. the complete photo in the case of conventional rectification, and the slit area in the case of differential rectification), are twice as small in the photomaps as when using a 15-cm wide-angle camera. At the same negative scale, here 1:11,500, however, wide-angle photography would provide twice better height accuracy than the narrow-angle photography.

STREET MAPS*

Paper presented by New Zealand

RÉSUMÉ

Facteurs influant sur les travaux de dessin et de préparation :

1. Travaux de dessin et de révision effectués par les dessinateurs du service des levés dans 12 bureaux répartis à travers le territoire néo-zélandais.
2. Toutes opérations photomécaniques effectuées à Wellington. Bureaux de dessin non dotés de matériel de reproduction d'images.
3. De 1950 à 1968 toutes opérations intermédiaires et travaux de préparation des plaques effectués par l'Imprimerie nationale. A partir de 1968, laboratoire du Department of Lands and Survey (Département des affaires foncières et des levés) équipé pour opérations avec chambre de prise de vues à grand format et tirage par contact direct.
4. Préparation des plaques et impression des cartes effectuées uniquement par l'Imprimerie nationale.

Le premier plan urbain publié en Nouvelle-Zélande a été celui de Palmerston North, qui a été dessiné par le Service cartographique sur support plastique Ethulon avec collage de caractères imprimés sur papier adhésif transparent. Travail entièrement dessiné à la main avec quelques signes conventionnels imprimés sur papier transparent adhésif Zip-A-Tone. Six planches dessinées, chacune avec des détails déterminés, en vue de l'obtention d'une carte en sept couleurs.

Trois autres cartes ont été dessinées au Service cartographique avant qu'un District Office (Bureau départemental) n'en produise une. Les caractères d'imprimerie destinés aux cartes sont maintenant fournis par l'Imprimerie nationale sur papier transparent adhésif Zip-A-Tone. La première caisse d'emballage de cartes à plat a été construite à Dunedin pour transporter à Wellington des dessins portant des collages de papillons imprimés.

Tous les bureaux départementaux sont progressivement entrés dans le programme d'établissement des plans urbains et un système de révision a été mis sur pied. Différents supports de dessin ont été essayés. L'Ethulon a été remplacé par l'Astralon et le Cronaflex. Dans les bureaux départementaux, certains détails identiques étaient reproduits à la main sur trois planches, faute de matériel de reproduction d'images.

Après que le laboratoire photographique ait été équipé pour les travaux en grand format, et avec l'introduction du traçage sur couche opaque et du pelliculage, les méthodes de production ont été en partie rationalisées. Il a été fait davantage appel aux techniques photomécaniques pour reporter les détails d'une planche couleurs à une autre. Des procédés de masquage ont été introduits.

Des trames biangulaires ont été acquises en 1976 et les méthodes de production ont été remaniées en vue de l'utilisation de ces accessoires pour tramer les lignes et les symboles. Grâce aux surimpressions de couleurs et à l'utilisation de trames pour obtenir différentes teintes, le nombre des plaques d'impression est maintenant ramené à quatre, mais permet toujours d'obtenir six couleurs.

*The original text of this paper, prepared by J. D. Meadows, Department of Lands and Survey, appeared as document E/CONF.72/L.13.

La nécessité de faire apparaître un nouveau symbole d'itinéraire a conduit à modifier l'aspect général des plans urbains. Les lignes d'autobus étaient déjà représentées. Il a fallu indiquer des itinéraires urbains et l'on a constaté qu'on pouvait également représenter des itinéraires de traversée des villes au prix d'un réagencement radical des couleurs.

On trouvera ci-après une description de la méthode de préparation de toutes les opérations distinctes de dessin, de combinaison et de tramage requises pour obtenir les positifs inversés des quatre plaques définitives. Les perforations de repérage de toutes les plaques sont effectuées en utilisant le propre système de perforation du Département.

The drawing and publication of street maps in New Zealand spans a period of 30 years. The manner in which original drawings and subsequent revisions are produced is influenced by the following factors:

(*a*) After the first four pilot maps were drawn in the Cartographic Branch, at the Head Office of the Department of Lands and Survey, all other drawing and revision work has been done in the Department's district offices by survey drafting staff. New Zealand is divided into 12 land districts, each with its own district office. Technical staff in each office is responsible for survey work and drafting within that Land District;

(*b*) District offices do not have any photomechanical equipment installed to enable drafting staff to make use of image transference and so avoid duplication of effort when infills, dropouts or masks are required;

(*c*) From 1950 to 1968 all intermediate and final processing for plate was made by the Government Printer, on his own premises, in another part of Wellington, about two miles from the Cartographic Branch; since 1968 the Department's photolaboratory has been able to provide large-format camera and contact work for making intermediates and plate copy, but always in a separate building from the Cartographic Branch;

(*d*) Platemaking and map printing is controlled by the Government Printer. He is the official printer for all government departments in New Zealand, be it forms, school journals, parliamentary proceedings or maps. Printing deadlines are subject to pressure from any or all of these sources.

In 1950 the first New Zealand street map was drawn in the Cartographic Branch. The town chosen was Palmerston North. In the absence of any prior specifications or example, the first map was modelled on a copy of the street map of Washington, D.C.

The drawing medium in use in the Cartographic Branch at that time was Ethulon. Type for all names had to be ordered from the Government Printer. This was hand-set in lead and printed using a flat-bed printer. Application of type onto the Ethulon sheets was by the "scissor and stick" method, using glue or rubber cement.

Paste-up type precluded contact process work, necessitating the use of a large-format camera.

All linework was hand-drawn with a ruling pen or Crow Quill, as were masks and infills. Zip-A-Tone dot patterns were used initially to show the extent of built-up areas; later, their use was extended to show also parks and reserves (in green).

Six drawings were required to show the map's various features in colours which subsequently became the Department's style; except for minor changes they remained the same for more than 25 years:

Black: Border, grid and most type; public buildings and amenities;

Grey: Roadsides, paths, some buildings and symbols, some type, built-up area and boundaries of areas having a green infill;

Red: Public body boundaries, with names, suburb names, house numbers, dot stipple on bus routes;

Dark blue: Hydrography and related type;

Yellow: Street infill plus parks;

Light blue: Water infill plus parks.

From the above, it can be deduced that on early maps the green infill for parks, reserves etc. was obtained by double printing solid yellow over solid light blue. This was changed in the late 1950s when a single green infill sheet was drawn and printed in green, making the number of plates seven. The red dot stipple over solid yellow infill showed bus routes as a sienna infill.

Following the first street map, maps of three other towns were drawn in the Cartographic Branch. They were Wellington City, the Hutt Valley and Christchurch City. Wellington City, the first of these three, was commenced in 1952.

Type for map names was still set in lead by the Government Printer, but was printed onto blank sheets of the transparent medium Zip-A-Tone, which replaced type on paper. Contact processing was then used as an alternative to camera work.

Once specifications and drawing methods had been tried and finalized in the Cartographic Branch, instructions were issued for the first map to be drawn outside of Wellington. The map and the office chosen to draw it was Dunedin. The year was 1953.

A roll of Ethulon was forwarded to the district office together with specifications, layout and measurements supplied by the Computing Branch for plotting national yard grid cuts and latitude and longitude cuts around the map neat lines.

The District Office drafting staff compiled the map using office cadastral records supplemented with field work to obtain cultural and topographical detail. Type lists for map names and figures, as well as a full index list, were compiled in the drawing office, then forwarded via the Cartographic Branch to the Government Printer for setting and supply on Zip-A-Tone.

After drawing and checking was completed in the Dunedin district office, paper prints of each sheet were sent to the Cartographic Branch in Wellington for an editor's check. Any item requiring check or correction was listed, as well as being marked on the print. List and print were returned to Dunedin and the corrections made. The drawings were now ready for sending to Wellington for printing. That was, and still is, all the

involvement district office drafting staff have with map production. Planning photomechanical work, arranging for it to be carried out as and when necessary, and preparation of plate reversals is all done by the Cartographic Branch staff.

The Dunedin draftsmen, however, were to encounter a unique problem associated with original drawing transportation and to solve it most successfully.

Up until the time "stick-on" type was introduced for mapping, all lettering was hand-drawn in India ink on to original drawings. This was the practice for cadastral and topographical maps which were already being drawn in all district offices. The completed drawings were transported from districts to Wellington for printing, rolled, enclosed in stout fibre or metal cylinders.

During the process of applying type and making subsequent amendments, the draftsmen in Dunedin encountered the problem—still with us today—of some waxed type not adhering permanently.

They rightly deduced that it would be too risky to roll these drawings for transportation to Wellington. Their concern was that rolling and unrolling the drawings could loosen some of the type and that type would either get lost or reattach itself—sometimes unnoticed until too late—elsewhere on the map. Their solution was to produce the first flat map crate made especially for carrying fragile original drawings with "stick-on" type.

Stout plywood braced with wooden battens was used to make two sides, which were bolted together using up to five bolts along each of the four edges. Packed safely with paper interleaved between each sheet, the Dunedin street map arrived in Wellington in perfect condition. This method of packing and dispatching drawings was considered to be so successful, as well as being the most practical, that the method is still used today. The basic crate design is virtually unchanged except that hexagon nuts have been replaced by wing nuts to facilitate packing and unpacking.

The Department then embarked upon a programme of drawing street maps covering all of the major cities and towns. Instructions, specifications, plotting tabulation and drawing material were progressively sent to each of the 12 district offices with the requirement that each should produce street maps to cover cities and important towns within its jurisdiction. The rule initially was "one town, one map". With more rapid transport systems on the one hand for reasons of economy of printing on the other, adjacent towns within a district, or those having a community of interest, are now grouped together and shown on one map.

After the first street maps were published and sold, and as more towns were added to the drawing programme, a system of planned revision became necessary. Once a pattern and rate of sale is established for any map, the Cartographic Branch is advised by the Map Centre of the estimated exhaustion date.

The District Office concerned is informed that more stock is required and they decide whether the number of amendments that have accumulated for the map warrant a revision. In some cases a reprint is all that is required. If so, Cartographic Branch staff arrange this with the Government Printer.

If a revision is necessary the original drawings are uplifted from safe storage, in Wellington, packed and despatched to the appropriate District Office. The initial despatch of original drawings with instructions to revise must be calculated far enough ahead of the exhaustion date to allow time for field work, revision, type to be set and supplied from Wellington, return of drawings to the Cartographic Branch, processing of plate reversals, examination of same, stopping out etc., platemaking, printing, trimming, folding and delivery by the Government Printer to the Map Centre.

To allow adequate safeguards for unforeseen delays at any stage of the work, drawings are usually despatched to a district office for revision, up to two years before exhaustion of existing stock in the Map Centre. Printing quantities are calculated to produce enough maps of the main cities to last for three years. For small cities and towns this may be extended to four or five years, depending on the rate of development of the town in question. Annual usage is determined from recorded sales figures kept by the Map Centre.

Once the style of New Zealand street maps had become established and the specifications to produce them distributed to all drawing offices, changes were gradual and dictated mostly by the acquisition, by the photolaboratory and the Cartographic Branch, of more sophisticated processing equipment and versatile materials. Ethulon was withdrawn from use, to be replaced by Astralon, then Cronaflex, together with the recommended inks for each material.

Because all drawing work was being done in district offices, where there were no photomechanical facilities, it was considered more expedient that all drawings, masks and infills should be hand-drawn positive than to send partly completed drawings back to Wellington for labour-saving intermediate processes. Considerable duplication of drawing resulted. For instance, roadsides were all drawn, using a ruling pen, in black ink on the grey sheet. Exactly the same roadsides were drawn again for the yellow sheet, then completely masked between to make the road infill.

Built-up area, shown by a 30 per cent dot on the grey sheet from 1957 to 1977, was drawn as a solid mask to be screened (in Wellington) during processing. This mask required about half, but in some cities more, of all street sides to be drawn once more. The whole extent of built-up area had then to be masked out ready for combining with the other grey detail during final processing before plate-making.

To have to draw the same item (roadsides) of a map two and on some maps nearly three times was not good economy; but remembering that the drawing was done in one part of New Zealand while photomechanical process work was carried out only in Wellington, it was accepted that the speediest and probably the cheapest solution was for the whole map to the hand-drawn, linework, masks, infills and all. In other words, drawing methods were designed to fit the circumstances.

Drawing material selected for street maps ranged from Ethulon to Cronaflex. It was necessary to choose a matte-surface material guaranteed to last for 15 to 20 years which could stand being revised several times during that period. Ethulon became very brittle and shattered at a touch. Astralon tended to crack with frequent handling, but lasted longer than Ethulon before this happened. To date, Cronaflex and Stabilene drafting film have presented no problems.

Astrascribe, with its polished surface, was not suitable for frequent and sometimes extensive revision in a drawing-office situation without recourse to astrafoil blacklining process. The policy was to get the most out of one set of drawings before producing a duplicate or redrawing.

Specifications, drawing methods and plate processing procedures remained more or less static until the end of the 1970s.

In 1968, the Department's Photolaboratory moved to different, larger premises. At that time new equipment was acquired which enabled "Photolab" to provide the Cartographic Branch with large-format camera and contact services. Stabilene scribecoat and several brands of peelcoat material were also being used in the Branch. The time had arrived to rewrite the street-map specifications and design a production schedule which made the most use of photomechanical short cuts. Even then the departure from traditional drafting methods was not absolute.

The map of Masterton Borough, published in 1972, was the first street map drawn using scribecoat materials to produce the black and grey line sheets. All possible details were scribed on the black sheet. *Only the roadsides* were scribed on the grey sheet, both reverse reading. The scribed sheets were then sent to the photolaboratory for one right reading contact of each, on matte Cronaflex. The "black" positive became the "original drawing" on which extra symbols were added along with all type names printed black.

The "grey" contact which outlined all streets became the street infill (solid yellow) when inked solid between the street sides. Thus, one repetitive drawing job had been eliminated. Scribing on the grey sheet was then continued and another matte positive film contact made on completion. This became the "grey" original drawing. Both black and grey originals were now matte surface, right reading, capable of hand-drawn revision in the future. The scribing in this case was a means to an end towards producing the original drawing—not the original drawing itself. Except for producing the yellow street infill from the streets scribe sheet, we had not yet begun to think fully photomechanically.

By this time some small changes had been made to the map colours. Hydrography and related type was now shown on the grey sheet, which eliminated the dark blue plate, thus reducing the number of plates to six. Masks for built-up area and the three colour infills were handcut from transparent peelcoat material. The built-up area mask did not delineate street frontages, only the area perimeter. Streets were dropped out of the overall area, using the yellow infill sheet as a drop-out mask during processing.

Intermediate processing and plate copy preparation could be carried out either in the Department's Photolaboratory or by the Government Printer. Both darkrooms possessed similar sets of positive and negative screens. The Government Printer was equipped for both film and astrafoil deep etch processing. The photolaboratory handles only film work. Work is directed to either one according to the process required.

In 1976 the Cartographic Branch Reproduction Officer was instrumental in obtaining from America a set of 30″ x 40″ biangle dot screens in 33, 49 and 61 percentages. They were obtained for the express purpose of screening fine linework without slowing the zig-zag effect produced by conventional dot screens. Working copies of the new screens were made and distributed—one set to the Department's photolaboratory and one set to the Government Printer's photo litho section.

The use of biangle screens in processing work had two immediate effects:

(*a*) The number of printing plates was reduced from six to four without changing the apparent colours or style of street maps. It was reasoned that if the roadsides sheet, formerly printed in grey ink, was biangle screened and combined with the solid black sheet, the roadside and related detail would still appear grey to the eye, and a plate would be saved. Further developing that economic theme, the Reproductions Officer worked out a processing schedule to eliminate the green plate by reverting back to the first system of double-colour overprinting, but this time, although the light blue remained a solid colour, the yellow was a 40 per cent 133-dot screen, the one peelcoat sheet, representing green infill, being used twice in the darkroom, once contacted solid combined with the light blue infill and once screened 40 per cent combined with the yellow infill;

(*b*) The drawing method became more direct. Black and "grey" sheets were scribed right reading for contacting, combining and screening direct to plate reverse positive. Type was also combined with this reversal via a previously contacted intermediate negative.

Unnecessary steps were gradually being eliminated in a move towards the most direct way from drawing to plate.

North Shore was the first street map to be printed in four colours—the number of plate reversals having been reduced from six to four by using biangle screens. This was early in 1977. Before printing took place, a Cromalin colour proof was made in the Cartographic Branch, using powder mixes which exactly matched the ink colours used by the Government Printer—map colours that were traditional on Department of Lands and Survey street maps for over 25 years.

The colour proof was so true to the appearance of existing street maps that no change to screen percentages or screen combinations was necessary. The North Shore Street Map was duly printed and delivered. As other street maps were received in the Cartographic Branch after revision, all original drawings were processed into four plate reversals. This resulted in considerable saving of printing cost and time, especially when the map was printed on a two- or four-colour machine.

The most recent change to the appearance of street maps and certainly the most obvious came about as a result of Auckland district office advising that the Auckland Regional Authority had recognized, numbered and signposted a series of important arterial roads as "urban routes"—roads which are recommended as being the most direct way between nominated suburbs of the metropolitan area. Up until this time the only route symbols were (*a*) commuter bus routes shown by a 30 per cent dot-screen full width over solid yellow street infill; and (*b*) national and provincial state highways shown by numbered shields in solid red or "grey".

The Auckland urban routes were already signposted along each route with black numbered shields, the shields being upside down so as to be easily recognized

and not be confused with state highway shields. It was suggested that they be shown on the street map in the same style and colour. A preliminary markup of these urban route shields on an existing map showed that a coloured infill to tie the shields together would considerably simplify map reading. One other fact also became obvious. The urban routes joined, followed and departed from bus routes which were already shown by a sienna infill, and at the same time, *all* streets had a solid yellow infill. If another colour infill was to be introduced it would have to be combined with the yellow, and would change colour wherever it followed a bus route.

The solution to the problem brought about the greatest change to the appearance of New Zealand street maps since the time of their inception. After several Cromalin colour proofs were made and screen percentages varied, a final acceptable result was obtained, one which still used four printing plates, the same map colours, and also clearly defined through-routes, urban routes and bus routes.

The obvious change to appearance was to omit the solid yellow infill from all streets and to add a 20 per cent yellow dot to all land areas within the map neatlines. Principal routes into, through and out of each towns are shown by a 30 per cent 133-dot screen in red, full width over solid yellow infill, urban routes by a solid yellow infill and bus routes by a solid black casing on street sides which make up the bus route. In this manner bus routes can merge with the other routes without affecting infill colours.

A comprehensive specification for street maps was rewritten, incorporating as much direct scribing, mask cutting, etch and peel and etch scribe techniques, coupled with appropriate photomechanical procedures, so as to streamline production, eliminate unnecessary intermediate steps and at the same time allow for straightforward revision for further editions in district offices.

A compilation plot showing all linework and symbols is prepared in the district office and forwarded to the Cartographic Branch for two scribing keys.

1. Black Sheet

First scribe sheet. Border, grid and symbols are scribed right reading. Easy to revise and one process step to reverse positive plate copy. Contacted solid.

Second scribe sheet. Street sides, hydrography and symbols. Contacted in combination with border etc. Screened 33 per cent biangle screen.

Type sheet. Right reading on Cronaflex with some symbols added. Contacted to a reverse negative which in turn is contacted through the back when combined, solid, with the border and street scribe sheets.

Built-up area. Cut from peelcoat as a negative, ignoring road frontages. Roads are dropped out during processing using the yellow land area mask as a drop-out. Bush, symbols that cannot be scribed, and some highway shields are shown on a separate positive drawing for contact to a negative, which is screened and also combined with the other negatives and scribe sheets to make the final black plate reverse positive.

To produce the solid bus route roadsides, a sheet of peelcoat is registered over the scribed streets sheet, and sufficient material is cut and peeled out to expose the required street sides. This mask is used in conjunction with the streets scribe sheet and exposed solid in the black plate reverse position combination.

2. Yellow Sheet

A land area mask is produced by etching the roadsides scribe sheet, right reading, into a sheet of peelcoat material. Neat line borders are hand cut when the etched peelcoat is registered over the border scribe sheet. All land areas are peeled out, leaving on the water areas, parks etc. and all roads. During processing this negative is screened 20 per cent 133-dot.

Through and urban routes are hand cut as a negative on one sheet of peelcoat material registered right reading over the scribed streets sheet. A duplicate negative of this mask is made and the urban routes opaqued off. The duplicate makes a negative for through-routes only, which is processed with the red plate material.

Parks, reserves and all areas showing green on the final printed map are cut and peeled right reading negative from another sheet of peelcoat registered over the "grey" scribe sheet. This negative is screened 40 per cent 133-dot when combined with the land area mask and the routes mask during processing, to make the yellow plate reverse positive.

3. Light Blue Sheet

A water infill negative is cut right reading from a sheet of peelcoat registered over the "grey" scribed sheet. This is combined solid, with the parks and reserves sheet, also solid, to make the light blue plate reverse positive.

4. Red Sheet

Local body names and boundaries, suburb names, house numbers and some symbols are drawn as a positive. Two negatives are made. One is opaqued to leave information printed solid, the other is opaqued to leave information to be screened. Both these negatives are combined solid or screened together with the through-routes negative to make the red plate reverse positive.

These are the final 1979 production methods for street maps. Original drawing is done entirely in the district offices. The Cartographic Branch staff etches and peels the yellow land negative. Index lists are set in the Branch on an Itek Quadritek 1200 typesetter and the tapes stored for future revision. The index assembly and final checking for quality and fit is done in the Branch before drawings are sent to the photolaboratory for plate reverse positives.

All material is register punched from compilation plot through to final plate copy. The photolaboratory, of course, has a duplicate punch, with the same stations as the Cartographic Branch. The punches were made to the Department's own specification and are not similar to any other proprietary punching system.

Recently the Government Printer installed the protocol punch system and now uses punched plates. For true integration the Cartographic Branch and the photolaboratory should use the same system.

During 30 years, drawing methods, specifications, materials and photolitho processing have evolved to produce the present system. The processes have been streamlined to the most efficient and economic that our resources allow.

PRIVATE SECTOR SURVEYING IN NEW ZEALAND*

Paper presented by New Zealand

RÉSUMÉ

Le document énumère les conditions légales que doivent remplir tous les géomètres pour être autorisés à exercer leur profession, les normes auxquelles ils doivent se conformer et les règles professionnelles qu'ils doivent observer.

Il indique le nombre des géomètres du secteur privé, expose les travaux réalisés par les géomètres ne travaillant pas pour le Gouvernement néo-zélandais et indique la source de ces travaux.

Il récapitule les compétences multidisciplinaires que doivent désormais posséder les géomètres, et donne une idée de leur rôle dans l'aménagement du territoire au niveau sous-divisionnaire et dans la planification du développement foncier.

Il expose enfin les effets de la crise économique actuelle sur les géomètres du secteur privé.

LEGISLATIVE AUTHORITY

The Surveyors' Act of 1966 established the authority for the Survey Board of New Zealand and the New Zealand Institute of Surveyors. These bodies control almost all surveying in New Zealand.

The function of the Survey Board, while not clearly enunciated by the Act, is (*a*) to establish and control survey standards for cadastral surveying; (*b*) to establish the education and training standards for Registered Surveyors and to maintain a register of Registered Surveyors; and (*c*) to be the principal disciplinary agent for breaches of the established technical and professional standards.

The New Zealand Institute of Surveyors, on the other hand, does have its functions clearly defined under Section 27 of the Surveyors' Act, and these are:

(*a*) To promote and encourage proper conduct among registered surveyors and all other persons who constitute the several classes of membership of the Institute;

(*b*) To suppress illegal, dishonourable, improper and objectionable practices among registered surveyors and all other persons who constitute the several classes of membership of the Institute;

(*c*) To preserve and maintain the integrity and status of the profession of surveying;

(*d*) To provide opportunities for the acquisition and diffusion of knowledge in relation to surveying and allied subjects;

(*e*) To consider and suggest amendments in the law relating to surveys and surveying;

(*f*) To provide means for the amicable settlement of professional differences;

(*g*) Generally to protect and promote the interests of the profession of surveying and the interests of the public in relation to surveys and surveying.

For a registered surveyor, irrespective of employment, to practice cadastral surveying in New Zealand, it is necessary to take out an annual practising certificate. Such a certificate is issued by the New Zealand Institute of Surveyors under Section 33 (2) of the Surveyors' Act.

"Notwithstanding anything contrary in this Act no person shall be entitled to act as a registered surveyor unless he is the holder of an annual practising certificate".

Section 28 (4) of the Surveyors' Act reads:

"Every registered surveyor holding a current annual practising certificate under Section 33 of this Act shall be a corporate member of the Institute, whether or not he applies for membership".

Thus it can be seen that for a registered surveyor to practise in New Zealand it is compulsory for him to belong to the New Zealand Institute of Surveyors.

There are many arguments for and against such a compulsory clause, which are regularly raised by members of the profession from time to time, which will not be debated in this paper. The roots of this requirement go back to 1939 at the time of the first Labour Government when the first Surveyors' Act was passed. This Act gave legal status to the Institute and vested in it statutory responsibilities, and the price the profession had to pay was compulsory membership.

On balance most surveyors would concede that the advantages have outweighed the disadvantages. The Institute has been the vehicle for all surveyors to promote the profession, and the Institute has been seen to represent the whole survey profession, not only a sectional interest, when speaking on matters of public debate.

The Act grants both the Survey Board and the Institute disciplinary powers, and both bodies can levy fines of up to $1,000. It is only the Survey Board, however, which can suspend or cancel a surveyor's registration. The Board does exercise its powers of discipline on those matters that affect survey standards, technical negligence or incompetence. The Institute on the other hand is responsible for matters of professional ethics and standards of behaviour. It is only the Board that can cancel a surveyor's registration, so for the Institute to expel a registered surveyor it must prosecute a case before the Survey Board.

One of the prices the profession has to pay for compulsory membership is that any changes to the rules have to be first approved by the Minister of Lands.

The scale of fees used by the profession for surveyors' work in both the public and private sectors is a rule of

*The original text of this paper, prepared by Howard W. Hunter, Truebridge, Callender, Beach and Company, appeared as document E/CONF.72/L.14.

the Institute, and not only has this rule to be approved by the Minister of Lands but it must also be first approved by the Survey Board. The argument put forward for this control is "public protection". Surveying is a "closed shop", therefore the interest of the public must be looked after.

Membership of the Institute as at 1 July 1979 was:

	Members
Practising	556
Non-practising	345
Graduate	20
Honorary	3
Associate	9
TOTAL	933
Students	97
OVERALL TOTAL	1 030

PRIVATE PRACTICE

Of the 556 practising surveyors in New Zealand, probably about 50 per cent are self-employed or employed by private practices. There are 216 practitioners who are members of the Consultants' Division of the Institute, which is open only to principals of survey firms.

Since the early days of New Zealand settlement there have always been private sector surveyors, first bidding for Government contracts for the early subdivision of the bush, and then, as the amount of privately owned land increased, providing a service to the land-owner.

The integrated survey system of New Zealand is the responsibility of the Department of Lands and Survey under the direction of the Surveyor General. The Surveyor General is charged with the responsibility of keeping cadastral records and with the establishment of an adequate survey control system throughout the country. This control is the basis of all cadastral, national and project mapping for the whole country.

All of this information is available for public inspection and it is a requirement of the Survey Regulations that all cadastral surveys are carried out in terms of this control. It is also government policy, and regarded as good survey practice, to endeavour to carry out all other surveys in New Zealand in terms of the national control.

The private sector surveyors are responsible for the bulk of the cadastral survey work carried out in New Zealand, and it is their working within the national control framework that has built up the integrated system that exists today.

SOURCE OF WORK

The private practitioner offers survey service to the community and, depending on his location and his specialities, he draws his clients from:

(*a*) *The private sector*
Industry;
Land developers: large-scale subdivision;
Solicitors: legal surveys;
Contractors: civil engineering works, construction building;
Other professionals: architects, engineers;
Private individuals: subdivision, redefinition, title surveys;

(*b*) *Local government*
Legalization surveys;
Photocontrol;
Engineering surveys;
Land transfer surveys;

(*c*) *Central government*
Housing surveys;
Engineering surveys for project works;
Project mapping control;
Project topographical surveys.

While the volume from each sector will vary depending on location, a typical cross-section of source of work would be:

Private sector, 70 per cent;
Local government, 20 per cent;
Central government, 10 per cent.

Traditionally the early surveyors obtained their work from provincial and central government contracts and were entirely dependent on the public sector for a livelihood. As local government developed and took a greater development and administrative role, a significant source of work was created.

There has in recent times been a significant buildup of public sector professional staff employment in both central and local governments, such that they have now taken over more construction and development responsibilities as well as administrative ones. This has had a consequential effect on private sector employment opportunities, to such an extent that in many practices less than 10 per cent of gross fees would come from the public sector, whereas 20 years ago it was probably 40 per cent.

MULTIDISCIPLINE PRACTICES

Survey practices tended to start as a single practitioner and then, as the work-load increased, to take on staff and partners. But usually those practices that are principally straight survey practices, undertaking mainly title surveys, tended to stay small, perhaps up to 10 people.

Those practices that became involved in subdivision of land found with the housing booms of the 1960s and 1970s tremendous pressures and growth opportunities. Developments grew in scale from 20- and 30-lot subdivisions to whole towns or suburbs of hundreds of acres.

Such growth and development pressures brought up engineering problems which the surveyor was not trained to cope with, such as bridges, pumping stations, sewerage treatment plants, reservoirs etc. This required an engineering input from registered engineers, and it was often found that while joint ventures between different discipline firms could work, the most satisfactory solution was a joint partnership between surveyors and engineers.

The same pressures also saw architects and engineers joining forces and the emergence of the surveyor-planner.

As a result, most of the larger practices that are involved in land development are multidiscipline firms offering a comprehensive range of development skills to a client. The most common contribution is a combination of surveyor, engineer-architect and planner.

The nature of the work available to the survey practice also changed as public demands and requirements altered. Whereas 20 years ago cadastral survey work associated with the title system was responsible for probably 80 per cent of the surveyors' fees, today it is substantially less, in many firms as low as 25 per cent.

SURVEYORS AND SUBDIVISIONAL DESIGN

The surveyor has been pre-eminent in designing schemes of land subdivision since the early days. The Royal Instructions accompanying the New Zealand Charter of 1840 authorized the Surveyor General to report on lands it might be proper to reserve for roads, or sites for towns, villages or reserves.

Surveyors undertook all subdivisions of land but it was not until the passing of the Land Act, 1885 that the plan showing the proposed subdivision was required to be approved. This Act stated that where town allotments were to be sold, a plan of the town had to be prepared by a surveyor and approved by the Governor prior to sale.

From this date all plans of subdivision of town allotments required the approval of either the Governor, the Minister of Lands or, after 1920, the local authority.

The subdivision of land in New Zealand is now controlled by the Local Government Act, 1978. This Act lays down that a scheme plan of subdivision shall be prepared only by a registered surveyor. There have been many arguments brought forward that this is too restrictive, that much unimaginative design for urban areas is produced by surveyors, that others, such as architects-landscape architects, engineers etc. should be able to prepare such scheme plans.

The present legislation does not mean that no one else can design a subdivision. Anyone can produce a concept plan or layout plan, but only the surveyor can draw the plan which translates that concept into a plan depicting proposed title boundaries.

Notwithstanding that last statement, surveyors have been the prime designers of most of our suburban forms. Because of this the profession has been ever mindful that design must keep abreast of modern developments. With increasing emphasis being placed on recreation, open space and the environment as a whole, the quality and standards of subdivision are continually being upgraded and improved.

LAND DEVELOPMENT ENGINEERING

Much of New Zealand at the time of European settlement was covered with tropical rain forest. Before clearing and settlement could take place, the early surveyors were required to mark out the towns and farms before the granting of titles.

The country was for the most part rugged and difficult terrain, and development was dependent on roads, and later railways, to provide communication. Professionally trained people were few and far between and the surveyor became surveyor-explorer, road and rail route finder, bridge builder, timber and soil appraiser. He was a jack-of-all-trades.

The engineering content became a large part of the early surveyor's work; this was because of the rugged nature of the land he worked in, the difficulty of finding routes and the many streams and rivers to cross. As a result the New Zealand surveyor has retained, by a combination of accident and design, a quite large engineering involvement which is rather unique in similar developed countries.

It is evident when studying the education and training of New Zealand surveyors that significant emphasis is placed on engineering ability. This has been developed to the level that it has in order to retain the engineering involvement in land development. Some would criticize this as overemphasis to the detriment of the development of higher survey skills, particularly in the area of precise measurement.

Most private practitioners can and do carry out extensive engineering designs for the subdivisions for which they have prepared scheme plans. This will entail the preparation of working drawings for earthworks, street design, sewer, water and storm-water systems, specification and schedules of quantities. Surveyors who have prepared such design are expected to be able to supervise the works and to administer the contract. Such work will range in value from a few hundred dollars to in excess of a million dollars: a very real responsibility.

The land development engineering content of many of the larger survey practices would be in excess of 50 per cent of their gross fees, and it is a substantial part of most urban practices.

Without being parochial, it would be fair to say that the New Zealand surveyor with his in-depth training in a very narrow field of engineering is able to produce a better roading design for the subdivision of land than most other professionals. This is not being unfair to the engineering profession, who are required to cover the whole of the civil engineering field, of which urban street systems and design is only a very minute part.

THE ECONOMIC RECESSION AND THE PRIVATE SECTOR

A large percentage of the work of the New Zealand private surveyor has been to service the housing industry. Significant changes in this industry have consequential effects on the surveying profession.

The years 1973 and 1974 saw building activity of unprecedented proportions when homes were being erected at the rate of 33,000 per annum. Immigration into the country was also running at well over 30,000 people per year.

This, together with record receipts for export earnings, created very real pressures on all sectors of the economy. Massive inflation took place, land and building costs escalated out of all proportions to previous years and demand far exceeded supply.

As a consequence, the building and development sector tried to gear up to meet such pressures. This saw a period of significant growth in the number and size of surveying consultant practices.

The effects of the oil and energy crisis did not start to show in New Zealand until late 1975. This, coupled with a large drop in export earnings and the consequential monetary constraints, saw the property market in dire straits with very large stocks of developed land and completed houses without a market.

Whereas in 1973 immigration was running at over 30,000 people per annum, by 1979 this had reversed to a net out-flow of 30,000 per annum, a differential of 60,000, which represented 15,000 houses per annum or almost half of the previous annual rate.

Such a traumatic change has had very real consequences on the private practising surveyor. Many firms are now less than half their original strength, others have gone out of business altogether.

One of the most noticeable effects of the boom conditions was the investment in modern equipment. Tradi-

tionally, private surveyors have been conservative in the purchase of new or modern instruments; for many of the post-war years much of the gear being used could not be classed as up-to-date. This changed dramatically with the tremendous work-load pressures that could only be satisfied by modern time-saving instruments such as EDM, computers and plotters. The profession was also fortunate in that the marketing of these modern technological advances coincided with these times.

That part of the private sector which has traditionally serviced the rural sector did not experience to the same extent the pressures of their city counterparts. Likewise they have not felt the grave shortage of work now being experienced by others.

To survive as a viable entity the private sector is having to have a hard look at itself and to analyse its role in society and decide what service it is best able to offer. It is unlikely in the foreseeable future that housing will require the national priority it has been given in the past. It is therefore essential for the practitioner to look at national development directives and see what part basic survey skills have to play. These skills must be adapted by both training and education to meet society's needs. Now is the time of transferring of resources and diversification from traditional involvement.

CADASTRAL SURVEY RECORDS*

Paper presented by New Zealand

RÉSUMÉ

Le document traite de l'intégration des archives cadastrales, du levé établi sur le terrain au plan cadastral publié, en passant par la matrice cadastrale.

Les plans de levé constituent le document cadastral de base, l'intégration et la mise à jour des informations que contiennent ces plans ainsi qu'un accès rapide à ces informations étant assurés par l'établissement de matrices cadastrales et l'enregistrement quotidien sur ces matrices de tous les nouveaux plans et modifications cadastrales diverses.

Les matrices cadastrales servent aussi de base pour l'établissement d'autres documents cadastraux, y compris la série de plans cadastraux NZMS 261 au 1/50 000 publiée par le Department of Lands and Survey (Département des affaires foncières et des levés). Cette série constitue la contrepartie cadastrale de la série de cartes topographiques NZMS 260 et revêt une importance cruciale pour les activités de développement économique, de planification et d'utilisation des sols.

Cadastral surveys in New Zealand are part of an integrated survey system, a system in which all basic survey activities are undertaken within one structure of administration and positional control, where procedures and production are integrated and where associated activities are rationalized and co-ordinated.

Cadastral surveys may be undertaken only by registered surveyors holding a current practising certificate issued by the New Zealand Institute of Surveyors. The Institute, which includes surveyors from all sectors, is constituted under the Surveyors' Act. The conduct and standard of cadastral surveys are governed by regulations issued pursuant to the Surveyors' Act. These regulations, currently the Survey Regulations, 1972, also provide specifications for the preparation of the survey and title plans, field notes and co-ordinate traverse sheets which comprise the basic cadastral survey records.

The Department of Lands and Survey is responsible for the establishment and maintenance of an integrated, updated and freely available cadastral survey records system incorporating information contained in these survey plans.

SURVEY PLANS

Since the introduction of metric mensuration, under the Survey Regulations, 1972, all surveys have been presented as two separate plans, one showing title information and the other showing survey information. The plans are drawn on a transparent medium, in black, suitable for microfilm reproduction.

Survey and title plans, with supporting field notes and co-ordinate traverse sheets, are lodged in the district office of the Department of Lands and Survey and subjected to an examination process before formal approval by the district Chief Surveyor. Once approved, the plans and other documents become the property of the Crown, held by the Department and available to all professional and public users free of charge.

After approval, the plans are microfilmed on 35-mm aperture cards. Several copies of the cards are retained for use in the office of the district Chief Surveyor, one copy is forwarded to the Department's Head Office in Wellington for inclusion in the national reference set and, as a safeguard against disaster, one copy is stored in a location away from the parent office.

Microfilm plan viewing and copying facilities are provided at the public counters in each district office. The microfilm process has aided the availability and dissemination of survey plan records and improved the service offered by the Departmental to all plan users.

*The original text of this paper, prepared by R. A. Burns, Department of Lands and Survey, appeared as document E/CONF.72/L.18.

All original survey plans remain in the care and custody of district Chief Surveyors. These plans provide a historical archive record of all land subdivision and development and are the basis for other surveys and for the issue of land titles.

Survey monuments depicted on the Survey plans are utilized for the definition and control of subsequent cadastral surveys and for the protection of existing title boundaries. This utilization of previous monumentation is the basis for the integration of all surveys and a self-propagating subsidiary to the national survey control framework.

The approved title plans are used by the Department for the production of land-title diagrams which appear on freehold certificates of title, leases and other title documents issued by the appropriate land registration authority. With the new transparent plan format simple copying processes can be used to rationalize this procedure.

The survey plans held by the Department are the primary cadastral survey record and the base for the production of all cadastral mapping and other cadastral based records.

Cadastral record maps

All district offices of the Department have cadastral record maps providing a complete coverage of the land area in their district. Produced at scales of 1:1,000 to 1:25,000, according to the subdivisional pattern of a particular locality, they portray parcel boundaries, appellation, areas, survey plan references and other relevant information.

Immediately a survey plan is approved, or an approved alteration to existing cadastral information is received, the new parcel and any other information thus created is plotted on the appropriate cadastral record map. This procedure ensures that the record maps are constantly updated.

Previously drawn in colour on linen-backed paper, cadastral record maps are now drawn in black on a transparent medium. The linework and text are on separate overlays to facilitate the use of the linework as a base for the record map systems of other departments, local authorities and organizations. In either linework or combined map form the use of these maps is being successfully encouraged in an effort to further rationalize the basic use of cadastral records and avoid duplication of effort.

The daily update of the cadastral record maps is a vital element in the survey and cadastral systems but this, coupled with the continuing need to revise existing map coverage, makes demands on the Department's limited staff resources. For this reason research is currently being undertaken in the field of computer-assisted mapping. Successful trial drawings have already been produced with the aid of the computer and it is hoped that before too long cadastral record maps and an instant update system will become available through automation.

All record maps are drawn on a format which is a subdivision of the sheet lines of the published New Zealand Map Series (NZMS) 261 (1:50,000) Cadastral Map series. The updated record maps form the base for the production of these published maps and for other cadastral-based mapping covering the cities, towns and populated areas at various scales and for a variety of purposes.

Cadastral maps

The Department's basic cadastral map series is the NZMS 261 Cadastral Map. This is a one-colour printed map series which forms the cadastral counterpart in both scale and sheet layout to the new NZMS 260 Topographical Map series. There are 321 maps required to cover the country at a scale of 1:50,000.

Commenced in 1973 to replace the existing 1:63,360 cadastral map series, the NZMS 261 presents a comprehensive record of the position, extent and description of the land parcels of the nation.

Original production of the NZMS 261 utilized base material from existing maps and information from updated cadastral record maps. Production economies were obtained from the use of photographic reduction techniques. These techniques and economies continue to be utilized when the maps are revised and reprinted. This occurs every five years, or earlier if substantial changes in the subdivisional pattern occur. Revision information is taken from updated cadastral record maps, which makes these record maps the intermediate for the transmission of cadastral information from survey plan to published map.

The Department produces other, larger-scale, cadastral maps as part of the Town Cadastral series, but the NZMS 261 remains the basic and most important cadastral series. This series is an essential aid to government and administration at all levels and to all concerned with effective and rational land planning. They are a basic record of the nation's land resources, a base for the definition of statistical and administrative boundaries, an essential tool in census analysis and electoral definition, and an important aid in a multitude of planning, administrative and related activities. The value of these cadastral maps is enhanced by their compatability with the NZMS 260 Topographical Map series.

Conclusion

The Department's production of cadastral survey records is fully integrated, from the individual survey plan, through record maps, to the published cadastral map.

The survey plan records the definition, measurement, location and area of the land titles effected, and is the prime document for the issue of land title. It records the survey control and monumentation adopted or established by that survey, monumentation which is utilized for the control of subsequent surveys and for the protection of existing title boundaries.

The survey plan is the basic cadastral record, and it is essential that all survey plans are indexed and recorded in such a manner that the information they contain is interrelated, up-to-date and readily available.

The relationship, update and rapid retrieval of cadastral information is made possible through the production of the Department's cadastral record maps and the system of daily recording of new information on those maps.

The cadastral record maps provide a graphic record of parcel boundaries, appellations, areas, survey plan references and other relevant information. They are the

prime cadastral index and the basis for the production of other land-based records including published cadastral mapping.

The NZMS 261 (1:50,000) Cadastral Map is the main cadastral series published by the Department and the cadastral counterpart, in both scale and sheet layout, to the NZMS 260 Topographical Map series. Because landholding, which is recorded and portrayed on cadastral maps, is the key to economic development, these maps are indispensable in any programme of development, planning, administration or related activity involving the nation's land resources.

LAND INVENTORY MAPPING*

Paper presented by New Zealand

RÉSUMÉ

L'inventaire cartographique foncier est devenu en Nouvelle-Zélande une activité rationnelle et systématique fondée sur une coopération interdépartementale et fournissant différentes données thématiques de base dans les secteurs cartographiques prioritaires.

Le document décrit brièvement l'évolution des politiques, des méthodes et des techniques de représentation suivies pour la réalisation de l'inventaire cartographique foncier, y compris tout ce qui concerne l'utilisation des sols.

Une petite section de l'utilisation des sols a d'abord été créée peu après la seconde guerre mondiale pour établir des levés de vastes étendues inoccupées, en vue de leur colonisation. Un vaste inventaire foncier à l'échelle nationale a été entrepris en 1966 en vue de réaliser des cartes multithématiques couvrant l'ensemble du pays. Toutefois, 10 ans plus tard, ce projet n'avait guère avancé et ne permettait plus de répondre aux besoins des utilisateurs prévus.

Après étude, cette série nationale a été abandonnée et remplacée en 1977 par une nouvelle série de relevés cartographiques fonciers (NZMS 290). Une enquête concernant les méthodes utilisées pour relever, rassembler, emmagasiner et présenter les données pertinentes a été effectuée, et de nouvelles méthodes ont été examinées en vue de la réalisation de l'inventaire foncier.

Les nouvelles méthodes ont été essayées pour l'exécution d'un levé spécial du King County, et elles ont été adoptées avec des modifications mineures pour la réalisation d'une étude pilote dans le district de Northland, dans l'île du Nord.

Les levés et les travaux cartographiques relatifs à l'inventaire foncier sont actuellement effectués pour les secteurs cartographiques prioritaires suivant un découpage national correspondant aux séries topographiques et cadastrales métriques. L'échelle, le contenu thématique, les spécifications et les méthodes d'exécution ont été normalisés de façon que les différentes cartes ainsi réalisées puissent un jour être assemblées de manière à couvrir l'ensemble du pays.

Les différentes catégories thématiques de renseignements de base qui ont été retenues pour les cartes de la série NZMS 290 varient en fonction des exigences de la planification foncière, mais comprennent généralement :

1. L'occupation des terres et les exploitations;
2. L'utilisation actuelle des sols;
3. La faune sauvage;
4. Les types de roches et dépôts superficiels;
5. La composition des sols;
6. Les essences forestières et arbustives.

On établit également, selon les besoins, des calques indiquant les évaluations approximatives éventuelles du potentiel des zones couvertes par ces cartes dans les domaines suivants : conservation de la nature; agriculture; sylviculture (essences exotiques et locales); et activités récréatives.

Le document donne un aperçu des progrès réalisés à ce jour et examine brièvement l'évolution possible.

A parcel of land may be equally useful for agriculture, forestry development or a public facility. In other instances, a site may be capable of serving several needs, but clearly better suited for one of them. Under these circumstances, a systematic, ecologically well researched land-use policy would be able to guide the decision-makers in:

(*a*) Controlling large-scale development of regional impact and locating sites for key public facilities;

*The original text of this paper, prepared by B. K. Bradley, Department of Lands and Survey, appeared as document E/CONF.72/L.21.

(*b*) Guiding growth around areas unsuited to development, e.g. flood plains, steep slopes, agricultural lands, areas of critical environmental concern;

(*c*) Attracting desirable growth which can build on existing community resources.

"Land Inventory" is a comprehensive survey of land, for its physical, economic and cultural characteristics and their assessment for various uses. It is specifically designed as a planning tool for use in governmental (central, regional, local), and private agencies' land management decision-making processes.

Land Inventory provides a record (by way of maps) of the existing situation but does not direct land-use change to an optimum use. It provides a comprehensive data-base to help identify various land-uses and policies which will satisfy economic, social and environmental criteria for a particular area. The availability of such an inventory aids wise land-use decision-making, encourages conservation of critical environmental areas and enhances production in productive areas.

The need for a comprehensive inventory of New Zealand's resources has been emphasized continually by Government and private industry. Details of the nature and quality of land and its use and development are fundamental for determining land-use and for planning regional development.

Development of Land-use and Land Inventory Mapping in New Zealand

The need for a New Zealand Land Inventory did not arise suddenly. It has been the result of many years of technological and social change in the agricultural sector. The beginnings can be traced back to the days of land utilization surveys carried out by the Department of Lands and Survey. Shortly after the Second World War a small land utilization section was established in Auckland to survey large areas of undeveloped land for land settlement. After some years the emphasis changed to smaller-scale land development in established farming areas.

In 1964 the State Services Commission called a meeting to resolve long-standing problems with land-use surveys. All departments with land-use and resource management interests were instructed to attend.

The State Services Commission was concerned that the fragmentation of responsibilities for land resources and the duplication of land-use surveys impeded efficient production and dissemination of vital information.

The Interdepartmental Committee spent two years examining the problems. They concluded that some fragmentation of responsibilities was inevitable but duplication could be avoided by centralized co-ordination and mapping. This Committee's work resulted in the inauguration of a detailed land-use survey of New Zealand, to be known as the National Land Inventory Survey, with all departments contributing available data, and with the Department of Lands and Survey responsible for the co-ordination and mapping required for this activity. The aim of the survey was "to produce for each county in New Zealand, to the same scale and with the same background, a series of maps to depict different aspects of the land and its uses". To supplement the maps, short reports were to be produced comprising brief descriptions of the soils and geology of the area covered, as well as some statistical tables relating to the subjects mapped. Thus the NZMS 237, National Land Inventory Survey, County Series, mapped at 1 inch to 1 mile, came into being.

The maps to be prepared for each county were:

NZMS 237/1 Land cover
NZMS 237/2 Geological resources
NZMS 237/3 Soils
NZMS 237/4 Potential pastoral use of soils
NZMS 237/5 Land capability
NZMS 237/6 Land tenure
NZMS 237/7 Land use
*NZMS 237/8 Production and carrying capacity per holding
*NZMS 237/9 Production and carrying capacity per acre
NZMS 237/10 Location map
NZMS 237/11 Land slope

(Maps marked above with asterisks were not for publication.)

The written report accompanying the maps was to be prepared in its final form by a committee under the chairmanship of the local Commissioner of Crown Lands. As a general rule the reports were to comprise four parts:

1. *The County.* Background information relevant to basic land-use. For example, early settlement and development, local government, population, transport, industries, power resources and soil conservation.

2. *The Land.* Descriptive text on physical features, climate, geology, soils, land cover, land tenure and land use.

3. *Primary production.* Brief comments to accompany tables showing types of farms, present stock and production and their growth during at least the previous 10-year period.

4. *Future potential and conclusions.* After receipt of draft maps and survey data the Committee was to draw conclusions under three main headings:

Potential of the undeveloped land;
Potential of the developed land;
Future possibilities.

Production of the maps as based on the rate of one county per land district for each year, which meant that a possible time-scale to achieve complete national coverage could have been approximately 10 years.

During the period 1966-1975 there were a number of maps produced on a county basis covering approximately 20 per cent of New Zealand, and others for special-purpose requirements with the co-operation of government departments and various special-purpose authorities. (See figure 124.) However, the demands for and use of land inventory materials indicated that the National Land Inventory Survey, County Series, was not serving all the needs of users for which it was established. Parts of the Inventory had not kept pace with the evolution of government policy in the field of land-use planning, resource management and environmental conservation. Neither was there adequate exposure to, and reaction from, the variety of users who could benefit from information it contained, and despite frequent programme revisions, progress was slow because no additional resources were made available at the beginning of this major project.

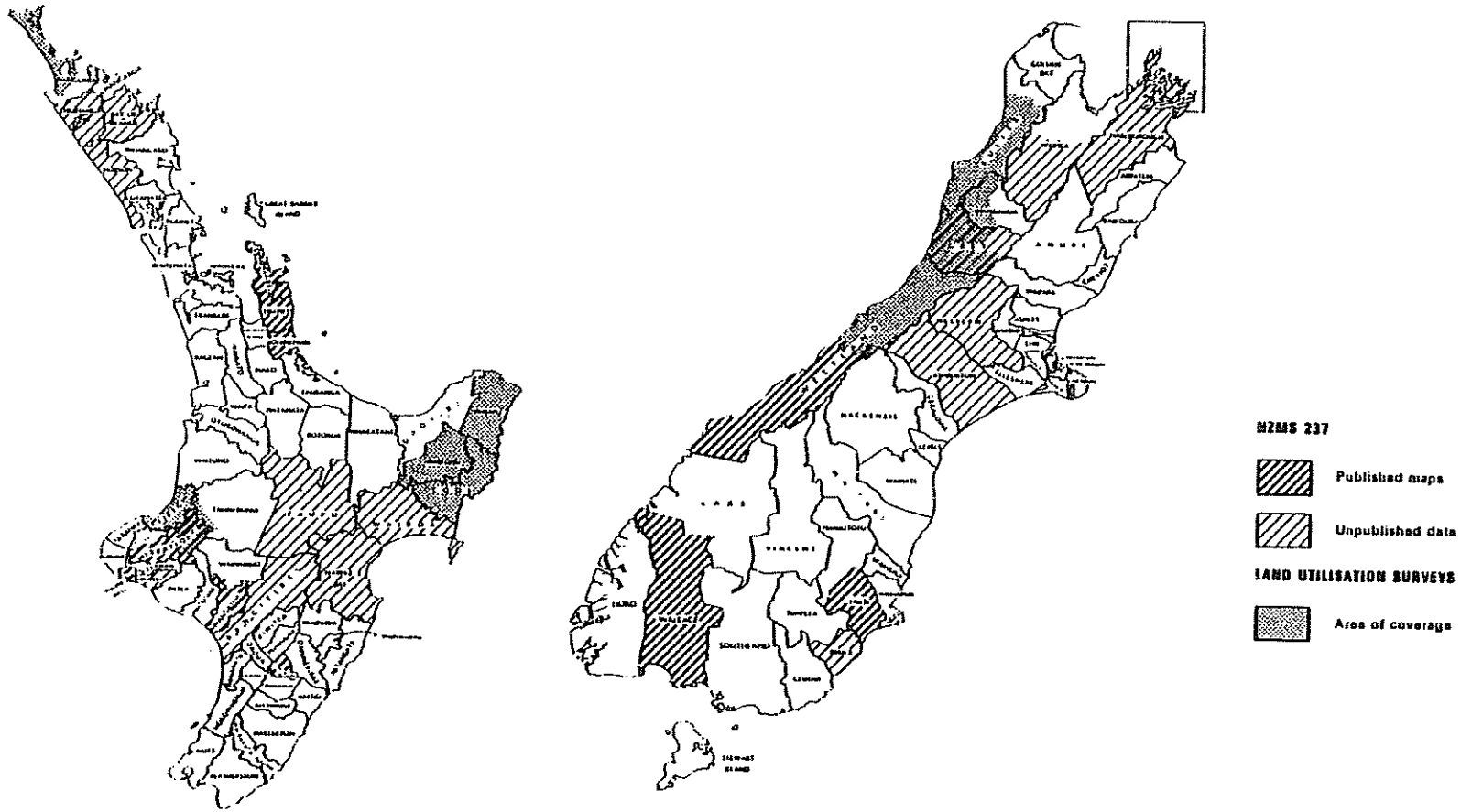


Figure 124. New Zealand: Index to NZMS 237, New Zealand Land Inventory Survey (County Series) and land utilization surveys

Consequently, in 1976, the Department of Lands and Survey reviewed past methods of inventory and presentation and investigated methods to improve them. As a result of this, and metrication, the New Zealand Land Inventory Series NZMS 290 was introduced.

The investigation covered methods of surveying, compiling, storing and presenting land information and examined alternative methods of preparing the Land Inventory.

NZMS 290 Land Inventory Mapping

In order to meet changing needs and to keep pace with the evolution of government policy in the fields of land-use planning, resource management and environmental conservation, new data collection and presentation techniques have been adopted for basic data maps. Interpretive maps of special areas, indicating the suitability of areas for specific land use, are also produced.

Although many systems have been developed by various countries, in particular Canada and Australia, almost all share the following three basic purposes:

(*a*) To develop understanding of separate ecosystem components and record the significant basic data;

(*b*) To develop understanding of the interrelationships of various ecosystem components;

(*c*) To determine the ranking for suitability of resource elements, both singly and collectively, of specified land-use functions.

All such systems provide an information base of physical characteristics which can then be used to relate or test the social and economic criteria, or requirements relevant to a land planning or management issue.

General purpose or objectives of the New Zealand Land Inventory (NZMS 290)

This is a comprehensive general-purpose infc: nation series on land resources made available to landowners and various landowner groups. It also provides a comprehensive base information for regional and district planning schemes.

By co-ordinating their work and manpower to concentrate on priority areas, government departments and agencies can provide different categories of data in the form of maps and text for lower overhead costs. Independent surveys by different departments are co-ordinated by the Department of Lands and Survey so that resources and expertise are used efficiently in providing land resource information to the decision-makers.

Objectives of the New Zealand Land Inventory are:

(*a*) To survey and classify land profile according to the interrelationshiop of physical land features (land form, soil) with climate, water and vegetative cover;

(*b*) To categorize basic information on land according to its inherent capability for use in agriculture, forestry, conservation, recreation and wildlife;

(*c*) To map the extent and location of each category or ranking of land;

(*d*) To facilitate planners and decision-makers in relating physical capability of land with socio-economic factors and historic land-use patterns in decision-making;

(*e*) To encourage the utilization of physical and capability data as an integral part of rural plan-making processes.

Organization of the New Zealand Land Inventory

The Director (Planning), Department of Lands and Survey, is responsible for supervising the production of the New Zealand Land Inventory. Day-to-day production and design of maps for the inventory is the task of the Resource Mapping Division Staff, Cartographic Branch, who generally work directly with contributors.

Data for the New Zealand Land Inventory are collected and compiled by many government departments and agencies, and from private sources. A committee comprising representatives of contributing parties meets at regular intervals to establish the survey programme, initiate policy and co-ordinate and monitor progress of individual priorities.

The Department of Lands and Survey is responsible for co-ordinating surveys and supplying topographic base maps (drawn to the metric sheetlines) to contributing parties. Field and record data are compiled and transferred onto stable-based copies of the base maps, correlated, edited and forwarded to the Resource Mapping Division for final cartographic production.

Surveying and mapping priority

It is now the policy of the Department of Lands and Survey to carry out Land Inventory surveys on a priority basis. Land-use trends, developments and problems throughout the country are monitored by planning personnel, and priorities are assigned according to the urgency and nature of the problem. By adopting this policy, regions more urgently requiring planning data are mapped first. In contrast to this policy, the County series inventory was a systematic approach to map the whole country. In many cases data were provided for areas where there was little demand (indicated by map sales and annual stocktaking) and often no data were provided in areas of immediate interest.

Cartographic Design and Production

With the introduction of a new Land Inventory series and the demand to revise map content in line with government policy and new concepts in land-use evaluation, a thorough investigation was initiated into cartographic design and production of Land Inventory maps.

The requirement to produce up-to-date information with the minimum turnaround calls for quickly produced maps using simple construction techniques. The maps need to be designed for a variety of users, both the scientific and planning communities, as inventory surveys of basic data or analytical tools, as well as for the public at large, to display findings or proposals.

To ensure the correct translation of planning concepts, interaction between the author (planner, scientist) and the translator (cartographer) is necessary, and encouraged throughout the entire process from data collection through to published map.

Rationalization of map format

The first stage in redesigning Land Inventory maps was the rationalization of scale, sheetlines and map format.

Scale. The change to metricated basic mapping of both the topographic and cadastral series led to a timely policy decision to relate all inventory mapping to these new series. Although basic mapping is published at 1:50,000 it was decided to collect inventory data at

1 inch to 1 mile (being the largest-scale published series completely covering New Zealand) and publish the maps at 1:100,000.

Sheetlines. The Land Inventory sheetlines are based on the NZMS 260, 1:50,000 layout. Standard sheets cover two 1:50,000 sheets in portrait. Some coastal sheets are extended into border areas to accommodate small residual land areas or island groups. By establishing a national sheetline system, individual survey areas may eventually be linked on the same framework, thus avoiding the previous problems associated with arbitrary sheetlines. Minor departures from the established sheetlines may be necessary when surveys are defined by geographic regions, and to complete survey data for areas outside the region would greatly increase field costs.

Map format. Both standard and extended sheets have been designed for printing on A1 paper (594 x 841 mm), and are published as flat sheets to facilitate overlaying of suitability option transparencies. Some themes are also issued by contributing departments in bulletins with accompanying descriptive text, and they require folding to a standard size.

Standardization of specifications and procedures

The land-use planning technique devised for producing the King Country Land Use Study[1] has been adopted with minor modifications and applied to the first regions mapped as part of the NZMS 290 New Zealand Land Inventory. The technique involves preparation of basic data maps, suitability overlays and reports containing descriptive text, tabulations and possible land-use options.

Basic data map themes adopted for NZMS 290 series vary according to the land-use planning requirements but generally include:

Land tenure and holdings;
Existing land use;
Wildlife;
Rock types and surface deposits;
Soils;
Forest and shrub types.

Although not presently mapped, provision has been made for the collection of data for landform and slopes, hydrology and climate.

Suitability overlays on transparent material showing the possible ranking of landscape assessment are produced as required for locating suitability of a particular use. These uses include:

Nature conservation;
Agriculture;
Forestry (exotic and indigenous);
Recreation.

Map specifications for individual themes have been derived mainly from experience gained in the preparation of maps for the King Country Land Use Study, but modified to suit the regions in question and to accommodate the scale change from 1 inch to 1 mile to 1:100,000.

Detailed specifications covering map content, symbols, colours and production systems have been produced for all basic data themes in direct consultation with authors and the Department of Lands and Survey district office personnel involved in the regional studies.

[1] *King Country Land Use Study, NZMS 288* (Wellington, Department of Lands and Survey, 1978).

MAP PRODUCTION PROCEDURES

The production of draft maps is the sole responsibility of contributors. The Department of Lands and Survey undertakes final cartography and publication of maps and reports. In the case of the land tenure and holdings and land-use maps, the Department of Lands and Survey is also the contributor.

The collection of land tenure and land-use information, their compilation and original drawing are done at District Offices. Where possible, photographically etched peelcoat colour masks are used to speed up production of all maps.

1. *Base maps.* Generalized topographic base maps are prepared by the Resource Mapping Division in conjunction with district offices. They are drawn, using technical pens, at the compilation of 1 inch to 1 mile in line weights and symbol-sizes suitable for direct reduction to the publishing scale of 1:100,000. The original drawings are forwarded to the direct office concerned for addition of landholding boundaries, which are obtained from Valuation Department records. The landholding boundaries are common to base maps for all themes, and along with topographic detail, provide an integrated physical/land ownership base map reference.

2. *Land Tenure and Holding Map.* (See figure 125.) The Land Tenure and Holding Map was required to reflect the general gradient of rights in tenure from Crown Land through to private free-hold. The choice of colours was to stimulate the perception of this gradient while also satisfying the requirements of a simple production system allowing for quick turnaround.

A spectral sequence, commencing with green for Reserve and Crown Lands (the general association being with lands in their more natural state), yellow for Local Authority and Crown Leasehold, orange for Maori Land and red for private land was chosen to indicate degrees of alienation of land from the Crown. The resultant colours are obtained by solid overprinting of the three-process colour printing inks to keep drafting and printing costs to a minimum as well as speed up production.

The flow chart below illustrates the production system of the Land Tenure and Holding Map.

3. *Land Use Map.* (See figure 126.) To ensure consistent interpretation of the land-use classifications throughout New Zealand, a workshop is held at the commencement of a regional study. Participants include members of local planning, field and drafting staff as well as Head Office personnel.

The land-use classifications show existing functional land uses rather than traditional forms of productive uses. In other words there is a change of focus from the form of land production to the nature of the use. In order to achieve this, individual types of land use are expressed in single use classes. To describe actual use as closely as possible, multiple codes are used.

The land-use classification is divided into three main groups shown on the map by separate colours, and these main groups are further subdivided into three subgroups, shown on the map by tints of the "parent" colour.

Four colours are used in printing. Separation of the nine main classifications is achieved by using screens rather than separate colours. This means that not only

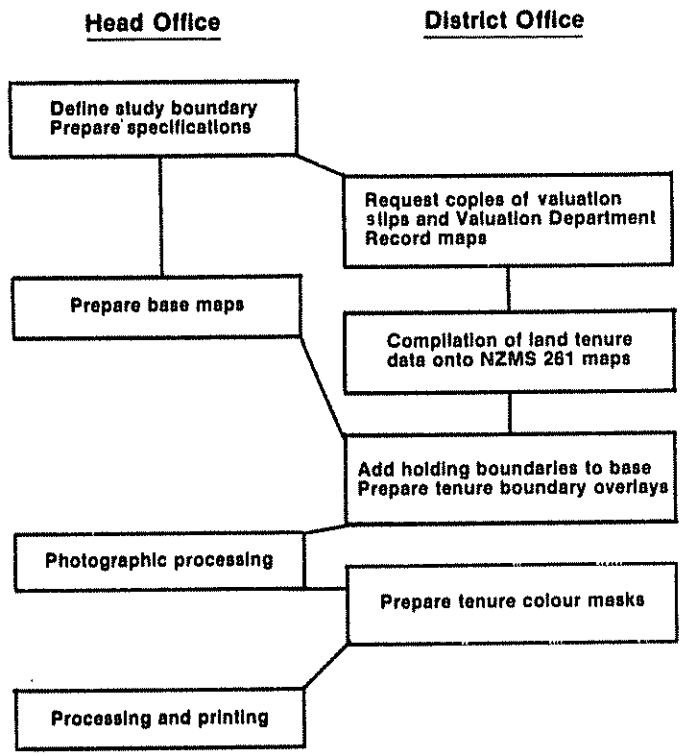


Diagram 1. Flow-chart illustrating the production of the Land Tenure Map

are costs kept to a minimum but also map checking is much simpler because combination colours are not used on the map.

The flow chart below illustrates the production system of the Land Use Map.

4. *Other themes.* These include maps showing wildlife, soils, rock types and surface deposits, and forest and shrub types. As previously mentioned, agencies contributing data for these themes compile manuscript drafts for forwarding to the Resource Mapping Section for final cartography. Direct liaison links between authors and cartographers have been established to discuss map design, content and production.

Generally, maps showing mainly areal data (for example, soils), are printed in four colours using the trichromatic system to provide a full range of hues. However, this system is not suitable for maps depicting many linear and point features, such as the Wildlife Map, and therefore it has been necessary to introduce different basic colours.

5. *Suitability overlays.* These drawings are prepared in single colour and are printed on transparent tracing paper to facilitate overlaying with Basic Data maps. Each draft overlay is compiled by a committee of related experts, and the final rankings of suitability are displayed on the transparencies using a selection of coarse ruling screens.

A complete set of master screens have been prepared by the Cartographic Branch to overcome problems of transparency and irregularity of commercially available stick-up patterns. The coarse ruling screens were designed to assist the user in visually ranking suitability data. (See figure 127 for examples of coarse ruling screens.)

PROGRESS TO DATE OF LAND INVENTORY MAPPING: NZMS 290 SERIES

Production of this series began in 1977 with a pilot study of the Northland region. At present the main effort is directed at completing this pilot study and a study in the Upper Waitaki-MacKenzie Basin of the South Island.

Northland region

The area comprises 11 sheets and is programmed for coverage in five basic data themes, giving a total of 55 maps. To date all Land Tenure and Holding maps have been published and field-work completed for the remaining themes. Seven Land Use and five Soil maps are in the final stages of cartographic drafting, and preliminary map design is being carried out for the Wildlife, and Rock Types and Surface Deposit maps. Slope maps prepared manually by visual inspection of contours were produced at an early date and supplied to input parties to assist in compilation of the various themes.

Research is in progress on the evaluation of Land Inventory mapping and the utilization of data by local land-use decision-makers and interested public.

Upper Waitaki-MacKenzie basin

The study area comprises 5 sheets to be mapped in three basic data themes and suitability overlays. To date all field-work is complete and a majority of the maps are in the final cartography stages.

Because topography has a large influence upon land-use patterns and potential in this area, the addition of

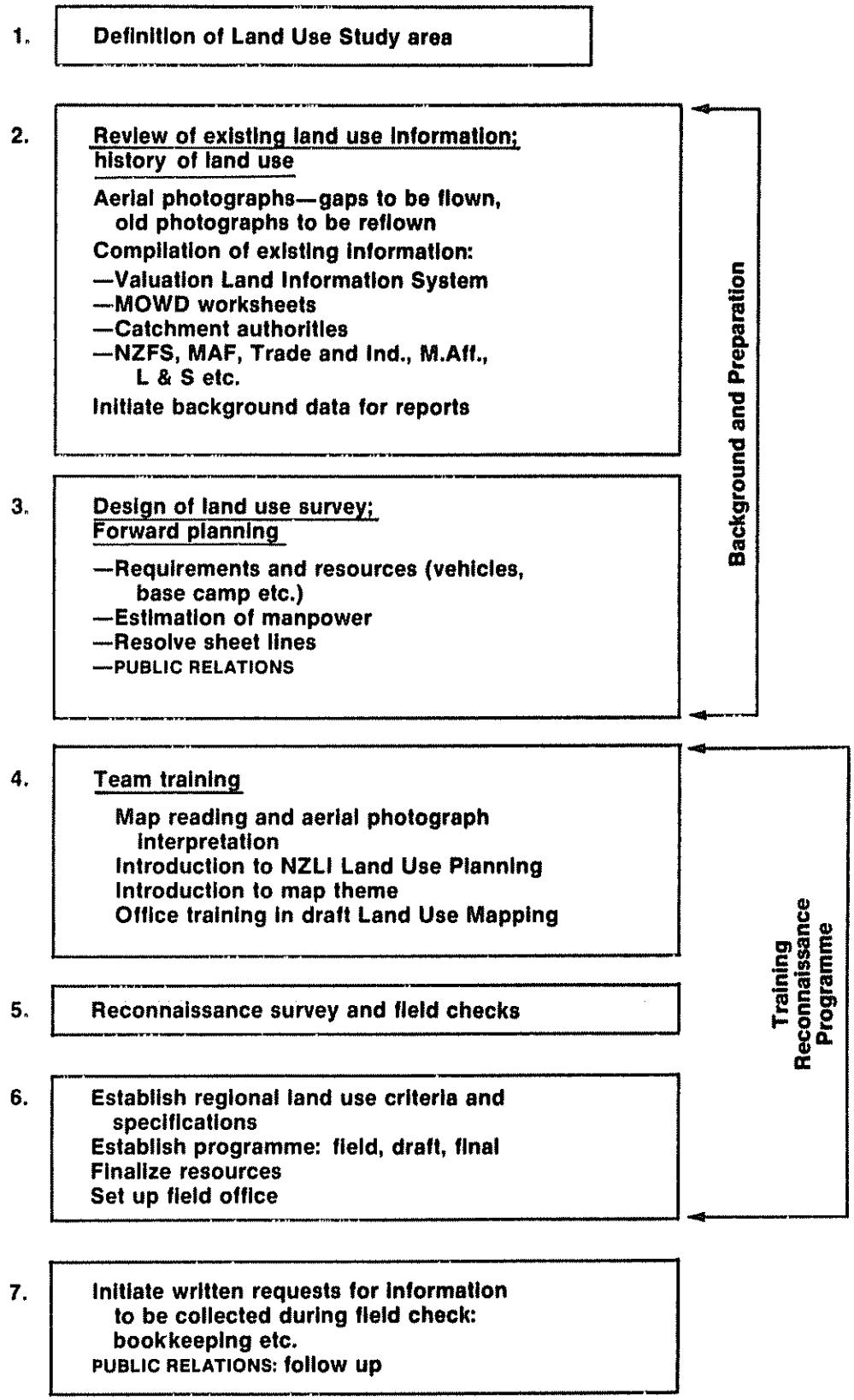


Diagram 2. Flow-chart illustrating the production of the Land Use Map

8. **Field work: draft land use mapping**

- Definition of unit boundaries on aerial photographs
- Estimation of land use codes—study of existing information (MCWD worksheets, Catchment Board plans etc.)
- Field verification/revisions: notes for report writing in field book; photographic record of land use
- Writing of field reports: finalization of draft land use on photos, including management functions
- Hand submission as soon as possible to field draughtsman for transfer to topographical maps

9. **Final draft map and written report**

- Examination of final draft by survey co-ordinator, field team and experts; final revisions and approval by survey co-ordinator
- Completion of draft area reports (background data for history of land use commenced in 2 above)
- (Above actions *must* be completed before field office is wound up)

10. **Sheet reports**

- Compiled, typed and illustrated from written draft area reports

11. **Cartographic mapping**

- Land use overlay
- Colour masking
- Area calculations/tabulations
- Reproduction and printing

12. **PUBLIC RELATIONS**

Diagram 2 (continued)

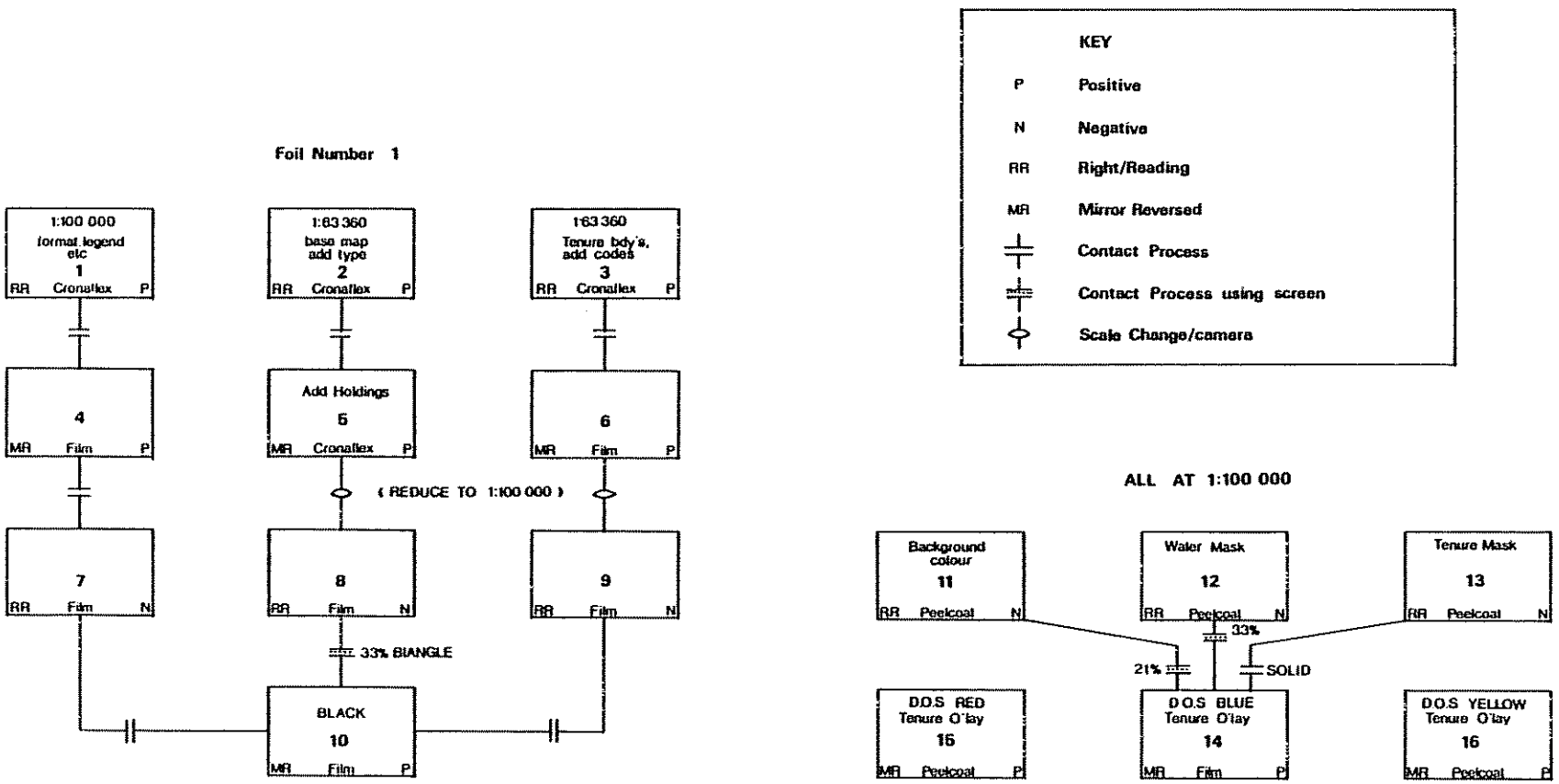


Figure 125. New Zealand: flow diagram; preparation of NZMS 290 Land Tenure map

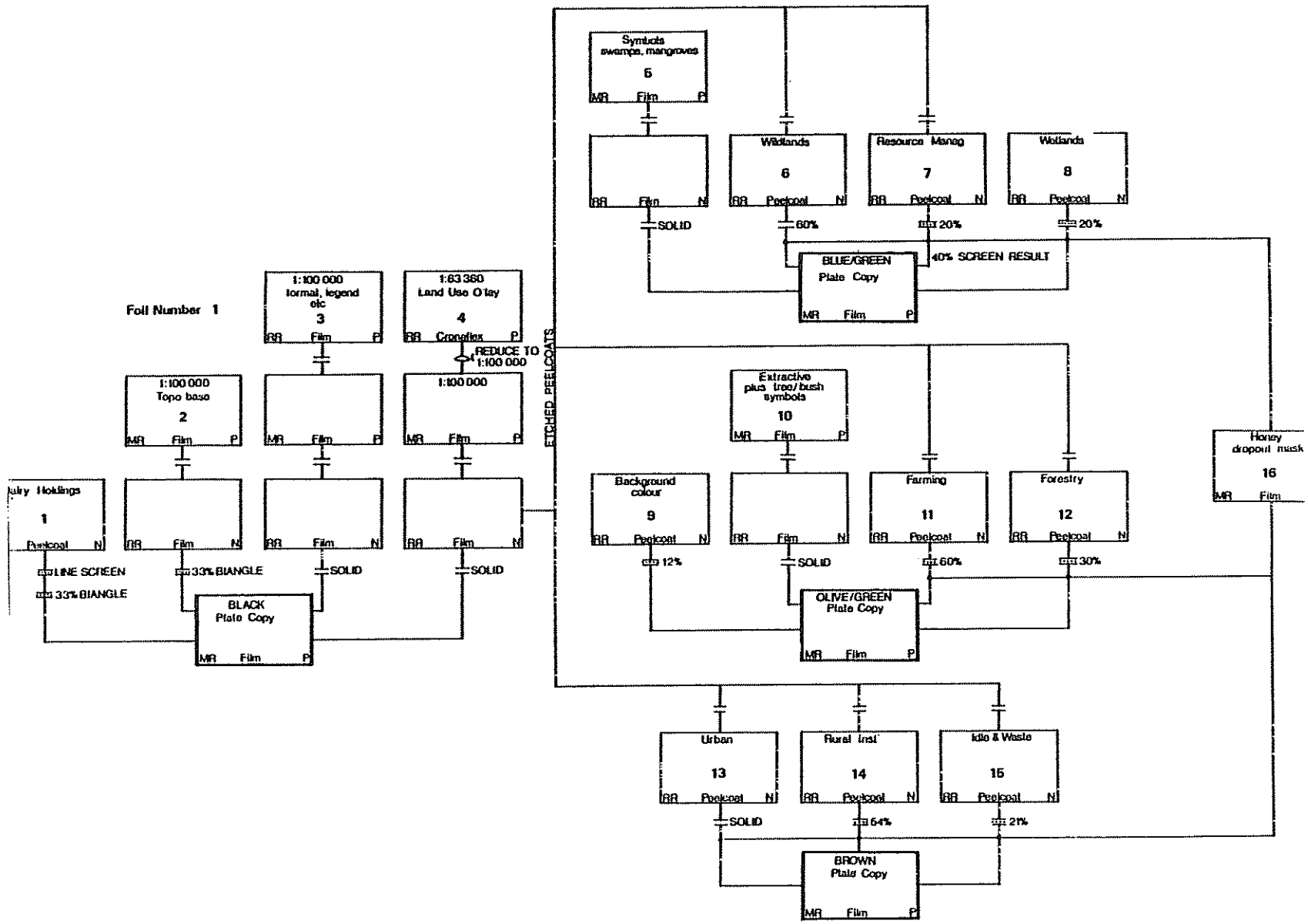


Figure 126. New Zealand: flow diagram; preparation of NZMS 290 Land Use map

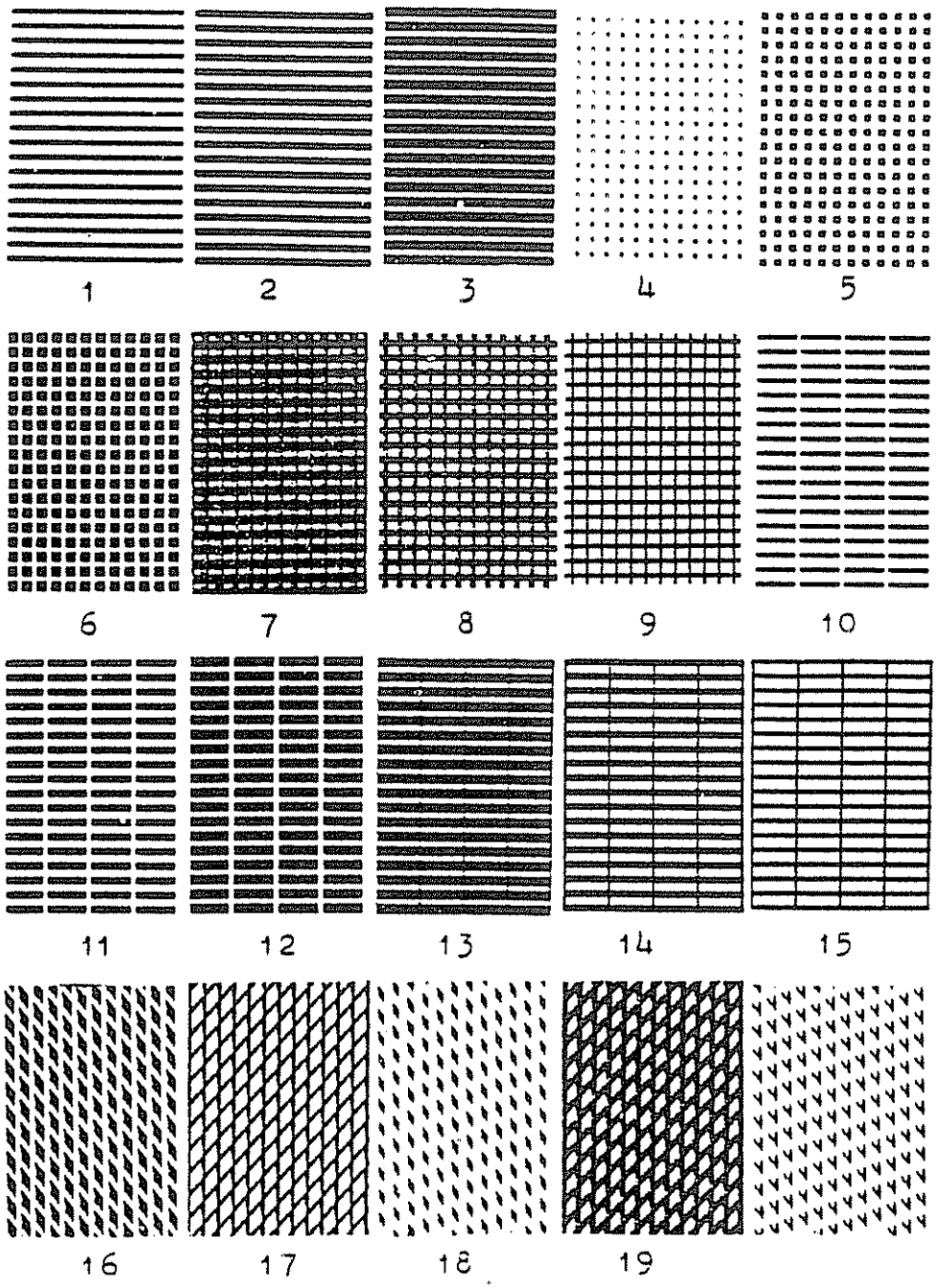


Figure 127. New Zealand: land inventory mapping; coarse ruling screens

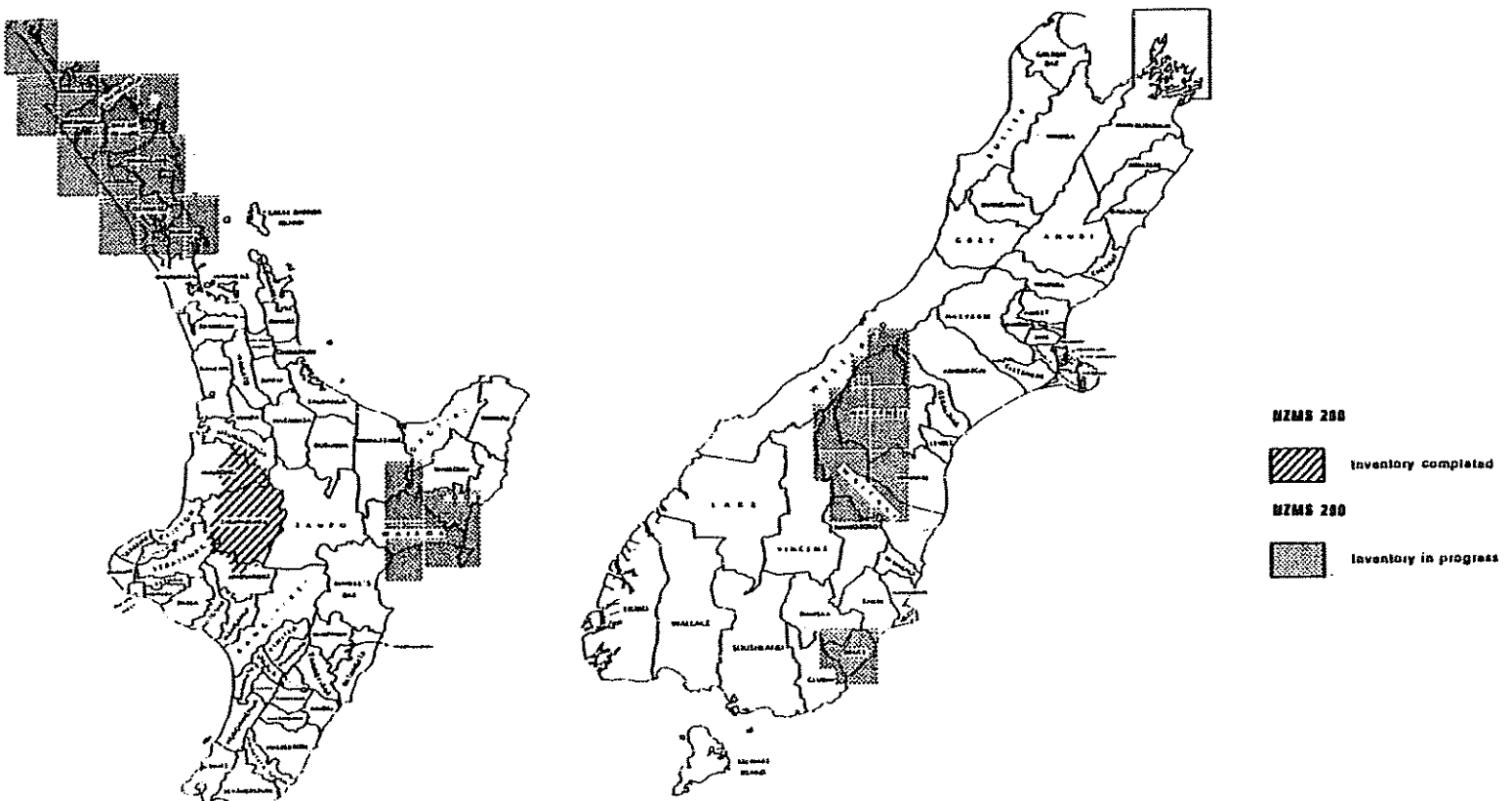


Figure 128. New Zealand: index to NZMS 288, King Country Land Use study and NZMS 290, New Zealand Land Inventory

relief portrayal to the base maps has been investigated. Three options were considered to provide relief shading: special new drawings, reduction and montaging of existing relief from basic topographic mapping, and the use of LANDSAT imagery. Initial experimental enlargements of LANDSAT imagery contained obvious scan lines and problems with projected shadow. However, more recent developments in the processing of data tapes have produced images acceptable for this application. The big advantage of using this imagery is that the entire area is almost completely contained in one scene.

Other areas

Some data originally collected for the NZMS 237, County series, has been transferred onto the NZMS 290 sheet lines and published as part of this series. This work is of lower priority than the surveys mentioned, but is progressing satisfactorily. (See figure 128 for map index showing NZMS 290, Land Inventory progress.)

Application of LANDSAT imagery to land inventory

Pilot studies have been initiated recently to explore the possibilities of manipulating LANDSAT data to provide land-use information. A land use investigation in the MacKenzie Basin utilizing LANDSAT imagery is being carried out parallel to the conventional field survey and aerial photographic interpretation technique. When complete, an evaluation of both techniques should provide guidelines for improving and streamlining data acquisition methods.

CONCLUSION

Although New Zealand has been carrying out different types of land inventory surveys for many years, it is only recently that the process has been revised to suit the present-day needs of natural resource planning.

This revised version of land inventory mapping is designed to convey the technical data of natural resources in a comprehensible manner to decision makers and interested public at large.

Map compilation and production procedures have been modified to supply this data in a minimum turnaround period.

Actual staff resource allocated for this activity in New Zealand is rather small in comparison to basic topographic mapping; however, production can be maintained by pooling departmental resources and continually monitoring and modifying data acquisition and presentation techniques.

A land inventory mapping procedure, as described in this paper, is an economical and efficient means of supplying natural resource information, and is recommended for countries about to initiate an inventory mapping programme.

(d) *Hydrographic surveying and nautical charting*

BATHYMETRIC MAPPING BY THE DIVISION OF NATIONAL MAPPING, AUSTRALIA, 1977-1979*

Paper presented by Australia

La Division of National Mapping (Service cartographique national) du Ministère du développement national est l'organisme australien qui est chargé d'établir des cartes du plateau continental australien. Il est prévu, dans le cadre de ce projet, de dresser 247 feuilles au 1/250 000 entre l'isobathe de 20 mètres le plus proche de la côte et l'isobathe de 300 mètres.

Les opérations de levé ont commencé à petite échelle en 1971 et, bien que le programme n'ait pas bénéficié d'autant de moyens financiers et de ressources en personnel qu'on l'avait initialement prévu, on a réalisé les opérations de levé pour 81 de ces feuilles, dont 43 ont été publiées.

Depuis 1977, les travaux océanographiques ont été effectués surtout au large de l'Australie occidentale, mais il y en a maintenant en cours dans la région de la Grande Barrière de corail.

Comme le Service ne possède pas de navire hydrographique, elle doit en affréter auprès du Commonwealth Department of Transport (Ministère des transports du Commonwealth) et d'armateurs privés. Le matériel de navigation dont sont équipés les navires hydrographiques comprend un système de positionnement par satellite/sonar Doppler Magnovox et de minitélémètres Decca Hifix 6 et Motorola appartenant au Service. Les données relatives aux marées sont normalement fournies par des enregistreurs placés sur le fond de la mer dans la zone où sont réalisées les opérations de levé. Pour mesurer les profondeurs, on utilise des échosondeurs Atlas Deso-10.

Depuis 1977, le Bureau of Mineral Resources, Geology and Geophysics (Bureau des ressources minérales, de la géologie et de la géophysique), qui fait également partie du Ministère du développement national, et le Service cartographique national ont entrepris de concert d'enregistrer sous une forme numérique, en mer, les données bathymétriques et les données relatives au géomagnétisme marin. Ces données sont recueillies au moyen de l'un quelconque des trois systèmes de positionnement mentionnés plus haut et sont intégrées sous une forme numérique avec d'autres données. On élabore actuellement des programmes pour l'exécution par ordinateur de feuilles bathymétriques et de calques de repérage des courbes isobathes.

The Division of National Mapping, Department of National Development, is the Australian agency responsible for mapping the Australian continental shelf. The project entails mapping 247 map sheets at 1:250,000 scale between the 20-metre isobath closest to the shoreline and the 300-metre isobath.

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF.72/L.29.

Survey operations commenced in a small way in 1971, and although the programme has not been funded or staffed to the degree first planned, 81 of the map sheets have been field surveyed and 43 of these have been published.

Since 1977, marine operations have been concentrated mainly off Western Australia, but work is now also in progress in the Great Barrier Reef area.

The Division does not own its own survey ships but charters vessels from the Commonwealth Department of Transport and from commercial ship owners. Navigation for the survey vessels is provided by Magnavox satellite navigation/Doppler sonar, Decca Hifix 6 and Motorola mini-ranger systems, which are all owned by the Division. Tidal information is normally supplied by recorders placed on the sea-bed in the vicinity of the survey area. Atlas Deso-10 echo sounders are used to record depths.

Since 1977, the Bureau of Mineral Resources, Geology and Geophysics (also a branch of the Department of National Development) and National Mapping have combined in a co-operative effort to record bathymetric and marine geomagnetic data in digital form while at sea. Navigation data is accepted from any of the three positioning systems mentioned above and integrated digitally with any other data. Programmes are being developed for the computer drawing of bathymetric manuscript sheets and contour overlays.

MARITIME BOUNDARIES*

Paper presented by Australia

En 1977, la Division of National Mapping (Service cartographique national) a créé une section chargée des questions relatives aux limites maritimes. Cette section fournit des avis et une assistance technique en matière de politique fédérale pour ce qui est de définir de telles limites. Ses principales activités ont été jusqu'à présent les suivantes :

a) Détermination et description des limites pour le Traité entre l'Australie et la Papouasie-Nouvelle-Guinée. Des cartes explicatives ont été imprimées mais la définition des limites est exprimée en termes géodésiques. L'Australie a également des questions de délimitation à résoudre avec la France, les Iles Salomon, l'Indonésie et la Nouvelle-Zélande;

b) Détermination et définition des limites de la zone de pêche australienne de 200 milles marins;

c) Etablissement de propositions relatives à la ligne de base de la mer territoriale de l'Australie et de ses territoires;

d) Etablissement de descriptions de parcs marins et d'autres zones devant faire l'objet de dispositions législatives.

In 1977 the Division of National Mapping created a section to handle maritime boundary matters. This section provides technical advice and assistance to federal government policy areas in the definition of such boundaries. Principal activities so far have been:

(*a*) Computation and description of the boundaries for the Treaty between Australia and Papua New Guinea. Illustrative maps were printed, but the definition of the boundaries is expressed in geodetic terms. Australia also has delimitations to resolve with France, Indonesia, New Zealand and the Solomon Islands;

(*b*) Computation and definition of the boundaries of the 200 nautical mile Australian fishing zone;

(*c*) Preparation of territorial sea base-line proposals for Australia and its territories;

(*d*) Preparation of descriptions of marine parks and other zones for inclusion in legislation.

*The original text of this paper, prepared by the Division of National Mapping, appeared as document E/CONF.72/L.37.

AUTOCHART*

Paper presented by Australia

Le système Autochart (système de cartographie marine automatisée) a été adopté par l'Hydrographic Office (Service hydrographique) en 1979. Lorsqu'on fait le bilan de la cartographie en Australie, on se rend compte que l'introduction de ce système a constitué un progrès important dans le domaine de la cartographie automatisée.

Bien que le fichier de base ait la même structure que celui qui est utilisé dans le cadre du système de cartographie automatisée de l'Armée (Automap), il est désormais possible, grâce à l'amélioration sensible de la conception du fichier central de contrôle des détails et au changement d'optique intervenu à l'égard de la formation des signes conventionnels, d'automatiser intégralement la production cartographique jusqu'au stade final de l'élaboration du matériel de reproduction. Bien qu'actuellement le pourcentage des opérations qui sont effectuées automatiquement avec le système Autochart soit d'environ 80 p. 100, une somme non négligeable de travaux (mise en pages, numérisation des données et certains aspects de la conception des autres signes conventionnels) reste à effectuer pour compléter la production pleinement automatisée, au moins en ce qui concerne le matériel de reproduction des cartes marines.

*The original text of this paper, prepared by the Royal Australian Navy, appeared as document E/CONF.72/L.48.

Il est désormais possible d'automatiser intégralement les processus de production des cartes, de la compilation des données à l'élaboration des documents de reproduction nécessaires pour l'impression, alors que ces processus répétitifs exigeaient jusque-là beaucoup d'opérations manuelles. Bien que l'application actuelle du système soit surtout adaptée à la production de documents utilisant des signes conventionnels normalisés, comme par exemple les séries cartographiques, on pense qu'il est maintenant possible d'étendre cette application à la production de documents tirés de la base générale de données, y compris certaines cartes thématiques. Le traitement manuel de signes conventionnels complexes et multiples, les masques et même la simple opacification des négatifs définitifs pourraient devenir une chose du passé.

Le système Autochart permet d'établir une proportion raisonnable de cartes dérivées et autres produits cartographiques à partir du fichier de base. Ce résultat est obtenu au moyen d'un certain nombre de dispositifs offrant diverses options de programmation des types de détails qui figurent dans le fichier. Les demandes présentées à l'ordinateur sont analysées par rapport aux critères de programmation fixés pour le produit désiré. Une fois effectuée la sélection des données nécessaires, celles-ci sont ensuite traitées selon les signes conventionnels correspondant aux types de détails identifiés. Bien qu'il ne soit pas possible pour l'instant d'automatiser intégralement la production de documents dérivés, le niveau actuel d'automatisation permettra sans doute d'accroître sensiblement la productivité du personnel lors de l'exécution des prochaines séries de cartes.

La mise à jour des cartes et autres produits cartographiques est facilitée par l'amélioration de la structure du fichier et l'utilisation de fichiers auxiliaires auxquels on peut avoir accès à partir des fichiers principaux. Les informations qui sont ajoutées à la base de données dans le cadre d'opérations de mise à jour entre deux révisions sont spécialement programmées aux fins d'intégration à la génération suivante de matériels de reproduction. On peut, si nécessaire, procéder à la refonte intégrale du matériel de reproduction. L'utilisation de fichiers auxiliaires permet la mise à jour de données d'information variant fréquemment en même temps qu'elles sont nécessaires à d'autres fins, comme par exemple les données relatives aux feux de navigation, aux marées, etc.

Bien que les progrès réalisés restent dans une large mesure du domaine de la cartographie semi-automatisée, le système Autochart a apporté au Service hydrographique, pour faire face à ses obligations au niveau national en augmentant sa capacité de production et de mise à jour de documents cartographiques, une solution offrant un meilleur rapport coût-efficacité qu'on ne pouvait escompter de toute autre manière. La nécessaire rationalisation de la base de données permet d'envisager bon nombre de services cartographiques qu'il n'aurait pas été possible d'envisager autrement.

Les ressources en personnel que ce système a libéré des tâches traditionnelles de production sont maintenant utilisées pour la numérisation des données d'entrée et les opérations de compilation et de sélection. On a dû modifier considérablement les méthodes de compilation pour les adapter aux exigences de la cartographie numérique. Les priorités et les critères utilisés pour les opérations de compilation doivent être soigneusement appliqués de manière à assurer un maximum de productivité et répondre aux exigences présentes et futures de la base de données.

Pour passer de la cartographie manuelle à la cartographie semi-automatisée, il faut tenir compte du fait qu'il existe actuellement un volume important de matériel de reproduction traditionnel. Le plafond imposé à l'effectif du personnel du Service hydrographique n'a pas permis de pratiquer simultanément les deux méthodes (numérique et manuelle), sauf pendant une brève période de transition, durant laquelle une gestion serrée a été nécessaire pour maintenir la production cartographique à un niveau raisonnable.

Les nouvelles méthodes de compilation ont été introduites 12 mois avant la date prévue pour la mise en service du système. Au cours des six derniers mois, toutes les méthodes manuelles de compilation et de production ont été progressivement abandonnées et remplacées par de nouvelles méthodes de sélection numérique. Pendant cette période, des programmes de formation théorique et pratique très complets ont été organisés à l'intention du personnel.

Il est évident que les établissements d'enseignement existants ne sont guère en mesure pour l'instant de répondre aux exigences de la formation aux techniques de la cartographie numérique. Le Service hydrographique a dû organiser lui-même toute la formation théorique et pratique effective. Cette situation persistera sans doute jusqu'à ce que les établissements d'enseignement soient en mesure de financer les dépenses d'équipement et de recruter le personnel enseignant qu'exige l'évolution des techniques. Les membres du personnel du Service hydrographique ont accueilli avec enthousiasme le recyclage et les innovations techniques. Cela les a incités à considérer leur rôle sous un angle nouveau et à explorer les possibilités encore inconnues que leur offre ce nouveau système pour la communication de données cartographiques. Finalement, il faudra procéder à des changements organisationnels et modifier la structure actuelle des emplois en fonction des nécessités du système Autochart. La mise au point sera suffisamment lente pour permettre aux membres du personnel de s'adapter à leurs nouveaux rôles tout en gardant leurs compétences cartographiques de base tandis que s'effectue l'automatisation.

During 1979 the Hydrographer's Autochart system was introduced. In reflecting the state of cartography within Australia, Autochart has offered a significant step forward in automative techniques.

While the basic file structure is similar to that of the Army Automap system, the significant enhancement of the central Feature Control File concept, together with a change in philosophy of symbol generation, had led to the feasibility of achieving full automation of cartographic output to the final repromat stage. While current levels of output automation for Autochart is about 80 per cent, there remains a quantifiable task in the layout, digitizing and certain design aspects of the remaining symbology to complete full output automation of at least the navigation chart repromat.

The previous manpower intensive and repetitive cartographic production processes, from the base compilation to the reproduction material required for printing, can now be fully automated. While current application is best suited to those products utilizing standardized symbology, such as series mapping or charting, the extension of these concepts to cover products derived from the general data base, including certain thematic mapping, is now considered practical. The manual handling of complex and multiple symbology, overlay masks and even the humble opaquing of final negatives could be a thing of the past.

Autochart is able to achieve a reasonable level of derivative charting and other cartographic products from the basic data file. This process operates through a number of facilities which provide tagging options for feature concepts held on file. Output requests are measured against specified tag criteria for the required product. Once selected, the required data is then processed according to the symbology required of the feature concepts identified. While full automation of the derivative product function is not achievable at this stage, the current level can significantly increase manpower productivity in subsequent series charting or mapping.

The revision of charts and other cartographic products is aided by the enhanced file structure and use of subsidiary files which are addressable on output from the main data files. Updating information entered into the base from the date of the last revision is specifically tagged for the subsequent generation of deleting and overprinting repromat. If required the complete regeneration of repromat can be undertaken. The use of the subsidiary file concept allows for the revision of information having a high frequency of variation, together with being required for other purposes, for example navigation light data, tidal information etc.

While much development remains in the field of computer-aided cartography, the Autochart system has provided the Hydrographer with a more cost-effective solution to increasing production and maintenance capacity for meeting national obligations, than would otherwise have been required. The necessary rationalization of basic information provides a base for a variety of cartographic services not otherwise possible.

Manpower capacity released from the traditional production processes is now diverted to aid data input digitizing and the compilation selection processes. Compilation procedures have required extensive revision to adapt to the requirements of digital cartography. The priorities of compilation and criteria used must be carefully managed to ensure maximum productivity to suit current and future requirements of the data base.

The transition from manual to computer-aided cartographic production must take into account the large volume of existing manual product repromat. The Hydrographer's staff ceiling did not permit the pursuing of dual production methods (digital and manual) save for a brief change-over period. The transition has called for careful management to ensure that reasonable charting levels could be maintained.

Variation to operating procedures for compilation were implemented twelve months in advance of expected system usage. During the last six months all manual compilation and production methods were phased out and digital selection methods introduced. Extensive staff training and experience programs were introduced during this period.

It is evident that at present there is little available within the existing educational institution which satisfies the training requirements of digital cartography. It has been the Hydrographer's experience that all real training and education has had to be generated within the organization. This lag will probably endure until the educational institutions can afford the capital equipment costs and recruit suitable academic staff that technological change demands.

The staff of the Hydrographic Office have responded to the training and technological change with enthusiasm. It has provided the intellectual stimulus to look again at their role and to explore the yet unknown potential of their new means to provide cartographic communication. Ultimately, organizational changes must come with a different mix of job classification from that in effect today. The organizational and job role under Autochart will be slow enough to allow individuals the chance to adapt to new roles while retaining their background cartographic skills in the introduction of automation.

L'ÉVOLUTION RÉCENTE DE L'HYDROGRAPHIE FACE À LA NOUVELLE ÉCONOMIE DE LA MER : LA COOPÉRATION AVEC LES JEUNES ÉTATS MARITIMES*

Document présenté par la France

SUMMARY

The aim of hydrography is to put at the navigator's disposal the nautical documentation and information necessary for the security of his navigation.

For a long time needs were limited to surface navigation with shallow-draught ships (some 10 m at most) and could be met with the rudimentary techniques of the time.

During the three last decades, needs have shown a rapid development (*a*) in navigation—extension of frequented areas, increase of ship speeds, tonnages and

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draughts, as a result of submarine navigation; and (*b*) in marine engineering—necessity for precise environment studies for offshore implantation, layout and maintenance of undersea pipelines etc.

Simultaneously new techniques (echo-sounders, radiolocalization, automation) have appeared, greatly modifying methods of work for data collection or data processing.

In the nations of old maritime tradition there has long existed a department entrusted with hydrography and more recently having competence in oceanography. In France this part is played by the Service hydrographique et océanographique de la Marine (SHOM) (Navy Hydrographic and Oceanographic Department).

In developing maritime countries, accession to independence often halted hydrographic activity, but the recent creation of economic zones will again increase their responsibilities for hydrography.

To meet them, the young maritime States are compelled to appeal to co-operation with foreign countries especially with a view to ensuring the training of qualified personnel, the creation of competent national organizations and the definition of means and programmes of work.

The temptation is great to provide them with full works and services. But a State's freedom of decision requires knowledge of the facts and techniques. For its part, SHOM prefers the notion of techniques transmitted and shared, associating the concerned nation with the studies and surveys undertaken.

A system must not be transposed but, on the contrary, through constructive dialogue, needs and local circumstances must be taken into account in order to imagine a specific and adapted organization.

The paper shows a possible plan, in several stages, for the receiving State to take over national hydrography progressively, to which SHOM can contribute by offering various categories of services, such as training of personnel in its schools, and advisory and study activities.

Qu'est-ce que l'hydrographie?

Il nous paraît essentiel, à la fois pour éclairer le lecteur non averti et pour éviter des confusions dans l'exposé, de commencer par définir le terme lui-même.

L'hydrographie se définit d'abord par sa finalité : elle a pour but de mettre à la disposition du navigateur (de surface ou sous-marin) la documentation qui lui est nécessaire pour assurer la localisation et la conduite de son navire dans les conditions optimales de sécurité : cartes marines, instructions nautiques décrivant les grandes routes océaniques, les parages fréquentés, les ports, livre des feux, annuaires de marées, cartes de courants, etc.

Mais l'hydrographie est également souvent comprise comme l'ensemble des techniques nécessaires pour atteindre cet objectif : sondage ultra-sonore, radiolocalisation, géodésie, cartographie, mesure des courants, de la houle, de la marée et traitement des informations correspondantes.

On conçoit aisément que ces techniques puissent être mises au service d'autres objectifs que l'élaboration de la documentation nautique.

Cette double approche nous paraît essentielle pour aborder notre sujet, à savoir l'évaluation des besoins des pays en développement dans ce domaine aujourd'hui et la question qui lui est concomitante : celle de la coopération qu'un pays comme la France peut développer avec ces partenaires potentiels.

Avant d'entrer dans le vif du sujet, nous rappellerons rapidement l'évolution de l'hydrographie dans le domaine propre de la navigation, au niveau des besoins et des méthodes : nous donnerons également un aperçu sur les nouvelles applications des techniques hydrographiques que suscite la mise en exploitation des océans.

L'HYDROGRAPHIE AU SERVICE DU NAVIGATEUR

Jusqu'au début de ce siècle, on ne navigue qu'en surface, avec des bâtiments de tirant d'eau limité à quelques mètres. Peu importe, sauf à de rares scientifiques et aux poseurs de câbles sous-marins, la morphologie des grands fonds. C'est heureux, car le seul moyen de déterminer les hauteurs d'eau entre la surface et le fond est la ligne de sonde graduée munie d'un plomb à son extrémité, procédé lent et discontinu mis en œuvre à bord de navires ou d'embarcations dont la position est souvent connue de façon incertaine. Malgré ces techniques rudimentaires, mais grâce à elles et à la ténacité des hommes qui les ont mises en œuvre pendant 150 ans (l'hydrographie méthodique commence au tout début du siècle dernier), un ensemble de documents remarquables a été établi par les services hydrographiques de pays à longue tradition maritime, comme la France et le Royaume-Uni de Grande-Bretagne et d'Irlande du Nord.

La carte marine va cependant rester longtemps une carte d'approche des côtes, de ces zones appelées par les marins du vieux nom d'« atterrages ». Certes les pêcheurs en savent un peu plus sur le fond de la mer, mais il s'agit d'une connaissance empirique qui leur suffit : on ne parle pas encore de surexploitation des stocks et chacun a ses terrains de chasse bien à lui.

Outre cette connaissance des fonds limitée aux zones côtières, deux phénomènes sont relativement bien appréhendés : la marée, qui s'observe aisément à la côte et dont la prédiction est faite de façon satisfaisante dès le milieu du XIXe siècle — moyennant des heures interminables de calcul — et les courants de marée, auxquels le marin est d'autant plus sensible que son bateau est lent et peu manœuvrant. Encore faut-il savoir que la marée au large est, même de nos jours, très mal

connue : on s'est aperçu, en particulier sur certaines plates-formes pétrolières en mer du Nord, d'erreurs de près d'un mètre sur le niveau moyen adopté par les ingénieurs. Quant aux courants océaniques qu'on s'imagine trop aisément comme de majestueux et paisibles écoulements, ils apparaissent aujourd'hui, grâce à l'observation des trajectoires de bouées dérivantes localisées par satellites, comme constitués de grands tourbillons dont le « diamètre » serait de quelques dizaines à deux ou trois centaines de kilomètres, fluctuant dans l'espace et dans le temps.

Mais revenons au début de ce siècle. L'apparition de la navigation sous-marine constitue une mutation essentielle : l'espace utile à cartographier n'est plus limité aux fonds d'une dizaine de mètres, mais s'étend à ceux de 200 à 300 m. Pourtant l'hydrographie, bien que dépendant en général de la Marine, n'en est pas révolutionnée pour autant. Ses techniques sont encore rudimentaires, et même le voudrait-on qu'on ne pourrait pas faire grand-chose.

Quels sont les éléments déterminants qui vont intervenir au cours des dernières décennies? Deux sauts technologiques marquent la fin de la première moitié de ce siècle pour l'hydrographie : le sondage ultrasonore, dont les premiers succès opérationnels sont dus au Français Marti dans les années 30, et qui va permettre la mesure de la profondeur de façon continue et instantanée suivant une route donnée jusque dans les plus grands fonds; la radiolocalisation, qui va se développer à partir de la seconde guerre mondiale : au positionnement discontinu et plus ou moins précis par moyens optiques complétés par l'estime et l'astronomie vont se substituer toute une gamme de systèmes radioélectriques dont les plus récents assurent une couverture globale (Omega, satellites Transit).

Le sonar latéral, le sondeur à faisceau étroit, puis tout récemment les sondeurs multifaisceaux — qui permettent le « balayage » acoustique sur le fond d'une bande continue de part et d'autre de la route suivie — vont encore améliorer la capacité d'investigation systématique des fonds. Au cours des deux dernières décennies les méthodes de travail vont profondément évoluer, premièrement, au stade des travaux à la mer, grâce à la gestion automatisée des mesures à bord des navires et des bouées fixes ou dérivantes, à la détection des épaves par mesure des perturbations du champ magnétique terrestre, à l'apport de la télédétection pour la mesure des températures de surface, de l'état de la mer, de la vitesse et de la direction du vent à partir d'avions et surtout de satellites (1)*, et ensuite, au stade du traitement de l'information, grâce à l'automatisation de la cartographie, à l'amélioration de la prédiction des marées, à la géostatistique.

L'APPARITION DE BESOINS NOUVEAUX

Simultanément, avec ce développement des techniques, s'est manifestée une évolution rapide des besoins, en particulier dans les secteurs de la navigation et de l'ingénierie en milieu marin.

En matière de navigation, on constate :

Une extension des zones fréquentées, qui dépassent largement les routes et les grands ports traditionnels; diversification des points de chargement des matières premières (hydrocarbures, minerais), multiplication des échanges de produits finis, création de liaisons régionales nouvelles, extension des trafics locaux pour parer à l'absence de voies de communications terrestres. Récemment la première Conférence hydrographique régionale pour l'Amérique constatait qu'une cartographie côtière et portuaire fiable était un élément favorable au développement économique d'un pays dans la mesure où elle incitait les grands armements à assurer de nouvelles liaisons.

Une spécialisation des navires et une augmentation de leur tonnage, de leur vitesse et de leur tirant d'eau : pétroliers géants, transporteurs de vrac, porte-containers, etc. En conséquence, la surface des zones à draguer * a considérablement augmenté ainsi que celle des zones à vérifier fréquemment (estuaires).

L'apparition de transports spéciaux, comme le remorquage des plates-formes en béton et peut-être un jour d'îles artificielles ou même d'icebergs. Ils se caractérisent par de très grands tirants d'eau et de faibles vitesses. Les grands tirants d'eau — de l'ordre de 60 à 100 m pour les plates-formes pétrolières, 200 à 300 m pour les icebergs — supposent une certitude absolue sur les hauteurs d'eau disponibles, et la recherche de « chenaux » dont la longueur peut dépasser la centaine de milles sur certains plateaux continentaux : c'est tout le problème des « routes en eau profonde » qui se pose déjà en certaines régions du globe pour les pétroliers géants.

Les faibles vitesses — de l'ordre de 1 à 2 nœuds — mettent en lumière notre ignorance des courants généraux déjà évoqués : la vitesse de ces derniers peut être du même ordre que celle des transports spéciaux envisagés, et faire varier dans des proportions considérables les durées de remorquage, sinon interdire certaines opérations dans les cas les plus défavorables.

Ces quelques indications suffisent à montrer l'évolution des besoins considérés comme traditionnels, à la satisfaction desquels a toujours travaillé l'hydrographe. Mais toute une gamme de nouvelles applications s'ouvre aujourd'hui aux techniques hydrographiques, dans le domaine des opérations *off shore* et de l'ingénierie marine qui se développe concurremment. La mise en exploitation des hydrocarbures dans le golfe de Floride et surtout en mer du Nord en a été le révélateur :

a) Nécessité d'études fines d'environnement, très localisées, parfois à plus de 100 milles des côtes et par des fonds atteignant 200 m, sur les futurs sites d'implantation de structures lourdes posées sur le fond : topographie très précise, nature du fond, connaissance des courants de marée et des courants généraux sur toute la tranche d'eau, valeurs significatives de la houle, etc. Toute une méthodologie originale a été développée à cette fin autour de l'utilisation de submersibles de travail habités (notamment par des sociétés comme Intersub et Vickers), qui se substituent pour ces tâches aux embarcations de sonde utilisées près des côtes; cela suppose toutefois la solution de problèmes d'équipements, de positionnement et de logistique d'un autre ordre de grandeur!

b) Choix des tracés d'oléoducs sous-marins. Ces derniers doivent à tout prix éviter les affleurements rocheux; ils doivent en outre être enfouis dans le sol (la

*Les chiffres entre parenthèses renvoient à la liste de références.

*Au sens hydrographique du terme, c'est-à-dire par remorquage d'un câble maintenu à profondeur constante qui garantit l'absence d'obstacle jusqu'à une cote donnée

réglementation norvégienne en fait une obligation absolue aux opérateurs) à cause des dangers qu'ils font courir aux engins de pêche, et des risques qu'ils courent eux-mêmes d'être crochés par des apparaux de mouillage. Il faut donc là encore disposer d'une cartographie très précise permettant le choix des tracés possibles, qui doit être complétée par une reconnaissance fine de la topographie et des propriétés mécaniques des premiers mètres sous le fond.

c) Choix des emplacements favorables à l'implantation d'usines productrices d'énergie : soit à la côte à partir de la marée, soit au large à partir de la houle. On connaît les projets britanniques destinés à exploiter l'énergie des vagues : ils sont basés sur de longues lignes de batteurs flottants en béton, ou de radeaux articulés, pour lesquelles les conditions optimales d'environnement devront être recherchées; zones de forte houle, tenue des mouillages satisfaisante (liée directement à la nature du fond et du sous-sol).

d) Mise en œuvre de multiples applications de l'acoustique sous-marine : « ancrage » dynamique de navires et de structures flottantes en eau profonde, obtenu sans liaison matérielle avec le fond, par mise en œuvre de l'appareil propulsif, pour maintenir la position en référence à un réseau de balises acoustiques; « ré-entrée » de trains de tiges de forages dans des puits existants; navigation des submersibles, transmission de l'information dans le milieu liquide, etc.

Tels sont quelques-uns des nouveaux problèmes à la solution desquels l'hydrographie d'aujourd'hui doit contribuer. Les structures, et les hommes qui les animent, sont-ils prêts à faire face à cette évolution rapide?

L'HYDROGRAPHIE, UNE RESPONSABILITÉ NATIONALE AU SERVICE DU NAVIGATEUR; L'APPARITION DE NOUVELLES STRUCTURES NOTAMMENT DANS LE SECTEUR PRIVÉ

En France, c'est le Service hydrographique et océanographique de la Marine (SHOM) qui est chargé de l'hydrographie nationale. Quatre missions hydro-océanographiques permanentes, dont trois sont basées en métropole et une dans le Pacifique, disposent de sept navires de haute mer pour effectuer tous les travaux de levé et de mesure « sur le terrain ». L'élaboration des documents nautiques — en particulier des cartes marines —, la gestion de l'information nautique, l'ensemble des études liées à l'océanographie, le soutien logistique des missions sont assurés par l'établissement principal situé à Brest. Définition des programmes, études générales, relations extérieures relèvent de la direction du service restée parisienne.

Dans les pays de tradition maritime ancienne où existait depuis longtemps un service hydrographique dont la tâche essentielle consistait — et consiste toujours — en l'élaboration, la publication, la diffusion et la tenue à jour des documents nautiques, la multiplication des besoins a conduit à une extension des compétences des organes existants et surtout à une diversification des structures : l'océanographie — comprise comme l'étude du comportement du milieu liquide — a pris une part croissante dans l'activité des services hydrographiques.

Si le SHOM est le seul en France à assurer une responsabilité statutaire en matière d'hydrographie, il existe d'autres organismes qui « font de l'hydrographie » au sens où ils mettent en œuvre des techniques analogues conduisant à une description de l'environnement marin : ainsi, dans le secteur public le Service des câbles sous-marins, ou dans le secteur privé des sociétés spécialisées dans les levés bathymétriques à la mer, les mesures de courant, etc. Ces sociétés, encore peu nombreuses chez nous, ont connu au Royaume-Uni un développement rapide induit par l'importance de la demande en mer du Nord. Un marché mondial en extension leur est ouvert dès maintenant.

LA SITUATION DANS LES PAYS EN DÉVELOPPEMENT

Rien de tout cela n'existe encore dans les pays en développement : une bonne soixantaine d'entre eux sont des Etats maritimes dont le portefeuille de cartes a été réalisé depuis un siècle par des pays qui se comptent sur les doigts d'une main : le Royaume-Uni pour la moitié d'entre eux, les Etats-Unis d'Amérique pour un quart et la France pour un autre quart.

Quelle est la situation à laquelle ils se trouvent confrontés?

La couverture cartographique y est en général incomplète et de qualité très inégale. Ainsi le SHOM a entretenu pendant de nombreuses années deux missions hydrographiques sur les côtes occidentales d'Afrique et à Madagascar, dotées de navires, d'équipements et de moyens en personnel et qui sont comparables à celles qui opéraient en métropole; mais leur activité a dû cesser au début des années 60 alors que l'hydrographie était encore inexistante en de nombreuses zones. Depuis, les cartes françaises sont restées en l'état, et ce sont les seules en service (les cartes étrangères concernant les mêmes zones ont été dessinées à partir des cartes françaises).

Du fait de l'accession à l'indépendance des Etats concernés, le SHOM n'a pu continuer à y exercer sa responsabilité : non seulement il a dû cesser les travaux de levé, mais il n'a pas été en mesure de tenir à jour les documents existants, faute de la mise en place d'une organisation locale pour la collecte et la diffusion de l'information.

Enfin deux éléments essentiels liés à la création des zones économiques de 200 milles viennent alourdir la tâche des Etats au moment où ceux-ci doivent prendre en charge leur hydrographie. Le premier est l'accroissement considérable de la surface de responsabilité des futurs services hydrographiques — cela est du reste vrai également pour les « vieux » pays —, le second est la nécessité d'une meilleure connaissance de l'environnement marin liée au contrôle de l'exploitation des ressources. Nous reviendrons plus loin sur cette nouvelle finalité de « l'hydrographie conçue comme ensemble de techniques ».

DISPOSER D'UNE COMPÉTENCE HYDRO-OCÉANOGRAPHIQUE NATIONALE, GAGE D'INDÉPENDANCE POLITIQUE

Bien conscients de cette situation, nombreux sont les Etats qui souhaitent se doter d'une capacité hydro-océanographique qui leur soit propre. Ils savent que cette capacité leur sera nécessaire, entre autres, pour contrôler par eux-mêmes une gestion équilibrée de leurs ressources marines et le développement harmonieux des activités économiques dans leurs zones de souveraineté.

La liberté de décision d'un Etat, c'est-à-dire en fin de compte son indépendance, passe dans ce domaine

comme dans beaucoup d'autres par la maîtrise des connaissances, et donc des techniques qui permettent d'y aboutir.

« C'est dans une optique largement multidisciplinaire et avec le souci de coordonner les efforts que les gouvernements s'attachent à gérer l'espace océanique et, plus précisément, les zones côtières où se concentre l'essentiel des ressources et qui donnent une nouvelle dimension aux problèmes de la maîtrise du développement ou de l'aménagement du territoire (2). »

Quelles sont les préoccupations majeures qui se manifestent concrètement pour traduire ces aspirations?

1. D'abord et avant tout, la formation de personnel qualifié, aux divers niveaux. Pour éviter la multiplication anarchique de spécialisations hâtives, un organe consultatif a été récemment constitué conjointement par l'Organisation hydrographique internationale (OHI) et la Fédération internationale des géomètres (FIG). Il a défini tout à la fois des « normes de compétence » et le niveau des diverses filières d'enseignement permettant ainsi aux Etats d'élaborer des programmes de formation cohérents. La France joue un rôle moteur dans cette concertation.

2. Vient ensuite la création de services hydro-océanographiques ayant une responsabilité statutaire au plan national. Les éléments constitutifs d'une bonne connaissance de l'environnement physique des zones économiques et du littoral ne sauraient s'acquérir une fois pour toutes, sur commande à l'extérieur. Il s'agit d'un milieu complexe et évolutif, théâtre d'activités multiples et souvent agressives. Que l'on songe par exemple au problème très actuel de la délimitation des couloirs de circulation pour pétroliers dans les passages dangereux : il ne peut être résolu — dans le respect de conventions internationales qui n'existent pas toujours ou sont souvent insuffisantes — sans qu'intervienne la libre décision de l'Etat riverain, s'appuyant sur l'expertise de services nationaux compétents.

3. Enfin la définition de programmes de travail, à savoir :

a) Rajeunissement de la cartographie marine existante, par remise à jour des documents — combien de nouveaux ports ne figurent-ils qu'incomplètement sur les cartes, quand ils n'en sont pas totalement absents, aussi étonnant que cela puisse paraître! — grâce à une collecte systématique de l'information nautique et la participation aux systèmes mondiaux d'avis aux navigateurs; il y va entre autres de la sécurité de la navigation;

b) Mise en route de travaux de première nécessité économique : levés localisés sur l'emplacement de futurs sites portuaires et de points de chargement en mer de minerai ou d'hydrocarbures, levés côtiers de zones en développement rapide caractérisées par l'accroissement du trafic local, levés de zones limitrophes dont la connaissance précise est la base essentielle de négociations satisfaisantes avec les Etats voisins en vue de la détermination des aires de souveraineté;

c) Programmes à long terme, débouchant sur une cartographie précise et homogène, sur la connaissance des grands mécanismes comme la marée, les courants. Ces programmes se chiffrent souvent en dizaines d'« années-navires ».

Dans la plupart des cas, les jeunes Etats maritimes ne peuvent que très imparfaitement résoudre par eux-mêmes tous ces problèmes. La nécessité, au moins temporaire, d'une coopération avec l'extérieur se fait donc sentir : appel auquel un pays comme la France, doté d'organes et de moyens spécialisés, se doit de répondre.

Clients ou partenaires?

Le Service hydrographique et océanographique de la Marine française, respectueux du désir des Etats d'accéder le plus rapidement possible au stade où ils disposeront de leurs propres structures spécialisées, s'oriente vers une attitude de coopération concertée. A la notion de client, il préfère celle de partenaire. A celle d'hydrographie livrée « clés en main », celle d'une technique transmise et partagée, associant au maximum le pays concerné aux études ou levés entrepris.

Pour illustrer cette doctrine, un schéma a été établi (figure 129), qui représente quelles pourraient être les phases successives qui conduiraient un pays en développement (que nous préférons appeler pays « receveur », ou PR) à la maîtrise progressive des techniques et à la mise sur pied des structures nécessaires avec l'aide d'un pays « donneur » (ou PD).

Phase 1. — Le PR organise la collecte de l'information nautique, ce qui est une façon simple d'appréhender les problèmes sans nécessiter des investissements significatifs : plans de ports en construction, modification du balisage, amers nouveaux, etc. Le PD la diffuse sur le réseau mondial, et l'utilise pour « rajeunir » les documents existants.

Les levés prioritaires sont entrepris par le PD, tandis que des techniciens de terrain du PR sont mis en formation à la fois dans le PD et « sur le tas » à l'occasion des premiers travaux dans leur propre pays.

Phase 2. — Des levés côtiers sont entrepris en commun par le PD et le PR avec du personnel et des équipements des deux pays. Leur exploitation est entamée dans le PD par des équipes qui intègrent des techniciens du PR.

La formation approfondie d'ingénieurs est entreprise; un embryon de service est créé.

Phase 3. — La gestion de l'information nautique est maintenant entièrement prise en charge par le PR. Les premiers documents et cartes sont produits, sous le timbre du PR, dans les ateliers du PD (dans l'hypothèse où le PR ne dispose pas par ailleurs du matériel lourd de traitement automatique et d'impression), mais l'exploitation cartographique primaire commence dans le PR.

Les premiers cycles de formation de techniciens sont mis en place dans le PR.

Le service hydro-océanographique du PR, outre la prise en charge progressive, partielle ou totale, d'opérations (levés, exploitation, études), se préoccupe de l'acquisition d'équipements lourds, notamment en matière de moyens flottants spécialisés.

Phase 4. — L'autonomie est presque complète, sauf sans doute en ce qui concerne certains projets ou études complexes et les formations de haut niveau ou très spécialisées.

Naturellement, une remarque importante s'impose : notre schéma n'est proposé qu'à titre d'illustration. Il ne constitue pas un tout rigide et peut être interrompu en cours de route. Certaines fonctions n'y apparaissent pas : par exemple le rôle de contrôle technique que peut jouer le PD au profit du PR pour des travaux de levé confiés sous contrat à des sociétés spécialisées.

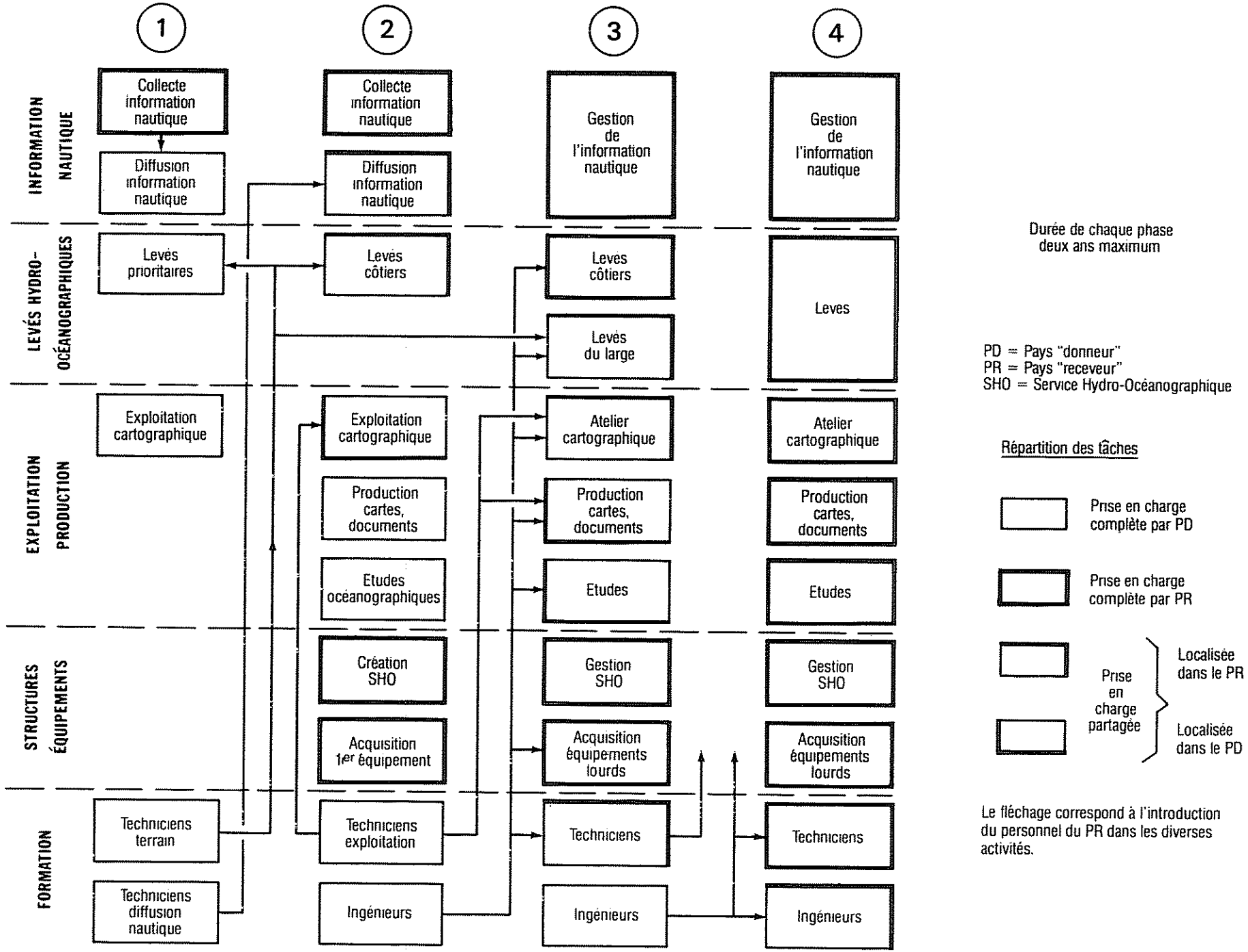


Figure 129. France : processus continu d'acquisition de compétence en hydro-océanographie

Une autre remarque nous paraît fondamentale : nous devons nous garder en permanence, dans ce processus de transfert, de la tentation qui consiste à transposer tel quel notre propre « modèle » en matière d'organisation.

Ainsi dans certains pays, c'est à partir des grandes directions portuaires ou de services de l'équipement connaissant bien les problèmes de la navigation et de l'information nautique qu'il faudra envisager de lancer une structure spécialisée, plutôt que de confier cette tâche à une marine parfois très embryonnaire. De la même façon, il n'est pas évident que les attributions statutaires d'un service hydro-océanographique créé dans un pays vierge de toute autre structure dans le domaine de la mer ne doivent pas aller au-delà de l'objectif de base que constitue la navigation.

Les nouveaux services hydro-océanographiques pourraient fort bien se voir attribuer un rôle consultatif réglementaire sur de nombreux aspects de l'exploitation des océans dépendant directement de facteurs naturels tels que la morphologie du fond et des zones littorales, et les grands mouvements du milieu liquide comme les courants, la marée et la houle. Ainsi que le constatait dans son rapport (3) le Groupe d'experts des levés hydrographiques et de la cartographie marine, réuni à l'invitation de l'Organisation des Nations Unies à New York en décembre 1977 : « Il faut que les responsables aux plus hauts niveaux gouvernementaux comprennent qu'on ne peut exploiter les ressources de la mer sans prospection et que sans hydrographie la prospection n'est pas possible. »

RÉFÉRENCES

1. Voir « La télédétection en océanographie », étude présentée par MM. Crepon et J. Dechamps aux XIVe Journées de l'hydraulique
2. Lucchini, L. et Voelckel, M. « Les Etats et la mer, le nationalisme maritime ». La Documentation française, Paris, janvier 1978.
3. *Deuxième Conférence cartographique régionale des Nations Unies pour l'Amérique, Mexico, 3 à 14 septembre 1979*, vol. 1 : *Rapport de la Conférence* (publication des Nations Unies, numéro de vente : F.81.I.4), annexe IV

THE APPLICATION OF SURVEY AND REMOTE SENSING TECHNIQUES IN COASTAL AND MARINE AREAS CARRIED OUT AT THE UNIVERSITY OF HANOVER*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

Grâce à un appui financier de la Fondation pour la recherche de la République fédérale d'Allemagne, un groupe spécial de recherche sur l'application des techniques d'établissement de levés et des techniques de télédétection pour l'étude des zones côtières et maritimes a été créé à l'Université de Hanovre. Bien que ce groupe se consacre principalement à des recherches méthodiques dans le domaine de l'établissement de levés et de la cartographie, il a établi des possibilités d'application à diverses disciplines géoscientifiques et techniques.

In 1973 a special research unit was formed at the University of Hanover, concerned with the application of survey and remote sensing techniques in coastal and marine areas. The unit is financially supported by the Research Foundation of the Federal Republic of Germany (DFG). Members are scientists principally of the four institutes of the University in the field of surveying and mapping (surveying, geodesy, photogrammetry and cartography). At the same time, links exist to coastal and marine authorities and institutes such as the local and federal authorities for water transport and water quality, to the Hydrographic Office, to coastal research institutes and to the Space Agency (DFVLR).

Research is organized in four different project areas:

(*a*) Determination of the geodetic reference surface at sea;

(*b*) Methods to determine point positions and heights in coastal areas and at sea;

(*c*) Topographic surveys of tidal lands, shallow water areas and on the continental shelf;

(*d*) Thematic surveys of tidal lands and of water areas with respect to ecological mapping, sedimentation surveys and the tracing of pollutants.

This paper summarizes the methods investigated and the results of practical significance obtained thus far in the four project areas.

*The original text of this paper, prepared by Gottfried Konecny, University of Hanover, and others, appeared as document E/CONF.72/L.83.

REFERENCE SURFACE

Determination of the geoid at sea and in coastal areas is largely handicapped by the difficulty of making astronomic observations by conventional means at triangulated points. For this purpose a rapidly operating zenith camera was developed which permits determination of astronomic directions to ± 0.5 seconds of arc within very short observation times. The zenith camera was utilized to determine the astrogeodetic geoid along the North German coast, including observations at lighthouses and sea platforms. Also, data of astrogeodetic deflections known from observations over central and north-western Europe (altogether 2,900 stations) were collected. From this material a North Sea geoid has been computed (figure 130).

Likewise, 150,000 available gravity observations (90,000 at sea) were collected (figure 131). The calculation of the gravimetric North Sea geoid is in progress. Preliminary results have been obtained from mean anomalies (figure 132).

A third method is being applied to obtain a North Sea geoid: the National Aeronautics and Space Administration (NASA) has provided 10,000 altimeter data for the North Sea. Its data processing is in progress to compute an altimeter geoid. Preliminary results have been obtained with 369 altimeter points (figure 133).

A combination of methods is intended. For transformation purposes Doppler positioning methods have been measured. They yielded mean square differences

of ± 0.5 on land and on fixed platforms at sea and ± 4 m on floating platforms at sea. The preliminary results give geoid differences between ± 0.2 to ± 1.4 m and differences in deflections of ± 0.7″ for ε and ± 1.0″ for η.

At the same time, tidal gauge registrations recorded at Wilhelmshaven from 1878 are now undergoing detailed analysis. The first effort has been directed to digitizing the graphs and subsequently subjecting the data to a frequency analysis. This is sometimes handicapped by gaps of a few weeks' duration between the recordings.

The tidal gauge analysis is of special interest in conjunction with the statistical analysis of the coastal level lines carried out in different decades in order to verify crustal movements in the North Sea area (figure 134).

In the attempt to determine sea surface topography using satellite altimeter data from SEASAT, a number of tidal gauges were required. Their positions and heights were to be determined by Doppler methods. When SEASAT failed, the work was in progress. However, now at least some data analysis can be obtained using extrapolations.

POSITIONING AND HEIGHTING METHODS

Of particular interest is the investigation of Doppler positioning methods at sea platforms: for this purpose two Canadian Marconi sets CMA 751 are available. A number of improved programs were developed to predict satellite passes and to reduce the data when they have been recorded in static mode on stable platforms and in dynamic mode on ships and floating platforms. Evaluations are under way.

For precise height measurements at sea a hydrostatic levelling system was developed on capacitive measurement principles. The system is able to record 20-mm height differences with an accuracy of ± 0.01 mm over short distances. Application to longer distances depends on the availability of longer hoses. Tests with somewhat reduced accuracy have been made, utilizing hoses of the Dutch Rijkswaterstaat.

Another heighting procedure over longer distance is trigonometric levelling. However, this method has severe limitations due to the ever-changing effects of vertical refraction, which is particularly disturbing close to the earth's surface and at sea. A remedy seems in sight if differential refraction can be measured by dispersion techniques. A dispersometer was built, which sends light of varying frequencies to a receiver where the directional difference of the incoming 2-frequency sequences is measured (figure 135). This dispersion angle is a measure for vertical refraction.

TOPOGRAPHIC SURVEYS

Tidal flats constitute areas in which terrestrial surveys are very difficult. Two methods, in particular, have been investigated which yield satisfactory results under tidal conditions. The first concerns electronic tacheometry. The electronic tacheometer is placed on a constructed platform, and rapid measurements of horizontal and vertical angles and slope distances can be made to a group of prism carriers, changing their positions rapidly between measurements. It is only in this way that a sufficiently large area may be covered within a tidal cycle. The development of this method included an automatic computation and drafting programme, including contour interpolation. The method is at best satisfactory for areas of a km² or less. With a speed of 0.7 pts/min a one square kilometre area of 100-m grid points can be measured in about one working day.

For larger areas a method using aerial photographs has been investigated. While stereophotogrammetry frequently fails under conditions of very low contrast in tidal flats, single image photogrammetry yields useful results. A "water-line" survey method was developed for practical use (figure 136). In this method, repeated aerial infra-red photographs are taken over the tidal area starting at low tide, and at every interval when the tide has risen for a fixed amount (e.g. about 10 cm). The water line will then be clearly visible. It can be digitized on an enlarged photograph. However, this water line will not correspond to a level surface, since the rising of the water is influenced by location, wind direction or local topography. Therefore a net of ground survey points must be known, the elevations of which are surveyed by levelling on the ground. These points serve as reference points to calculate heights along the recorded water lines (serving as form lines). The procedure is being automated so that a digital terrain model (DTM) is calculated from the water-line data. This DTM can be utilized to interpolate contours for a graphical output.

Survey techniques for underwater topography cannot be made by optical means in the turbid waters of the North Sea. Conventional echo-sounding methods, however, provide measurement at profiles, but lack area capability. Therefore side-scan sonar techniques offer a possibility to image the sea bottom. An EG&G sonar fish has been acquired, and this imagery has been tested for use in topographic surveys. In co-operation with coastal authorities of the Federal Republic of Germany and the Netherlands, the recording of sonar signals has been modified to receive them on magnetic tape. These data can be processed by digital image-processing techniques. An Optronics P1700 was utilized to play off image-processed sonar records. The image processing included contrast stretch, noise elimination or line enhancement. In particular it contained geometric corrections peculiar to a sonar recording. The programs available also permit the inclusion of recorded positional and rotational sensor attitude data, if such data are available e.g. from Hifix and from angular velocity recorders in 2 or 3 axes. Based upon these processing techniques a mosaic of sea bottom images could be compiled for a test area.

It was not possible, however, to derive height information by stereo-techniques using overlapping sonar strips. This was due to sonar shadows using opposite side scans and insufficient parallax for the same side scans. Therefore the sonar fish was modified to utilize the interferometric measurement principle (figure 137). The two ultra-sound sources (swingers) are mounted in the fish on top of each other, with both of their main lobes pointing sideways in one direction. The electronics of the sonar are changed to activate only one swinger as a source for the sonar pulse, but both swingers as receivers for the sonar pulse. The signal difference received between the two swingers is then displayed in the form of a radar image. It consists of interferometric sequences of light and dark, which permit derivation of the bottom topography.

Within a test area such data have been reduced to a DTM, from which sea bottom contours could be inter-

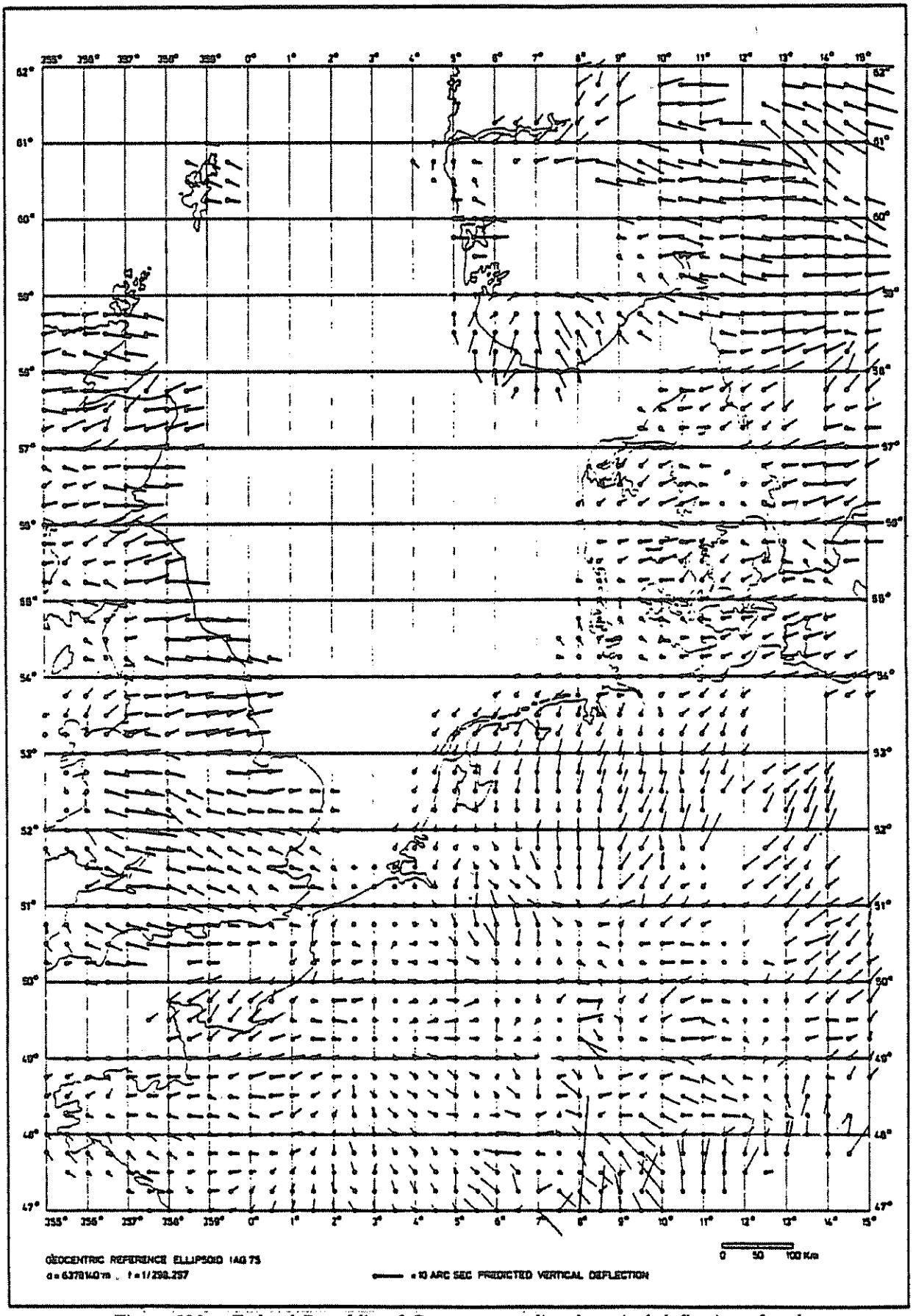


Figure 130. Federal Republic of Germany: predicted vertical deflections for the North Sea region obtained from astrogeodetic data

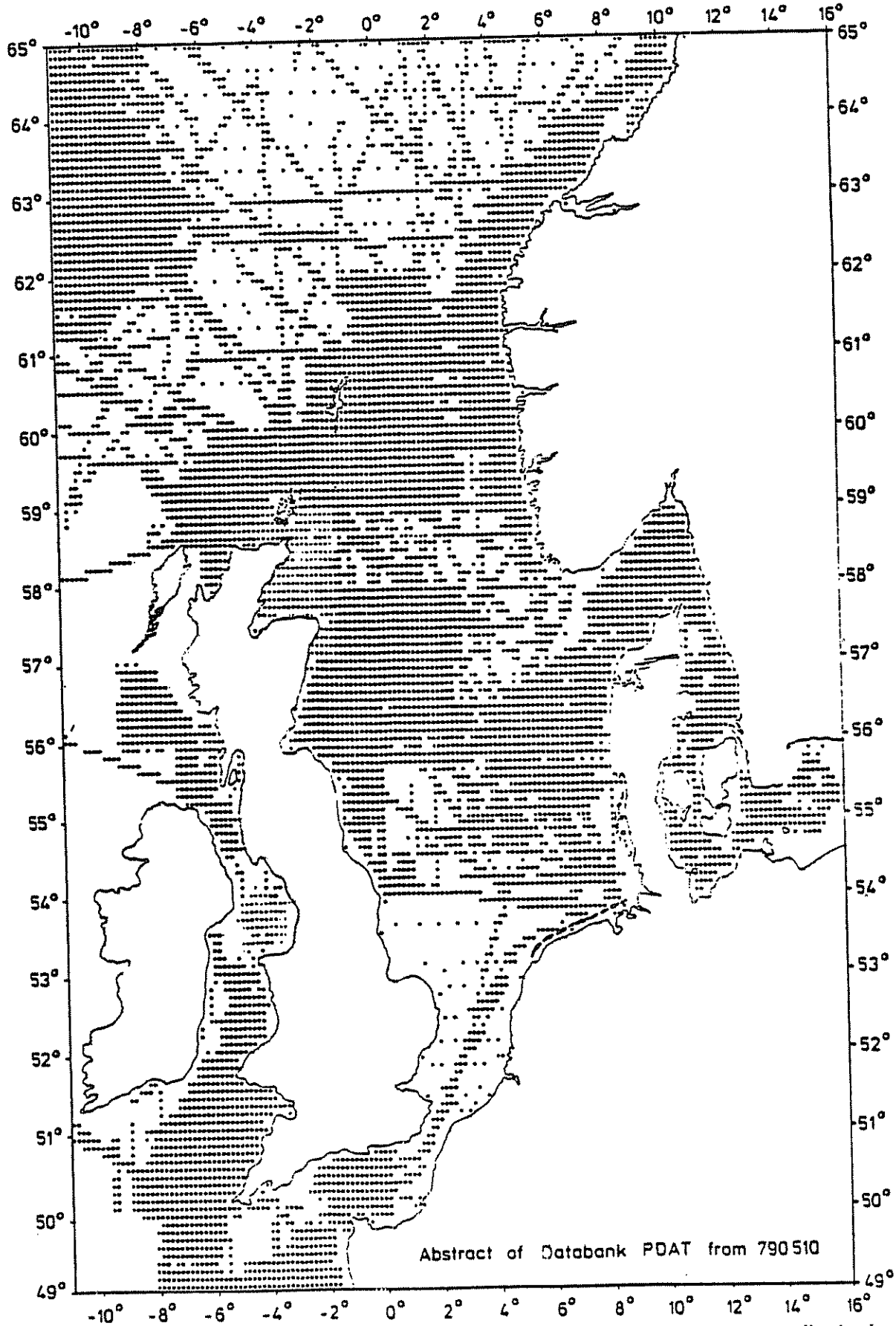


Figure 131. Federal Republic of Germany: distribution of sea gravity point anomalies in the North Sea region (approximately 90,000 observations)

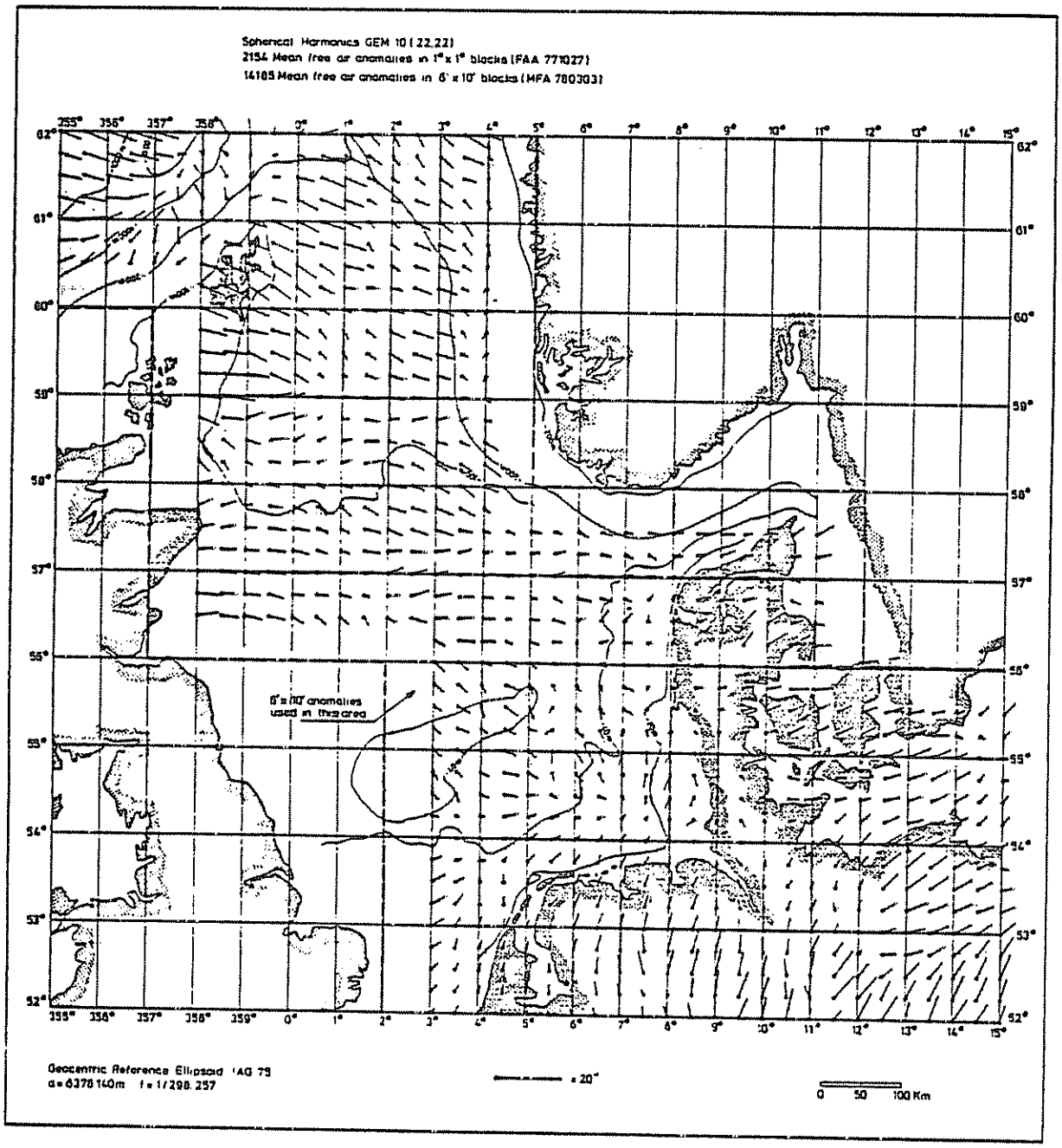


Figure 132. Federal Republic of Germany: GVDNS-I; gravimetric vertical deflections of the North Sea

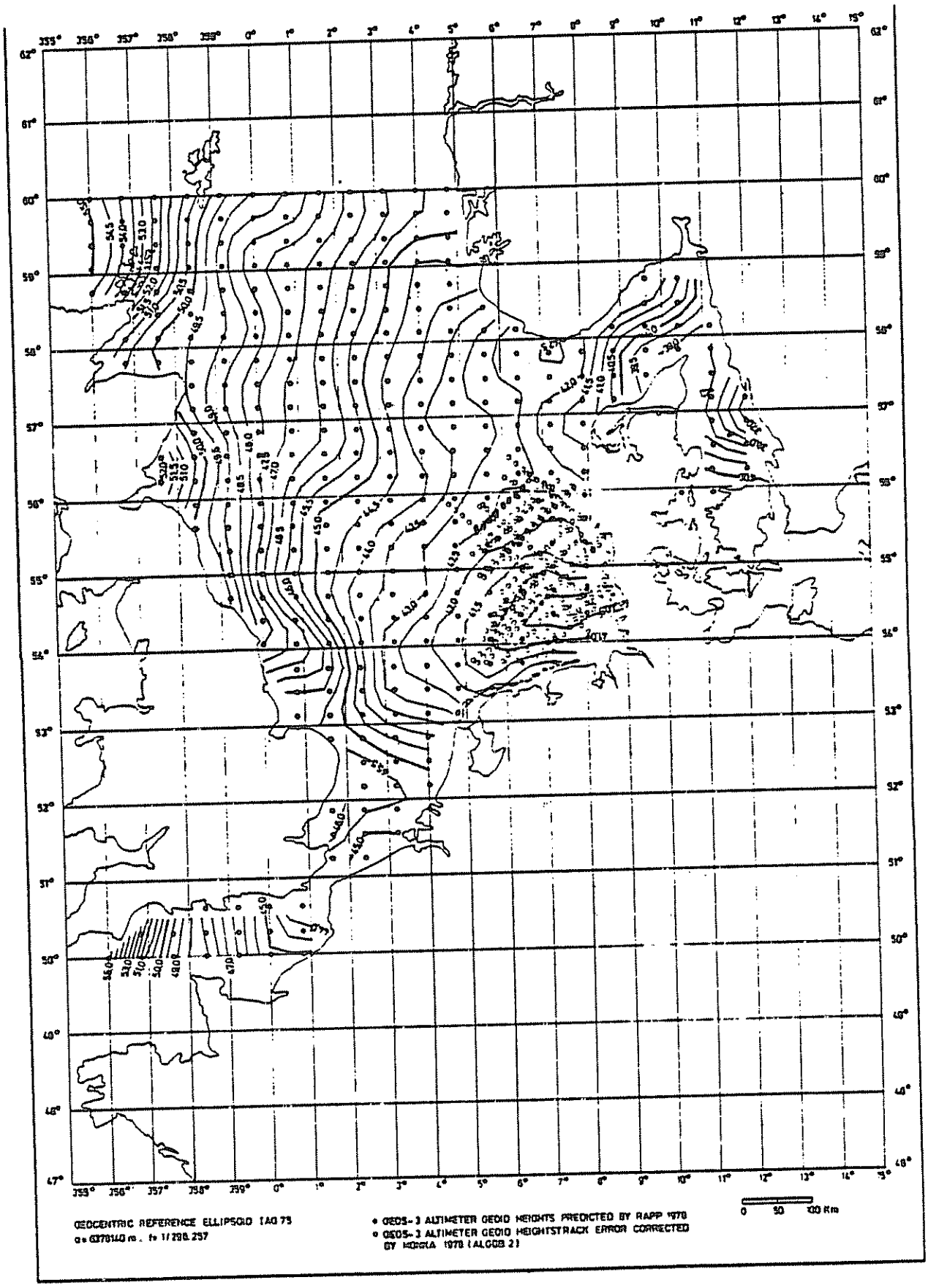


Figure 133. Federal Republic of Germany: GEOS-3 altimeter data for the North Sea geoid

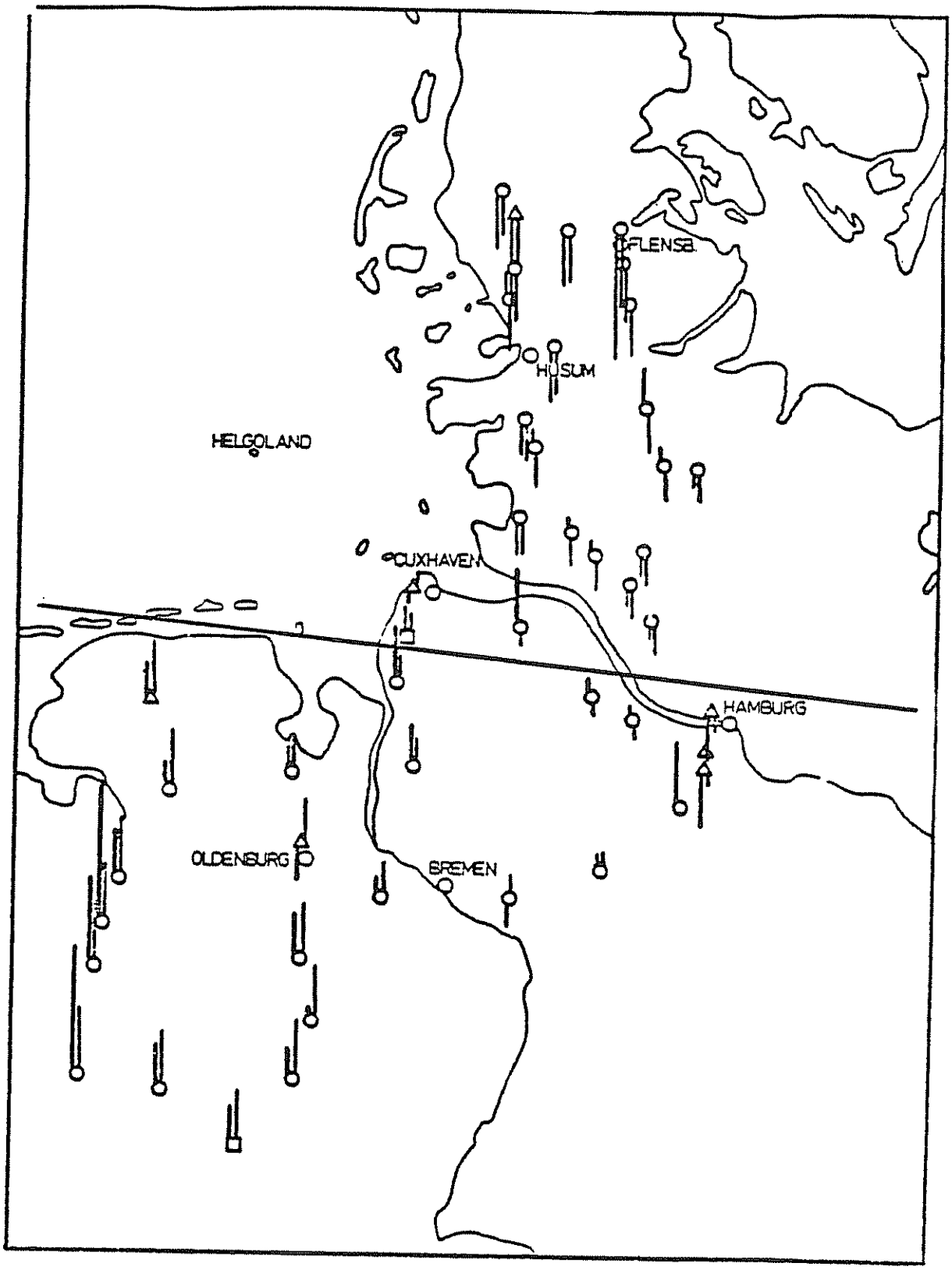


Figure 134. Federal Republic of Germany: analysis of the coastal level lines for crustal movements verification in the North Sea area

polated. The method looks promising, but still requires large investment in instrumentation and processing to make it practical.

REMOTE SENSING

The remote-sensing programme of coastal and marine areas in the Federal Republic of Germany started with the aircraft programme by the Federal Ministry of Research and Technology, in which DFVLR provided the imagery required.

Yearly flight campaigns have been organized since 1975. These were combined with ground observation programmes.

The following sensors were used: Hasselblad cameras, aerial mapping cameras with colour and infra-red false colour films, an M²S-11 channel multispectral scanner (with a thermal band) with digital output and the experimental sidelooking radar of the DFVLR. Besides this, LANDSAT imagery was available over the test area in digital form.

To analyse the imagery an interactive digital image analysis facility was set up in Hanover. It consists of an Optronics P1700 digital read-write drum scanner, which is linked to a computer with mass storage, fast processing facilities (array) and a colour CRT for display with a cursor, the latter being part of an interfaced image analyzer ISI 150.

This hardware is operated by an image processing system containing more than 80 modules for the enhancement, filtering, comparison or geometric transformation of images. The images may be read in from magnetic tape onto the mass storage. They are then processed and displayed on the CRT for further interactive measures. When the processing is deemed complete, the image is put out on the drum recorder on 23x23-cm film for reproduction. Multispectral classification routines requiring larger computer facilities are processed off-line on a Cyber 73/76 computer. This powerful image processing facility permitted the investigation of several remote-sensing applications in coastal areas, as described below.

Sediment transport. The coastal authorities are concerned about sediment changes along the ship channels, the dykes and the beaches. A method has been devised in the optical range to measure sediment concentration. In order to do this, sediment concentration of different intensities were measured in the laboratory and correlated to measurements of spectral reflectance. The reflectance curves permit surface sediment concentrations of clay in water bodies to be derived, if global irradiation is measured while the imagery is taken.

Mapping of pollutants. The test area near Wilhelmshaven contained various polluters (sewerage, industrial waste of a paper mill and chemical factories, thermal power plant). While the correlation of radiometric signatures with pollutants has been rather inconclusive in the optical range, it has been successful in the thermal range. Thermal images permit pollutants to be traced at varying tidal stages. A method has been developed to relate the digital image information to thermal measurements made on the water surface or to atmospheric parameters measured on the ground. The experiment yielded check accuracies of ± 0.2°C for the surface temperature of water with a minimum of about five control measurements in the image. If only atmospheric conditions are measured in the area no control points are required; however, the accuracy becomes ± 0.5°C.

Classification of tidal land. Multispectral classification of tidal lands was carried out by multivariate procedures with digitized colour aerial photographs, with M²S 11 channel images, and with LANDSAT images in four channels or more (multitemporal). All classifications were successful in separating up to eight classes of tidal lands. While the classifications of aerial photographs and of the M²S images were of experimental nature, LANDSAT imagery classifications have been made on an operational basis, separating moist sand areas from other tidal area types. These classifications were put out in a rectified manner conforming with a map grid. The Optronics output was produced as colour composites, to be combined with a 1:10,000 topographic map. In this way the moist sand areas of the North Sea coast of Schleswig-Holstein were rapidly mapped with a higher reliability than by conventional methods. A special concern is the inclusion of multitemporal images into the classification. For this purpose, investigations are being made which correlate different images over the same area made at different times in order to permit a geometric registration of these images.

HYDROGRAPHIC SURVEYING AND CHARTING: HYDRO-OCEANOGRAPHIC ACTIVITIES IN INDONESIA, 1977-1979*

Paper presented by Indonesia

RÉSUMÉ

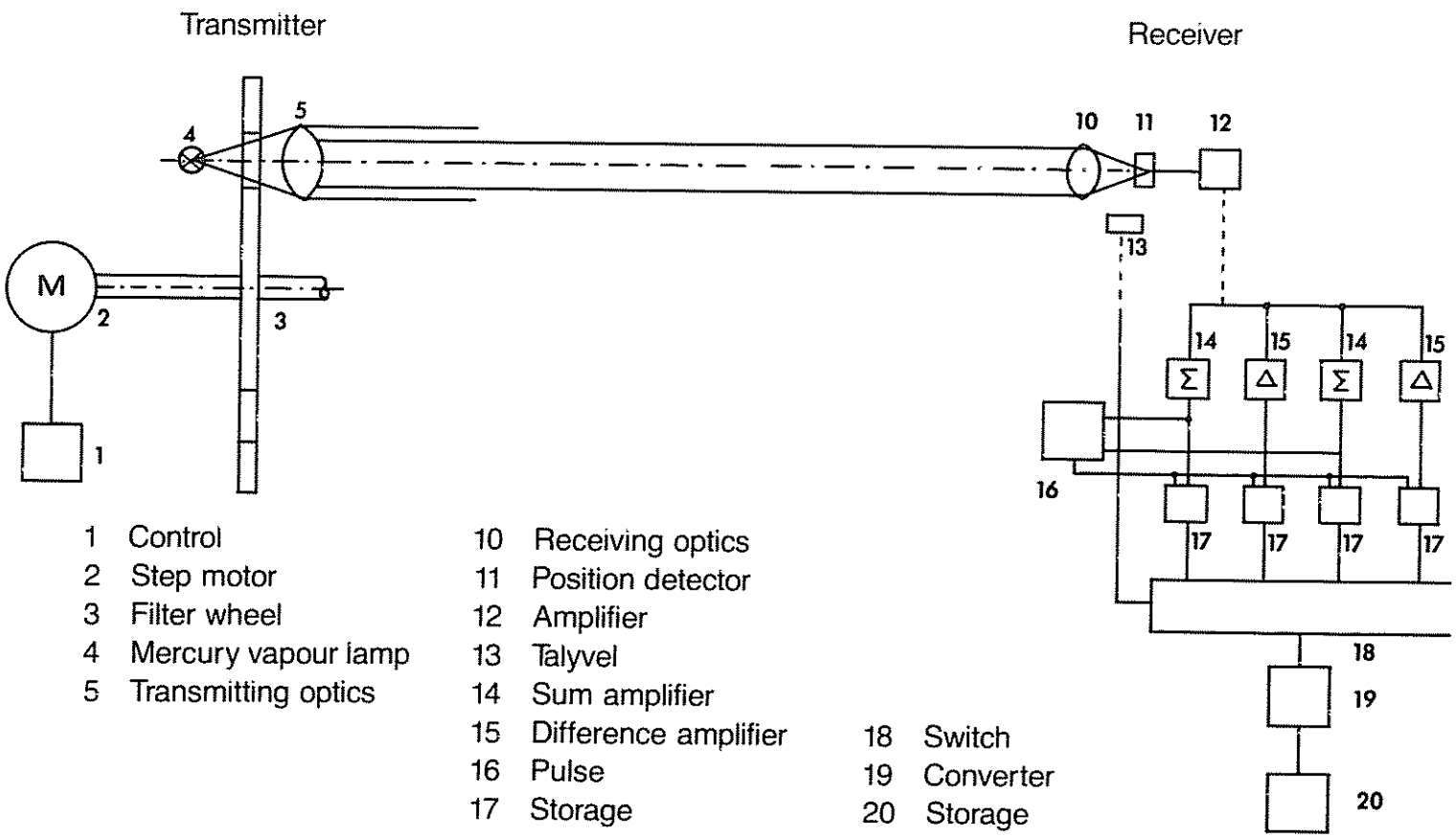
Le Naval Hydrographic Office (JANHIDROS-Service hydrographique de la marine) est chargé de diriger et réaliser les travaux hydro-océanographiques nécessaires aux départements de la marine ainsi que de la sécurité et de la défense, aux forces armées, et à des fins de caractère général et d'intérêt national.

Pour s'acquitter des tâches et responsabilités mentionnées ci-dessus, JANHIDROS assume les fonctions suivantes :

a) Planifier et définir un service hydro-océanographique dans le cadre des services topographiques et cartographiques des forces armées;

b) Planifier et programmer les activités hydro-océanographiques nécessaires à la marine;

*The original text of this paper, prepared by Jawatan Hidro-Oseanografi, appeared as document E/CONF.72/L.102.



1 Control
2 Step motor
3 Filter wheel
4 Mercury vapour lamp
5 Transmitting optics
10 Receiving optics
11 Position detector
12 Amplifier
13 Talyvel
14 Sum amplifier
15 Difference amplifier
16 Pulse
17 Storage
18 Switch
19 Converter
20 Storage

Figure 135. Federal Republic of Germany: dispersometer

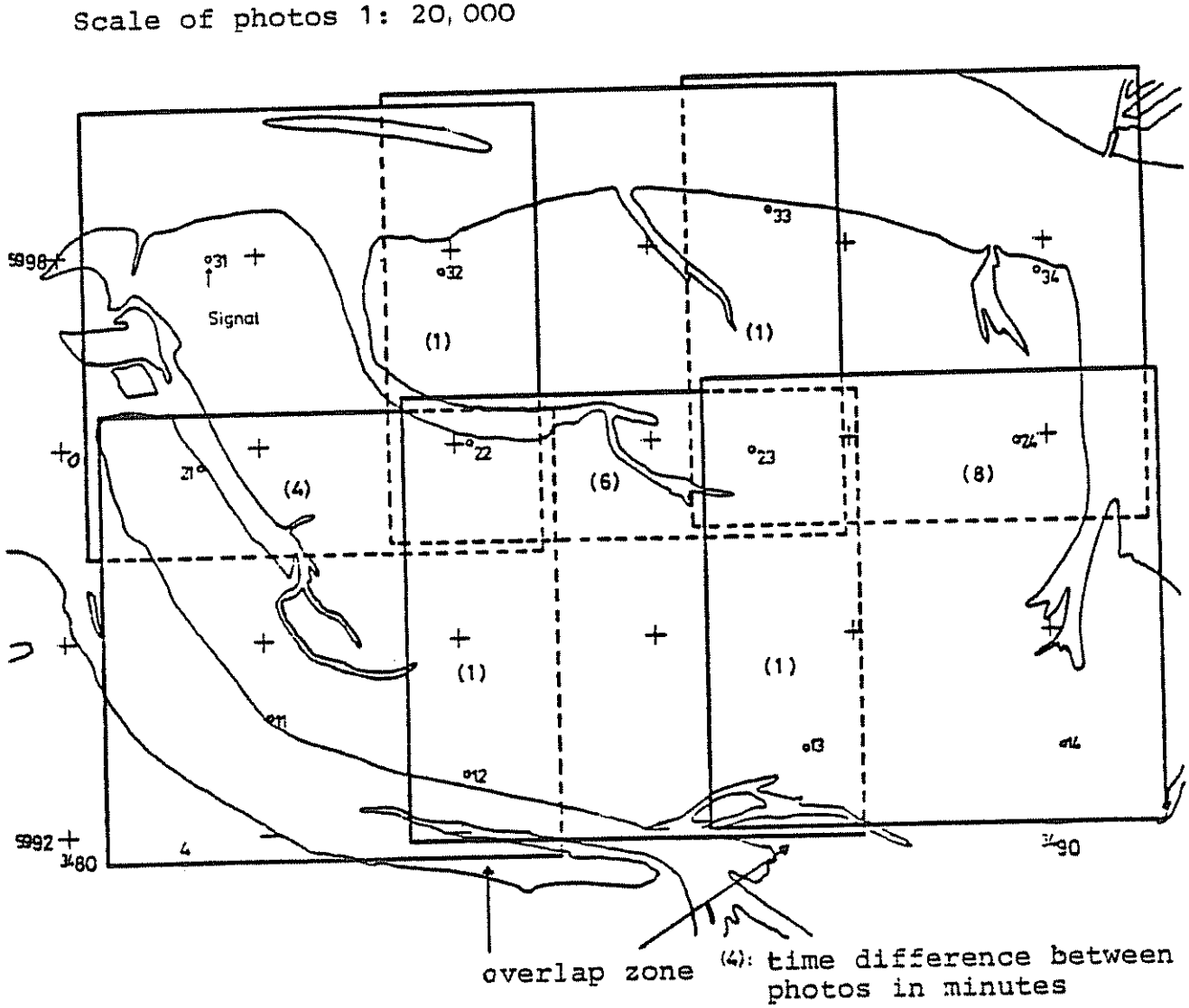


Figure 136. Federal Republic of Germany: "water-line" survey method

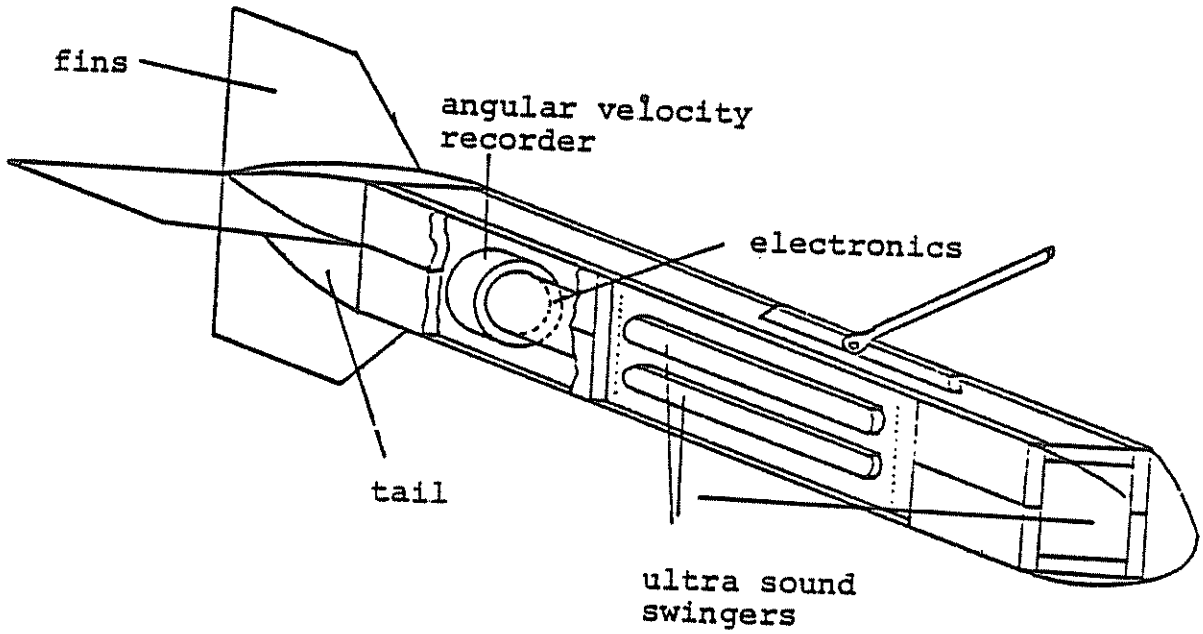


Figure 137. Federal Republic of Germany: EG&G sonar fish for underwater topographic surveys

c) Effectuer des levés hydro-océanographiques, publier et diffuser des informations et cartes marines et autres publications relatives à la navigation;

d) Assurer la coordination avec les institutions ou organes nationaux et internationaux d'hydrographie et d'océanographie dans le cadre des réglementations en vigueur;

e) Superviser l'exécution de ses programmes en vue d'obtenir des résultats satisfaisants;

f) Soumettre des propositions et des avis au chef d'état-major de la marine, notamment dans le domaine hydro-océanographique.

La programmation annuelle des travaux topographiques et cartographiques est fondée sur le plan quinquennal du National Co-ordination Agency for Surveys and Mapping (BAKOSURTANAL — Office national de coordination des activités topographiques et cartographiques). Ce plan tient compte des besoins des divers départements et services.

Les fonds nécessaires aux activités topographiques et cartographiques sont alloués par le BAKOSURTANAL, le Département des communications maritimes et d'autres organismes.

THE NAVAL HYDROGRAPHIC OFFICE

In August 1979 a minor structural change was made in the organization of the Naval Hydrographic Office (JANHIDROS). The structure of the organization as it now stands is shown in figure 138.

JANHIDROS is responsible for understanding and directing hydro-oceanographic works for naval, security and defence and armed forces requirements, as well as for the general purposes of the country. To accomplish those tasks and responsibilities, JANHIDROS carries out the following functions:

Planning and formulation of a hydro-oceanographic system within the framework of the Armed Forces Surveys and Mapping system;

Planning and programming hydro-oceanographic activities to fulfil naval requirements;

Conducting hydro-oceanographic surveys, issuing and publishing nautical information, charts and other sailing directories;

Co-ordination in hydro-oceanographic activities with national and international hydro-oceanographic institutions or bodies in accordance with existing regulations;

Supervising the execution of its programmes to ensure efficient and effective results;

Submitting proposals and advice to the Naval Chief of Staff especially regarding hydro-oceanographic matters.

PROGRAMME AND SURVEY ACTIVITIES

Annual programming for surveying and mapping is based on the Five-year Plan of the National Co-ordination Agency for Surveys and Mapping (BAKOSURTANAL). This plan incorporates requirements of various departments and agencies.

Funds for surveying and charting are allocated by BAKOSURTANAL, Department of Sea Communication, and other agencies.

HYDRO-OCEANOGRAPHIC SURVEYS

The following projects were carried out during the period under review (see figure 139):

(*a*) A hydrographic survey in the One Fathom Bank for the establishment and marking of a 23-metre navigable channel. The survey was performed by a joint team from Indonesia, Japan, Malaysia and Singapore; it commenced on 20 September 1978 and was completed on 2 November 1978, using Indonesian survey vessel *Kri. Burujulasad*. The results were made final in Jakarta and published in December 1978;

(*b*) Detailed hydrographic surveying in 20 ports, harbours and approaches to promote safety of navigation, in co-operation with the Directorate of Sea Communications and other government agencies;

(*c*) Minor hydrographic surveys for dredging and harbour facilities development projects;

(*d*) Tidal and current studies in the Straits of Malacca and Singapore were carried out by a joint team from Indonesia, Japan, Malaysia and Singapore from 1 March 1978 to 30 April 1979. The objective was to study characteristics of the tides and tidal currents in the straits of Malacca and Singapore. The results were finalized in Tokyo in November 1979 and will be published in February 1980;

(*e*) Establishment of tidal stations in Sunda Kelapa (Jakarta) and Bitung (North Sulawesi);

(*f*) A joint hydrographic survey with the United States Naval Oceanographic Office (NAVOCEANO) for the promotion of safe navigation in the Makassar and Lombok straits, using *KRI Jalanidhi, KRI Burujulasad* and *USNS Chauvenet*, started in 1978 and is still in progress. During the first phase, a Doppler receiver of Geoceiver type was used for the establishment of horizontal control points, while ARGO and Raydist were employed for positioning. The nautical charts resulting from this survey will be based on the WGS-72 datum;

(*g*) A joint magnetic survey with NAVOCEANO, using RP-3D aircraft in the Sunda, Makassar and Lombok straits was started and is in progress. During the first phase, the survey in the Sunda Straits was finished, and during the second phase parts of the Makassar Strait were surveyed;

(*h*) A joint landmark-investigation survey carried out by Indonesia, from 8 January to 21 January 1979 to update the drawing guides for the compassing of CDC of the Malacca and Singapore straits.

Based on the results of the surveys mentioned in (*a*) and (*e*) above, a total of 20 numbers of nautical charts at various scales ranging from 1:25,000 to 1:200,000

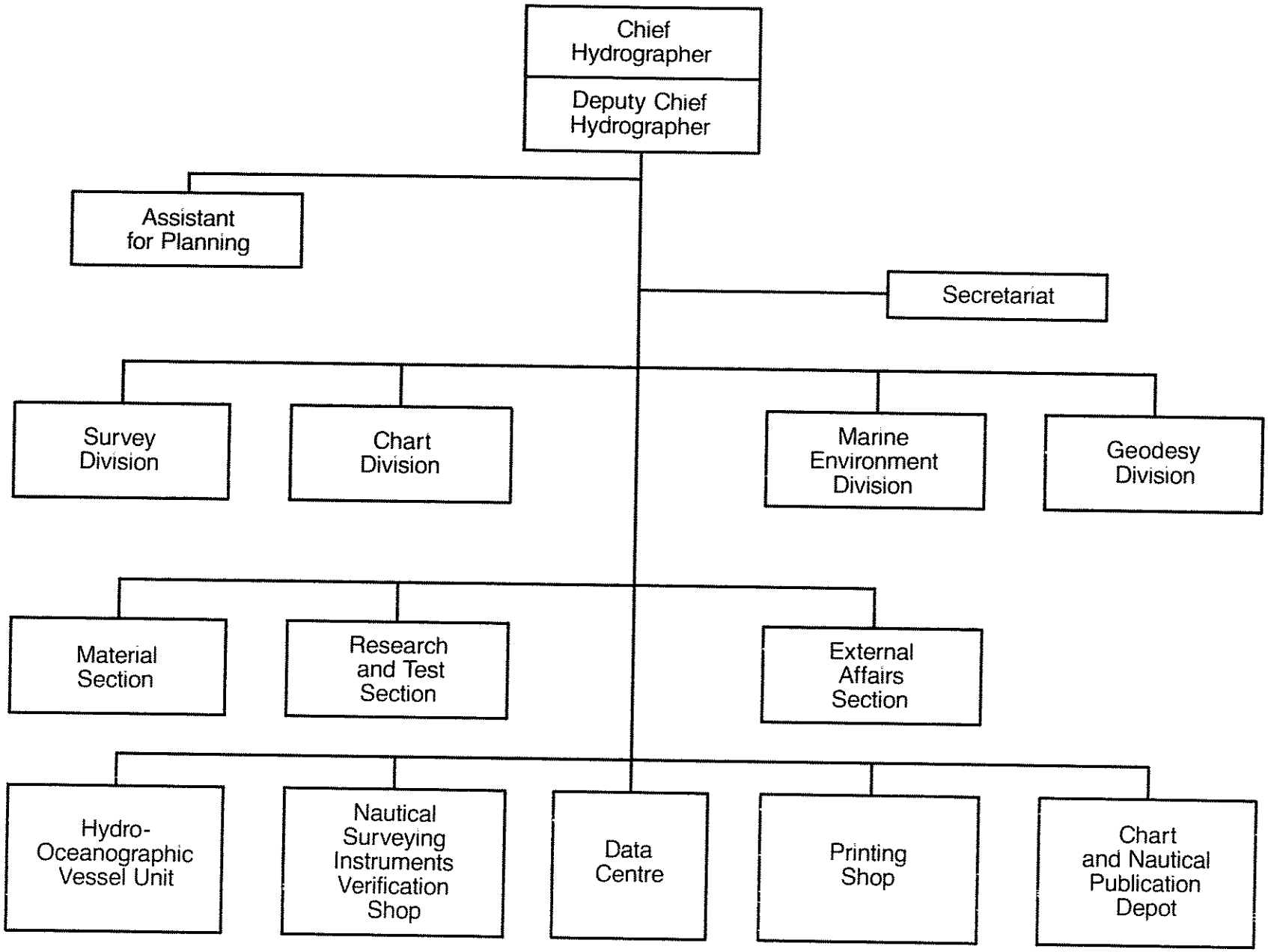


Figure 138. Indonesia: organization chart of the Naval Hydrographic Office (JANHIDROS)

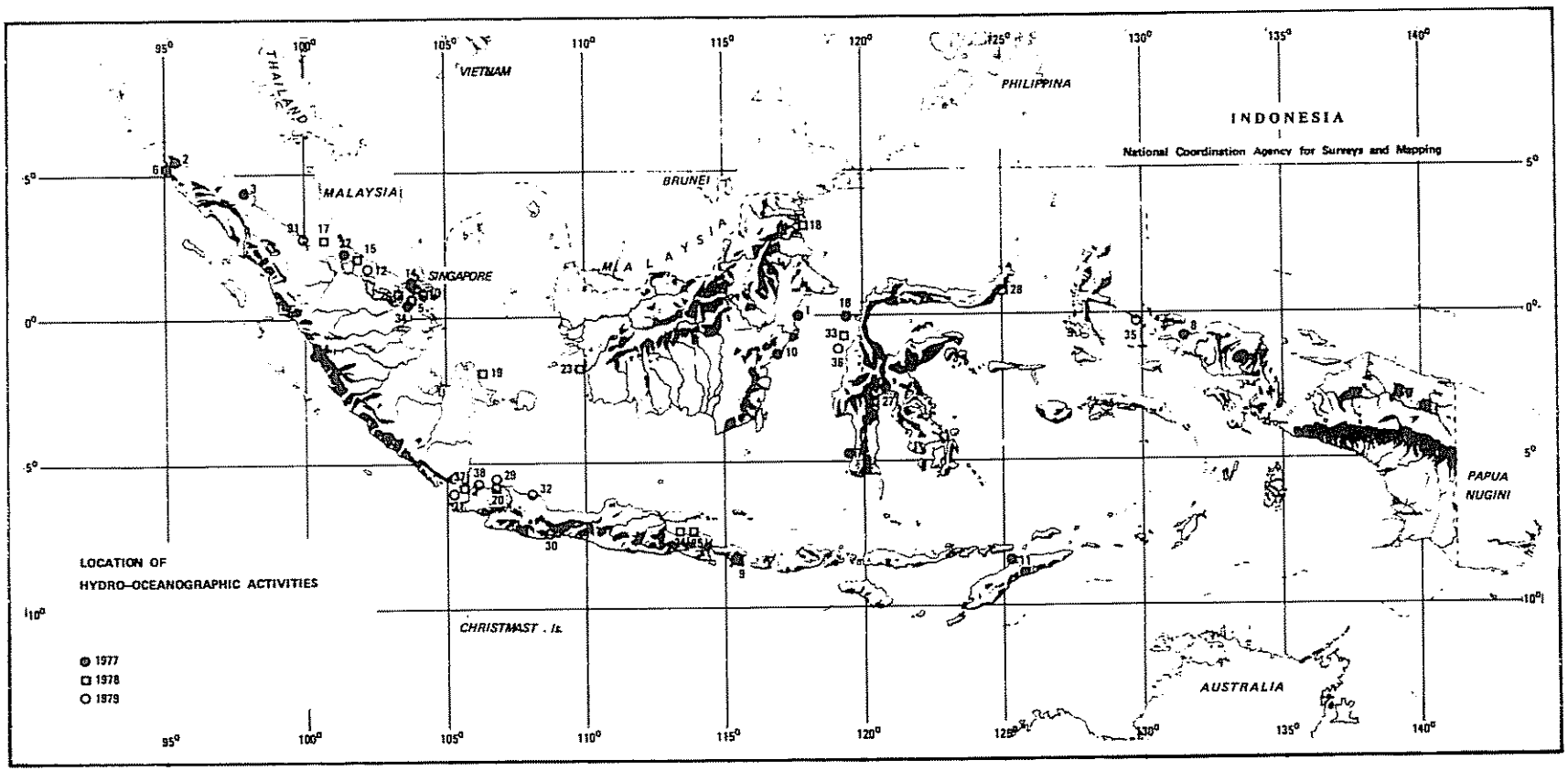


Figure 139. Indonesia: location of hydro-oceanographic activities

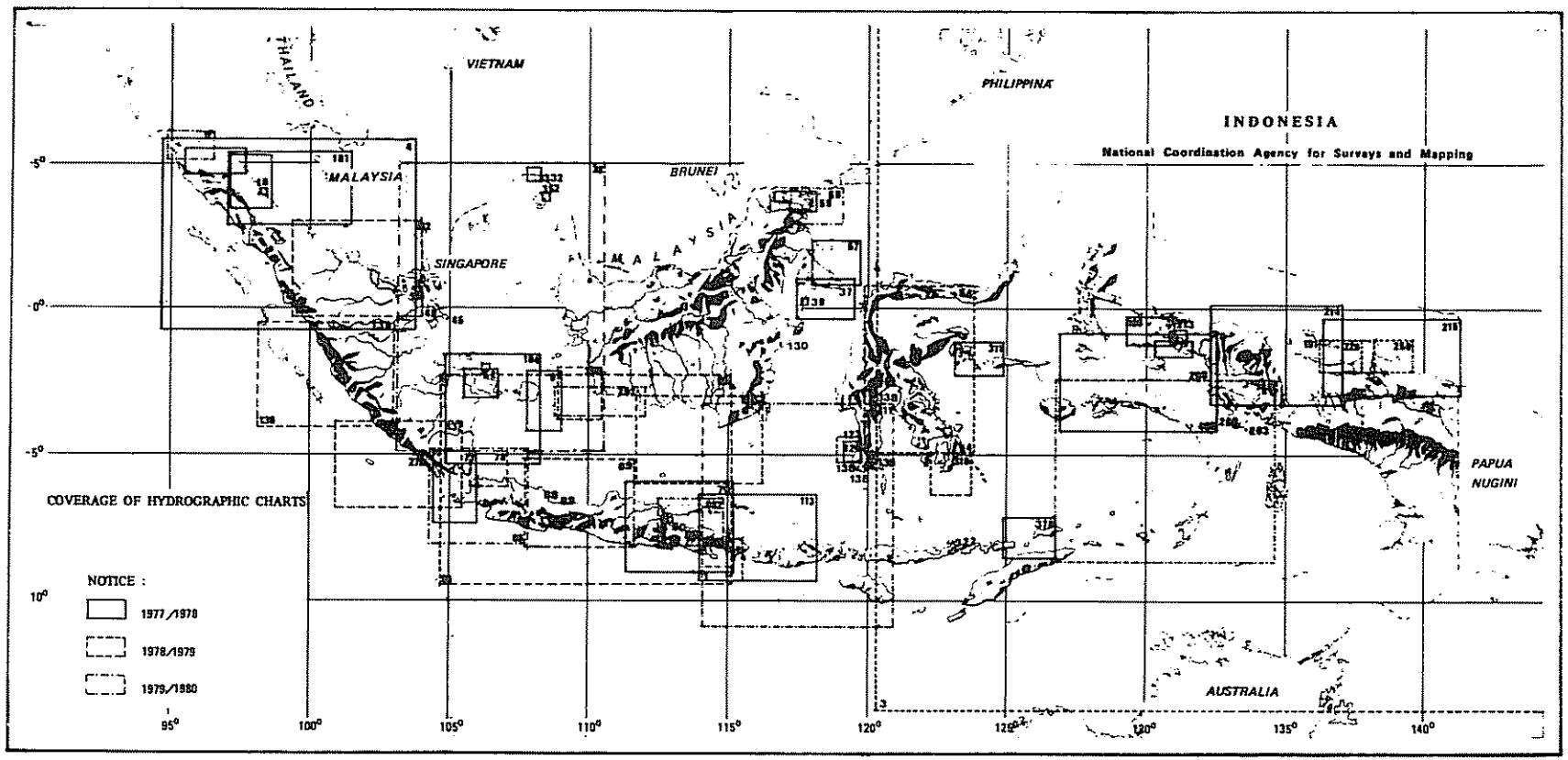


Figure 140. Indonesia: coverage of hydrographic charts

were revised and published as new editions. In addition to those, a total of 48 numbers of nautical charts were corrected or revised (figure 140).

As a follow-up of the joint surveys carried out in the Malacca and Singapore straits, the necessity was felt of having common charts of the straits based on a common datum. During the first stage, a total of three numbers of nautical charts covering the Singapore Strait were prepared in Tokyo between March 1978 and September 1979 and published in December 1979. The next phases are expected to start in 1981.

TECHNICAL ASSISTANCE

During the hydrographic survey in the Makassar Strait, technical assistance was received from NAVOCEANO. The assistance consisted in providing electronic positioning systems and the necessary technicians.

During the joint tidal and current studies in the Malacca and Singapore straits, technical assistance was provided by the Government of Japan consisting of tide gauges and current meters.

TRAINING

Training is undertaken locally or abroad. This training is urgently required to increase acquired knowledge, especially pertaining to hydrography and oceanography. The training is achieved within the framework of the general Navy programme as well as through JANHIDROS programmes adjusted to requirements of JANHIDROS' specific responsibilities. Training undertaken abroad has been in the fields of hydrography, oceanography, lithography, navigation, operational research and computer programming.

The countries where training was obtained were: Australia, India, Japan and the United States of America.

Local training consisted mainly of training required for promotion of officers, petty officers and ratings in accordance with the Navy programme. Within the framework of the JANHIDROS programmes mainly petty officers, ratings and civilian personnel are trained to carry out technical as well as administrative tasks of JANHIDROS.

Taking into consideration that India supplies training facilities in the field of hydro-oceanography, it is expected that the United Nations specialized agencies will provide scholarships for JANHIDROS personnel.

OTHER MATTERS

Five General Bathymetric Chart of the Oceans (GEBCO) sheets were updated with data from the Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP).

Publication of bilingual charts is scheduled when the joint surveys in the Makassar and Lombok straits are completed in co-operation with the United States Defense Mapping Agency.

MAGNETIC SURVEY IN THE SUNDA, LOMBOK AND MAKASSAR STRAITS*

Paper presented by Indonesia

RÉSUMÉ

Des mesures du champ magnétique ont été effectuées dans les zones du détroit de la Sonde et une partie des zones II et III du détroit de Macassar par des aéronefs de la Marine des Etats-Unis d'Amérique spécialement équipés d'appareils magnétométriques. Cette opération entre dans le cadre du projet du Comité pour la coordination de la prospection commune des ressources minérales au large des côtes d'Asie que des équipes de l'Office naval hydro-océanographique indonésien et du Naval Oceanographic Office des Etats-Unis exécutent de concert.

Les aéronefs de la Marine des Etats-Unis équipés de magnétomètres RP-3D à hélium métastable et vanne de flux ont parcouru environ 25 000 milles à une altitude de 500 pieds (150 mètres) au-dessus du niveau de la mer en effectuant des passages à intervalles de 3 milles parallèlement à l'axe principal de mesure, et à intervalles de 15 milles perpendiculairement à cet axe.

Les données recueillies ont été traitées à la Division géomagnétique du Naval Oceanographic Office des Etats-Unis.

The Memorandum of Procedure of the Hydrographic and Magnetic Survey was signed in Jakarta between the Indonesian Hydro-Oceanographic Service (JANHIDROS) and the United States Naval Oceanographic Office (NAVOCEANO) in April 1978. Based on that Memorandum, the magnetic survey was to be conducted jointly by JANHIDROS and NAVOCEANO, in the area of the Sunda, Lombok and Makassar straits.

*The original text of this paper, prepared by Jawatan Hidro-Oseanografi, appeared as document E/CONF.72/L.104.

SURVEY AREAS

The areas to be surveyed, excluding all land areas, are as follows:

1. *Sunda Strait with limits*
   Lat. 04°20′ S - 07°20′ S
   Long. 103°30′ E - 107°00′ E (see figure 141)
2. *Lombok Strait and vicinity with limits*
   Lat. 06°00′ S - 10°00′ S
   Long. 114°40′ E - 119°00′ E (see figure 142)

3. *Makassar Strait with limits*

Area I

Lat. 00°00′ - 02°40′ N
Long. 116°00′ E - 112°00′ E

Area II

Lat. 00°00′ - 03°00′ S
Long. 116°00′ E - 112°00′ E

Area III

Lat. 03°00′ S - 06°00′ S
Long. 116°00′ E - 112°00′ E (see figure 142)

OUTLINE OF OPERATIONS

The survey was conducted from a United States naval aircraft especially equipped with magnetic observations instruments.

Survey flights were flown out of:

(*a*) Sunda Strait area: Kemayoran Airport, Jakarta;

(*b*) Lombok and Makassar straits: Ngurah Rai Airport Denpasar, Bali.

Ground stations were set up at:

(*a*) Sunda Strait area: Kemayoran Airport;

(*b*) Lombok and Makassar straits area: Ngurah Rai Airport, Denpasar, Bali.

Procedures

This magnetic survey was carried out with the use of a fluxgate and helium vapour airborne magnetometer. The instrument was fixed on board the aircraft. The aircraft flew with the following specifications.

Course—NS/SN and EW/WE

Interval—Sunda Strait; 3 miles for SN/NS and 15 miles for WE/EW
Makassar Strait; 3 miles for WE/EW and 15 miles for NS/SN

Altitude and speed—500 feet above sea level, 240 knots

Equipment

Craft: RP3D survey aircraft *Orion*

Measurement and data product:

(*a*) Data measured by the magnetic survey system are formatted for recording on an H 316 airborne computer. The following data are recorded digitally on magnetic tape:

Vector magnetic measurements;
Scalar magnetic measurements;
Satellite observation;
Inertial navigational information;
Loran-C positions;
Doppler radar altimeter;
Celestial observations;

(*b*) During the surveys ground station data consisting of digital and analog recording of the earth's diurnal change were recorded and analysed to determine the effects of this change on the survey.

FIELD OPERATIONS

Sunda Strait area

(*a*) The survey was carried out from 26 October 1978 until 2 November 1978;

(*b*) RP3D survey aircraft *Orion* was used in this operation;

(*c*) Daily working hours were approximately 10 hours;

(*d*) Total survey mileage can be determined:
NS/SN 72 lines, length: 7,896 miles
WE/EW 12 lines, length: 1,669 miles
Total mileage: 9,565 miles;

(*e*) Base and ground station was established at Kemayoran Airport, Jakarta.

Makassar Strait

Area III

(*a*) The survey was carried out from 6 November 1978 to 5 December 1978;

(*b*) RP3D survey aircraft *Orion* was used in this operation;

(*c*) Daily working hours were approximately 10 hours;

(*d*) Total survey mileage: 20,620 miles;

(*e*) Base and ground station was established at Ngurah Rai Airport, Denpasar, Bali.

Area II

(*a*) The survey was carried out from 12 October 1979 until 13 December 1979;

(*b*) RP3D survey aircraft *Orion* was used in this operation;

(*c*) Daily working hours were approximately 10 hours;

(*d*) Total survey mileage: 20,482 miles;

(*e*) Base and ground station was established at Ngurah Rai Airport, Denpasar, Bali.

Area I

Area I of Makassar Strait and Lombok Strait will be done in 1980/1981.

DATA PROCESSING

The magnetic data of the Sunda Strait and Makassar Strait, area III, were processed at the Geomagnetic Division of the Naval Oceanographic Office from 15 January to 25 July 1979, with two Indonesian personnel participating.

The field data were analysed on the UNIVAC 1108; the computer provided:

1. Navigation correction
2. Digitizing of the ground station data
3. Out file
4. Profiles
5. Navigation plots
6. Cross contour
7. Contour
8. Daily variation removed

Contour drawings have now been corrected. Geologic interpretation is not yet completed. The total magnetic intensity chart has now been done. Compilation and chart printing will be reproduced at the Defense Mapping Agency, Washington, D.C.

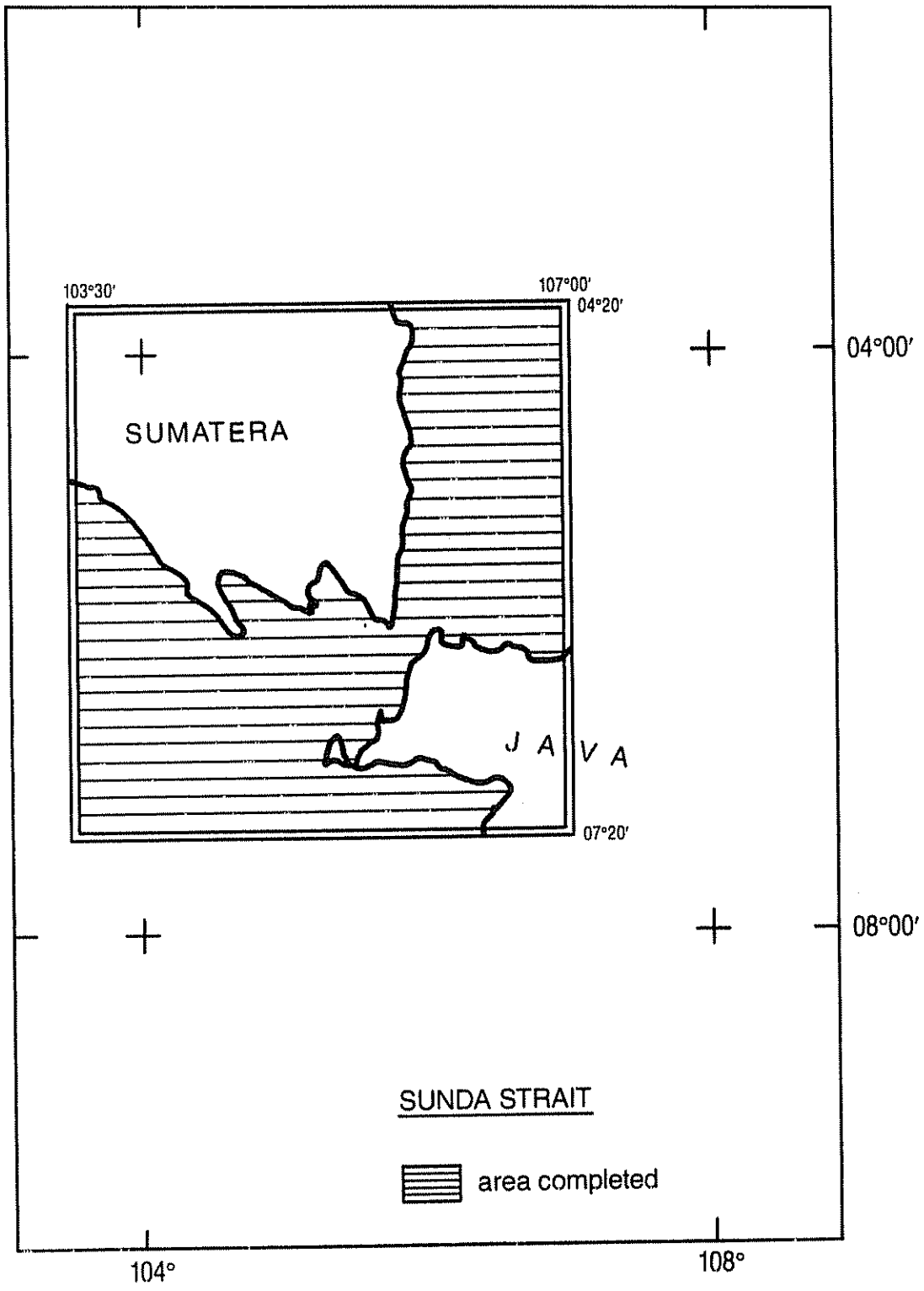


Figure 141. Indonesia: magnetic survey in Sunda Strait

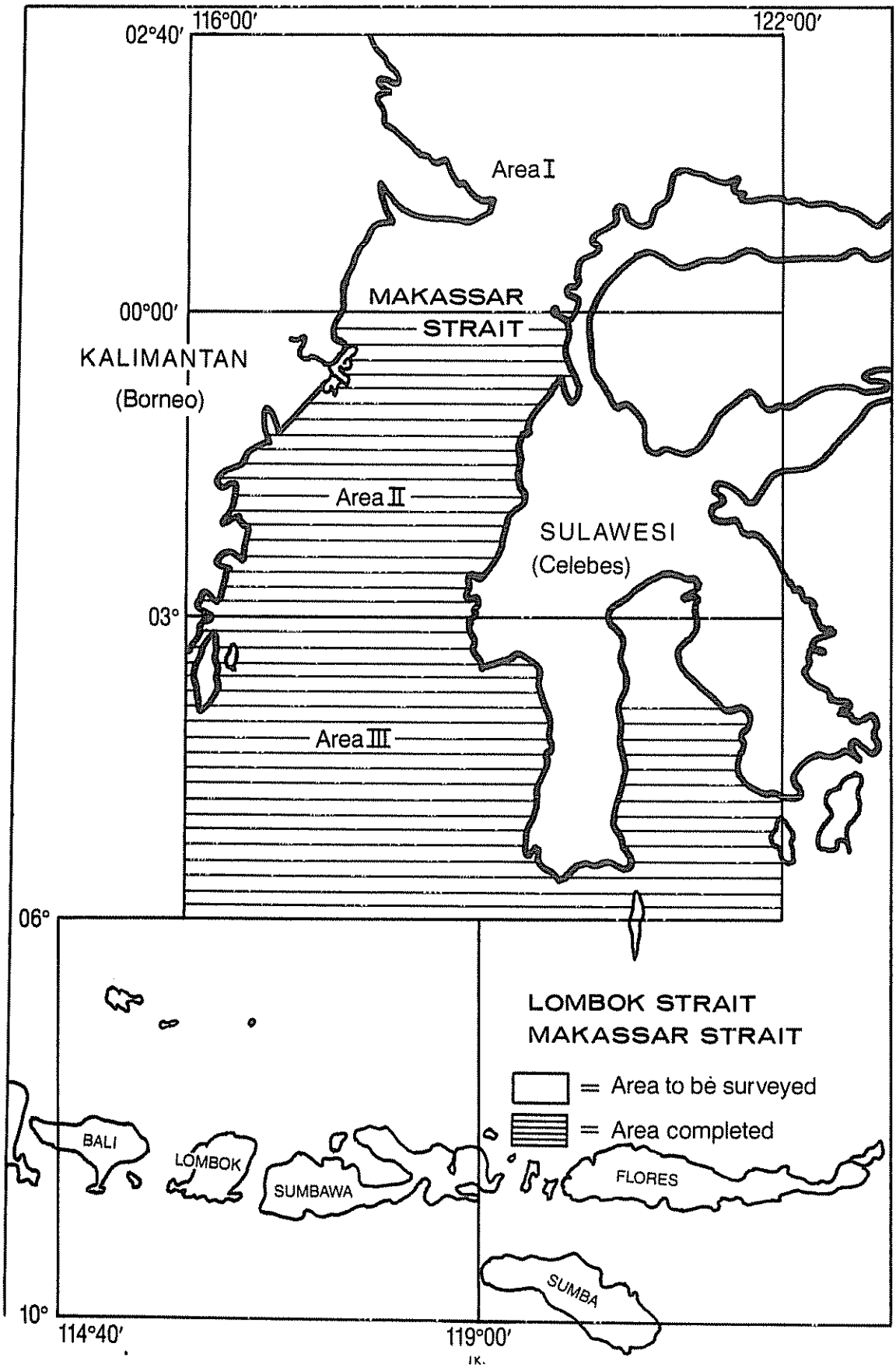


Figure 142. Indonesia: magnetic survey in Lombok and Makassar straits

JOINT PRODUCTION OF THE COMMON DATUM CHARTS OF THE STRAITS OF MALACCA AND SINGAPORE*

Paper presented by Japan

RÉSUMÉ

L'Indonésie, le Japon, la Malaisie et Singapour ont, de 1969 à 1975, effectué conjointement des levés hydrographiques sur les détroits de Malacca et de Singapour. Les résultats de ces levés collectifs ont été utilisés pour réviser les cartes marines correspondantes.

Les cartes existant actuellement sur les détroits se fondent sur différents systèmes de référence géodésique, notamment le système révisé de Kertau et le système de Bangka, ce qui entraîne des erreurs dans la détermination des positions lorsque les relèvements sont pris sur des objets situés sur des côtés opposés des détroits. Les quatre Etats sont convenus en 1977 d'éliminer ces causes d'erreur et d'établir des cartes fondées sur un système de référence géodésique commun. Ces cartes ont été achevées en 1979.

Joint hydrographic surveys on the Straits of Malacca and Singapore were carried out by Indonesia, Japan, Malaysia and Singapore from 1969 to 1975. The results of the joint surveys were utilized in revising the nautical charts concerned.

Existing charts covering the Straits are based on different geodetic datums, viz. Revised Kertau Datum and Bangka Datum, which give discrepancies in position fixing when bearings are taken from objects located at opposite sides of the Straits. In 1977, it was agreed upon by the four nations to eliminate such discrepancies and to produce charts based on a common geodetic datum.

Fortunately, there was a fundamental point fixed on WGS-72 at Pulau Pisan in the western approach to the Singapore Strait. This was also the point where the geographical co-ordinates on the Revised Kertau Datum on the Malaysian side and those on the Bangka Datum on the Indonesian side were connected during the joint hydrographic surveys.

The geographical co-ordinates of existing smooth sheets were modified according to the differences between both datums and WGS-72. The Common Datum Charts are the master sheets to be used for producing nautical charts of each nation, with minimum modifications in line with the format of each nation. The coverage and scale of the Common Datum Charts are as follows:

Sheet 1:	1:50,000	103°21'0"E	01°16'30"N 00°57'48"N	103°47'0"E
Sheet 2:	1:50,000	103°36'0"E	01°20'0"N 01°02'0"N	104°03'0"E
Sheet 3:	1:75,000	103°58'0"E	01°32'0"N 01°04'0"N	104°37'0"E

Joint production of the Common Datum Charts was performed through the following stages: collection of source materials, verification of source materials, preparation of specifications, chart compilation, investigation of landmarks, preparation of repromats and finalization. The Common Datum Charts were completed and finalized in 1979.

*The original text of this paper, prepared by T. Sato, Hydrographic Department, appeared as document E/CONF.72/L.87.

THE MARINE GEODETIC NETWORK AROUND JAPAN: A NEW PROJECT*

Paper presented by Japan

RÉSUMÉ

Pour rattacher les cartes marines japonaises à l'ellipsoïde de référence mondiale, l'Hydrographic Department (Service hydrographique) du Japon doit veiller à ce que : *a*) toutes les îles appartenant au Japon soient rattachées au système local de référence géodésique du Japon, à savoir le système de Tokyo, et *b*) à ce que le système de Tokyo soit rattaché à l'ellipsoïde de référence mondiale. Sur la base de ces considérations, le Service hydrographique japonais entreprendra, à partir de l'exercice budgétaire 1980, un nouveau projet de construction du réseau géodésique maritime autour du Japon. Ce projet permettra de rattacher toutes les îles appartenant au Japon au système de Tokyo avec une précision de l'ordre de moins de 10 mètres, en utilisant les observations géodésiques Doppler des satellites du système de satellites de navigation de la marine des Etats-Unis d'Amérique. Une technique d'observations simultanées à partir de positions différentes *(translocation)* sera appliquée au moyen de trois récepteurs Doppler portatifs.

In order to relate the Japanese nautical charts to the World Geodetic Datum, the Hydrographic Department of Japan must consider: (*a*) that all the islands belonging to Japan should be related to the Japanese local geodetic datum, i.e. the Tokyo Datum; and (*b*) that the Tokyo Datum should be related to the World Geodetic

*The original text of this paper, prepared by A. Yamazaki, Hydrographic Department, appeared as document E/CONF.72/L.88.

Datum. Based on these considerations, the Hydrographic Department of Japan will start a new project of constructing the Marine Geodetic Network around Japan from fiscal 1980. In this project, all the islands belonging to Japan will be related to the Tokyo Datum with an accuracy of better than 10 metres by using the geodetic Doppler observations of satellites of the Navy Navigational Satellite System. A translocation technique will be employed by using three portable Doppler receivers.

The network station located at each of those islands will be maintained as a permanent station where a markstone will be placed in a way similar to a triangulation station on land. A gravity value and a geoidal height will be given at the station with the conventional geodetic co-ordinates, i.e. latitude, longitude and height above mean sea level.

Laser trackings of geodetic satellites such as Lageos and Geos will also be carried out for the purpose of relating the Tokyo Datum to the World Geodetic Datum. The laser tracking device, to be located near the central part of the mainland of Japan, will range Lageos with an accuracy of one decimetre or better. It will be available for the routine satellite trackings around mid-year 1981. Located in such a region in the world, where satellite tracking stations are sparse, this station will be very useful for construction of an improved world geodetic co-ordinate system.

THE HISTORY AND DEVELOPMENT OF THE NEW ZEALAND HYDROGRAPHIC OFFICE, 1950-1980*

Paper presented by New Zealand

RÉSUMÉ

Ce document retrace l'historique d'un petit service hydrographique et donne un aperçu de son expansion et de son développement durant ses 30 années d'existence.

On y trouve des suggestions et orientations susceptibles d'intéresser les pays qui envisagent de créer un service hydrographique.

The history of the New Zealand Hydrographic Office can be said to have begun in July 1939 with the termination of the British survey (commenced only two years earlier) because of the imminent outbreak of hostilities between Great Britain and Germany. After the end of the war various interests demanded a resumption of the survey, and the matter was discussed with the Admiralty who were approached to take up the survey as before: that is, the Royal Navy provided the ship and men, and the Government of New Zealand met the cost. This proposal, however, was declined because of heavy demands on the Royal Navy Surveying Service and the need to survey more important strategic areas. It was suggested that the New Zealand Government should find their own survey ship, the Admiralty indicating that they would be prepared to loan experienced surveying officers and recorders to the Royal New Zealand Navy so that the task could be undertaken. The Government agreed to this approach and the loan from the Royal Australian Navy of a frigate converted for surveying operations was negotiated. The *Lachlan*, as she was known, commenced work in New Zealand waters in November 1949 by surveying the Cook Strait area and Wellington Harbour, on completion of which the scene of operations moved south to Foveaux Strait, where the first half of 1950 was spent.

The shore-based part of hydrography in New Zealand began with the provision by the Department of Lands and Survey of a draughtsman who initially worked aboard the survey vessel, the chart being compiled there and brought ashore to be printed locally. It was soon found however, that this procedure was unsatisfactory. Nevertheless the decision to compile and print charts in New Zealand, instead of sending the surveys to the Admiralty for processing and chart production in England, marked the beginning of a Hydrographic Office in New Zealand. It was fortunate that these events coincided with the recruitment of two draughtsmen by the Department of Lands and Survey for duties in their cartographic branch who had considerable hydrographic chart compilation experience and who had, until their arrival in New Zealand, been employed and trained in the British Admiralty Hydrographic Department. The first of these, followed soon afterwards by the second, was soon employed in the embryo hydrographic section in place of the Lands and Survey draughtsman earlier loaned for duties on the *Lachlan*. At this time supervision of cartographic activities was achieved by the captain of the survey ship visiting the drawing office ashore between survey voyages to inspect, advise and inform himself of the progress. Assistance to these activities was also given by the posting ashore from the survey ship of a Petty Officer who assisted the draughting staff. Somewhat later, a Wren rating was provided by the Navy for draughting-assistant duties in the office.

At this stage, about 80 per cent of the British Admiralty charts of New Zealand were based on data collected 100 years earlier. Thus, the situation at this time was that New Zealand had acquired a survey ship of some 1,450 tons, manned by five trained and two untrained surveying officers who, together with half a dozen trained surveying recorders, formed the specialist nucleus of the ship's company.

In the early days very rapid progress was made, both in surveying and chart production, so that by the end of 1956 some eight coastal charts and nine harbour charts had been produced. It may be of interest to note that the initial rate of production of charts diminished after the first three years, four charts being published each year in 1951 and 1952 reducing to two or three in succeeding years despite the number of draughting staff being double that of the first year. One of the main reasons for

*The original text of this paper, prepared by R. Evins, Assistant Hydrographer (civil), Ministry of Defence, appeared as document E/CONF.72/L.15.

this was the requirement, which still of course exists, to keep published charts constantly corrected to date. Thus the more charts published, the greater the proportion of cartographic time which must be spent on chart correction, paper-work and records. In addition, production of charts generates other related activities—to name but a few: distribution, stockholding and reprinting. With such a small office it was not possible to carry out all the functions of large hydrographic offices elsewhere. Such tasks as the publication of tide tables, light lists, sailing directions etc., were not attempted. Data and information on these subjects were sent to the United Kingdom Hydrographer for inclusion in his publications. In the interests of centralization of activities relating to hydrographic charting, the Hydrographic Section was transferred from the Department of Lands and Survey to the Navy Office in 1953.

In those early formative times hydrographic charts were produced from an original drawing made on opaque and later transparent plastic sheets. Various methods and techniques were used but a high standard of draughting was achieved, using various experimental inks with a pen or brush. Drawings were mostly at the same scale and were photographed to wet plate glass negatives, which incidentally frequently required an enormous amount of cutting in of weak lines; from thence they went to albumen-coated zinc plates and were printed on rotary offset printing presses one colour at a time. The earliest charts were completely hand-drawn, but it was not long before sounding numerals, and later names, were produced on stripping film and applied by means of a wax adhesive to the drawing. Various improvements in materials and techniques followed. Chief among these was the introduction of stable matt transparent plastic foils, the drawings on which could be contacted to film negatives on equally stable plastics and thence to deep-etch aluminium printing plates.

Scribing on coated foils began to be utilized in 1958, and this process is now used almost exclusively for the preparation of line-work, the resulting engraved negative being contacted to a positive to which lettering etc. is added. Positives are used throughout the preparation of drawings until the final stage of colour-proofing when reproduction negatives are made and supplied to the printer for plate-making. Today these techniques have been further refined, so that now all lettering, soundings and symbols are applied by means of photographic impressions on wax stripping film, and colour masks, from which screened blue tints are made, are prepared from strip-and-peel foils. On certain charts relief is depicted by means of hill shading, and drawings for these are prepared by the dark-plate method by which shadows are added with a crayon and light areas created by selectively removing a mid-tone grey coating from a translucent white plastic sheet.

Lettering has for modern charts been standardized at Univers and Times Roman, which is produced on a photo-typesetting machine, the resultant copy being photographed to stripping film in the office.

In 1963 a charting arrangement was made between the Admiralty and the New Zealand Naval Board to replace the existing British Admiralty charts with New Zealand charts as they existed or were produced. The Admiralty would in turn reproduce in facsimile those charts which they had decided to adopt into their series, issue and put on sale through their own chart agents. Thus, one of the main purposes of this arrangement was to eliminate duplication. During the preceding ten years the New Zealand charting programme had been making good progress, and from these charts the Admiralty had been correcting and deriving their own charts of New Zealand waters. In the early days of the formation of the New Zealand office the Admiralty were reluctant to allow the replacement of British Admiralty charts by New Zealand charts, but as the quality of New Zealand charts reached a standard acceptable to that of the Admiralty, and as the problem of maintaining global coverage became increasingly more difficult, the logical decision to eliminate chart duplication was made. One of the main benefits of this arrangement, apart from the saving of effort, is that new information is got to the mariner more quickly. On the other hand a disadvantage is an increase in the number of Notices to Mariners because of the need to reproduce certain Admiralty and Australian Notices in our own editions. In 1956 the decision had been taken to centralize the function of chart correction at the Hydrographic Office. It was thought more practical to avoid sharing between two departments what is essentially a part of the same task. Accordingly, the responsibility for the publication of Notices to Mariners was taken over from the Marine Department, thus gaining uniform standards of control, terminology and application. These events helped to ensure world-wide sales of New Zealand charts and a place of equal standing within the British global chart coverage.

In 1971 another significant event took place. This was the move of the office from rather cramped accommodation in Wellington to a new, specially constructed building in Auckland. The new building was sufficiently large to enable the chart depot function, which previously had occupied separate accommodation, to be joined together with the chart production activities of the office. A photographic laboratory and darkroom facility was also provided and this enabled many production processes, previously carried out by the Government Printer, to be accomplished within our own resources.

With more space available the acquisition of more equipment was undertaken. A large precision plotting table was purchased to replace a small X-Y axis plotter. Acquisition of a medium-sized process camera enabled an epidiascope projector which had previously been used for the reduction and enlargement of drawings to be disposed of. This, together with the installation of a flip-top plate exposure table, enabled photomechanical contact work to be undertaken and all stages of production process work, except plate-making, to be done within the office. In order to cope with the ever-increasing demands of chart correction without the recruitment of further chart correcting staff, a silk-screen printing machine was acquired.

The office is also the repository of hydrographic information for New Zealand and some adjacent ocean areas. Original Royal New Zealand Navy surveys and other hydrographic and oceanographic data, microfilm records, together with copies of published New Zealand and British Admiralty charts and tidal records are held in the archives.

Charts are schemed in this office and the hydrographic instructions for the surveying vessels prepared in order that the data essential for the production of charts may be collected.

The office also prepares and promulgates Notices to Mariners in weekly editions, answers many hydrographic enquiries and requests for data and receives and processes information from various marine, harbour and Government Department authorities in New Zealand. Additionally New Zealand has assumed responsibility in a large area surrounding New Zealand for the compilation of plotting sheets for the General Bathymetric Chart of the Oceans to be published for the International Hydrographic Organization.

The Hydrographic Supplies Depot, as part of the office, functions as a Naval Chart Depot, a Chart Agency and holds considerable stocks of charts and other hydrographic publications for issue to the Fleet and for sale to the general public through agents appointed throughout the country and in some major overseas ports.

Thirteen civilian employees are directly engaged in chart correction, distribution and procurement. Press correction is a service to the Depot provided by the photographic laboratory. At present, with the publication of about a hundred New Zealand charts, such good progress has been made in the replacement of Admiralty charts of New Zealand waters that today only six remain, and it is planned to produce provisional New Zealand charts to allow the withdrawal of these within the next three years. Thus within the space of little more than thirty years the Admiralty chart coverage of New Zealand will have been replaced by New Zealand charts.

A similar situation exists for the adjacent ocean areas in the south-west Pacific where British Admiralty small-scale charts are being progressively replaced as the International Chart Scheme is implemented. This scheme arose from the International Hydrographic Conference of 1967 at which it was agreed to set up a commission to study the constitution of an international set of charts. The first two world-wide schemes agreed were series at scales of 1:3,500,000 and 1:10,000,000. The production was shared between sixteen national hydrographic offices, New Zealand volunteering responsibility for five sheets, of which four have already been published. As a result of the 1972 International Hydrographic Organization Conference, a group was set up to investigate the application of the international chart concept to medium and large scales, and this has extended to the development of a comprehensive detailed International Chart Specification. Thus the way has been opened to the full standardization of all nautical charts which, with little modification, possibly confined to language translation, titles, legends and notes, could be produced by any hydrographic office.

The traditional task of a hydrographic office was to explore and describe those parts of the ocean between the shore and a depth of some tens of metres at the most. Such descriptions were based on only a few data, essentially depths, tides and currents. However today the task is enlarged, and the requirement is to explore and describe the whole mass of the ocean by taking measurements, no longer of only those parameters of immediate interest to mariners, but measurements such as temperature, salinity; oxygen content, gravity field and magnetic field. Requirements other than those of the seaman are now assuming greater importance, or may do so in the future. These requirements mainly originate from the problems relating to mineral resource exploitation of the sea-bed and sub-bottom as well as the food which may be extracted from the sea. Thus the initial demand is for charts supplying a general description of the ocean environment on which more specialized organizations can base their research. The description and exploration of the whole mass of the ocean is such an enormous task and is obviously beyond even the largest of hydrographic offices and, as it has little in common with the work for which a small hydrographic office would be established, need not be dwelt on further.

Such a small office is envisaged as being limited to preparing and publishing nautical charts without encroaching much on other marine sciences. The New Zealand Hydrographic Office is a small unit producing charts to international standards and responsible for a very extensive area of coastal and oceanic waters. Despite occasional shortages of skilled and experienced staff more than 100 charts have been produced, and stocks are maintained by means of an ongoing printing programme during which all necessary corrections and amendments are incorporated. Progress has been made towards the conversion to metric units of existing fathoms charts. Investigations into the utilization of automatic data processing and the introduction of an automated cartographic system are being undertaken, as it is considered that these techniques provide a means by which the formidable task of charting the New Zealand area can be achieved in the face of staffing difficulties, combined with an ever-increasing data inflow.

The history of the New Zealand Hydrographic Office has been dwelt on at some length because in this description may lie indications as to the direction that may be taken by developing countries in the process of establishing their own hydrographic services. This paper has described cartographic facilities and has not discussed surveying craft or intruments. The first requirement of any country wishing to establish a hydrographic service is of course government recognition of the need for such a service, and financial and material support to enable it to be established and maintained. Second is the recruitment and training of the staff and the provision or creation of the administrative, supply and technical services to enable it to function. These necessary services include accommodation, office administration, staff control, clerical services, pay, drawing office supplies, stores and recruiting and they need to exist either within the organization or be provided by another local unit. It is assumed that most developing countries contemplating the formation of a hydrographic service will have a topographic or cadastral survey department already in existence and this could form the base, as it did in New Zealand, from which either temporary or permanent service could develop.

Personnel, unless they already possessed the technical expertise and experience, which is unlikely unless they had been recruited from an overseas hydrographic establishment, would need to be trained. To this end the advice and assistance of other nations with developed and established institutions would need to be sought. In this respect the International Hydrographic Bureau is an invaluable source of information on this subject. It is unlikely that such newly developed hydrographic services would aim at more than the simple provision of an

organization for the direction and supervision of hydrographic surveys through the operation of surveying vessels.

From the data resulting from the operations of the surveying vessels the compilation and publication of navigational charts would be achieved. However, once these charts were published, a means would need to be devised for their maintenance and correction. In the interests of maritime safety, dangers to navigation and important changes affecting navigation would need to be promulgated by some means of Notices to Mariners or through radio warnings. From the outset a record system would need to be devised and an archives established in which survey and tidal data would be held. Elaborate and expensive surveying and cartographic systems should be avoided and it is likely that such systems would in any case not be established, simply because of their high cost. Such an office should aim at an organization based on simple systems and methods, capable of being used and sustained by local resources. The essential element in such an office is of course the technical personnel and these should be trained so that they can achieve results with the simplest of means. In this respect it may be that the New Zealand office represents a model which could be followed. Providing there is a clear understanding of the design and purpose of a navigational chart, good progress can be made towards achieving the objective with fairly basic facilities. It will not be long before a comprehensive specification and guidance for the production of charts of all scales is available.

The initial equipment needed for such a small hydrographic/cartographic unit need consist of little more than hand-scribing equipment, a light table, a small precision plotter, an epidiascope projector and an electronic calculating machine. It is likely that, initially at least, local process and printing houses could provide the necessary back-up so that the resulting drawings could be processed to the publishing stage. As procedures were established and experience gained, more sophisticated equipment could be acquired and additional staff recruited and trained through a system of local instruction and overseas courses at established hydrographic offices. As in any enterprise success would depend on the recruitment and retention of suitably qualified personnel, and it is this component which is possibly the most vulnerable. Therefore, apart from the continuing provision of support finance the most important aspect is the establishment of a staff structure capable of undertaking and continuing the task. It would seem that it would be many years, if ever, before small newly established organizations in developing countries could afford, even if the need existed, complicated automatic or semi-automatic cartographic systems. These systems require for their continued and efficient functioning the existence of a local sophisticated electronics servicing industry. They are eminently suitable for large establishments through which large volumes of data are processed, but their introduction into small offices is likely to create more problems than they would solve. In short, it would be better to create, in the beginning at least, a simple system, largely manual, that would be compatible with local technologies and resources and which would provide a foundation on which future development could be based.

NATIONAL OCEAN SURVEY AUTOMATED INFORMATION SYSTEM*

Paper presented by the United States of America

RÉSUMÉ

Le Service océanographique national s'efforce d'automatiser les procédures d'établissement et de mise à jour des cartes marines. Pour cela, il lui faut introduire l'automatisation dans trois secteurs fondamentaux : la gestion des données, l'établissement des graphiques par méthode interactive, et la production des états de gestion.

Le système d'information automatisé du Service océanographique national utilise à cet effet certains des plus récents progrès accomplis en matière de traitement des données. Une base de données à accès direct contenant principalement des informations d'ordre géographique, qui a été couplée avec un ensemble de systèmes de graphiques interactifs, a donné aux cartographes les moyens nécessaires pour mettre les cartes à jour en temps opportun.

The National Ocean Survey (NOS) of the National Oceanic and Atmospheric Administration (NOAA) has, as one of its primary missions, the production and maintenance of nautical charts for the navigable waters of the United States and its possessions. This is a continuous effort due to the constant changes caused by natural and human processes. To measure these changes, NOAA has a fleet of ships and aircraft gathering data for charting purposes. Information is also received from other United States Government agencies and the private sector. The current base of charting information must be updated to reflect any potential dangers to navigation that are uncovered by the new data.

In theory, new data are collected in the field, and charts are modified to reflect the changes. However, in practice, bottlenecks have developed. Sophisticated data collection techniques using computers, rapid navigation and digital fathometers have outpaced the ability of the cartographer to utilize all of the new information. As the volume of data increased, NOS found itself

*The original text of this paper, prepared by William G. Swisher, National Ocean Survey, National Oceanic and Atmospheric Administration, appeared as document E/CONF.72/L.24.

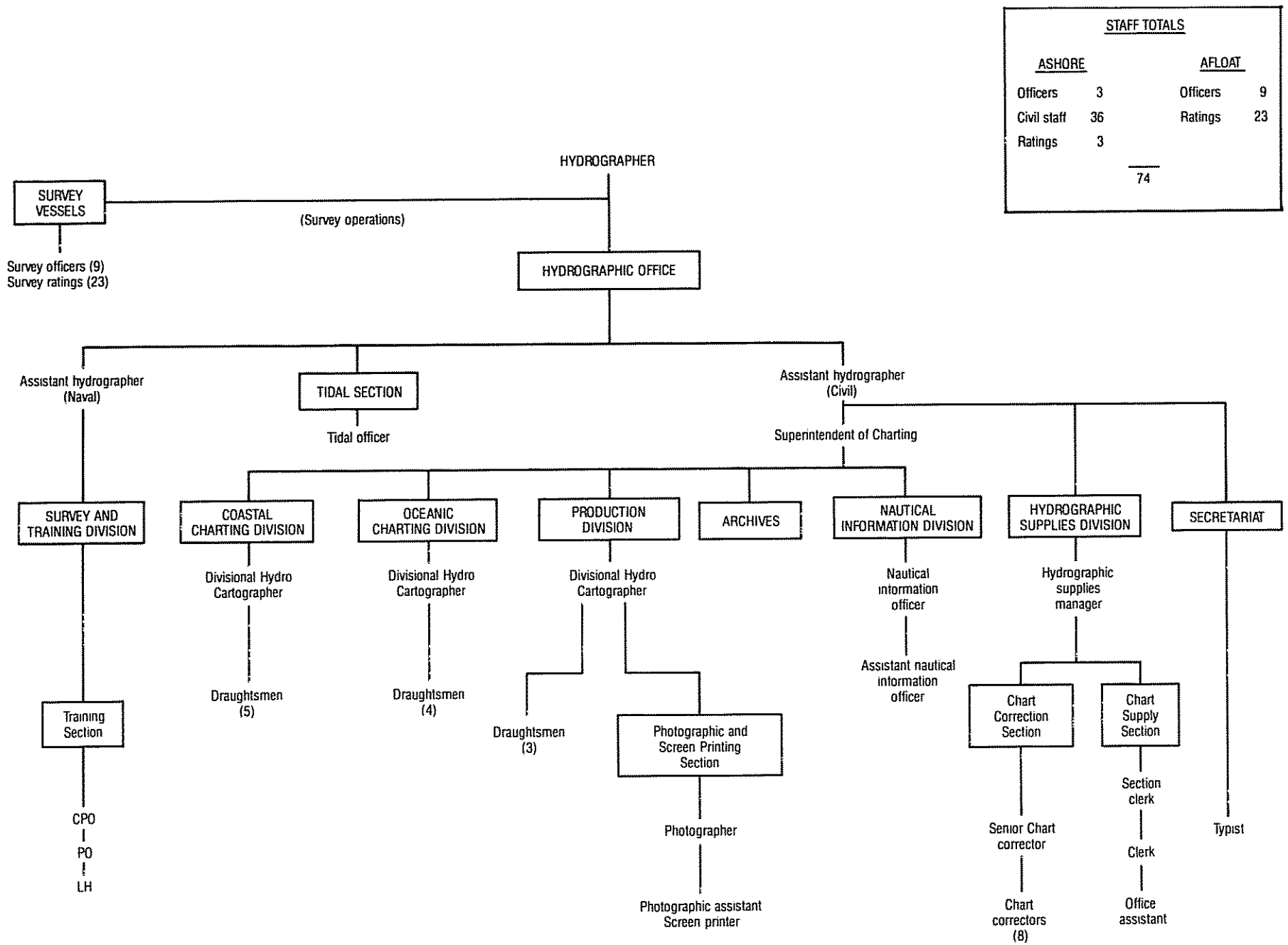


Figure 143. New Zealand: organization of the New Zealand Hydrographic Office

in the position of applying only the critical adjustments to charts while the rest of the data were stored for future use.

To alleviate this problem NOS has developed a set of computer-based systems that will speed the application of data to nautical charts. These include:

(*a*) Automated data acquisition systems aboard NOAA ships that also accomplish some preprocessing functions;

(*b*) Automated processing facilities at the Atlantic and Pacific marine centers for verification of data before it is sent to NOS headquarters;

(*c*) A digitizing system to capture graphic information in digital form;

(*d*) Flatbed scribe plotters and a laser raster drum plotter to produce negatives for chart printing.

The missing link in this automated chain of processes has been recently developed, under contract, by the Planning Research Corporation. This system, the National Ocean Survey Automated Information System (NOS/AIS), receives data from the Marine Centers, the digitizing subsystem and outside sources. It stores this data in a readily accessible form and allows retrieval for interactive compilation of charts. The system also produces digital output which can be plotted for use in chart reproduction. Figure 144 shows the relationship of the AIS to other computer-based systems in NOS.

NOS/AIS

The NOS/AIS is the backbone of the National Ocean Survey's automated nautical charting effort. It performs three critical functions that are necessary for chart construction and maintenance. First, it provides a mechanism for managing the vast amounts of data that are required to create and maintain a complete chart product. Second, it provides the cartographer with a tool that allows the interactive manipulation of cartographic information. Third, it provides the management information necessary to control the charting process. The AIS not only handles these basic functions, it also performs them in a timely manner. An explanation will now be given on how the AIS fulfils these requirements.

Data management

NOS is responsible for charting approximately two million square miles of the earth's surface. The amount of data necessary to represent this area is immense and, therefore, requires an effective management tool. Automated data processing provides this tool in the form of an online data base.

In a data base environment all data relevant to an organization's tasks are stored in a central repository. Access to these data is controlled by a sophisticated set of computer software called a data base management system (DBMS).

The way the data is organized within a data base is very important to the successful operation of the system. An organization must analyze how its data are used and structure the data base accordingly. NOS examined two different approaches to data base organization. The first was based on a chart-oriented data base. Since the ultimate output of the system is a chart, it seemed logical to organize the data base by chart product. However, the same cartographic feature will likely appear on multiple charts due to the hierarchy of scales and overlapping coverage. Therefore, in a chart-oriented data base, the same feature would be stored once for each chart on which it appeared. This redundant storage of data would greatly increase the size of the data base. It would also require each chart representation of a feature to be modified when a change occurred.

An alternative scheme for organizing the data base solved these problems. By using a geographically oriented data base, each feature is stored only once. Accompanying information is used to tell how the data are depicted on the various charts. This technique eliminates redundant storage, which in turn decreases the size of the data base and prevents conflicting depictions of features within a set of charts.

In this structure a feature is stored according to its geographic position. To make the storage scheme more manageable, the earth's surface is subdivided into one degree by one degree squares. Certain types of data that fall within a given degree block are stored together. These are:

(*a*) *Published traveling features and channels.* These features typically extend distances greater than five minutes, and they are currently published on at least one chart. Examples are: pipe-lines, cables and channels;

(*b*) *Unpublished traveling features and channels.* These are the same as above except that they are not currently published on any chart;

(*c*) *Small-scale topographic data.* This is published and unpublished topographic data that may appear on charts of smaller scale than 1:100,000.

The data base management system used in the NOS/AIS is named TOTAL. This DBMS allows direct access to master records on disk storage devices. Direct access is important, because it is the fastest way to retrieve information from a computer system. Each degree block is defined as a master record to the TOTAL data management system. This allows rapid access to the above types of information.

Near the shoreline, where data is more heavily congested, a further refinement is made to the degree block subdivisions. In these areas a master record represents an area that is five minutes by five minutes square. The types of data that are stored within each of these blocks are:

(*a*) *Large-scale published features.* These are features that are published on charts of scale larger than 1:100,000 and are not travelling features or channels;

(*b*) *Small-scale published features.* This category contains published features that appear on small-scale charts excluding traveling features and channels. If a feature appears on both small- and large-scale charts, it is grouped with the small-scale data;

(*c*) *Unpublished features.* This group contains all unpublished features except traveling features, channels and small-scale topographic data.

A variety of data records have been devised to represent the different types of cartographic features. Usually a group of these records is required to represent one feature. A shipwreck, for example, requires four records to be stored. The first record, called the base data record, holds information about the type of feature and its geographic position. The second record in the

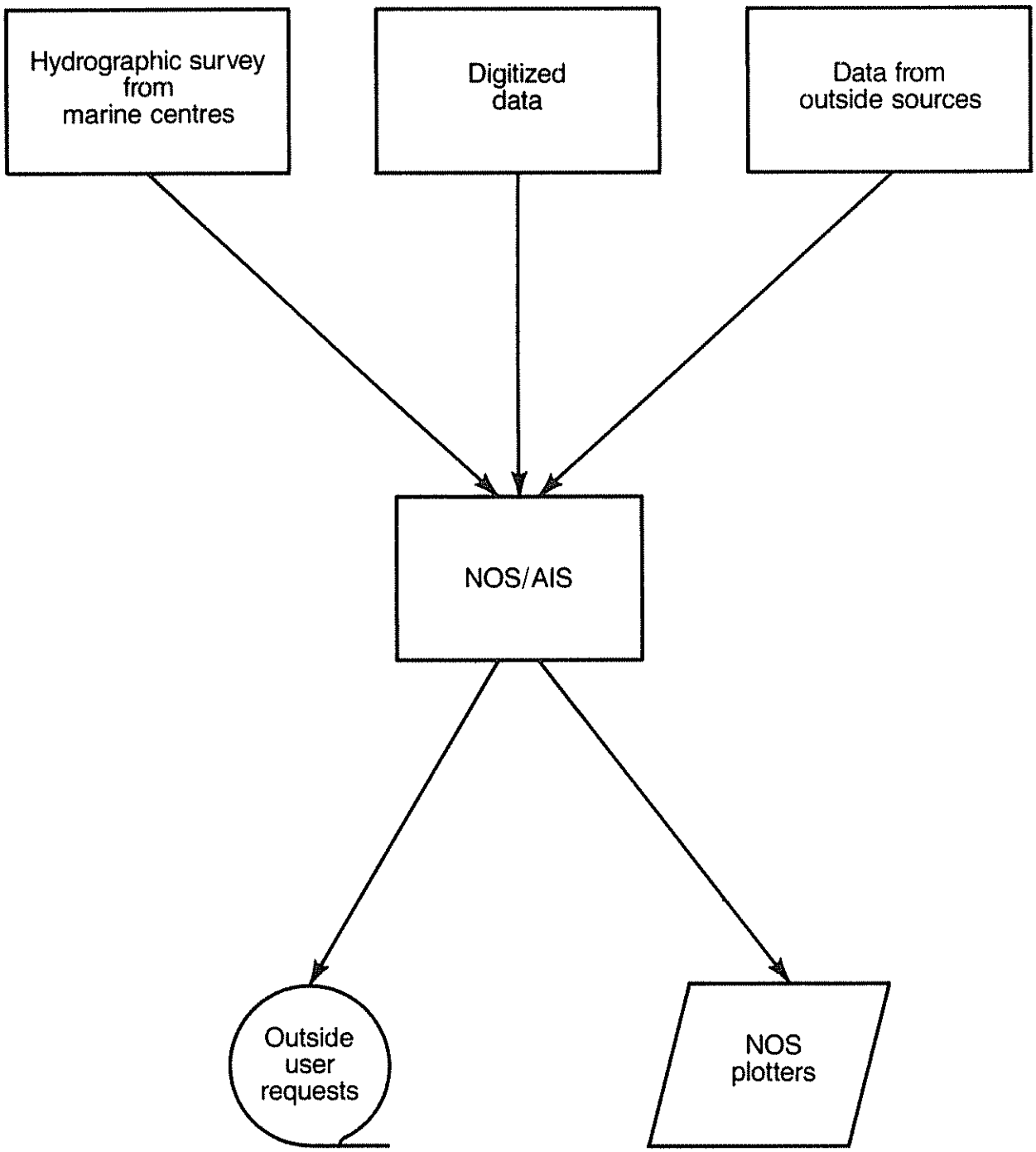


Figure 144. United States of America: relationship to other computer-based systems in NOS

sequence is called the compilation fact. It tells which chart entities the feature appears on. The next record describes the position, characteristics and publication status of any nomenclature that accompanies the symbol. The last record in the sequence gives the actual text which appears on the chart, for example, "SUBMERGED WRECK".

That basically describes how the data are organized. Data are to be loaded into the data base in phases. The first area to be loaded is the Gulf of Mexico and will be completed by early 1980. All of the data for a given area are loaded at the same time, so that cartographers will be able to use the system's full capabilities just as soon as an area is loaded. Other areas will follow the Gulf as the data collection effort is completed, and the entire three billion character data base will be loaded by 1983.

AIS hardware

To store and access three billion characters of data requires a sophisticated computer system. Figure 145 is a diagram of the NOS/AIS hardware configuration.

The central site portion of the system consists of two UNIVAC V76 minicomputers in a master and slave configuration. The data are stored on disk storage units with a 300-million character capacity. There are three high-speed tape drives attached to each central site minicomputer. These are used to input new data to the system, output data to the NOS plotters and for other system functions. The central site is attached to the cartographic work stations by a high-speed data link. The work stations will be described in detail later.

AIS software

Having now seen how the data are organized and the hardware components that are available, it would be beneficial to start a cartographic request through the system to see how everything works. This will also provide an opportunity to describe the computer software that controls the system.

A cartographer initiates the process by submitting a request for data to be sent to one of the cartographic work stations. The request may take many forms. The most frequent requests are for data that lie within a given geographic area or on a given chart. The area can be any polygon with from three to eight sides. Chart and area requests can be qualified to limit unwanted data from being sent to the work station in numerous ways. For example, one can request only published data, only unpublished data or only a certain type of data, like soundings or buoys. The request must also include control-type information, for example, a user number for security purposes, a request number and the number of the work station to which the data are to be sent.

A typical example of a cartographer's use of the system is to apply the information supplied by a new hydrographic survey to the appropriate charts. When a new survey is received at NOS headquarters it is loaded into the AIS "new data holding file". A cartographer then submits a request for the published data covering an area slightly larger than the survey to be retrieved from the data base.

Once the request is submitted, an executive control program schedules the various programs that are needed without operator intervention. The first program edits the request for errors.

The next program makes sure all of the resources needed by the request are available. This mainly involves making sure that the data requested from the data base are not currently being used by another cartographer. In order to preserve integrity in the data base, two requests cannot use the same data at the same time. If all resources are available, the retrieval program then extracts the requested data from the data base and the new data holding file and sends it over the high-speed data link to the work station.

When the data arrive at the work station the cartographer may begin the work session. The activities at the work station are a part of the second function of the AIS, interactive graphics, and will be discussed in the next section of the paper. After the cartographer has finished with the data at the work station the new and edited data are sent back to the central site to update the data base. The update program modifies the data base records that were edited at the work station, adds records that were introduced and archives records that are no longer applicable. Records that are archived from the online data base are written to magnetic tape for long-term storage.

The last step of the AIS data management function is to back up those portions of the data base which were modified by the work station edit. All cell blocks that underwent changes are copied to magnetic tape. These tape copies along with a back-up copy of the whole data base on disk will allow recovery from a failure of the online data base.

Interactive graphics

The second major function of the NOS/AIS is to give the cartographer a tool for applying data in a graphic form. The cartographic user does not really care about data base management systems or retrieval and update programs. What he or she does care about is the chart's graphic image. The user wants to see cartographic symbols, shoreline and soundings the way they are represented on the chart. He or she is not particularly interested in strings of data base records.

To provide the transition from strings of records to a usable graphic display the AIS has incorporated the latest techniques in interactive graphics. Figure 146 shows the work station hardware that provides this power. At this point it should be pointed out that only two of the full complement of ten work stations have been installed. Experience gained from the use of these prototype work stations will play an important part in the selection of the next eight.

The current work station configuration contains the following hardware:

1 UNIVAC V76 minicomputer to control work station processing;
2 disk storage units to hold work files and programs;
1 Bendix digitizing table for cartographic reference and input;
1 refresh color graphics display screen for edit;
1 graphics display screen for reference;
1 hard copy device.

These hardware components plus a large group of computer programs allow the cartographer to perform many cartographic functions.

To illustrate some of these functions the hydrographic survey example that was introduced earlier will be continued. The example was left with the carto-

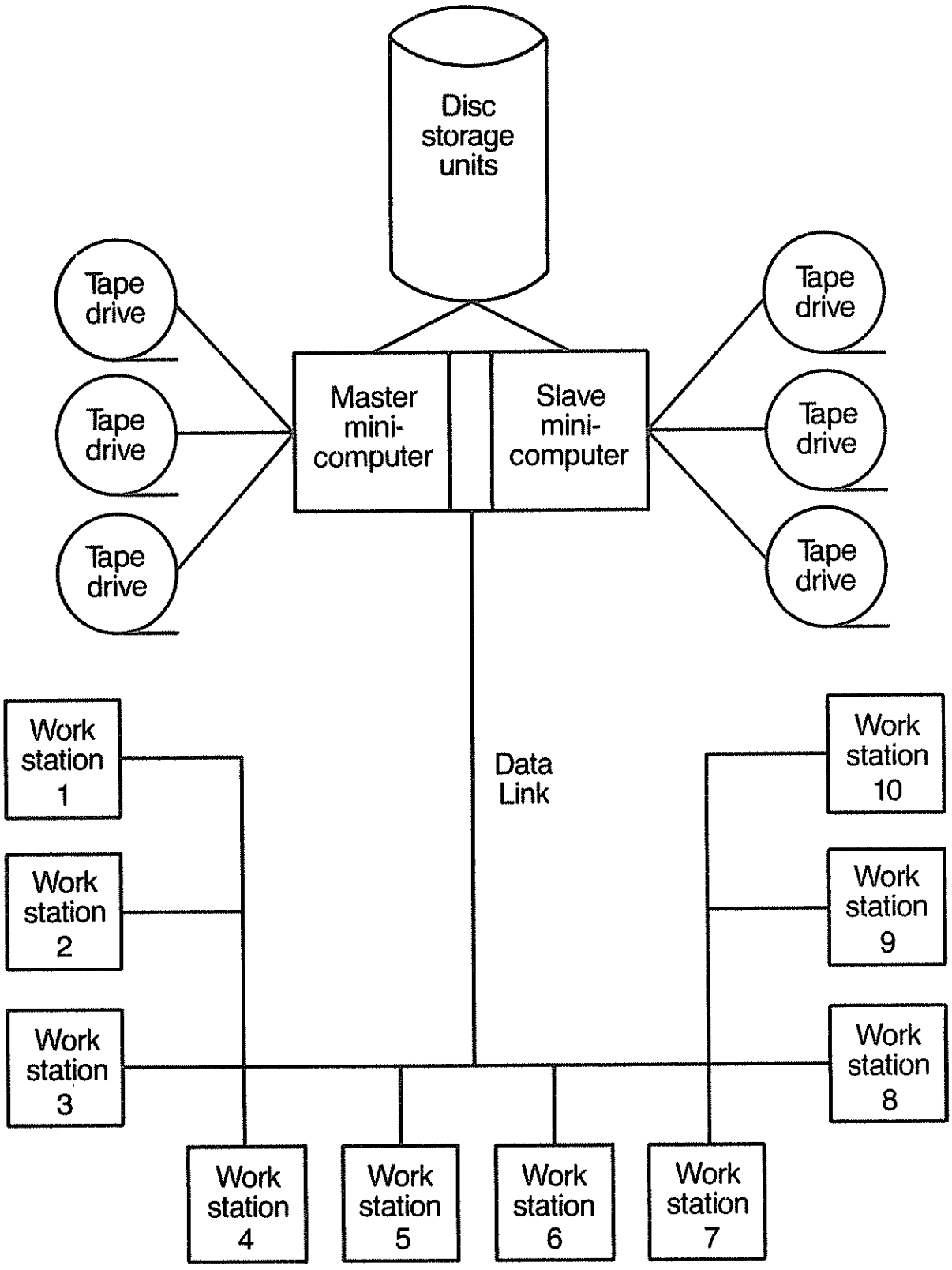


Figure 145. United States of America: hardware configuration

graphic request, including the new survey, having been sent across the data link to the work station. The TOTAL data base management system is used at the work station to control access to the work file.

The cartographer has a scheduled time to use a work station. This time was chosen by the cartographer when the request was initiated. At the pre-established time, using the appropriate employee number and security identifier, the cartographer will attempt to sign on the system. Unauthorized access, based on these numbers, will cause the work station to disallow further actions, and a message will be sent to the central site operator.

Upon completion of a successful "sign on", the cartographer will place the largest scale chart to which the survey will be applied on the digitizing table. This will be used as a reference to the graphic displayed on the edit screen. The cartographer then selects the area of the chart that will be edited first. Data from the data base that is currently published on the registered chart will be displayed on the screen in the color green. (The screen is capable of displaying five colors.) The cartographer will also ask to see preselected data from the new hydrographic survey. These are the new survey data that have been run through an automated sounding selection program. This program selects soundings that are critical to navigation and removes cluttered soundings so that an appealing graphic representation is given on a chart. These soundings are displayed on the screen in orange. If the cartographer wishes, the entire survey can also be displayed.

The cartographer then applies the soundings from the survey by publishing the appropriate ones. This is done by selecting a sounding on the screen by positioning a cursor under the displayed symbol. When a sounding is found, it will blink on the screen. The "publish" button on a keyboard is depressed, and the status of that sounding is changed accordingly. In the same manner, soundings from the data base may be changed to an unpublished status for the registered chart.

The survey is applied to the whole chart, and then the next smallest scale chart is registered on the digitizing table. The cartographer now asks for selected soundings. These appear in red and are those that were published on the larger scale chart. Since the level of detail at the larger scale is greater than at the smaller, only those soundings selected at the large scale will be applicable. This process will continue until the survey has been applied to all appropriate charts at the various scales.

The concept of applying data "through the scales" is a great benefit provided by the AIS. In the past, *all* new data were used at each scale. With the AIS a refined subset is used for each successive scale. This provides a great saving of time.

When the cartographer is finished editing the data a "sign off" command is issued. Before the data are sent back to the central site for update the transactions must be checked by an authorized reviewer. The reviewer signs on the work station with a special security identifier. If the chart has been incorrectly compiled, the reviewer may modify the data or have the cartographer sign back on to do so. When the chart is correct, the reviewer signs off for update. The data is then sent back to the central data base for update as was described earlier.

The application of a hydrographic survey is just one example of how the AIS aids in chart compilation. Channels, shore-line or any cartographic feature can be added or modified in the same way. A very real benefit is gained by using the AIS to continually maintain charts. Continual maintenance means that when a change to a chart is received at NOS it is immediately applied to the existing base of chart data. In this way, a chart is ready for publication with the most current data at all times.

When a new edition of a chart is to be issued, a cartographer will make a request for a chart retrieval to the AIS. The chart will be sent to the work station and the cartographer can manipulate the data to improve the chart's appearance. This might include the rotation of cartographic symbols, repositioning nomenclature or clearing an area for text. Rotation is accomplished by finding the desired feature and depressing the rotate button until the desired angle is reached. Repositioning of features is handled by using four function buttons which move the feature up, down, left and right. To blank an area of shore-line the two points on the line that bound the area are found and unpublished.

With this type of interactive capability the AIS has removed the need for a cartographer to spend time drafting. With manual techniques the cartographer must draw in all of the changes. With the AIS these functions are performed by pushing a button. The cartographer's major effort is in applying cartographic skills, not drafting.

One final example of the power of the AIS must be cited before going on, and that is the creation of a new chart. In this example, assume that a smaller scale chart is being created. The cartographer will first add the geographic limits of the chart to the chart information file. Then an area retrieval will be made that encompasses the new chart. When the data arrives at the work station the cartographer will display the data for the larger scale chart and designate it as "selected". This means that the data will be applied to another chart. The system will ask the cartographer what chart is to be the compilation chart, that is, the one which the selected data will be applied to. The cartographer enters the number of the new chart and then proceeds to publish the appropriate data from the selected chart to the compilation, or new, chart. This technique provides considerable time savings over the manual creation of new charts.

Management reports

The final function of the NOS/AIS is to provide management with sufficient information to aid in scheduling, in controlling costs and in the evaluation of the system's performance. Information gathering modules have been incorporated in the AIS software to supply input to the management reporting function. Some of the reports that are available to cartographic management are:

(*a*) *Chart job accounting*. This report gives the work station time, system time (retrieval and update), the number of transactions and the cost incurred based on cartographer and reviewer time. The report can be generated for each chart;

(*b*) *Geographic area job accounting*. NOS cartographic staff are broken up into seven teams, each with

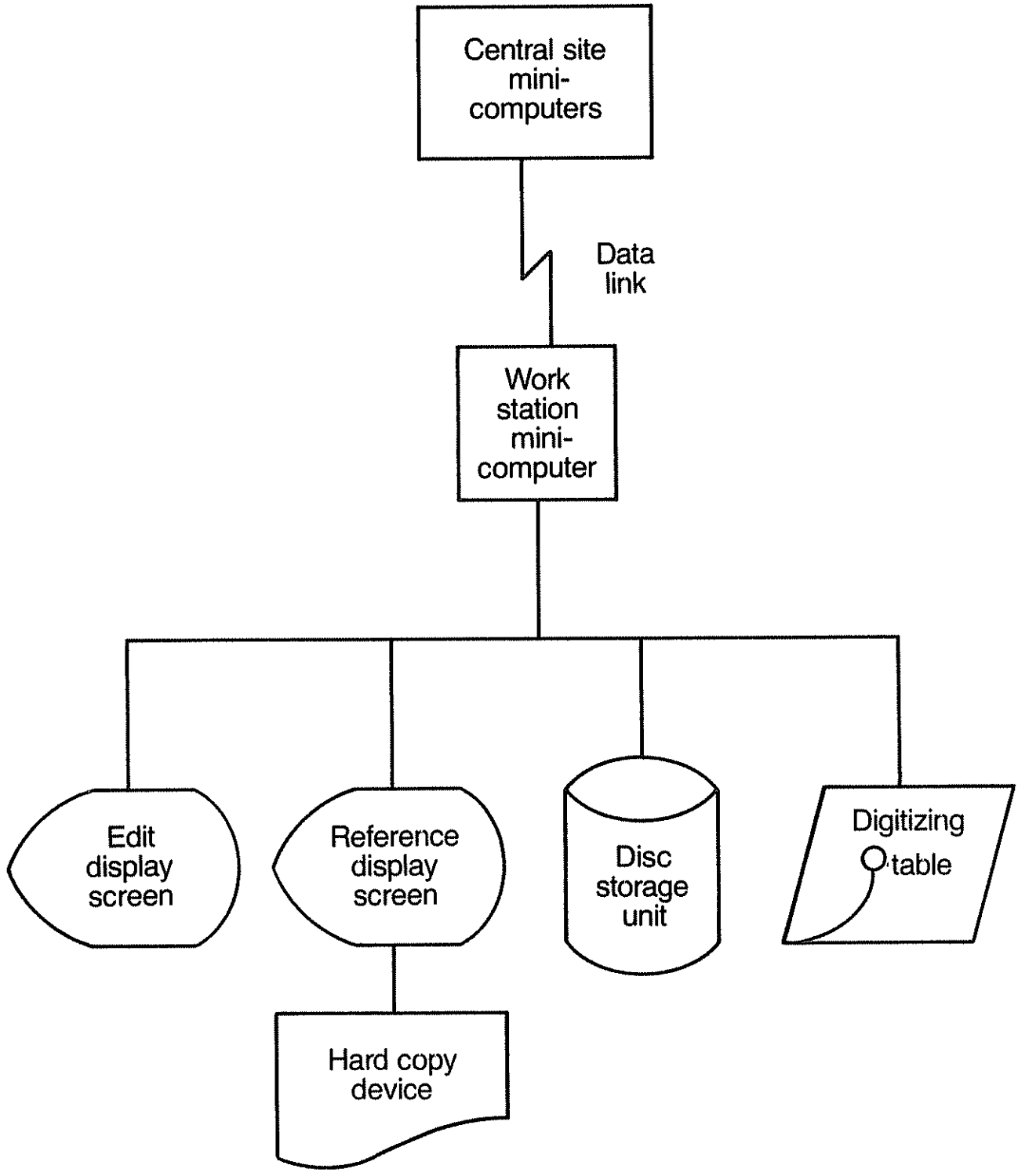


Figure 146. United States of America: work station hardware

responsibility for a geographic area. This report gives time, transactions and cost information as above except that it is based on a whole area rather than one chart;

(*c*) *Reviewer job accounting.* This gives the same information keyed to a reviewer;

(*d*) *Outside user job accounting.* This gives the same information keyed to a request outside of NOS;

(*e*) *Cartographer job accounting.* This gives the same information on a given cartographer;

(*f*) *Work station usage.* This gives the time the work station was active, number of transactions and various file sizes of a given work station;

(*g*) *Data base access.* This reports the frequency and types of data accessed, number of transactions and area of data base access;

(*h*) *New document status.* This tells which new documents fall on a given chart;

(*i*) *Chart status.* This reports which charts fall on a given new document. The last two reports are used to help schedule work;

(*j*) *Chart history.* This report tells what new documents have been applied to a chart.

In addition to the above reports there are many others that supply information to systems programmers and the Data Base Manager. All of the reports can be generated on an "as needed" basis.

CONCLUSION

The National Ocean Survey is one of the world's leaders in the advancing technology of automated cartography. The NOS/AIS was a pioneering effort in this field, and, as a consequence, many lessons had to be learned along the way. The most valuable information was gained once the system was in place and cartographers started using it. NOS will put this knowledge to use when the next eight work stations are procured. But this will not end the evaluation process that analyses user needs and implements appropriate solutions. Technology is advancing at a tremendous rate. But the technical advancements are only good if they are put to use. NOS will stay abreast of technology to give its cartographers the tools they need to cope with our dynamic environment.

NORMES DE COMPÉTENCE POUR LES HYDROGRAPHES*

Document présenté par l'Organisation hydrographique internationale et la Fédération internationale des géomètres

SUMMARY

During the Congress of the International Federation of Surveyors (FIG) at Wiesbaden in 1971 a working group was formed by Commission IV (Hydrography) to develop international standards of competence within the profession of surveying at sea. In 1972, at the International Hydrographic Conference at Monte Carlo, the International Hydrographic Organization (IHO) set up a working group for the compilation of training courses in hydrography to be conducted by member States. In 1974, at the Fourteenth FIG Congress in Washington, it was resolved that the FIG and IHO working groups would combine to study and modify the report of the FIG working group on educational standards.

The report of the joint FIG/IHO working group was accepted by the two parent bodies at their respective conferences in 1977. In consequence of similar resolutions adopted at those conferences an International Advisory Board was appointed to report to IHO and act on behalf of IHO and FIG. The Board would be composed of a small number of persons (a maximum of eight), half of them nominated by IHO and half by FIG, of known competence worldwide in the civil, government and educational sectors of hydrographic surveying.

The Board would meet as required by the Chairman, at least once a year.

The paper follows on the inaugural meeting of the Advisory Board, held in London from 7 to 9 February 1978.

Au Congrès de la Fédération internationale des géomètres (FIG) à Wiesbaden en 1971, la Commission IV (hydrographie) a créé un groupe de travail chargé d'établir des normes de compétence internationales pour la profession d'hydrographe. En 1972, à la Conférence hydrographique internationale de Monte-Carlo, l'Organisation hydrographique internationale (OHI) a mis en place un groupe de travail pour rassembler des données sur les cours de formation à l'hydrographie dans les différents Etats membres. En 1974, la 14e conférence de la FIG à Washington a décidé que les groupes de travail de la FIG et de l'OHI fusionneraient pour étudier et amender le rapport du groupe de la FIG sur les normes de compétence.

Les deux organisations mères ont adopté le rapport du groupe FIG-OHI durant leurs congrès et conférence de 1977. Suite aux résolutions similaires qui ont été adoptées au cours de ces deux réunions, un Conseil consultatif international a été mis en place. Son mandat est d'agir au nom de l'OHI et de la FIG, et d'en rendre compte à l'OHI. Il doit comprendre un petit nombre de personnes (huit au maximum), désignées pour moitié par l'OHI et pour moitié par la FIG, de compétence

*Le texte original de ce rapport, préparé par l'Organisation hydrographique internationale et la Fédération internationale des géomètres, a paru sous la cote E/CONF.72/L.96.

mondialement reconnue, et appartenant aux secteurs public, privé, ou de l'enseignement dans le domaine de l'hydrographie.

Le Conseil se réunira sur la demande du Président et au moins une fois par an.

Le présent document fait suite à la première réunion du Conseil consultatif, tenue du 7 au 9 février 1978 à Londres.

LE CONSEIL CONSULTATIF INTERNATIONAL

Composition du Conseil

Les membres du Conseil représentant la FIG seront désignés à chaque conférence de cet organisme.

Mandat du Conseil consultatif

Le mandat du Conseil consultatif international a été défini comme suit par les résolutions complémentaires de la FIG et de l'OHI :

a) Passer en revue les programmes de cours, proposés par le groupe de travail FIG-OHI, et les modifier si besoin est, après consultation de la FIG et de l'OHI;

b) Préparer une liste de publications en différentes langues, qui sont recommandées pour mettre en œuvre ces programmes;

c) Revoir régulièrement les normes recommandées et les mettre à jour si nécessaire;

d) Diffuser les versions initiales, puis les versions mises à jour, de ces normes aux responsables nationaux selon les voies normales de l'OHI;

e) Informer les responsables nationaux qu'il est prêt à examiner tous les programmes de cours envoyés par les universités, écoles ou organismes hydrographiques;

f) Etudier les programmes reçus selon le processus décrit en *e*); donner des conseils ou commentaires après comparaison avec les normes minimales recommandées; fournir un certificat reconnaissant que le programme de l'établissement d'enseignement concerné répond à ces normes.

NOTES EXPLICATIVES POUR LES NORMES DE COMPÉTENCE

Catégories

Trois catégories de personnel ont été déterminées :

Catégorie A : (Ingénieurs) Hydrographes ayant des connaissances approfondies dans toutes les branches de l'hydrographie;

Catégorie B : Hydrographes ayant reçu une formation dans les différentes spécialités de l'hydrographie;

Catégorie C : Assistants des catégories A et B, ayant reçu une formation pour la collecte des données et les travaux d'exécution en opérations hydrographiques.

Les fonctions et normes de compétence des catégories ci-dessus sont les suivantes :

(Ingénieur) Hydrographe, catégorie A

Doit posséder une compétence vaste et approfondie dans tous les domaines théoriques et pratiques de l'hydrographie et les domaines connexes. Avec une expérience adéquate, doit être à même de projeter et diriger des opérations hydrographiques de toute nature et d'assumer la responsabilité de la qualité de leur exécution. Doit être capable de développer de nouvelles techniques hydrographiques et de faire une évaluation critique des données collectées.

Hydrographe, catégorie B

Doit avoir une connaissance pratique des levés hydrographiques et avoir acquis une certaine habileté dans les divers travaux hydrographiques. Travaille normalement comme assistant, mais avec une expérience adéquate peut exécuter les travaux ci-dessus sans surveillance directe et analyser les données collectées.

Personnel d'exécution hydrographique, catégorie C

Cette catégorie comprend le personnel d'exécution nécessaire pour les opérations de levé hydrographique. Aucun niveau de formation n'a encore été précisé au stade actuel et cette catégorie n'est pas étudiée dans ce document.

Niveau exigé des hydrographes

Les hydrographes des catégories A et B doivent avoir une formation suffisante pour répondre aux définitions ci-dessus. Il est admis qu'une expérience de plusieurs années leur sera nécessaire pour atteindre réellement le niveau de compétence requis.

On trouvera dans ce document des programmes spécifiant les connaissances minimales qui sont requises pour les hydrographes des catégories A et B.

Pour être admis à un cours de formation, l'hydrographe de catégorie A devra avoir des connaissances théoriques plus approfondies que celui de catégorie B, en mathématiques et physique appliquée.

Un hydrographe de catégorie B qui souhaite avoir la qualification de catégorie A devra suivre les cours correspondants, avec les dispenses convenables.

L'expérience est indispensable pour atteindre le niveau des catégories A ou B; cela devrait se traduire, dans les cours de formation, par un ou plusieurs stages de levé hydrographique en mer convenablement encadrés, d'une durée totale d'au moins deux mois pendant le cours de la formation.

Les programmes de formation prévus pour les catégories A et B devront comprendre des projets de levés hydrographiques en conditions réelles qui compteront pour une part assez importante dans le jugement de l'étudiant. Ces projets s'ajouteront à l'expérience en mer indiquée ci-dessus. Pour l'ingénieur de catégorie A, un projet complexe et pluridisciplinaire serait souhaitable; pour l'hydrographe de catégorie B, plusieurs projets concernant chacun une seule matière seraient préférables.

Une expérience pratique d'au moins deux ans au total en levé hydrographique est indispensable pour acquérir la qualification d'hydrographe dans les catégories A et B.

Bien que ne faisant pas partie du minimum exigé pour l'accession aux catégories A ou B, certains éléments supplémentaires sont souhaitables :

Les candidats aux catégories A et B devraient être confrontés à l'environnement marin pour une courte période avant de s'inscrire à un cours d'hydrographie, ce qui les familiariserait avec les conditions de travail à la mer.

Les cours de catégorie A devraient comprendre des études interdisciplinaires concernant :

a) Les relations entre les origines de l'astronomie, de la navigation, des levés hydrographiques et les sociétés dans lesquelles ces sciences et techniques se sont développées;

b) Les problèmes résultant du progrès scientifique et de l'évolution de la technologie;

c) La nature de la recherche scientifique;

d) Les relations entre les sciences sociales et les sciences de l'environment naturel.

Procédure d'homologation des programmes de formation

Le responsable national d'un pays sera normalement le Directeur de son service hydrographique agissant en liaison avec l'organisme national représentant ce pays à la FIG. Une liste des adresses des responsables nationaux peut être obtenue au secrétariat du Conseil consultatif international à l'OHI, Monte-Carlo.

Toute correspondance concernant l'homologation des programmes de formation au niveau international doit passer par l'intermédiaire des responsables nationaux.

Les établissements d'enseignement et les organismes hydrographiques publics et privés sont invités à soumettre leurs programmes de formation en hydrographie à l'examen du Conseil consultatif international. Bien qu'aucune obligation ne puisse exister, le Conseil espère que les responsables nationaux reconnaîtront d'eux-mêmes l'intérêt d'une évaluation de ces programmes particuliers sur la base de critères internationaux.

Il est possible que certains organismes de formation n'enseignent que certaines parties du programme; dans ce cas il est demandé aux responsables nationaux d'en avertir le Conseil consultatif international et de s'assurer que les étudiants reçoivent l'enseignement complémentaire dans d'autres organismes.

Les organisations professionnelles qui font passer les examens conduisant à une qualification sont également invitées à soumettre au Conseil leurs programmes d'examen et la procédure de délivrance du diplôme par l'intermédiaire des responsables nationaux.

Il est demandé aux responsables nationaux d'examiner tous les programmes qui leurs sont adressés, puis de les envoyer au secrétariat du Conseil avec leurs observations.

Le Conseil correspondra avec eux pour recommander des amendements ou demander des éclaircissements si c'est nécessaire. Un certificat d'homologation sera délivré pour les programmes qui respectent les normes internationales.

Le Conseil devrait être informé par les responsables nationaux des modifications apportées aux programmes postérieurement à leur approbation.

Le Conseil serait reconnaissant aux responsables nationaux de lui envoyer les remarques qu'ils peuvent faire sur les programmes d'enseignement à la lumière de l'expérience acquise.

Envoi de programmes au Conseil pour examen

Les informations suivantes devront être fournies avec tout dossier pour en faciliter l'examen.

a) Un programme de cours indiquant clairement les heures consacrées aux différentes matières sous forme de cours magistraux en laboratoire et travaux pratiques sur le terrain, et l'importance donnée à chaque élément dans les différents groupes de matières.

b) Une liste des enseignants indiquant leur qualification et donnant des renseignements sur d'autres points importants tels que leur expérience, leurs publications éventuelles et les matières dont ils sont responsables.

c) Les sujets d'examen qui ont été posés au cours des deux années précédant le diplôme (donc pas seulement les examens finaux) avec le système de notation et les moyennes exigées.

d) Le détail des projets, travaux de laboratoire, etc., qui sont notés en plus des examens écrits.

e) Un inventaire des équipements dont disposent les étudiants : installations matérielles, laboratoires, navires, bibliothèques.

f) Des renseignements détaillés sur le cours, indiquant ses objectifs, les qualifications nécessaires pour s'y inscrire, les dispenses qui peuvent être accordées, les diplômes étrangers admis pour l'inscription.

Les informations doivent être fournies en 10 exemplaires, en anglais ou en français. L'institution concernée devra être prête à recevoir un comité d'inspection, à le laisser rencontrer le personnel d'enseignement et les élèves. Les membres de ce comité seront désignés par le responsable national.

Si un cours n'inclut pas certaines matières fondamentales inscrites au programme international, il devra être clairement indiqué que ces matières sont exigées pour l'accès au cours.

Si un cours n'inclut pas certaines des autres matières du programme international, il peut être demandé que le cours soit reconnu au niveau international comme satisfaisant seulement à une partie déterminée des normes internationales.

Les organismes professionnels qui sont responsables d'examens conduisant à une qualification sont invités à soumettre au Conseil leur programme d'examen et la procédure de délivrance du diplôme.

Programmes d'enseignement détaillés

Dans ces programmes, les matières passées en revue sont regroupées comme suit (voir figure plus loin) :

Matières fondamentales

1. Mathématiques, mécanique et statistiques
2. Métrologie (théorie)
3. Appareils et systèmes de mesure

Toute l'hydrographie est basée sur ces matières fondamentales; elles comportent les connaissances nécessaires à la réduction, à l'évaluation de la précision et au traitement des données ainsi qu'à la compréhension des principes qui président à la conception et à l'utilisation des équipements de levé.

Matières de soutien

4. Collecte et traitement automatiques des données
5. Sciences de l'environnement

Ces matières sont destinées à compléter celles du groupe précédent. La première permet à l'hydrographe d'appliquer à son travail les techniques informatiques modernes; la seconde, d'acquérir certains éléments de géologie, de géophysique et d'océanographie utiles aux levés en mer.

Matières essentielles

6. Levés terrestres
7. Levés à la mer

L'objet de ce groupe de matières est d'étudier l'application des connaissances précédentes à tous les aspects des travaux sur le terrain, à la mer et à terre.

Matières connexes

8. Droit de la mer
9. Navigation et météorologie

L'étude de ces matières est essentielle pour une application intelligente des connaissances acquises dans les autres matières.

Les sujets 1 à 9 ci-dessus recouvrent l'ensemble des connaissances jugées nécessaires à l'acquisition d'une compétence en hydrographie. Le niveau minimal de connaissances exigé sur ces sujets pour chaque catégorie d'hydrographes est indiqué par les mentions : « connaissance générale », « connaissance pratique », ou « connaissance approfondie ».

« Connaissance générale » signifie que l'hydrographe connaît l'essentiel du sujet et sa place dans l'ensemble.

« Connaissance pratique » signifie qu'il en connaît les principes et est capable de les appliquer dans des situations pratiques.

« Connaissance approfondie » signifie une maîtrise totale de la matière. Il est jugé souhaitable que l'hydrographe se spécialise soit en hydrographie côtière soit en levés océaniques; la zone des levés côtiers comprend les ports, les estuaires et une bande côtière; le large comprend la marge continentale et les grandes profondeurs. Les sujets correspondants sont énumérés en annexes I et II mais aucun niveau n'est indiqué parce que l'étudiant doit accroître ses connaissances bien au-dessus du niveau minimum avant d'aborder ces sujets.

Les programmes de spécialisation concernent donc :

L'hydrographie côtière *(nearshore)* [annexe I];

Les levés océaniques *(offshore)* [annexe II].

Un cours qui couvre les matières 1 à 9 au niveau convenable sera considéré comme de catégorie A ou B. Un cours qui comprend en outre les sujets énumérés en annexes I ou II sera considéré comme de catégorie A_N ou A_O (N pour *nearshore*, O pour *offshore*).

Programme d'études avancées

« Etudes avancées » peut être compris comme se rapportant soit à une discipline connexe d'intérêt majeur (par exemple le génie océanique), soit à l'hydrographie à un niveau très approfondi. Seul ce dernier cas est considéré ici.

Avant de suivre un cours de formation avancée, l'étudiant devra avoir atteint le niveau minimal défini ci-dessus; des études avancées dans les matières essentielles doivent s'appuyer sur des études approfondies dans les matières fondamentales correspondantes (indiquées par un astérisque dans les programmes d'enseignement détaillés ci-après).

Pour un programme d'études avancées, les domaines qui suivent pourront être retenus comme étant (ou pouvant devenir) dignes d'être développés ou approfondis.

Secteurs en développement technique :

- Sondage par laser
- Sonar à balayage
- Sondage surfacique (par exemple : sondage multifaisceaux)
- Positionnement par le système GPS NAVSTAR, conséquences géodésiques, compensations
- Levés à grande échelle par submersible
- Technologie des microprocesseurs
- Méthodes inertielles
- Positionnement intégré-géodésique et rayons sonores.

Sujets qui peuvent faire l'objet d'études avancées :

- Géodésie dynamique
- Océanographie spatiale, en particulier techniques de télédétection
- Le droit commercial et ses usages (contrats, législations locales, droits des propriétaires riverains, droit de la navigation, etc.)
- Protection de la nature
- Etudes de pollution
- Analyse des données océanographiques, en particulier analyse statistique de la mer du vent et de la houle.

PROGRAMMES D'ENSEIGNEMENT

N° repère des matières	*Connaissance* Générale	Pratique	Approfondie
1. *Mathématiques, mécanique et statistiques*			
1.1 Analyse			
a) Calcul différentiel : limites; dérivées; différentielles; différentiation des fonctions élémentaires; dérivées partielles d'ordre supérieur; maxima et minima		A	
b) Calcul intégral : intégrale indéfinie; intégration, aire limitée par une courbe; intégrales définies; intégrales multiples élémentaires		A	
1.2 Séries			
Fonctions des variables réelles; limites et continuité; convergence; polynômes; formule de Leibnitz; formules de Taylor et de Maclaurin; méthode de Newton pour la résolution numérique des équations; fonctions implicites et inverses	A*		

PROGRAMMES D'ENSEIGNEMENT

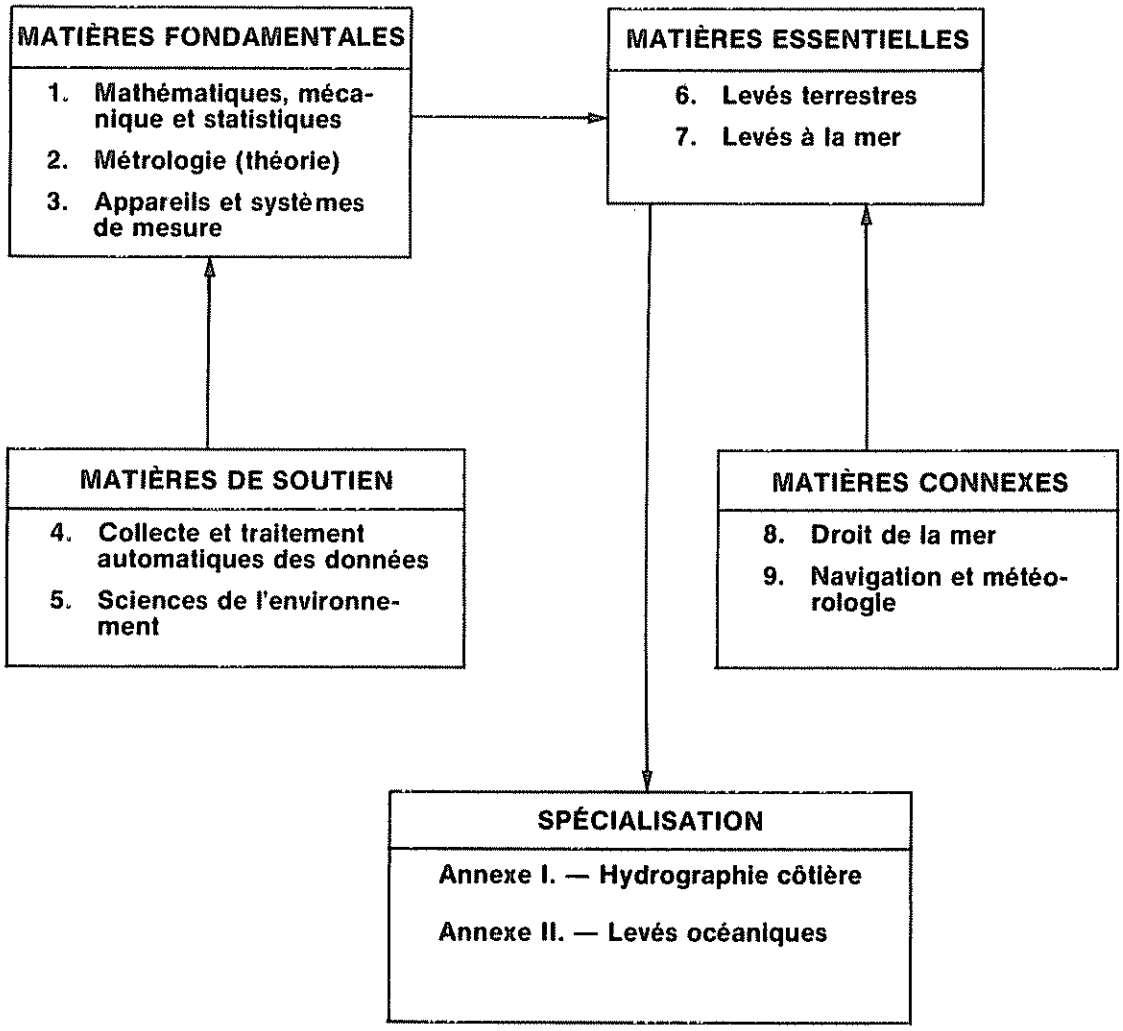
N° repère des matières	*Connaissance* Générale	Pratique	Approfondie
1.3 Algèbre matricielle			
Types de matrices; opérations sur les matrices; matrices transposées et sous-matrices; déterminants et cofacteurs; matrices inverses; résolution des équations linéaires		A	
1.4 Variables complexes			
Nombres complexes, opérations fondamentales; représentations géométrique et polaire; produits, puissances, quotients et racines des nombres complexes		A	
1.5 Géométrie analytique			
a) Dans le plan : système de coordonnées; equations linéaires, cosinus directeur d'une droite; equations quadratiques : le cercle, l'ellipse, la parabole, l'hyperbole; intersection des droites et des coniques; équations paramétriques	B	A	

N° repère des matières	Connaissance générale	Connaissance pratique	Connaissance approfondie
b) Dans l'espace : cosinus directeurs, paramètres directeurs; équation d'un plan; angle entre plans et droites; intersection de droites et de plans; distance d'un point à un plan		A	
1.6 Trigonométrie sphérique La sphère, les grands cercles; les angles sphériques, excès sphérique; les triangles sphériques; formule fondamentale analogie des sinus; formule de Neper; analogie de Neper et de Delambre	B	A*	
1.7 Mécanique Vitesse, accélération, équation du mouvement; vecteurs, opérations fondamentales; dynamique, force, masse, définition des unités de force; équations du mouvement angulaire		A	
Force centrifuge; la loi de Newton, la gravitation; energie, potentiel; statique, leviers, couple, moment; mouvement harmonique simple; vibrations, pendule; théorie du gyroscope	A*		
1.8 Statistique, traitement des erreurs de mesure Echantillonnages; notions élémentaires de probabilités; variables stochastiques, classement des erreurs, résidus; écart quadratique moyen (variance)		A*	
Loi de probabilité et distribution de fréquence; corrélation, covariance; estimation de l'écart-type; pondération; compensation, variation des coordonnées; compensation, équations de conditions; résolution d'un système d'équations normales, matrices	A*		
2. *Métrologie (théorie)*			
2.1 Unités de mesure *a*) Système international d'unités (SI); système impérial (unités britanniques) et autres systèmes couramment usités; unités de base et dérivées		A,B	
b) Le temps (sidéral et solaire)		A,B	
2.2 Mécanique oscillatoire *a*) Théorie des oscillations (oscillations harmoniques; oscillations modulées : composition des mouvements sinusoïdaux; battements; oscillations amorties; oscillations forcées)	B	A	
b) Théorie des ondes (équation de propagation; fonctions d'onde; conditions de propagation; interférences et ondes stationnaires; équations de Maxwell)	B	A	
c) Systèmes oscillatoires	B	A	
2.3 Electricité et magnétisme *a*) Electrostatique (quantité d'électricité; champ électrique; le potentiel; conducteurs et isolants; condensateurs)	B	A	
b) Courant continu (courant, tension, loi d'Ohm; résistance et conductance des circuits; puissance et énergie; f.e.m. de contact; thermoélectricité)	B	A	
c) Electromagnétisme (notions de base; champ magnétique dû à un courant; forces du champ; circuits magnétiques; action d'un champ magnétique sur un courant; caractéristiques magnétiques des corps; production de champs magnétiques)	B	A	

N° repère des matières	Connaissance générale	Connaissance pratique	Connaissance approfondie
d) Courant alternatif (lois d'Ohm, impédance, déphasage; résolution des problèmes par les méthodes vectorielles et les nombres imaginaires; résonance; puissance et énergie; systèmes multiphasés)	B	A	
2.4 Electronique et radioélectricité *a*) Signaux et messages : information et fréquences (série et analyse de Fourier, spectres des signaux, bruits, etc.); l'information (messages discrets, bits; redondance; échantillonnage des messages non discrets); modulation (d'amplitude, de fréquence, par impulsions analogiques, par impulsions codées; multiplexage)	A*		
b) Sous-ensembles électroniques : composants électroniques (composants passifs, tubes hyperfréquences, semi-conducteurs); amplificateurs et filtres; générateurs et oscillateurs; circuits logiques; circuits intégrés; modulateurs et démodulateurs; transducteurs (acoustique, thermique, hertzien, optique, magnétique)	A*		
c) Ondes électromagnétiques : propagation des ondes, équations de Maxwell (différents milieux de propagation; équation de propagation; cas du champ sinusoïdal; propagation au voisinage du sol; réflexion et réfraction; propagation par ondes directe et indirecte; propagation au-delà de l'horizon, onde de surface; propagation des ondes de très basse fréquence); lignes et guides d'ondes; notions sur les antennes	B	A*	
2.5 Acoustique sous-marine *a*) Propagation d'une onde plane ou sphérique, équation du son; analogie avec l'optique; solution harmonique de l'équation du son; théorie des rayons sonores; énergie acoustique (unité, intensité, impédance, niveaux sonores); pertes de propagation (absorption, réverbération, réflexion, divergence)	A*		
b) Propagation dans l'eau de mer : influence des propriétés physiques de l'eau de mer sur la vitesse du son; construction et analyse des champs sonores (notions de zones d'ombre, de chenaux sonores); pertes de propagation (influence de la structure des masses d'eau, de la nature du fond, de la pente...); le bruit (bruits ambiants, couche diffusante profonde)	A*		
2.6 Optique *a*) Généralités : nature des ondes électromagnétiques (interaction de la lumière et des atomes); émission et absorption du rayonnement; lumière naturelle; propagation, dispersion et absorption de la lumière; réfraction et réflexion; diffraction de la lumière	B	A	
b) Systèmes optiques : l'optique géométrique; appareillage optique (miroirs, prismes, lentilles, filtres)	B	A	
c) Instruments et propagation : caractéristiques des instruments (grossissement, champ, clarté, pouvoir séparateur, aberrations); lunettes	B	A	

PROGRAMMES D'ENSEIGNEMENT

REGROUPEMENT DES MATIÈRES



N° repère des matières	Connaissance Générale	Pratique	Approfondie
d) Détection des faibles flux; amplification des impulsions et des signaux continus; lasers; propagation de la lumière dans l'eau de mer	A*		
2.7 Télédétection : capteurs à spectre limité (appareils photographiques, radiomètres); traitement des données; applications à l'environnement marin (température de surface, salinité, pollution, propriétés des eaux, géodésie)	A*,B		
2.8 Technologie de la mesure			
a) Qualités des instruments de mesure	B	A	
b) Réglage et étalonnage des instruments	B	A	
c) Méthodes de mesure	B	A	
d) Exécution des mesures; erreurs	B	A	
e) Origine des erreurs (mécaniques et externes)	B	A	
3. *Appareils et systèmes de mesure*			
3.1 Mesure du temps Les usages du temps en astronomie, géodésie et radiolocalisation, horloges et étalons de fréquence; chronomètres mécaniques, chronographes, horloges atomiques, transmission et comparaison du temps; transport d'horloges	B	A	
3.2 Instruments de mesure d'angles, de directions, de distance			
a) Mesures d'angles et de directions : le sextant, le théodolite, les niveaux et les mires de nivellement; les compas magnétique et gyroscopique		A,B	
b) Mesures de distance (optique et mécanique); instruments de mesure directe (chaînes et rubans); instruments de mesures indirectes (stadimètres, tachéomètres, télémètres)			
c) Mesures de distance : méthodes électromagnétiques (terrestres)		A,B	
3.3 Les systèmes de localisation électroniques en mer			
a) Principes des mesures : systèmes à mesure de différence de temps et systèmes à comparaison de phase (synchronisation des émetteurs, lever d'ambiguïté); avantages et inconvénients des divers procédés en usage (systèmes hyperboliques et circulaires)		A,B	
b) Systèmes à courte portée (visuelle)		A,B	
c) Systèmes à moyenne portée (≃100 km)		A,B	
d) Systèmes à longue portée (≃500 km)	A*,B		
e) Systèmes à couverture mondiale : VLF et satellites	A*,B		
f) Systèmes intégrés avec et sans mesure de vitesse (sonar Doppler, systèmes inertiels)	A*,B		
g) Précision, étalonnage et réglage	B	A	
3.4 Systèmes acoustiques			
a) Transducteurs : les divers types de transducteurs (magnétostriction, électrostriction, piézoélectricité); caractéristiques des transducteurs (niveau d'émission, bande passante, puissance, diagrammes de rayonnement)	B	A	
b) Enregistreurs analogiques et numériques	B	A	
c) Sondeurs à écho : caractéristiques (fréquence, puissance, durée des impulsions, cadence de récurrence des impulsions, ouverture du faisceau); influence de la topographie du fond	B	A	
d) Sondeurs à écho : types et configurations spéciaux (pinceau étroit, faisceau large et dispositifs à transducteurs multiples)	B	A	
e) Sonars : caractéristiques (type, fréquence, seuil de détection, ouverture du faisceau, durée efficace des impulsions, etc.)	A*,B		
f) Appareillages acoustiques divers : balises répondeuses, pingers, déclencheurs, célérimètres, etc	A*,B		
3.5 Instrumentation océanographique courante			
a) Capteurs : de température, de conductivité, de vitesse du son, etc	A*,B		
b) Instruments à usage hydrographique : marégraphes, courantomètres, appareils de prélèvement d'échantillons du fond, etc		A,B	
3.6 Appareillages et mesures géophysiques marines			
a) Gravimétrie : mesures sur le fond; gravimètres de bord et sources d'erreur associées	A*		
b) Magnétisme : utilisation des magnétomètres à protons	A*		
c) Sondage sismique continu : les appareillages (enregistreurs, émetteurs, récepteurs)	A*		
d) Reconnaissance géotechnique des sols : notions de mécanique des sols; appareils et techniques de carottage; mesures *in situ*	A*		
4. *Collecte et traitement automatiques des données*			
4.1 Notions de base sur les ordinateurs et la programmation			
a) Introduction aux ordinateurs : utilité des ordinateurs; systèmes de numérisation; représentations des nombres; structure des ordinateurs; opérations arithmétiques et logiques; phases de préparation des programmes; symboles et conventions de programmation; systèmes de conduite et classes d'ordinateurs		B	A
b) Langages de programmation : langage machine; langage assembleur; langages de haut niveau, surtout Fortran IV; autres langages, dont Basic	B	A	
4.2 Emploi des calculateurs et ordinateurs : choix d'un système pour un usage donné; calculateurs de bureau et de poche; mini-ordinateurs; systèmes à micro-processeurs; systèmes de grande puissance; systèmes partagés	B	A	
4.3 Emploi des appareils de traçage : à tambour; à plat; à microfilm; à balayage par trame; à écran cathodique	B	A	
4.4 Emploi des systèmes de numérisation et d'enregistrement automatique des données	B	A	
4.5 Systèmes intégrés de traitement et de commande : algorithmes pour le choix de sonde; algorithmes de lissage des données; intégration des données; traitement à terre en différé	B	A	

N° repère des matières	Connaissance générale	Connaissance pratique	Connaissance approfondie
4.6 Supports d'enregistrement des données : ruban perforé et bande magnétique; cassettes et cartouches; recopie d'écran; vérification et correction des données	B	A	
4.7 Systèmes destinés à des usages particuliers : conduite des dragages; positionnement des plates-formes *offshore*	A,B		
5. *Sciences de l'environnement*			
5.1 Océanographie			
a) Notions de base : distribution de la température et de la salinité, application à l'étude de la circulation marine : bilan thermique des océans (et répercussion des échanges air-mer sur la répartition verticale de la température); la répartition générale des températures (variations dans l'espace et dans le temps); composition et propriétés physicochimiques de l'eau de mer; salinité et conductivité; répartition générale de la salinité : utilisation de la température et de la salinité comme traceurs, mélange des masses d'eau, diagrammes T.S. (diffusion turbulente); oxygène dissous et sels nutritifs	A		
b) Dynamique de la circulation marine : forces agissant sur le milieu marin (pesanteur, pression, vent, forces lunisolaires, force de Coriolis, frottement); courants géostrophiques; circulation induite par le vent, théorie d'Ekman; courants de pente; circulation littorale; circulation profonde	A*		
c) Mer du vent, houle; réfraction, diffraction et réflexion de la houle, déferlement; tsunamis; seiches; ondes de tempête; ondes internes	A*		
5.2 Marées			
a) Concepts : force génératrice de la marée; théories statique et dynamique de la marée; formule harmonique (analyse et prédiction de la marée); principales composantes harmoniques et divers types de marées, niveaux caractéristiques; les marées à la surface du globe : lignes cotidales et d'égale amplitude; points amphidromiques; marée dans les mers littorales; marée dans les estuaires	B	A	
b) Courants de marée : courants alternatifs et giratoires; observations lagrangienne et eulerienne des courants; analyse et prédiction des courants; relation entre les courants de marée et la marée	B	A	
5.3 Géologie et géophysique			
a) Classification des roches et composition de la Terre	A		
b) Echelle des temps géologiques	A		
c) Principes de la tectonique des plaques	A		
d) Erosion, transport et dépôt de matériaux dans le milieu marin, y compris les processus fluviaux	A*		
e) Méthodes géophysiques pour l'interprétation de la géologie marine	A		
5.4 Gravité et magnétisme			
a) Formule internationale de la pesanteur	A		
b) Expression du champ de pesanteur en termes d'anomalies; anomalie à l'air libre et anomalie de Bouguer; cartes isanomales			
c) Champ géomagnétique international de référence	A		
d) Champ magnétique terrestre et ses fluctuations; inversions des pôles	A		
e) Expression des données magnétiques en termes d'anomalies	A		
6. *Levés terrestres*			
6.1 Géodésie			
a) L'ellipsoïde de révolution et sa relation avec le géoïde	A*		
b) Systèmes géodésiques	A*		
6.2 Réseaux géodésiques			
a) Préparation d'un levé planimétrique : rigidité des figures, choix des méthodes (triangulation, cheminement ou trilatération), structuration du réseau et choix des points, observations nécessaires et appareillage à utiliser	B		A
b) Reprise des points			
Marquage et description des points géodésiques			
Construction de plates-formes d'observation et de bornes			
Choix et marquage de points pour la photographie aérienne		A,B	
c) Mesure optique et électronique des directions et des distances; méthodes pour minimiser les erreurs; réduction des observations		B	A
d) Compensation des figures et des réseaux	B	A	
e) Calcul du réseau en projection; transformations des coordonnées géographiques en coordonnées rectangulaires et vice versa; calcul de la convergence des méridiens, du facteur d'échelle et de la correction des longueurs finies	B	A	
6.3 Réseaux altimétriques			
a) Choix et détermination des niveaux de référence (niveau moyen de la mer, zéro des cartes, laisse de haute mer)		A	
b) Méthodes d'observation et mode de calcul des altitudes à l'aide du niveau à bulle, du théodolite, du sextant et du baromètre		B	A
c) Calcul de l'altitude à partir des observations corrigées des effets de la courbure de la terre et de la réfraction, et à partir de la dépression de l'horizon à la mer et à terre		B	A
d) Choix et détermination du niveau de réduction des sondes; reprise et transport des niveaux de référence; établissement et utilisation de cartes cotidales; niveau de référence dans les cours d'eau et estuaires	B	A	
6.4 Astronomie			
a) La sphère céleste; définition des termes astronomiques	B	A	
b) Emploi des tables astronomiques	B	A	
c) Méthodes et procédés de détermination de la latitude et de la longitude	B	A	
d) Méthodes et procédés de détermination de l'azimut	B	A	
6.5 Photogrammétrie			
a) Appareils de prise de vues aériennes,			

N° repère des matières	Connaissance générale	Connaissance pratique	Connaissance approfondie
leurs caractéristiques géométriques et optiques; la photographie appliquée au levé aérien	A		
b) La stéréoscopie et l'application du fusionnement stéréoscopique aux mesures linéaires	A		
c) Le concept de modèle plastique appliqué à la photogrammétrie analogique et analytique	A		
d) Evaluation des possibilités du restituteur analogique	A		
e) Principe et utilisations de la triangulation aérienne	A		
7. *Levés à la mer*			
7.1 Détermination des positions			
a) Méthodes optiques et directes : relèvements au cercle hydrographique, constructions graphiques; méthodes diverses, y compris l'emploi d'alignements, la mesure des distances par angles stadimétriques ou par fils tendus; sources d'erreurs et précision attendue		B	A
b) Méthodes électromagnétiques utilisant des systèmes à impulsion et à comparaison de phase : choix des sites de stations à terre, sources d'erreurs, méthodes d'étalonnage et précision attendue; avantages relatifs des systèmes ou modes hyperboliques, à deux distances ou à relèvement-distance		B	A
c) Méthodes hybrides : combinaisons de *a*) et *b*) ci-dessus		B	A
d) Détermination des positions à l'aide de satellites artificiels : principe de l'éphéméride émis par le satellite et du comptage Doppler; sources et importance des erreurs; précision attendue	B	A	
e) Détermination de la position à l'aide de balises acoustiques sous-marines : problèmes liés au mouillage, à l'étalonnage et à l'exploitation d'un réseau; sources d'erreurs et précision attendue	B	A	
7.2 Guidage d'un navire			
Diverses méthodes de guidage d'un navire sur une route donnée : dispositif d'affichage d'un système de radiolocalisation, navigation au compas et relèvements à partir de la côte au théodolite, angles au cercle hydrographique, utilisation d'alignements		B	A
7.3 Détermination de la profondeur [voir aussi 3.4 *b*)]			
a) Sondage par écho : Etalonnage du sondeur à écho (barre, cône, plaque) et correction des sondages de la vitesse du son		B	A
b) Choix de l'instrument en fonction de la nature du levé et de la précision recherchée	B		A
c) Réduction de la profondeur mesurée de la hauteur de la marée, de l'immersion des bases, du déjaugeage et de l'écartement des bases		B	A
d) Précision du sondage fonction de la précision de positionnement, de la résolution du sondeur, de la réduction de marée, des mouvements du navire ou de l'embarcation et de la topographie du fond marin	B		A

N° repère des matières	Connaissance générale	Connaissance pratique	Connaissance approfondie
7.4 Levés hydrographiques			
a) Sondages :			
i) Contraintes liées aux cartes et aux documents de levé	B	A	
ii) Espacement des profils de sonde et choix de l'écart entre stations pour une couverture optimale; relation entre la vitesse du navire et l'échelle du levé	B		A
iii) Profils intercalaires, profils transversaux, alignements et limites de sécurité	B		A
iv) Construction des mappes de travail, des projections de préparation des réseaux de radiolocalisation et des minutes de sondage	B		A
v) Enregistrement des données		B	A
vi) Interprétation des enregistrements du sondeur à écho		B	A
vii) Rédaction des sondages et tracé des courbes de niveau		B	A
b) Levés à la drague et au sonar :			
i) Balayage au sonar : emploi des dispositifs acoustiques à balayage usuels, préparation des opérations de balayage, interprétation des enregistrements sonar et inclusion de ces données dans les résultats du levé	B	A	
ii) Dragage hydrographique au fil ou à la barre : techniques de dragage, préparation des projections de travail à grande échelle, contrôle de l'immersion de la drague, rédaction des dragages et inclusion des données recueillies dans les résultats du levé	B	A	
iii) Vérifications et recherches d'obstructions à l'aide du sondeur à écho, du sonar, de la drague hydrographique, du magnétomètre, des plongeurs et de la photo sous-marine	B	A	
c) Techniques aéro et spatioportées			
Techniques aériennes et spatiales de sondage dans les eaux peu profondes	A*,B		
d) Topographie côtière, aides à la navigation et publications nautiques			
i) Tracé du trait de côte et levé topographique en vue de la cartographie marine en fonction de l'échelle; levé topographique à partir du large; amers remarquables; vues de côte; emploi de la photographie (terrestre et aérienne)		A,B	
ii) Choix de l'emplacement des marques d'alignement et de limite de sécurité	B	A	
iii) Aides classiques à la navigation : choix des emplacements et positionnement : balises (inerte, radar et radio), phares et bateaux-feu, bouées, secteurs lumineux	A*,B		
iv) Préparation des données devant figurer dans les publications nautiques : instructions nautiques, livres des feux, guides de ports	A*,B		
7.5 Cartographie			
a) Projections cartographiques usuelles (Mercator, Mercator transverse; coni-			

N° repère des matières	Connaissance Générale	Pratique	Approfondie
que et stéréographique), transformations de coordonnées, carroyages et canevas géographiques; mise en place des réseaux sur les projections	B	A	
b) Processus de réalisation des cartes marines : rassemblement et choix des données, réduction des données, choix des sondes, généralisation, tracé des courbes de niveau et tenue à jour	A*,B		
c) Techniques et matériaux de dessin : papier, supports plastiques, encres, plumes, outils de tracé, règles, échelles, compas à verge et autres instruments		A,B	
d) Rédaction en mission : carroyages, réseaux, construction des stations, écriture des sondes, trait de côte; tracé des courbes de niveau et vérification; réalisation des écritures; signes conventionnels et abréviations		A,B	
e) Rédaction des cartes marines : dessin, préparation des typons; planches d'impression, épreuves en couleurs, méthodes d'impression	A		
f) Techniques de cartographie automatique	A*,B		
7.6 Levés géologiques et géophysiques [voir aussi 3.6]			
a) Détermination des profils et des réseaux de stations pour obtenir une couverture optimale selon le but du levé (échantillonnage, balayage, études sismiques, etc.)	A*		
b) Etude du fond marin par sonar à balayage, photographie sous-marine et échantillonnage; interprétation et présentation des résultats	A*		
c) Détermination de la géologie du fond marin à partir d'observations gravimétriques, magnétiques, sismiques et de forages; enregistrement et prétraitement des données	A*		
7.7 Océanographie physique [voir aussi 3.5 et 5.2]			
a) Collecte d'échantillons et mesure des paramètres océanographiques classiques	A*		
b) Choix des emplacements, installation, étalonnage et utilisation des échelles de marée et des marégraphes; enregistrement, traitement et analyse des observations de marée		A,B	
c) Choix des emplacements, mouillage, étalonnage et utilisation de courantomètres à lecture directe et enregistreurs; enregistrement, traitement des observations de courants et de courants de marée	B	A	
7.8 Rédaction des rapports de mission		B	A
8. *Droit de la mer*			
8.1 Historique des principes du droit international	A*,B		
8.2 Mer territoriale : nature, caractéristiques; largeur; eaux intérieures; baies et baies à caractère historique; ouvrages permanents dans les ports et rades; délimitation entre Etats côtiers limitrophes ou se faisant face	A*,B		
8.3 Zone contiguë : nature et caractéristiques, limites, droits des Etats côtiers	A*,B		
8.4 Détroits utilisés pour la navigation internationale : droit de passage; dispositifs d'organisation et de séparation de trafic, droits des Etats côtiers, responsabilité en cas de dommages	A*,B		
8.5 Plateau continental et zone économique exclusive : nature et étendue, droits et obligations des Etats côtiers, régime juridique des ressources (vivantes ou non), câbles sous-marins et pipelines, installations artificielles, règles de navigation, recherche scientifique; délimitation entre Etats côtiers limitrophes ou se faisant face	A*,B		
8.6 Dispositions générales relatives à la haute mer, au passage inoffensif; règles concernant les îles, les pêcheries, les îles et installations artificielles, les archipels, les mers fermées ou semi-fermées; droits et intérêts des Etats côtiers sur les mers fermées et des Etats sans façade maritime; autorité maritime internationale pour le fond des mers	A*,B		
8.7 Problèmes de délimitation : références géodésiques et altimétriques, lignes de base normales, lignes de base droites, lignes de fermeture de baies, lignes médianes et équidistantes, îles au large, bancs couvrant et découvrant, embouchures de fleuves, ports et rades	B	A	
8.8 Règles nationales et internationales relatives à la prévention et la lutte contre la pollution marine, et à la préservation du milieu marin	A*,B		
9. *Navigation et météorologie*			
9.1 Navigation, pilotage et matelotage			
a) Navigation côtière et utilisation des cartes		A,B	
b) Observations astronomiques à la mer	A*		
c) Règles de route et règlements pour la prévention des collisions		A,B	
d) Utilisation du radar, point radar	B	A	
e) Manœuvre de petits bateaux		A,B	
f) Caractéristiques et comportement des bateaux	A,B		
g) Matelotage : en fonction des besoins hydrographiques		A,B	
h) Connaissances maritimes générales (terminologie marine)	A,B		
i) Procédures d'urgence et de sécurité concernant les travaux hydrographiques		A,B	
j) Fonctions de l'officier de quart	A,B		
k) Transmissions	B	A	
l) Compas magnétiques et gyroscopiques : utilisation et erreurs		A,B	
9.2 Météorologie			
a) Atmosphère : densité et isobares, origine et répartition de la chaleur, humidité relative	A*,B		
b) Nuages : types associés à la convection, aux effets orographiques, aux fronts et à la turbulence	A,B		
c) Précipitations : pluie, neige, grêle, givre, brume, brouillard humide et brume sèche	A,B		
d) Vent : gradients de pression, relation avec les isobares, effet du frottement de surface, turbulence, conditions locales causées par des variations de température; échelle Beaufort	A*,B		

N° repère des matières	Connaissance générale	Connaissance pratique	Connaissance approfondie
e) Masses d'air et fronts	A*,B		
f) Phénomènes météorologiques, optiques et autres y compris les orages, les tornades et les trombes marines	A,B		
g) Cyclones tropicaux	A,B		
h) Vagues et houle : formation des vagues, conditions régissant l'amplitude et la longueur d'onde, échelle Beaufort	B	A	
i) Glace de mer et icebergs	A,B		
j) Climats océaniques	A,B		
k) Observation et enregistrement météorologiques			A,B
l) Prévisions de base et cartes synoptiques	B	A	

Annexe I

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Hydrographie côtière

I.1 Régime des côtes et aménagement du littoral

a) Alluvionnement et érosion : types de fonds, transport et dépôt des sédiments, apports fluviaux, formation de barres et d'autres foyers d'alluvionnement, méthode d'élimination des déblais et choix des zones de déblais, méthodes d'évaluation du transport de sédiments, floculation, problème de la vase fluide

b) Gestion du littoral : formation et rythme d'évolution des divers types de fonds marins, approvisionnements en eau, habitat et communications, rapport entre le milieu naturel et les programmes d'aménagement marin

c) Conception et construction d'installations portuaires (brise-lames, jetées, etc.), méthodes de récupération de terrains sur la mer et de lutte contre l'érosion, types de dragues et méthodes de dragage

d) Aménagement des chenaux et passes, emploi de modèles hydrauliques, physiques et numériques, prise en compte du régime hydraulique général, méthodes pratiques d'intervention (jetées, épis, dragage, etc.)

e) Enlèvement et dispersion des épaves, des obstructions, etc.; effets de la dispersion partielle sur la profondeur des chenaux

f) Balisage des chenaux : choix et mise en place des bouées, des balises, etc. assurant la sécurité de la navigation; mise en place des feux et des marques d'alignement; profondeur et largeur des chenaux en regard des marges de sécurité selon les dimensions et la vitesse des navires

I.2 Aspects juridiques

a) Levés se rapportant à la délimitation des ports et des zones de juridiction et législation les concernant

b) Législation sur la sécurité en matière d'explosifs

I.3 Détermination des positions [voir aussi 3.3 *b*)]

a) Considérations spéciales relatives à l'étalonnage et au fonctionnement des systèmes de localisation radioélectrique dans le cas des levés portuaires (par exemple, réflexion, interférences, phénomènes d'ombres portées, choix du site des stations à terre en vue d'optimiser la couverture et la précision)

b) Aspects économiques et logistiques des interventions dans les ports

I.4 Aspects relatifs aux marées [voir aussi 5.2]

a) Considérations spéciales pour la détermination du niveau de réduction des sondes et son transport dans les ports, cours d'eau et estuaires

Annexe I

N° repère des matières

b) Systèmes de diffusion des hauteurs de marée; la prédiction des seiches et ondes de tempête ainsi que leurs effets

I.5 Levés à grande échelle

a) Considérations spécifiques relatives à la grande précision nécessaire pour les levés répétitifs à grande échelle des chenaux, postes d'amarrage à quai ou en appontement

b) Problèmes et principes de l'automatisation de tels levés et état actuel des réalisations

I.6 Levés spéciaux

a) Levés en vue de travaux de dragage : cahier des charges pour le dragage et contrats; mise en place de repères de dragage; détermination des volumes dragués; installation de marégraphes dans le cadre des contrats de dragage; choix des zones de dépôt des déblais

b) Levés préalables à la réalisation de modèles hydrauliques et d'études de faisabilité; planification de tels levés et des observations requises, y compris l'observation du déplacement des sédiments, la mesure de la houle et des courants, des forces dues au vent, et l'étude de la nature du fond

c) Levés en vue de la surveillance de la pollution : méthodes utilisant des colorants et des traceurs pour suivre les polluants; représentation graphique de la répartition des polluants au cours d'une période de temps donnée; acquisition de données permettant la surveillance du milieu, y compris la température, la salinité, le pH, les matières en suspension et l'oxygène dissous; présentation des résultats faisant apparaître les tendances à long et à court terme

Annexe II

N° repère des matières

Levés océaniques

II.1 Planification et exécution des levés au large en relation avec :

a) Des projets de génie océanique

b) La mise en place et l'ancrage des plates-formes de forage

c) Les études de tracé et la localisation de pipelines

d) La construction d'ouvrages et de dispositifs de mouillage au large

II.2 Action des éléments (vent et vagues)

a) Action du vent : distribution verticale du vent; coups de vent; statistiques et prévision du vent (lois de Gumbell et de Weibull); forces dues au vent

b) Action de la houle sur les structures fixes : statistiques et prévisions de houle; écoulement autour d'un cylindre, formule de Morison; coefficients de traînée et d'inertie

c) Action de la houle sur une structure flottante : paramètres définissant le corps flottant; excitation; coefficients hydrodynamiques; équations du mouvement

d) Applications : mécanique des lignes de mouillage; les bouées et plates-formes océanographiques

II.3 Equipements océanographiques et leur mise en œuvre
Etude des équipements océanographiques tels que treuils et grues, équipements pour l'échantillonnage de l'eau de mer et du fond

II.4 Mesures de marées et courants sur le plateau continental

a) Méthodes de mesure de la marée au large

b) Détermination des niveaux de référence au large

c) Mesures des courants de surface et subsurface au large

II.5 Planification et réalisation des études de pollution

AGENDA ITEM 8

Technical assistance (including training)

FORMATION DE CADRES ET DE TECHNICIENS À L'ÉCOLE NATIONALE DES SCIENCES GÉOGRAPHIQUES*

Document présenté par la France

SUMMARY

At any given time more than 200 students are following courses at the French National Geographic Sciences College.

Two major characteristics of that college need to be stressed.

The first concerns admission to the courses. They are open to non-French students and are followed by many young people studying for short or long periods. Since its foundation more than 700 students and trainees coming from 80 different countries have studied in the college.

The second characteristic concerns the training system. A great deal of time is devoted to concrete examples. The technical courses are completed not only by practical laboratory instruction but also by training in the field. Each year, in early May, the students travel to southern France where the college has its own buildings. During the following four months the students are trained in the field in topographic, levelling and astrogeodetic techniques.

Local training outside France for other national cartographic services is also provided by the Institut géographique national, using the services of the college adapted to meet the needs of each specific case.

L'Ecole nationale des sciences géographiques (ENSG), située à Saint-Mandé, à proximité immédiate de Paris, fait partie de l'Institut géographique national (IGN) français. Fondée en 1941 en vue de la formation de base des fonctionnaires destinés à l'IGN, elle a, peu à peu, étendu ses attributions à la formation d'élèves et stagiaires étrangers.

L'enseignement

Sont enseignées à l'Ecole les disciplines qui interviennent dans l'équipement géographique et cartographique de base d'un pays, à savoir :

a) La géodésie : astronomie de campagne, triangulations, nivellement, gravimétrie;

b) La topographie : topométrie, tachéométrie, levé direct et complètement des levés photogrammétriques à la planchette, toponymie;

c) La photogrammétrie : prise de vues aériennes, aspect physique des photos aériennes, établissement du canevas de restitution (aérotriangulation), restitution;

d) La télédétection : lecture des photographies aériennes, photo-interprétation, procédés modernes de télédétection;

e) La cartographie topographique et thématique : rédaction, techniques graphiques.

L'Ecole dispense également l'enseignement complémentaire dans les disciplines scientifiques nécessaires à la mise en œuvre des techniques géographiques, mathématiques, mathématiques appliquées, sciences physiques (optique, photographie, mécanique, électricité et électronique), informatique, sciences de gestion, sciences de la terre (géologie, géomorphologie, pédologie, magnétisme, océanographie), sciences humaines et écologie.

Enfin, aux futurs ingénieurs, l'Ecole dispense l'enseignement de certaines disciplines connexes des disciplines géographiques et dans lesquelles ces dernières jouent un rôle important : techniques de génie civil, techniques de génie rural.

L'enseignement dispensé uniquement en langue française revêt trois aspects :

a) L'enseignement magistral, donné dans les leçons et les conférences d'information.

b) L'enseignement dirigé, dispensé par petites classes; le dialogue y est permanent entre le professeur et les élèves; ceux-ci sont invités à passer au tableau sur des exercices d'application ou à faire à leurs camarades des exposés sur un sujet donné à l'avance par le professeur. Ces petites classes ou séances d'application ont un rôle capital : elles permettent en particulier au professeur de se rendre compte si son enseignement est bien assimilé par les élèves.

c) L'enseignement pratique, confié à des assistants; comme ceux-ci assurent la liaison entre l'enseignement

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théorique et les applications au cours de séances de travaux pratiques, ils doivent travailler en collaboration étroite avec les professeurs.

Si pour une catégorie donnée l'enseignement d'une discipline présente le triple aspect qui vient d'être défini, cette même discipline est enseignée à plusieurs niveaux différents, correspondant aux cycles ci-après.

Le corps professoral est essentiellement constitué d'ingénieurs de l'IGN choisis en fonction de leur compétence et de leur expérience dans chaque discipline.

Pour l'enseignement des sciences de la terre, des sciences humaines, l'Ecole fait appel à des professeurs d'université.

Cycles d'enseignements—stages groupés

Le *cycle des ingénieurs géographes* (cycle A) recrute des élèves étrangers au niveau de la maîtrise ès-sciences, correspondant à quatre années d'études scientifiques après le baccalauréat; il forme en deux ans des ingénieurs polyvalents destinés à occuper des postes de haute direction, de recherche, d'enseignement supérieur.

Le *cycle des ingénieurs des travaux* (cycle B) recrute des élèves étrangers au niveau de la classe de mathématiques spéciales ou du DEUG mathématiques et physique, correspondant à deux années d'études après le baccalauréat; il forme en trois ans des ingénieurs chargés de diriger des missions de terrain et des ateliers de production.

Le *cycle des géomètres* (cycle C) recrute des élèves étrangers au niveau du baccalauréat des séries scientifiques; il forme en deux ans des techniciens supérieurs d'études et de travaux géographiques, aptes à encadrer des personnels d'exécution ou à exécuter eux-mêmes certains travaux de haute qualification en géodésie, topographie, photogrammétrie.

Le *cycle des cartographes* (cycle D) recrute aussi au niveau du baccalauréat des élèves étrangers ayant une réelle aptitude pour la cartographie; il forme en deux ans des techniciens supérieurs cartographes capables d'exécuter des travaux de conception cartographique et de diriger des ateliers de rédaction cartographique.

Le *cycle des techniciens topographes* (cycle C') recrute des élèves étrangers au niveau de la classe de première et leur donne en deux ans une formation pratique en géodésie, topographie, photogrammétrie, l'une des trois disciplines ci-dessus faisant l'objet d'une spécialisation en fin de cycle.

Ce cycle est installé en permanence à Forcalquier, où l'IGN dispose d'un bâtiment qui vient d'être agrandi récemment.

Le *cycle des techniciens cartographes* (cycle D') recrute au niveau de la classe de première des élèves étrangers ayant des aptitudes pour le dessin cartographique; il forme en deux ans, à Saint-Mandé, des techniciens cartographes aptes à encadrer des dessinateurs ou à exécuter eux-mêmes des rédactions délicates.

Le *cycle des dessinateurs photo-identificateurs cartographes* (cycle E) recrute au niveau de la classe de troisième et forme uniquement du personnel destiné à l'IGN. Les Etats étrangers n'ont pas intérêt à confier à ce cycle la formation de leurs dessinateurs d'exécution. Nous pensons que les ingénieurs techniciens supérieurs et même les techniciens cartographes sortis de l'ENSG devraient pouvoir assurer cette formation, après quelques années de pratique.

Pour les cycles A, B et C, l'Ecole organise de mai à août, dans le midi de la France, de véritables travaux d'application sur le terrain : astronomie, géodésie, nivellement, stéréopréparation, topographie, topométrie.

Sanction des études

Les élèves sont soumis à un contrôle de connaissances permanent au moyen de compositions et interrogations échelonnées durant l'année scolaire.

Pour l'admission en année supérieure et pour l'obtention du titre de fin d'études, les élèves doivent satisfaire à un certain nombre de conditions, énumérées dans le règlement intérieur de l'Ecole, notamment obtenir :

a) Une moyenne minimale de 10 pour l'ensemble des interrogations et compositions;

b) Une moyenne minimale de 12 pour les travaux pratiques et les travaux d'application sur le terrain.

Les élèves étrangers ayant satisfait à ces conditions se voient décerner :

Cycle A — le Diplôme d'ingénieur civil géographe;

Cycle B — le Diplôme d'ingénieur diplômé de l'Ecole nationale des sciences géographiques;

Cycle C — le Brevet de technicien supérieur d'études et de travaux géographiques;

Cycle D — le Certificat de fin d'études de technicien supérieur en cartographie;

Cycle C' — le Certificat de fin d'études de technicien topographe;

Cycle D' — le Certificat de fin d'études de technicien cartographe.

Les diplômes d'ingénieurs sont reconnus par la commission du titre d'ingénieur diplômé au sens de la loi de 1934 (*Journal officiel* du 21 juillet 1971) et sont homologués au niveau I ou II dans la classification des diplômes technologiques français. Dans cette même classification, les titres de fin d'études des cycles C et D sont homologués au niveau III (technicien supérieur) et les titres de fin d'études des cycles C' et D' sont homologués au niveau IV (technicien).

Cycles et stages spéciaux

Cycle de préparation au diplôme de docteur ingénieur en sciences géographiques

Ce cycle comprend une année d'études et d'initiation à la recherche dans le cycle A de l'ENSG sanctionnée par le diplôme d'études approfondies de sciences géographiques, et deux années de recherche dans un laboratoire de l'Institut géographique national. Après soutenance d'une thèse, les candidats peuvent obtenir le diplôme de docteur ingénieur en sciences géographiques.

Cycle d'enseignement de téléinterprétation et de cartographie (CETIC)

Ce cycle donne en une année une formation solide en téléinterprétation et de bonnes notions de télédétection. Il s'adresse plus spécialement à des candidats ayant leur maîtrise de géographie ou en sciences de la terre : géologie, pédologie.

Les candidats titulaires d'une maîtrise qui s'inscrivent en début d'année universitaire à l'Université Pierre et Marie Curie (Paris VI) reçoivent en fin d'études le diplôme d'études supérieures spécialisées de téléinter-

prétation et cartographie, délivré conjointement par l'Ecole et par l'Université Paris VI. Les autres candidats reçoivent un certificat de spécialité.

Autres cycles d'un an

L'Ecole admet des auditeurs libres autorisés à ne suivre qu'une partie de l'enseignement de l'un des cycles A, B, C', D, D'.

Ces auditeurs peuvent prétendre sous certaines conditions énumérées dans le règlement intérieur de l'Ecole à :

Un certificat d'études supérieures dans le cycle A;

Un certificat de spécialité (topométrie-topographie, géodésie-astronomie, photogrammétrie) dans le cycle B;

Des brevets de qualification (levé direct aux grandes échelles, complètement des levés photogrammétriques, triangulation, nivellement de précision, stéréopréparation) dans le cycle C;

Des brevets de technicien dans le cycle C'.

Stages

Citons parmi les stages le stage d'enseignement de télédétection organisé chaque année durant sept semaines en mai et juin.

Ce stage ainsi que le CETIC, cité plus haut, sont coordonnés par le groupement pour le développement de la télédétection aérospatiale (GDTA) qui comprend :

Le Bureau de recherches géologiques et minières;

Le Bureau pour le développement de la production agricole;

Le Centre national d'études spatiales;

L'Institut français du pétrole;

L'Institut géographique national.

Sous l'égide du GDTA sont organisés d'autres enseignements de télédétection à Toulouse.

Evolution de l'Ecole durant ces dernières années

L'organisation de l'Ecole et les conditions de recrutement qui viennent d'être énumérées ne correspondent pas à celles que d'anciens élèves ou stagiaires ont connues avant 1967. Depuis cette époque, l'Ecole a subi une évolution très sensible caractérisée essentiellement par l'élévation du niveau de recrutement des élèves étrangers dans les cycles B et C; en effet, l'actuel cycle B recrute sensiblement à l'ancien niveau du Cycle A; de même l'actuel cycle C recrute à peu près au même niveau que l'ancien cycle B.

Ces nouvelles dispositions ont dû être prises pour nous permettre de faire reconnaître officiellement par le ministère de l'Education nationale les diplômes délivrés par l'Ecole.

Parallèlement, l'Ecole a créé le cycle D' qui fonctionne depuis une douzaine d'années, ainsi que le cycle C' dont la création remonte seulement à 1977. Ces deux cycles forment des techniciens praticiens, alors que les autres cycles dispensent un enseignement supérieur à la fois théorique et technique.

Nous avons donc dû mettre en application de nouvelles mesures de sélection des élèves étrangers, comportant de véritables examens passés sur place dans les ambassades de France. Au début, les organismes cartographiques qui nous confiaient la formation de leurs cadres et techniciens ont rencontré des difficultés mais ils ont parfaitement compris qu'ils seraient les principaux bénéficiaires des nouvelles mesures, un bon niveau de connaissances de base étant le plus sûr garant d'une formation solide. Aussi ont-ils fait des efforts méritoires pour rechercher des candidats valables.

Malgré le soin apporté dans la sélection, on constate quelques échecs, certains élèves n'arrivant pas à obtenir leur diplôme de fin d'études. Ces échecs proviennent en grande partie des difficultés d'adaptation des élèves africains à la vie française et surtout à la vie en région parisienne. Nous le constatons depuis qu'a été créé le centre de Forcalquier, où les élèves africains se sentent beaucoup plus à l'aise que dans la région parisienne. Les conditions matérielles plus faciles et le caractère plus concret de l'enseignement font que les échecs y sont pour le moment inexistants.

FORMATION LOCALE DE TECHNICIENS

La formation sur place présente de gros avantages (élèves formés dans leur milieu, enseignement adapté en fonction du niveau des élèves et des caractéristiques spécifiques du pays) et quelques inconvénients (locaux non adaptés à l'enseignement, matériel insuffisant).

Cette solution est efficace et permet de réduire au maximum les délais et les frais de formation. On peut considérer que les élèves diplômés sont des opérateurs tout à faire corrects.

Reste le problème de l'encadrement après école; le cycle B de l'ENSG semble le plus approprié à fournir des cadres valables à moyen terme à condition toutefois d'être conseillés sur place à court terme (minimum deux ans) par des experts français.

Dans l'exemple choisi et développé ci-après, une convention de coopération avait été signée, aux termes de laquelle la partie française devait assurer en moins de six ans la formation sur place des opérateurs d'un service géographique national.

La durée prévue a été de six ans (dans un centre de formation adapté).

Nombre d'élèves à former : environ 220 (100 seront formés fin 1979);

Nombre de cycles : 4;

Nombre d'experts techniques enseignants : environ 1,5 par cycle;

Recrutement : sur titres après un diplôme équivalant au baccalauréat français.

La description des cycles a été prévue ainsi :

a) FT *Field technician* (technicien topographe) : 4 promotions; durée : 2 ans (11 mois par an, 5 jours par semaine, 7 heures et demie par jour); nombre d'élèves à former : 90 (30 géodésiens, 30 topographes, 30 stéréopréparateurs); enseignement axé sur la formation d'opérateurs de terrain; spécialisation dans les six derniers mois; diplôme de niveau 4.

b) DP *Drafter-plotter* (technicien cartographe restituteur) : 2 promotions; durée : 2 ans (11 mois par an, 5 jours par semaine, 7 heures et demie par jour); nombre d'élèves à former : 45; formation en double spécialité; tronc commun théorique pendant 4 mois avec la section FT, puis enseignement spécifique axé sur l'élaboration de la carte depuis la restitution jusqu'à l'obtention des planches mères; diplôme de niveau 4.

c) DPT *Drafter-plotter technician* (opérateur cartographe restituteur) : 2 promotions; durée : 1 an (11 mois par an, 5 jours par semaine, 7 heures et demie par jour); nombre d'élèves à former : 35; spécialisation après 3 mois; les élèves font peu de théorie et beaucoup de travaux pratiques en vue de tâche d'exécution en dessin, gravure sur couche, restitution; diplôme de niveau 5.

d) PP *Printer photographer* (opérateur imprimeur photograveur) : 2 promotions; nombre d'élèves à former : 50; enseignement pratique axé sur l'obtention des films planches mères; copie au diazoïque zincographie, imprimerie *offset*.

Tous les cycles reçoivent de plus un enseignement général préparatoire de deux mois (anglais, français, mathématiques, physique, dessin).

L'enseignement technique peut se faire en anglais.

Les cycles de deux ans (FT et DP) suivent des cours de français pendant toute leur scolarité.

Dans l'opération pilote effectuée, après quatre ans, le pourcentage des élèves renvoyés en cours de scolarité s'élève à environ 20. A noter que la majeure partie de ces élèves ne possédait qu'un diplôme équivalant au baccalauréat littéraire.

POST-GRADUATE TRAINING IN GEODESY: A PREREQUISITE FOR THE INFRASTRUCTURAL DEVELOPMENT OF A COUNTRY*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

L'une des principales conditions du développement de l'infrastructure d'un pays est l'établissement et la tenue à jour de cartes utilisables pour la planification. Des cartes à différentes échelles sont nécessaires selon l'étendue des zones à développer.

Les spécialistes de la géodésie jouent un rôle capital dans l'établissement et la révision des cartes. Pour que la cartographie occupe la place qui doit être la sienne, il faut concentrer l'effort d'organisation voulu au niveau national. Il faut que le pays se dote, si possible, de centres permettant d'assurer la formation nécessaire, tant d'un point de vue qualitatif que quantitatif.

On indique dans le document comment il est possible de relever le niveau de la formation, et on donne l'exemple de ce qui s'est fait au centre de formation géodésique de Curitiba dans l'Etat de Paraná (Brésil). On y traite en particulier de la formation géodésique du troisième cycle et notamment de la transformation en doctorat de l'actuelle maîtrise de géodésie; ces mesures sont censées encourager les travaux indépendants.

Cet exemple permettra de se faire une idée du processus qui a été suivi et qui, dans son principe, vaut pour d'autres cas.

IMPORTANCE OF POST-GRADUATE TRAINING IN DEVELOPMENT

A supply of sufficient map material for planning is a prerequisite for the development of a country's infrastructure. This applies in particular to developing countries where considerable demand generally exists and where large and small tasks in infrastructural development call for maps, as for instance the improvement of traffic routes and the controlled development of vigorously expanding urban regions.

There is no question about the contribution of surveying to the compilation of exact maps. Yet, surveying can only do its share of the work if it is properly organized within a country. For this purpose training centres must exist which conform in quality and quantity to the tasks at hand. Promotion of geodetic training at the universities of developing countries can contribute to the quality of education in this field. It would be desirable to raise existing graduate-training at selected universities to the level of a Master's course in geodesy. In certain circumstances it seems even to be appropriate to extend the Master's course to the doctorate level.

This extension of training can, for the time being, be realized in developing countries only at a few selected universities which then must serve as a guide for geodetic training and research over a larger region. In the South American area such an extension is planned within the scope of technical-scientific co-operation between Brazil and the Federal Republic of Germany, starting at the Federal University of Paraná in 1980. In Mexico, a comparable development is at hand at the Universidad Nacional de México.

The University of Curitiba is presented here as an example which can easily be applied to other conditions, and to other projects.

THE PROJECT "GEODESY: POST-GRADUATE TRAINING AND RESEARCH AT THE FEDERAL UNIVERSITY OF PARANÁ, BRAZIL"

In 1977 the Government of Brazil applied to the Federal Republic of Germany for an extension of post-graduate training and research in the field of geodesy at

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the University of Curitiba within the scope of the contract on technical co-operation. In 1978, this application was investigated by two experts, Dieter Morgenstern of Bonn, and Günter Seeber of Hanover, by order of the Gesellschaft für technische Zusammenarbeit (GTZ) (Society for Technical Co-operation). The investigators elaborated a proposal on the extent and strategy of the contribution of the Federal Republic of Germany.

Training of surveyors at the University of Curitiba

University education in Brazil is, in general, divided into the *graduaçao* which follows the higher primary school and lasts at least five years, and *pós-graduaçao* study based upon it. Both education sections lead to an examination at different levels qualifying for a certain profession. The title, bestowed after a successful examination, is differentiated according to the respective field for the *graduaçao*, e.g. *engenheiro cartógrafo*; while for the *pós-graduaçao*, independently of the branch of study, there is, at a medium level, the *mestrado* and at a higher level the *doutorado*.

The level of the *graduaçao* examination corresponds approximately to the North American "Bachelor". The ensuing *pós-graduaçao* may lead, after about two additional years, within the scope of strictly organized course of study to the *mestrado* which corresponds approximately to the North American "Master".

The *doutorado* course is not as strictly organized as the *mestrado* course. Certain lectures are compulsory, but independent research is central to the course (*doutorado-dissertaçao*).

Training of surveyors at university level in Brazil has existed for only a short time, so far at three universities and one military university. In general, the course is called *"Curso de Engenharia Cartografica"*, and leads to a diploma *Engenheiro Cartógrafo*. This corresponds approximately to the North American degree of "Bachelor".

At the Universidade Federal do Paraná in Curitiba (UFP), in the "Departemento du Ciências Geodesiquas", a *Curso de Engenharia Cartografica* was established two years ago. The graduates will obtain the diploma of *Engenheiro Cartógrafo*. Here, too, the curriculum is scheduled for ten periods (five years); however, the otherwise usual sharp separation between propaedeutic subjects and professional study is removed. Starting with the first semester, elementary lectures in cartography and topography are held. Geodesy, photogrammetry and adjustment computation are presented to a balanced extent.

In 1971, a *curso de pós-graduaçao* in geodesy was established. This is the only *pós-graduaçao* course with *mestrado* examination in the field of geodesy in Brazil corresponding to the North American Master's degree. The course aims at:

(*a*) Education of professors at a higher level;

(*b*) Advancement of research in the geodetic field;

(*c*) Education of highly qualified experts for tasks in national cartography.

The curriculum comprises mainly subjects of higher geodesy, adjustment computation and photogrammetry. In the field of surveying (cartography) there still exists no doctorate course in Brazil.

Planned raising of the Master's course in geodesy at the University of Curitiba

In order to make available higher qualified experts to carry out urgent cartographic tasks, as well as appropriate teachers for the various training centres of Brazil, the training level must be raised. This should be achieved by the following project aims:

(*a*) Raising the level of the Master's course;

(*b*) Intensification of research;

(*c*) Development of the Master's course to the doctorate level.

At present, there exists no such course in Brazil, only a course leading to the *mestrado*. Indeed, there is no doctorate course in this technical field in all South America. Brazilian geodesists who want to attain a Doctor's degree must go to foreign countries for some years. Apart from European training centres, two North American universities are preferred, namely Ohio State University in Columbus, Ohio, and the University of New Brunswick in Fredericton, Canada.

The likely candidates, however, being as a rule Brazilian teachers who are urgently required for teaching tasks in their own country, have in many cases no possibility of obtaining a leave of absence for several years. For this reason, teaching within a certain course is done mostly by professors who have themselves not gone beyond graduation from this course. Because of this, a rise of the training level can be expected only in the long term.

The situation would greatly improve if at least some of the professors required for teaching could attain a doctorate in their own country. For one thing, graduates of a doctorate course in Curitiba might consolidate the quality of the *mestrado* course at that institution; for another, the prerequisite would be provided for raising training to the *mestrado* level at other institutions in Brazil.

As the teachers of the *pós-graduaçao* courses teach also in the *graduaçao* courses, the quality of the undergraduate courses would also be raised considerably. Consequently, by raising the level in Curitiba, if the project aims are achieved, an elevation of the training level in surveying in all fields may be expected throughout Brazil within a calculable time. By such a development, the following results can be expected:

(*a*) On a short-term basis, the quality of the training at *pós-graduaçao* level in Curitiba is improved and a course is established to attain a doctorate;

(*b*) On a medium-term basis, more qualified teaching personnel will be available for all geodetic centres in Brazil, thus improving the quality of teaching at all levels, especially in the *graduaçao* range. For official and private survey institutions better qualified graduates will be available;

(*c*) On a long-term basis, the higher training level is consolidated for Brazilian training centres. The University of Curitiba may develop to become a centre for geodetic science and research, thus influencing other universities in Brazil and in other countries of South America.

Scientific technical co-operation to attain the aims of training at Curitiba

The planned raising of the existing Master's courses in geodesy at the University of Curitiba to the level of

doctorate may be advanced by the following measures:

(*a*) Sending highly qualified long-term experts in the fields of geodesy and photogrammetry to Curitiba;

(*b*) Sending highly qualified short-term experts in various special fields of surveying to Curitiba;

(*c*) Procurement and supply of measuring and plotting instruments for geodesy and photogrammetry;

(*d*) Fellowships for Brazilian graduates for the purpose of acquiring a doctorate in Europe or North America.

The proposed fields of geodesy and photogrammetry for long-term experts are appropriate, because the introduction of the fundamentals of geodesy and photogrammetry as the nearly exclusive methods of mapping in Brazil is of considerable importance. For formal reasons, as well as for improvements of the quality of training at the highest level, it is necessary that these experts have a Doctor's degree.

Since long-term experts are unable to cover all special fields in surveying, short-term experts are required. They will initiate and furnish new ideas for research work in the different fields. The employment of short-term experts seems especially suited to identify tasks in geodesy which in Europe are conventional geodetic tasks, but which in Brazil, at present, are being done by engineers who are not especially trained, as for instance civil engineering and cadastral work.

Additional instrumental equipment is urgently needed for research as well as for teaching at the *pós-graduaçao* level. In order to take into account the various teaching and research tasks in photogrammetry, an increase in photogrammetric equipment is recommended, highest priority being given to educational needs. The practice-related task of aerial photogrammetry—capture and graphic output of topographic information—should be considered, especially when procuring the instruments.

At least, places for attaining a doctorate for fellowship holders should be made available in Europe or America. Expenses for fellowships could be paid partly by Brazil. It would be desirable for qualified graduates from the *mestrado* course, who are becoming or are already active in education and research at universities to be given the possibility of getting acquainted with methods of research and education in other countries and of attaining a doctorate within the scope of a fellowship. All these measures will contribute to achieving the project aims within a calculable time.

AIMS RESULTING FROM EXTENSION OF POST-GRADUATE TRAINING IN GEODESY IN DEVELOPING COUNTRIES

Apart from the higher aim of promoting the infrastructural development of the country, for training in surveying, the following can result:

(*a*) The level of existing study courses will be raised (under certain conditions to the Master course level);

(*b*) Geodetic research will be intensified;

(*c*) Existing Master's courses will, if necessary, be extended to the doctorate.

Intensification and raising of the level of training and research in the domain of surveying at selected universities of developing countries has the aim of supplying more qualified graduates for the solution of urgent cartographic problems and for establishing qualified teaching programmes at all geodetic training centres of the country, especially in the north and north-east.

REFERENCE

Morgenstern, D. and G. Seeber (1978) "Gutachten zum Förderungsvorhaben Geodäsie-Postgraduiertenausbildung und Forschung an der Bundesuniversität von Paraná, Brasilien".

THE POSSIBILITIES FOR TECHNICAL ASSISTANCE BY THE FEDERAL REPUBLIC OF GERMANY*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

Le document indique brièvement les possibilités de coopération technique offertes par la République fédérale d'Allemagne dans les domaines de l'établissement de levés, de la géodésie, de la photogrammétrie et de la cartographie. Cette coopération peut revêtir la forme de stages de formation théorique et pratique dans des établissements d'enseignement de la République fédérale d'Allemagne, de réunions d'étude pour des responsables et des spécialistes de haut niveau et de projets d'assistance technique.

In the Federal Republic of Germany, technical co-operation in the fields of surveying, geodesy, photogrammetry and cartography is carried out in various ways, which this paper outlines.

EDUCATION AND TRAINING

Several possibilities for scholarships and fellowships exist:

(*a*) For attending studies at the seven universities specializing in survey education at the Dipl.-Ing. and doctorate level, arranged by the Deutscher Akademischer Austauschdienst;

(*b*) For pursuing studies at some ten engineering schools for survey and cartography specialization at the graduate engineer level, arranged by the Carl-Duisberg-Gesellschaft;

(*c*) For technical attachments of several months duration in geodetic and cadastral surveying (and in car-

*The original text of this paper, prepared by Gottfried Konecny, Institute for Photogrammetry, University of Hanover, appeared as document E/CONF.72/L.84.

tography) at various organizations in the country, arranged by the Central Agency for Employment;

(*d*) For training as photogrammetric operator at the newly established photogrammetric training centre in Stuttgart, arranged by the Carl-Duisberg-Gesellschaft.

CONTINUOUS INFORMATION EXCHANGE

In order to meet the requirements of up-to-date information exchange on technical matters by top-level managers and specialists, the co-ordination group for technical co-operation in surveying and mapping (BEV) initiates the organization of workshops and seminars of 2 to 3 weeks duration at intervals of two to four years.

In the past, two such workshops have been held in the field of cadastral surveys and land information. In 1974, jointly with the United Nations, the Inter-regional Seminar on Cadastral Surveying and Urban Mapping was held at Berlin (West). This workshop was attended by about 50 participants from developing countries. It was organized by the Foundation for Technical Co-operation (DSE) of the Federal Republic of Germany.

In 1978, in co-operation with the Cartography Section of the United Nations Secretariat, a Workshop on Cadastral Surveying, Mapping and Land Information took place to which about 30 participants were invited on behalf of the Government of the Federal Republic of Germany. The workshop was organized at Hanover by the Carl-Duisberg-Gesellschaft.

The next workshop will be held in connection with the XIV Congress of the International Society of Photogrammetry to be held at Hamburg from 13 to 25 July 1980. Again, 30 developing countries will receive invitations from the Government of the Federal Republic of Germany to send a top-ranking specialist on the management level. Further workshops for 1982 and 1984 are foreseen in remote sensing and in cadastral surveys.

TECHNICAL ASSISTANCE PROJECTS

Projects rendering technical co-operation in surveying and mapping have been completed in various countries including Brazil, Liberia, Nigeria, Rwanda, Thailand, Tunisia, Upper Volta and some Central American countries. They are usually pilot projects and include provision of instruments and on-the-job training. They may also be concerned with technical co-operation in the establishment of educational facilities.

Countries desiring such assistance by the Federal Republic of Germany should initiate this by a request for technical co-operation. Requests must come from the Government of the country desiring assistance to the Government of the Federal Republic of Germany and should be directed through the embassies of the Federal Republic in the respective countries.

TRAINING AND EDUCATION IN SURVEYING AND MAPPING IN INDONESIA*

Paper presented by Indonesia

RÉSUMÉ

Au commencement du deuxième Plan quinquennal de développement national, en 1974 (Pelita II et Pelita III), on a assisté à une intensification spectaculaire des activités topographiques et cartographiques qui a conduit à une pénurie de géomètres, de techniciens et d'ingénieurs qualifiés, situation qui a failli tourner à la crise. Des programmes de formation accélérée, financés par le gouvernement et des institutions privées, ont permis dans une certaine mesure de satisfaire les besoins en techniciens; mais ces derniers étaient inégalement qualifiés, ce qui ne manquera pas d'avoir ses propres répercussions sur les professions de topographe et de cartographe.

Les demandes croissantes auxquelles Pelita II et Pelita III soumettent ces professions requièrent à leur tour une accélération et une extension de la formation dispensée par les établissements d'enseignement existants, qui sont déjà surchargés et manquent de moyens. L'introduction de nouvelles techniques, telles que la détermination des positions par satellite, la télédétection et la cartographie automatisée a encore aggravé une situation déjà difficile.

At the start of the second Five-year Development Plan in 1974 (Pelita II and Pelita III), a boom in surveying and mapping activities was created which resulted in a shortage of well-qualified surveyors and technicians as well as engineers; this almost became a crisis. Crash training programmes by Government and private institutions to a certain extent filled the need for technicians, but their qualifications were unequal; and this could have its own impact on the surveying and mapping profession.

The increasing demands of Pelita II and Pelita III on the profession have brought about a need for acceleration and expansion of training by established educational institutions, which are already overburdened and short of facilities. The introduction of new technology, such as satellite positioning, remote sensing and automation in cartography, has added problems to the already difficult situation.

THE INDONESIAN EDUCATIONAL SYSTEM

Although there are numerous private schools, besides the public schools, there is only one system of education in Indonesia: the State school system, the outline of which is given below. In figure 147 only schools leading to potential study in surveying are outlined.

*The original text of this paper, prepared by the Bandung Institute of Technology, appeared as document E/CONF.72/L.103.

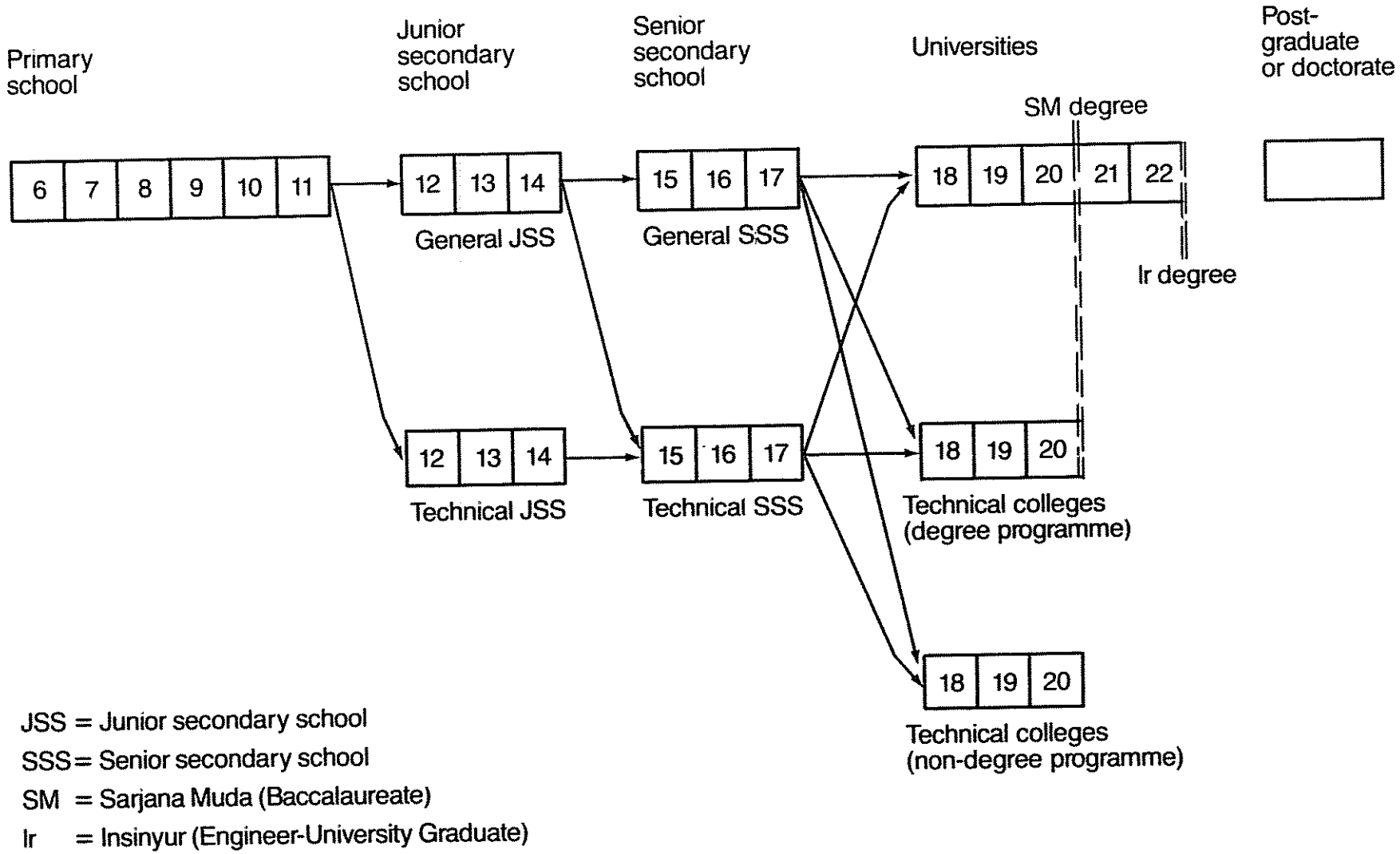


Figure 147. Indonesia: the educational system

There are at present 92,499 primary schools, 9,505 junior secondary schools, 3,681 senior secondary schools and 401 universities and technical colleges. The first degree at a university, the Sarjana Muda (B.Sc.), requires a minimum of three years of study. On graduating from a university, the student obtains another degree, Sarjana Teknik (Ir). A graduate from a technical college obtains the Sarjana Muda (B.Sc.) degree.

UNIVERSITY COURSES

Geodetic engineering departments

The Institut Teknologi Bandung (ITB) (Bandung Institute of Technology) and the Gajah Mada University in Yogyakarta are the only two universities having a geodetic department offering courses covering the spectrum of surveying, geodesy, photogrammetry, cartography, hydrography and land data administration. As the School for photogrammetric and cartographic operators (described later) is attached to the Bandung Institute of Technology, its Department of Geodesy is relatively well-equipped, also in levels, theodolites, electronic distance measuring (EDM) and other surveying instruments. The Department of Geodesy of the Gajah Mada University urgently needs additional equipment and library facilities. The curriculum of the two departments does not differ much from the curricula at European or American universities. At present, the average study years of a student is six years. The following table gives the year of study, student body, enrolment and potential output for 1980.

University	*Years of study*	*Student body*	*Enrolment per year*	*Graduates as of 1980*	*Output per year (potential, 1980)*
ITB	4½	389	60	179	50
Gajah Mada .	5	358	45	43	40

Geography departments

Of the 47 State universities and institutions of higher learning, 17 have a department of geography and the Gajah Mada University has a faculty of geography with eight departments. Surveying and photogrammetry are included in the courses, varying in degrees of comprehensiveness.

Other engineering departments

Surveying and photogrammetry are also included in the courses of other engineering departments such as civil engineering, architecture, geology, mining, sanitary, town and regional planning, agriculture, forestry and soil. Together there are almost 60 departments of the State universities and, roughly estimated, the same number of departments of private universities that include surveying in their courses.

Replies to a questionnaire, prepared by the Department of Geodesy of ITB and distributed to those departments, expressed the need for upgrading courses for the survey lecturers. In response to this, the Department of Geodesy of ITB in 1979 arranged a comprehensive three-month upgrading course for survey lecturers of other universities and will continue to do this every year. The content of the upgrading course are lectures and practical training in surveying, photogrammetry, route surveying, geodetic astronomy, geodetic computations, horizontal networks and adjustment computations. Because of budget problems only eight lecturers were able to come to Bandung for the upgrading courses of 1979.

TECHNICAL COLLEGE COURSES

Geodetic departments

Five technical colleges have a geodetic/topographic department. These are: Akademi Teknologi Nasional (ATENAS) in Bandung; Politeknik PU-ITB in Bandung; Akademi Teknik PU-Jabar in Bandung; Akademi Agraria in Semarang; Akademi Minyak dan Gas (AKAMIGAS) in Cepu.

The first three have curricula with courses that follow much the same pattern as the university courses, but with little stress on theoretical aspects and more stress on application and practical works. Together they have a student population (only geodetic students) of approximately 250 students with an output of 10 per cent yearly. ATENAS is a private technical college, while Politeknik PU-ITB and Akademi Teknik PU-Jabar are technical colleges of the Ministry of Public Works. The Akademi Agraria is a technical college of the Ministry of the Interior with a curriculum that puts heavy stress on governmental and land data administration. AKAMIGAS is a technical college of the State-owned oil company PERTAMINA. The student body of the last-mentioned colleges is small.

These technical colleges have a three-year curriculum that leads to a Sarjana Muda (B.Sc.) degree on the survey-technologist level. There are also other training or upgrading courses which have the same level as a technical college with a non-degree programme, e.g. military topographic colleges for officers in Bandung and Solo. Other technical colleges with a non-degree programme in surveying and mapping are being developed such as the School for Survey and Mapping Technicians (PTSP) of the Bandung Institute of Technology, which will be described later.

Non-geodetic departments

The technical colleges have other departments where surveying and photogrammetry are also taught. These are mostly civil engineering departments.

TECHNICIAN TRAINING

Formal training of survey technicians is organized by the National Co-ordination Agency for Surveys and Mapping (BAKOSURTANAL), the Ministry of Public Works and the Directorate of Land Registration. Private interests in this sector are beginning to appear.

School for Photogrammetry and Cartographic operators (PPFK)

In 1975, with the technical assistance of the Netherlands (DITH) and the International Institute for Aerial Surveys and Earth Sciences (ITC), a school for photogrammetric and cartographic operators, the Pusat Pendidikan Fotogrametri dan Kartografi (PPFK), was established under the auspices of BAKOSURTANAL. The school, attached to the ITB, is aimed primarily at training of operators/technicians for the government agencies BAKOSURTANAL, Army Topographic Service, Directorate of Land Registration and the Mapping Centre of the Ministry of Public Works. The initial target is to train 100 photogrammetric and 100 cartographic operators in five years. Following the urgent

request of the concerned agencies, the standard course has been changed and is now as follows:

Photogrammetry:
- Standard course for photogrammetric operators (A) — 12 months
- Photogrammetric plotting (B) — 6 months
- Orthophototechnique (B) — 6 months
- Aerial-triangulation (B) — 6 months
- Upgrading course for photogrammetric operators — 6 months

Cartography:
- Standard course for cartographic operators (A) — 12 months
- Short course for cartographic operators (B) — 6 months
- Upgrading course for cartographic operators — 6 months

The actual output of graduated students is as follows:

Operator course	*1975/76*	*1976/77*	*1977/78*	*1978/79*	*1979/80*
Photogrammetry	17	17	17		
Cartography	19	18	18		
Photogrammetry A				9	
Cartography A				9	
Photogrammetry B				19	9
Cartography B				16	10

The equipment available at the PPFK will be listed later when the follow-up project of the PPFK will be described. The courses of the school are run by the academic staff of the Department of Geodesy of the Bandung Institute of Technology with advice from the Netherlands project officer and two Netherlands instructors. The ITB lecturers and assistants are trained in advance at the ITC in the Netherlands. Two Malaysian students participated in the 1976/77 courses.

Technical school

A technical senior secondary school in geodesy, the STM-PU of West Java is the only technical school in surveying in Indonesia. This school was established by the Department of Public Works of the Province of West Java. The main stress of the courses is on terrestrial and plane surveying. About 30 survey technicians graduate yearly from this school.

Training centre for survey technicians of the public works

The Training Centre for Survey Technicians of the Ministry of Public Works has three courses. Course A is for lower technicians and runs for 7½ months, held in Yogyakarta and in Ujung Pandang. Course B is a 12-month course, and those from Course B who have a Senior Secondary School education may proceed to Course C for another two years. The C course is comparable to that of a technical college with a non-degree programme. The B and C courses are held in Yogyakarta. Course C is aimed at providing instructors for Courses A and B. The projected target (1974) was 172 graduates of the C course, 516 of the B course and 2064 of the A course. Less than one third of the target was reached by 1980.

Training centres for cadastral surveyors

The Directorate of Land Registration has six training centres for cadastral/land surveyors, respectively in Medan, Tanjungkarang, Semarang, Kupang, Ujung Pandang and Banjarmasin. The initial target was to train 120 technicians a year. The students must have a senior secondary school diploma. It seems that the output is far short of the actual need, and a crash programme will be implemented in 1980 to train 2,000 technicians in 6-12 months for the Pelita III programme on land administration.

School for Survey and Mapping Technicians (PTSP)

Having predicted a future shortage of survey-technicians, the Department of Geodesy of ITB has tried to make its own contribution towards providing the needed manpower by establishing, in 1979, the School for Survey and Mapping Technicians. The curriculum is nine months; training is very intensive and is intended to be a pilot project for designing a standard curriculum for the training of technicians and technologists. Already 28 students have graduated and the yearly number of graduates is estimated to be 80 technicians. This school will be expanded to a non-degree technical college by the opening of second- and third-year classes.

Training Centre for Image Interpretation and Integrated Surveys

Fully aware of the lack of remote-sensing specialists, in contrast with the increasing use of remote-sensing techniques by various government agencies, particularly for its own comprehensive National Programme for the Inventory and Evaluation of Natural Resources, BAKOSURTANAL, in a joint effort with the Faculty of Geography of the University of Gajah Mada in Yogyakarta, in 1976, established a training centre for remote sensing.

The objectives of this project are:

(*a*) To train participants sent by government agencies in extracting data from remote-sensing images and transcribe these data into verbal descriptions, maps or computer outputs;

(*b*) To train participants in the compilation of information acquired from analysis of remote-sensing images into an integrated resources information system;

(*c*) To develop appropriate remote-sensing techniques with respect to development of science and technology and the present needs;

(*d*) To support education and research at the Gajah Mada University, in graduate as well as post-graduate studies.

This initiative immediately obtained positive response from various government agencies such as the National Institute for Aeronautics and Space (LAPAN), the Soil Research Institute (LPT), Bogor Institute of Agriculture (IPB), Bandung Institute of Technology (ITB), the directorates of Forestry, Geology and Volcanology, and from ITC-Enschede, who, in co-sponsoring this project, is committed to make its experts available to teach at the training centre.

The curriculum runs for eight months each academic year, i.e. from July to March, and offers courses in the following subjects:

Inventory and evaluation of natural resources in Indonesia
The state of basic mapping in Indonesia
Basic physics of remote sensing
Development of remote sensing in Indonesia
Fundamentals of image interpretation
Basic photogrammetry
Planning aerial survey projects
Basic cartography
Cartographic presentation

Information systems
Image interpretation for geomorphological, geological, soil, hydrological, vegetation, rural and urban land-use surveys as well as for Cadastral Mapping
Environmental inventory by land systems approach
Watershed management
Inventory of land resources and multi-stage survey systems

The training centre can accommodate 30 trainees and has already trained 95 persons in the past five academic years. It is roughly estimated that 260 well-qualified image interpreters are needed to speed up the resources inventory.

Institute for Photogrammetry and Cartography (IPC)

In 1980, the School for Photogrammetric and Cartographic Operators already described, will be transformed into an Institute for Photogrammetry and Cartography with the following expanded objectives:

(*a*) To support the theoretical and practical educational programme of the Department of Geodesy, Bandung Institute of Technology, in the subjects of photogrammetry and cartography;

(*b*) To support the practical exercises in the curriculum of the Department of Geodesy of the Gajah Mada University;

(*c*) To support the curricula of other departments of ITB, e.g. the Department of Civil Engineering;

(*d*) To support programmes of specialization in photogrammetry and cartography at post-graduate level for graduates of ITB and other universities who have acquired the basic knowledge.

The average yearly capacity of the IPC is estimated at:

20 photogrammetric operators
5 photogrammetric supervising technicians
20 cartographic operators
5 cartographic supervising technicians
Approximately 100 students in third-year geodetic study at the ITB and a number of students of the Gajah Mada University
10 post-graduate students in photogrammetry
5 post-graduate students in cartography

Availability of equipment at present is as follows:

Photogrammetric equipment:
13 ITC stereotrainers, 3 with profiling device
7 sets of Multiplex projectors
3 Wild B8 plotters, 1 with pantograph, drawing table and instruction oculars
3 Wild B9 plotters, 1 with drawing table and instruction oculars
2 Wild A8 plotters with drawing tables, 1 with EK-22, IBM typewriter and IBM cardpuncher
1 Wild A9 universal instrument
1 Zeiss Planitop F2 with pantograph and drawing table
2 Wild E4 rectifiers
1 Zeiss 03P orthoplotter
1 OMI stereo facet plotter
1 Dainippon repro camera
1 Wild PUG4 point transfer device
3 Zeiss stereotopes
12 mirror stereoscopes
1 Wild RC9 aerial camera
1 Wild reduction printer
2 polar co-ordinatographs

Cartographic equipment:
1 Paus Druck-Sack vacuum printing frame with violight S
1 Klimsch light table
1 Waldhauser horizontal whirler
1 Metoschnitt cutting apparatus
1 Polypress etching table
1 Klimsch Vakuprint
1 Du Pont cromalin system
1 Rost planvariograph
1 Klimsch Sekant film cutter
1 Daige waxing machine
1 Buscher drying machine
1 Haag Streit co-ordinatograph
1 Metabo grinding machine
1 Ravena diazo printing machine
1 Morisawa phototypesetter

Expatriate support is needed to make possible the extension of the Institute's functions on the academic level, and it is hoped that further staff training could be done at the International Institute for Aerial Survey and Earth Sciences (ITC) in the Netherlands.

This Institute is open to trainees from government agencies as well as from private firms and also to trainees from South-East Asian countries and other countries.

Conclusion

The importance of and the national need for the surveying and mapping profession is increasingly being recognized. Standardization of training, education, ethics, private practice and registration are at present topics of discussion. A working group of BAKOSURTANAL is working on an academic draft for a new National Survey Act. As the National Five-Year Development Plans are placing increasing demands on the surveying and mapping profession, professional training and education in that field becomes one of main importance.

PERFORMANCE FIGURES FOR THE GEODETIC ENGINEERING WORKS OF THE JORDAN VALLEY IRRIGATION PROJECT, PHASE II*

Paper presented by the Federal Republic of Germany

RÉSUMÉ

Le document décrit un projet dont l'objectif essentiel est de permettre l'établissement d'un réseau géodésique homogène, ainsi que de cartes et de profils topo-

*The original text of this paper, prepared by Ronald Fladner, consultant for surveying and planning, appeared as document E/CONF.72/L.69.

graphiques en vue de la mise au point détaillée de la deuxième phase du projet d'irrigation de la vallée du Jourdain.

Le projet a été exécuté pour la Harza Engineering Company de Chicago (Illinois, Etats-Unis d'Amérique), sous la supervision du bureau d'études Dar al Handasah de Beyrouth et pour le compte de l'Autorité de la vallée du Jourdain qui est sise à Amman et qui, avec l'assistance de divers cabinets de consultants et une aide financière extérieure (y compris en provenance de la République fédérale d'Allemagne), assure la mise en œuvre du plan de développement économique de la vallée du Jourdain.

La vallée du Jourdain s'étend du lac de Tibériade au nord, à 212 m au-dessous du niveau de la mer, jusqu'à la mer Morte au sud, à 400 m au-dessous du niveau de la mer, sur une distance d'environ 100 km et une largeur de 14 à 16 km.

Les chaînes montagneuses environnantes s'élèvent jusqu'à 900 m au-dessus du niveau de la mer.

La vallée est divisée en deux parties, la partie occidentale étant actuellement occupée par Israël. La délicate situation politique régnant dans la région a empêché d'exécuter le projet au moyen des techniques photogrammétriques, ce qui aurait presque certainement été plus pratique tout en assurant une meilleure couverture de l'ensemble de la région.

En résumé, les principales tâches à exécuter consistaient à établir 143 points géodésiques par rapport auxquels 930 km de profils en long ainsi que 3 000 profils en travers ont été définis et mesurés.

Des méthodes terrestres de levé ont en outre été utilisées sur 3 400 ha de terres potentiellement irrigables.

Sur la base de projets antérieurs analogues, la durée des travaux sur le terrain avait été estimée à 160 jours et la durée totale d'exécution du projet à 180 jours. Malheureusement, en raison de diverses circonstances locales particulières, ce programme s'est révélé irréalisable.

Une quinzaine d'ingénieurs et techniciens étrangers et 20 géomètres jordaniens avec 20 assistants ainsi que 18 véhicules tout terrain ont été affectés au projet.

La gamme des instruments utilisés allait des niveaux automatiques aux tachéomètres entièrement électroniques, avec enregistrement automatique des données mesurées.

BACKGROUND OF THE PROJECT

The main objective of this survey project was to provide a homogeneous geodetic network, topographic maps and profiles, for detailed design of the Jordan Valley Irrigation Project, phase II.

The project was carried out for the Harza Engineering Co. of Chicago, Illinois, United States of America, supervised by Dar al Handasah, Consultants, Beirut, and on behalf of the Jordan Valley Authority, Amman, which, with the assistance of various consultants, contractors and foreign financial aid (partly from the Federal Republic of Germany), implements the economic development of the Jordan Valley.

The Jordan Valley (figure 148) stretches from Lake Tiberias in the north at -212 m below mean sea level to the Dead Sea in the south at -400 m below mean sea level—a distance of approximately 100 km. The area is approximately 14-16 km wide; the surrounding mountain ranges rise up to 900 m above sea level.

The valley is divided into two parts, the western part being, during the term of the project, under Israeli occupation. The sensitive political situation prohibited execution of the project by photogrammetric engineering, a method that would almost certainly have been more expedient, while giving better coverage of the whole area.

The main tasks to be executed were, in brief, to establish some 143 ground control stations from which 930 km of profile lines were laid out and measured, and some 3,000 selected cross-sections taken. A further 3,400 hectares of potentially irrigable lands were surveyed by terrestrial methods. Based on previous similar projects we estimated 160 days of field-work and a total of 180 days to complete the project. Unfortunately, owing to various local circumstances, that schedule proved to be unachievable.

Some 15 expatriate engineers and technicians, as well as 20 Jordanian surveyors with 20 helpers and 18 four-wheel drive vehicles were allocated to the project. Instruments ranged from automotive levels to full electronic tacheometers with automatic registration of measured data.

SCOPE OF WORK AND EXECUTION

Ground control network

Although there are a multitude of survey beacons in the Jordan Valley their accuracy was dubious, so that one of the prime requirements of the project was the establishment of a homogeneous control network with an average spacing of 3 km between the stations.

The accuracy in distance measurement was specified to be 1:40,000, and all ground control stations had also to be determined in elevation, whereby an accuracy of 7 mm x $\sqrt{D}$ [in km] was specified.

Reconnaissance

In order to have certain visibility between the stations, 3 crews, comprising 1 engineer, 1 Jordanian

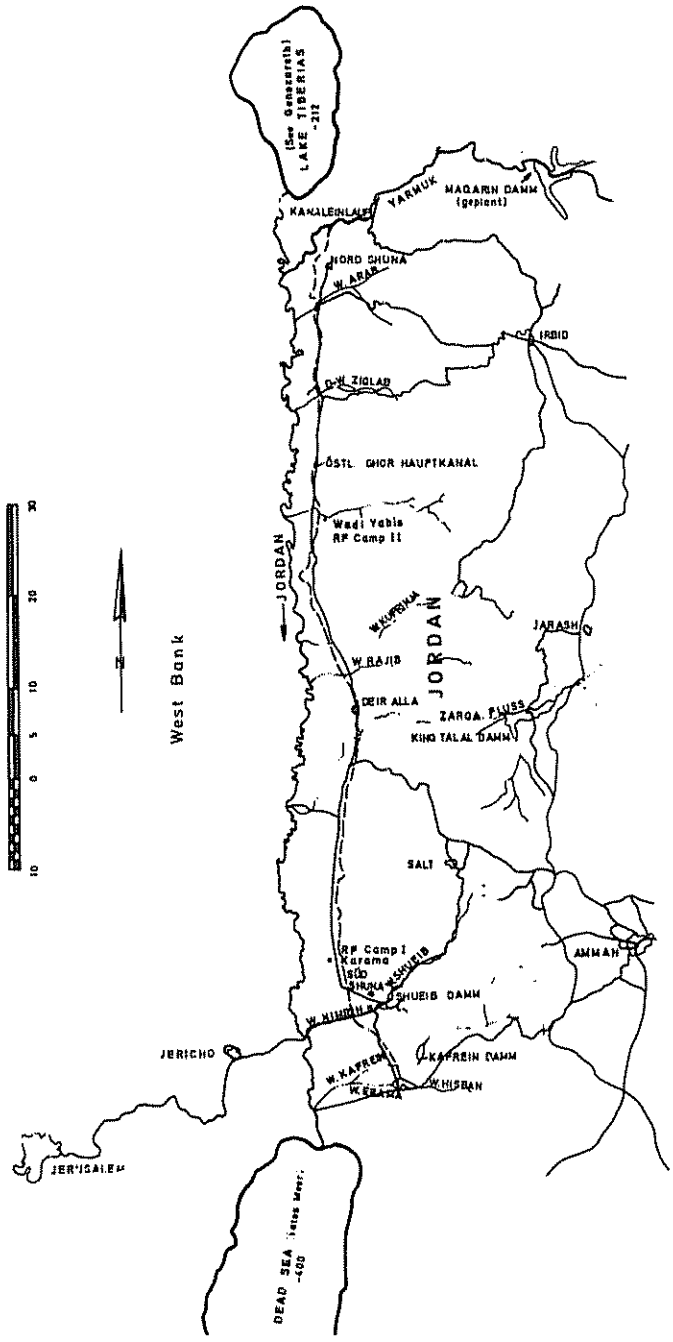


Figure 148. Federal Republic of Germany: the Jordan Valley

PRODUCTION FIGURES

Activity	Achieved (per crew-day)	Estimated (per crew-day)	Remarks
1. *Ground control network*			
Reconnaissance	2 stations	3 stations	Non-availability of vehicles; difficult access to the stations; unqualified support personnel
Distance measurement	3.5 sides	8 sides	
Traverses, including trigonometric heighting	approx. 4 km	10 km	Remote areas, long mobilization
Levelling	1.5 km	4 km	Low performance due to unqualified support personnel
2. *Main Canal*			
Traverses, levelling longitudinal and cross-section	400 m	600 m	Low progress due to dense and valuable vegetation
3. *Pipe distribution network*			
Traverses, lay-out longitudinal and cross-section	2.0 km	4.0 km	1 marker per km specified; 3-4 markers per km had to be installed
4. *Turn-out and/or pumping stations*			
Tacheometric topography	1 location	2 locations	100 points per location specified; 200-300 measured
5. *Potentially irrigable lands*			
Tacheometric topography	42.5 ha	100 ha	Rugged terrain, scattered areas; three times the specified number of ground points measured
6. *Wide natural courses (wadis)*			
Tacheometric topography	1.60 km	1.20 km	Good progress, rational field-work; complicated processing

surveyor, 2 labourers and 1 vehicle were employed for the reconnaissance, construction of the stations and preparation of station description sheets.

A total of 75 crew-days were required for establishing the 143 stations.

These figures are indicative of the terrain difficulties near the outlying stations. Additional problems such as old mine-fields cropped up, so that work had to proceed with caution, which resulted in delays.

Trilateration

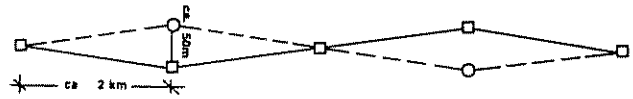
It was decided at the beginning of the project that trilateration would be the fastest method to derive coordinates while maintaining the specified accuracy. Two crews, comprising 2 engineers, 2 Jordanian surveyors, 2 labourers, a set of MRA 3 or CA 1000 Tellurometers and 2 vehicles, were utilized for this phase.

Four-hundred thirty sides (including the diagonals of the quadrilaterals) were measured in 120 crew-days. This resulted in the rather poor performance of only 3½ sides per crew-day, as opposed to 10-15 sides on previous projects. The low performance was in no small way directly attributable to the unskilled support personnel.

It was not uncommon to have vehicles bogged down for an entire day, so that no measurements could be made.

Traverses

Control was carried into inaccessible areas by means of double station traversing with side lengths of approximately 2 km, as no connecting national stations were available.



The traverses were calculated individually and adjusted to give optimum undistorted fit on the common stations.

Levelling

Elevations for the ground control stations were determined by geometric levelling. The field-work was carried out by five Jordanian crews, route planning and computation being supervised by our staff.

Inexperienced observers, difficult terrain (up to 100-m difference in elevation on 3 km), and frequent multiple reruns of lines led to an output of only 1½ km/crew-day, although it was shown that an output of 4 km/day could be achieved by experienced observers.

Trigonometric levelling

Height determination for stations situated in very rugged terrain was carried out by reciprocal and simultaneous trigonometric levelling to the specified accuracy ± 7 mm $\sqrt{D}$ km. Geometric levelling would have proved to be uneconomical for such terrain. Performance figures cannot be given for this phase, as time was primarily spent in reaching the stations. An empirical figure for such work can, however, be given as 10-15 stations per crew-day.

Computations

The relative differences in elevation were computed in our office in the Valley in order to have a running check on the work. Final computation and adjustment were computed on the basis of a free network at our offices in the Federal Republic of Germany. Accuracy after adjustment was $\pm\sqrt{4.8}$ mm D km. However, the various bench-mark values supplied by the local authorities proved to be rather contradictory, so that the free network was connected to the East Ghor Main Canal bench-marks in order to maintain a unified system.

Tellurometer ranges were reduced to plane in the field and then subjected to a network adjustment programme based on observation equations. Standard deviation of an adjusted distance after adjustment was ±0.068 m/distance.

Co-ordinates were initially computed on a local plane and after protracted searching and negotiations, co-ordinates of 8 third-order triangulation stations were obtained from the local authorities. The network was then subjected to a Helmert transformation which showed beyond any doubt that 2 of the third-order stations had gross errors.

Final co-ordinates in the Palestine Grid System were derived after the third transformation run, with only 6 third-order stations. Even so there remains an error of 0.65 m in the northern part of the net, which is obviously due to tensions in the existing third-order stations in the northern part of the project.

Scale difference between the plane and national third-order net was derived at +3.6 cm on 1,000 m. The above operations were carried out in the Federal Republic of Germany. Having thus obtained a unified and homogeneous network all traverses were then computed on location, using programmable pocket calculators. Extensive traversing showed good relative accuracies between the ground control stations so that misclosures of ±5 cm were seldom exceeded.

MAIN CANAL EXTENSION

The existing East Ghor Main Canal, originating at Adasiya, is fed from the Yarmuk River and at present terminates approximately 2 km south of Karamah. It was part of the project task to extend the route of this canal for 14 km to the south. Considerable sections of this extension run through existing agricultural lands, including citrus groves, where line clearing was obviously prohibited.

In order to fix the centre line of the canal, a traverse with side length of approximately 500 m was established in close proximity to the final centre line so as to facilitate setting out later. Upon computation of traverse point co-ordinates the centre line was laid out and all points were levelled.

Longitudinal sections with height points at every change of slope, at a maximum spacing of 30 m, were then taken. Cross-sections were required for all points on the longitudinal sections. Road crossings were measured up by detailed tacheometry. One crew, consisting of 1 engineer, 1 technician, 3 labourers and 1 car, were occupied for six weeks in accomplishing this task. This results in a total output of 400 m per crew-day.

All the necessary reductions and computations were carried out at the project field office, while the drawing of sections and lay-out plans was carried out on drum and flat-bed plotters in the Federal Republic of Germany.

PIPE DISTRIBUTION NETWORK

Nine hundred thirty km of pipeline profiles and 3,000 cross-sections were tacheometrically surveyed under this item. There is a difference, however, between the various land and water distribution systems.

New lands

As the name implies these are new lands to be developed for agricultural use by installing a system of irrigation pipes and drains, which will also form the individual plot boundaries. The basic scheme, drain—irrigation line—drain, had a total width of 450 m per plot and ran parallel to one another. A diagrammatic layout was provided in the form of 1:10,000 drawings. Co-ordinates of the terminal points and breaks in alignment, as well as relevant setting out data, were computed at the field project office by one engineer.

Traverses were established around the individual areas from which the lines were then laid out, using imported (especially from the United States of America) aluminium markers with a cap, on which the Authority's logo and line data were embossed.

Depending upon line classification, the following terrain profiles were surveyed, using electronic tacheometers.

Carrier pipes—All changes of slope; spacing was, however, not to exceed 50 m
50-m wide cross-sections were taken at all profile points

Main drainage collectors—As for carrier pipes

Distribution pipes—All changes of slope; spacing not to exceed 100 m

Drainage collectors—As distribution pipes

Conversion lands

These areas are already under extensive agricultural use and are irrigated by a system of open canals which are deemed to be wasteful and are to be replaced by pipelines.

The new pipelines usually follow the route of existing canals or roads which was fixed in the field using the aforementioned markers in the presence of the irrigation engineers. These lines were subsequently surveyed by a combination of traverses and polar methods.

All computations—traverses, elevation of terminal points, running chainages and profile closures on the terminal points—were calculated in the field office. Reduction of profiles and the plotting of plans and profiles were carried out on plotters in the Federal Republic of Germany.

Four crews, comprising 1 engineer, 1 technician, 2 Jordanian surveyors, 4 labourers and 2-3 vehicles per crew carried out this task. The production figures varied considerably, depending on terrain and vegetation structure of the area, so that only a mean performance of 2.0 km per crew-day can be cited as a typical example.

Four thousand markers were installed under this item although only 1,500 had been estimated prior to the commencement of the project.

LOCATION OF PUMPING STATION AND DIVERSION WEIRS

Detailed topographic maps with 1/2-m contour lines at a scale of 1:500 were required for these 25 locations, having an area of 1-2 ha. Although a larger area might have been surveyed by a crew comprising 1 engineer, 1 technician, 2 labourers and 1 vehicle, the siting of the locations seldom allowed more than one to be surveyed per crew-day.

Processing of the 25 maps was carried out by manual methods in the Federal Republic of Germany, in a period of 60 draftsman-days.

POTENTIALLY IRRIGABLE LANDS

Detailed topographic maps at a scale of 1:2,500, showing 1-m contour lines, were required for 3,400 ha of potentially irrigable lands, split into seven main areas.

Although it was planned to utilize one AGA 700 and one AGA 710 with automatic data recording, the instruments proved to be rather unreliable in the field, so that only one was ever in use.

The crew comprised 1 engineer, 1 technician and 3 labourers. Rugged terrain, rising up to 400 m above mean sea level, required long mobilization periods and many changes of instrument stations resulting in the rather poor performance of 42.5 ha per day, which is considerably below the mean figure of 100 ha per day gained over many projects in the past years.

The processing of this item was carried out exclusively in the Federal Republic of Germany with the aid of an IBM 370-145 computer coupled to a Calcomp 7000 flat-bed plotter. The data were processed in the form of a digital terrain model from which the 1-m contours and all terrain details were interpolated. In this manner, 55 plans were drawn.

It may be interesting to note that although most of the data were processed automatically, it took three months to finalize this item, most of the time being spent on manual incorporation of field sketches detailing terrain discontinuities, tracks, wadis etc.

WIDE NATURAL COURSES

Sixteen wadis, having a total length of 72 m, were to be surveyed by the longitudinal and cross-section method. Owing to strong meandering of the wadi courses the specified method proved to be highly impractical, as it is rather difficult to determine a cross-section perpendicular to the longitudinal sections without laying the centre line out.

Tacheometric cross-sections were visibly defined approximately every 50 m and tacheometrically surveyed in from the adjoining traverse stations.

Field-work was carried out by three crews consisting of 1 engineer, 1 technician, 1 Jordanian surveyor, 4 labourers and 2 vehicles per crew in fifteen days, resulting in a performance of 1.6 km per day, including traverses. This can be considered a good rate of progress and is in no small way attributable to the local support personnel who, with the experience gained on the previous tasks, showed a good understanding of the requirements and were able to facilitate the flow of work.

The data were processed in rather the same manner as described above for potentially irrigable lands. The lowest point of the cross-sections were extracted and combined to form the flow line of the wadi, this giving the true centre line, perpendicular to the flow line at 50-m spacings. Cross-sections were then interpolated.

PERSONNEL, INSTRUMENTATION, DRAWINGS

The resources employed were as follows:

1 *Project Manager*: Liaison with the client, irrigation consultant, government authorities and administration

1 *Chief Engineer*: Overall project control, management and allocation of field crews, quality control, coordination of management and processing facilities

1 *engineer*: Execution of all field computations (traverses, lay-out data, chainage, field sketches etc.)

1 *engineer*: Management and allocation of five levelling crews, levelling reductions and computations

1 *CA 1000 crew*: 1 engineer, 2 Jordanian surveyors, 2 labourers, 2 vehicles

1 *MRA 3 crew*: 1 engineer, 1 technician, 2 Jordanian surveyors, 2 labourers, 2 vehicles

4 *DI 3 crews*: 1 engineer, 1 technician, 1-3 Jordanian surveyors, 3-4 labourers, 2 vehicles

1 *AGA 700 crew*: 1 engineer, 2 technicians, 2 Jordanian surveyors, 4 labourers, 2 vehicles

1 *DI 10 traverse and back-up crew*: 1 engineer, 1 technician, 2 Jordanian surveyors, 2 labourers, 2 vehicles

5-6 *Ni 2/NAK 2 levelling crews*: 1-2 Jordanian surveyors, 1-2 labourers

In addition to the above, some 4-5 Jordanian surveyors were employed in the field office.

Field office and field calculations consisted of simple mechanical adding machines, Hewlett Packard Series HP 97 and HP 67 programmable calculators, HP 45 and 25 calculators. Reductions, processing and plotting of profiles, tacheometry and mapping were executed by an IBM 370/145 computer, and peripherals coupled to a Calcomp 1036/925 drum plotter and a Calcomp 7000 flat-bed plotter, by OPM, Munich.

The following graphical output was executed by the above system:

343 layout drawings/maps
387 sheets of longitudinal sections
308 sheets of cross-sections

1 038 total DIN A 1 (594 x 841 mm) sheets.

Processing of field data commenced two months after the beginning of field-work and was completed six months after end of field-work. This does allow for any publication of production figures for the utilized processing system, as there were many changes in the required format of the output, necessitating substantial modification to the existing programs. Also, field operations were re-scheduled to suit particular local requirements so that there was often a discontinuity of data flow, which resulted in staggered and interrupted processing. There is no doubt at all that the processing system employed could have met the required schedule had the planned flow of data been adhered to.

TRAINING PROGRAMME

Based on the experiences gained during project execution, it was quite obvious that the Jordanian surveyors allocated to the project had little grounding in

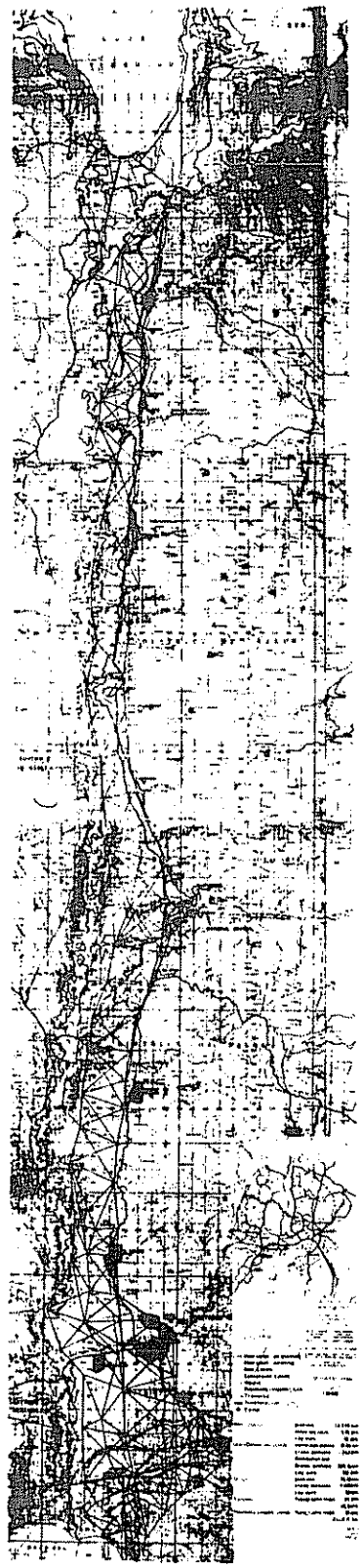


Figure 149. Federal Republic of Germany: ground survey work, Jordan Valley

the subject matter. It should also be borne in mind that it is very difficult, if not impossible, to give on-job training on a project that has tight schedules and lacks proper training facilities.

Nevertheless, an engineering scheme such as the Jordan Valley Irrigation Project requires the constant presence and collaboration of surveyors; therefore the Jordan Valley Authority decided to implement a crash course in basic engineering surveying for nine of their surveyors upon completion of field-work. An intensive 2-month training programme, covering the basics of co-ordinate geometry and the most common engineering survey procedures, was conducted in Legau, Federal Republic of Germany. This training was continued for a period of four months under actual field conditions by carrying out surveys on the project, supervised and aided by two engineers. While such a training programme can never substitute for formal training, it achieved its objective in that the nine persons trained are able to carry out basic engineering surveys in the Jordan Valley.

CONCLUSION

Performance in engineering and geodetic surveys is governed by many factors, of which three may be eliminated at the outset: namely, the selection of qualified and motivated staff; the right equipment for the job at hand; and the experience and necessary organizational background gained on many varied projects over a period of time.

Terrain, climatic, political and particular local circumstances that are too varied to describe in detail can often lead to substantial escalation of costs and time requirements over which the surveyor has little or no influence.

MODERN COMPONENTS IN THE ITC COURSES IN AERIAL PHOTOGRAPHY, PHOTOGRAMMETRY AND CARTOGRAPHY*

Paper presented by the Netherlands

RÉSUMÉ

AVION DE L'INSTITUT ET INSTRUMENTS DE POINTE

L'avion de l'Institut international de levés aériens et sciences de la terre a été conçu et est utilisé : *a*) pour servir de salle de cours volante; *b*) pour produire des photographies aériennes normales et spéciales; *c*) pour exécuter des activités expérimentales et de recherche dans le domaine de la télédétection; *d*) pour servir de plate-forme de recherche afin de mettre au point et d'expérimenter des instruments de pointe.

SIMULATION

L'enseignement et la formation ont été rendus beaucoup plus efficaces grâce à l'installation de trois "simulateurs" : *a*) un simulateur de vol; *b*) un simulateur de navigation; et *c*) un simulateur de prise de vues.

NUMÉRISATION

Les cours de photographie aérienne utilisent les possibilités offertes par la numérisation pour la solution de nombreux problèmes de photographie aérienne et de navigation pour l'établissement des levés qui, jusqu'à une époque récente, étaient résolus par des moyens analogiques.

ELÉMENTS MODERNES DES COURS DE PHOTOGRAMMÉTRIE DE L'INSTITUT

D'une manière progressive et conformément à l'évolution des techniques, des *éléments nouveaux* ont été introduits dans les cours préparant au diplôme de technicien (P5) et au diplôme d'études supérieures (P1), tels que (éléments les plus récents) : la production automatique à commande numérique d'orthophotographies, les modèles de terrain numériques (acquisition; interpolation), la restitution stéréoscopique assistée par ordinateur, etc. Toutefois, la portée du traitement de ces éléments est nécessairement limitée par l'objectif de ces cours (qui ont pour objet de fournir un enseignement complet, théorique et pratique de la photogrammétrie) et par le temps limité dont on dispose (c'est-à-dire douze mois à peine). Le programme actuel comprend environ 60 heures de cours, auxquelles vient s'ajouter environ le même nombre d'heures consacrées aux exercices, et il faut compter au moins 600 à 000 heures supplémentaires pour les études et la préparation.

Beaucoup plus de temps est disponsible, et effectivement utilisé, pour le traitement des éléments modernes dans le cadre du *programme de maîtrise en sciences de*

*The original text of this paper, prepared by J. Visser, L. Corten and F. Ormeling, International Institute for Aerial Survey and Earth Sciences, appeared as document E/CONF.72/L.71.

l'Institut (c'est-à-dire le cours P2). Ce programme dure de 18 à 22 mois et a été conçu comme une prolongation du cours P1. Afin de satisfaire les besoins actuels des organismes de cartographie en vue d'améliorer leur efficacité grâce à une utilisation appropriée de l'informatique dans leur domaine de compétence, l'Institut organise depuis 1976 un cours de spécialisation intitulé « Le traitement des données numériques en photogrammétrie » d'une durée de six mois. Ce cours est organisé à l'intention des personnes qui ont déjà suivi (peut-être à une époque antérieure) le cours P1 ou P5 de l'Institut ou tout autre cours de photogrammétrie. Actuellement, ce cours de traitement des données porte principalement sur la compensation par blocs de triangulation aérienne, mais on envisage déjà l'organisation de cours dans d'autres domaines photogrammétriques tels que les applications en génie civil.

LES COURS DE CARTOGRAPHIE DE L'INSTITUT SONT ADAPTÉS EN FONCTION DES TENDANCES MODERNES DE LA CARTOGRAPHIE

Le Département cartographique de l'Institut, qui a été créé en 1971, offre un enseignement portant sur les connaissances spécialisées qui sont requises pour les différentes phases de la production des cartes. Ces connaissances sont applicables à la cartographie topographique, la cartographie des ressources naturelles et de l'environnement, la planification régionale, la cartographie pour les recensements et pour d'autres aspects du développement et activités spéciales. Cet enseignement est dispensé sous la forme de cours à quatre niveaux différents (C4, C3, C2 et C1), qui s'inspirent des recommandations de la Commission de l'enseignement de l'Association cartographique internationale et qui sont orientés essentiellement vers la pratique de la profession. Cela signifie qu'après avoir achevé leurs cours avec des résultats satisfaisants, les étudiants sont censés être capables de mettre en pratique dans leur centre national de production de cartes les connaissances techniques qu'ils ont acquises. Grâce à sa capacité de recherche, le Département cartographique de l'Institut, tout comme l'Institut en général, d'une part, suit l'évolution de la science et, d'autre part, par l'intermédiaire d'un réseau de liens étroits, reste en contact avec les besoins des pays en développement. Ces deux aspects donnent au système une base solide. Le fait même qu'il soit assez facile, dans le cadre du programme des cours de l'Institut, de suivre les tendances nouvelles de l'évolution turbulente de la cartographie a certainement contribué à la force du système et à la popularité des cours. Depuis 1972, plus de 200 étudiants ont quitté l'Institut avec un diplôme en cartographie et sont rentrés dans leur pays d'origine.

AERIAL PHOTOGRAPHY

ITC aircraft and advanced instrumentation

Aircraft used at the International Institute for Aerial Survey and Earth Sciences (ITC) is designed (*a*) to be a flying classroom; (*b*) to produce regular and special types of aerial photography; (*c*) to carry out tests and research in remote sensing; and (*d*) to serve as a research platform to develop and to test advanced instrumentation. The aircraft is convertible into these various configurations to serve both in education and in research.

Simulation

Education and training have been made significantly more efficient by introducing three simulators:

(*a*) Flight simulator, used to familiarize students with the principles of flying for aerial survey;

(*b*) Navigation simulator, designed and constructed by the ITC as a computer programmed survey navigation trainer;

(*c*) Camera simulator (under construction to ITC design) to be used for education and training in aerial photography operations.

Digitizing

The courses in aerial photography make use of the possibilities of digitization in many problems of aerial photography and survey navigation which, until recently, were solved by analog means. Examples are the use of advanced digitized electronic instrumentation (the Doppler Navigation System) by means of simulation programs, and the introduction of programmable and pre-programmed calculators and mini-computers in many aspects of survey flight and navigation.

Audio-visual assistance in education

The educational programme is relieved from some of its routine tasks by using audio-visual training programmes.

PHOTOGRAMMETRY

In the course of time, and in accordance with the development of the state of the art, new components have been introduced into the technologist's (P5) and post-graduate (P1) diploma courses, such as, recently, digitally-steered automatic orthophoto production, digital terrain models (acquisition, interpolation) and computer-supported stereo-restitution.

The breadth and depth of the treatment of these components, however, is necessarily limited by the objective of the courses (i.e., to give all-round education in both the theory and practice of photogrammetry) and the limited time-budget available (only twelve months). The present courses comprise some 600 lecture hours, with about the same number of exercise hours, while at least an additional 600 to 1,000 hours are needed for studies and preparation.

Much more time is available—and indeed used—for the treatment of modern components in the ITC's Master of Science degree programme (the P2 course). The program lasts 18 to 22 months and is intended as an extension of the P1 course. The total of these two courses (P1 + P2) thus requires as much as $2^1/_2$ to 3 years of study at the ITC. Per country, however, only a limited number of such broadly and deeply educated professionals are required (viz, mainly for scientific and/or educational activities in the field of photogrammetry).

In order to meet the present need of mapping organizations to improve their efficiency by appropriate use of electronic computers in their field, since 1976 ITC has arranged 6-month courses for specialization in digital data processing in photogrammetry. This course is meant for those who have followed (perhaps earlier) our P1 or P5 course, or some other course in photogrammetry. At present, this data-processing course is directed to aerial triangulation block-adjustment, but courses in other photogrammetric fields such as civil engineering applications are already being considered.

ITC CARTOGRAPHY COURSES ADJUSTED TO MODERN TRENDS IN CARTOGRAPHY

The Cartographic Department of ITC, established in 1971, offers education in the specialized skills required for the various phases of the production of maps. These skills are applicable in topo-mapping, natural resources and environment mapping, regional planning, census mapping and other development and special purpose mapping.

This education is given in the form of courses at four different levels, C4, C3, C2 and C1, which are inspired by the recommendations of the Commission on Education of the International Cartographic Association, and which are aimed primarily at the practice of the profession. This means that after finishing their course with good results, students are supposed to be able to put into practice the acquired know-how in their national map production. The four course levels may be described briefly, as follows.

The C4 course trains the cartographic technician who is expected to have sufficient experience and knowledge to produce at an acceptable speed accurate originals to reproduction standards on various media, using various equipment. The C3 man, called the cartographic technologist, when leaving ITC, should have sufficient theoretical and practical background to perform a leading task in the cartographic design and construction section. He is the cartographer *par excellence*, who distributes, checks and supervises the work and is responsible for its quality. The C2 and C1 courses form the basis for the scientific or academic cartographers responsible for documentation, research, conceptual design and editing. These categories are supposed to have sufficient theoretical and practical knowledge to teach in the various cartographic subjects and to take part in higher levels of cartographic organization and management.

The programmes of the various cartography courses are a reflection of the trends that have characterized development in cartography in the last decades. Among these trends are:

(*a*) The growing awareness of maps as communication channels through which graphically coded information is transmitted from the cartographer to the map user. Within this concept ITC cartography students, particularly at C2 and C3 levels, are introduced into the grammar of graphic language and into the problems of communication and perception;

(*b*) The growing consciousness that map production is a combined operation of cartographers and reproduction technicians. Consequently map construction and reproduction techniques, both forming an integral part of cartography, are closely interwoven in the programmes. Students are familiarized with modern materials and techniques, i.e. in scribing, masking, peel-coating, photo-setting, screen-printing, modern colour-proofing etc.;

(*c*) The quick advance of computer-assisted cartography in several branches of map production in western countries. It is taken for granted that this development will not stop at the gates of the third world countries for which ITC courses are primarily intended. Modern cartography education, therefore, is no longer conceivable without a programme on the role the computer can play in map production. The ITC has accepted the consequences of this development and a programme on computer-assisted cartography, theory and practicals is introduced in all courses at varying degrees of difficulty and complexity. For all levels, digitizing exercises are included, while C2 and C3 students have also computer programming exercises and practicals on the automatic drafting machine;

(*d*) The increasing demand for thematic maps, which have become an indispensable tool in natural resources surveys, environmental control, regional planning, touristic mapping and school cartography. Though most of the graphic principles upon which cartography is based are equally applicable to both topographic and thematic maps, the last category, intended to communicate geographical concepts as distributions, densities, relationships and/or movements, are sufficiently different from topo-maps to justify a separate and thorough treatment at all course levels;

(*e*) The experience that C2 and C3 students respectively as section heads and departments leaders, particularly in third world countries are increasingly involved in economical and managerial aspects of map production, has led to the introduction into the curriculum of subjects such as production schedules, flow diagrams, network planning, cost estimation and cost control;

(*f*) The pressing recommendations of the United Nations for standardization of geographical names on a national, and subsequently on an international, level have led to the inclusion of toponymy in the lecture programme of all categories. Students are given some notion of field collection and office treatment of names, of problems arising in regions with more than one language, of the uncertainties in areas with non-written languages, of the necessity of transcription/transliteration of one writing system into another, and all the problems arising thereby that have to be solved by linguists.

The ITC Cartography Department, as ITC in general, through its research capacity, feels with one hand the pulse of science, while with the other hand through a network of close relationships is in close contact with the needs of the developing countries. This double mooring provides the system with a solid base. The very fact that within the ITC course programme it is easy to annex new trends in the turbulent development of car-

tography has undoubtedly contributed to the strength of the system and the popularity of the courses. Since 1972 more than 200 students have left ITC with diplomas in cartography and returned to their home countries. Since the department first began its activities, the number of applications has increased rapidly to more than 80 per year since 1977. As the present day capacity of the department does not exceed 35-40 students, unfortunately each year quite a number of applicants have to be disappointed.

SURVEYING EDUCATION IN NEW ZEALAND*

Paper presented by New Zealand

RÉSUMÉ

La tâche des géomètres néo-zélandais est extrêmement variée. Ils peuvent être appelés à réaliser des levés cadastraux, des levés topographiques, des levés d'étude et des levés géodésiques, ainsi que des travaux ayant trait à l'utilisation et à la gestion des terres, tels que lotissements, aménagements communaux, mise en valeur des sols et gestion des ressources. La diversité de ces activités soumet les établissements d'enseignement chargés de la formation théorique et pratique des techniciens et experts géomètres à des difficultés et des exigences peu communes.

Pour pouvoir être agréé comme géomètre expert en Nouvelle-Zélande, il est nécessaire d'être titulaire d'un diplôme de Bachelor of Surveying (licence de géomètre) ou d'un titre équivalent. L'Université d'Otago est la seule université néo-zélandaise qui prépare à ce diplôme. Les cours s'étendent sur quatre années d'études à plein temps. La première année, qui est une année préparatoire, est consacrée à un enseignement scientifique général (mathématiques, physique et géologie ou géographie) et peut être effectuée dans n'importe quelle université du pays. Les trois années suivantes doivent être effectuées à l'Université d'Otago. En raison de l'insuffisance des locaux d'hébergement et autres installations, l'admission à la première de ces trois années de formation supérieure est limitée à 33 candidats par an. Le programme d'enseignement est suffisamment vaste pour donner aux candidats une base solide dans les divers domaines que comporte la pratique du métier de géomètre néo-zélandais et les préparer à suivre l'évolution de leur profession. Sur l'ensemble des trois années de formation supérieure, l'emploi du temps est réparti comme suit entre les différents sujets d'étude :

Levés (généralités)	25 p. 100
Cadastre	17 p. 100
Géodésie	7 p. 100
Génie civil	9 p. 100
Cartographie	17 p. 100
Aménagement du territoire	17 p. 100
Divers	8 p. 100

Les cours font une large place aux travaux pratiques. En plus des travaux pratiques prévus durant l'année universitaire, les étudiants sont tenus d'effectuer 11 semaines de stage pratique sur le terrain et 100 jours de travail pratique sous la supervision d'un géomètre expert ou ingénieur civil agréé.

Le New Zealand Survey Board (Conseil néo-zélandais des géomètres) est l'organe officiel chargé de réglementer l'exercice de la profession. Pour être agréés comme géomètres experts, les étudiants diplômés doivent acquérir deux années d'expérience pratique sous la supervision d'un géomètre expert agréé, passer avec succès un examen de droit organisé par le Conseil, et être reconnus par ce dernier aptes à exercer la profession de géomètre expert.

Deux diplômes qualifient comme technicien géomètre, à savoir le Technician Certificate (Survey) [brevet de technicien (géomètre)] et le New Zealand Certificate in Land Surveying (certificat néo-zélandais d'aptitude à la profession de géomètre arpenteur). Le premier de ces diplômes sanctionne un cours en trois parties s'étendant sur trois années d'études à temps partiel. Le second sanctionne un cours en cinq parties s'étendant sur cinq années d'études à temps partiel. Pour l'un et l'autre diplôme, les candidats doivent occuper pendant trois années un emploi approprié dans un service de levés. Ces diplômes peuvent être préparés dans des établissements d'enseignement technique n'importe où dans le pays, ainsi que par correspondance.

Les candidats qui ont obtenu le New Zealand Certificate in Land Surveying avec une mention suffisante et qui possèdent des connaissances supplémentaires en

*The original text of this paper, prepared by B. M. Jones, University of Otago, appeared as document E/CONF.72/L.16.

mathématiques peuvent être dispensés d'une à deux années des cours préparant à la licence de géomètre à l'Université d'Otago.

Reconnaissant la nécessité d'accroître la capacité des locaux d'hébergement et autres installations de l'Ecole des experts géomètres de l'Université d'Otago, l'University Grants Committee (Comité des dotations universitaires) a autorisé l'élaboration des plans d'un nouveau bâtiment permettant de recevoir 150 étudiants non diplômés et 15 étudiants diplômés. Une fois que ce bâtiment sera terminé, on pourra accueillir chaque année 50 nouveaux étudiants au lieu de 33.

La Nouvelle-Zélande a un rôle important à jouer dans le développement de la région du Pacifique. Ce rôle n'est en aucun domaine plus important que dans celui de la formation des géomètres. La Nouvelle-Zélande a largement contribué à la création d'écoles et à la fourniture de personnel enseignant pour la formation de techniciens géomètres à Sarawak et aux Iles Salomon. De nombreux géomètres experts du Pacifique et de l'Asie du Sud-Est ont reçu leur formation universitaire en Nouvelle-Zélande. Lorsque l'Ecole des géomètres experts de l'Université d'Otago aura été agrandie, la Nouvelle-Zélande sera encore mieux équipée pour former les géomètres experts dont la région du Pacifique a besoin.

THE SCOPE OF SURVEYING IN NEW ZEALAND

The profession of surveying encompasses a wide field of endeavour. Article 4 of the Statutes of the Federation Internationale des Géomètres (FIG) defines a surveyor in the following terms:

> "The Surveyor is a professional man who identifies, determines the boundaries of, measures and values public or private landed property, whether urban or rural, and whether on the surface or below, as well as works executed thereon; and who arranges for the registration of the property and settles questions of the ownership connected therewith. The Surveyor also studies, plans and is responsible for land development and town and country planning. He deals with the technical, legal, economic, agricultural and social aspects of the aforementioned."

In New Zealand, the surveyor carries out most of the functions embodied in the above definition. Unlike his colleagues in many other countries he is not solely a measurement specialist but is intimately involved with functions relating to land and the management of land. New Zealand is an agricultural country and land is its greatest material resource. It is a limited resource. It is thus in the best interests of all New Zealanders that the best use should be made of the country's land. As a profession with close links with land, the surveying profession plays a vital role in endeavours aimed at achieving this objective.

The wide-ranging activities of the surveying profession have been shaped by many factors—geographical, historical, social and political—over the past 150 years of New Zealand's growth as a nation. In the early days of European colonization, when much of the country was covered by dense forest and communications were difficult due to the rugged terrain, the surveyor came on the scene to demarcate land holdings so that a secure form of title could be granted. At this early stage of the country's development professionally trained and qualified personnel were at a premium, and it is not surprising that it fell to the surveyor to carry out many of the operations that would normally have been carried out by engineers. Roads, and later railroads, were required to provide communications over difficult terrain, and as a result the field of endeavour of the surveyor expanded to encompass such engineering fields as road and rail location, bridge-building and municipal engineering, together with allied activities such as land appraisal, timber appraisal and geological exploration. It was at this stage of development that the surveyor's involvement with engineering work first began, and it has continued through the years. Today the field of land development engineering forms an important component of the activities of the private surveyor.

In the public sector the Department of Lands and Survey is responsible for the maintenance and extension of the national triangulation and height network, the cadastral survey and the national mapping system, together with a certain amount of regional and resource planning. The extension of New Zealand's territorial waters during the past year to 200 miles off-shore will probably have the effect of further extending the range of activities of this department.

The educational institutions which exist for the education and training of professional and technician surveyors have their immediate educational objectives defined by the range of activities of the private and public sectors of the surveying industry. Because of the wide range of these activities, the call made upon these institutions is a demanding one and the educational system evolved to meet these demands is one that has adapted to the needs of the country and its people.

THE EDUCATION AND TRAINING OF PROFESSIONAL SURVEYORS

In 1900 a Board of Examiners was established for the purpose of conducting examinations and registering surveyors. The Board became the Surveyors' Board in 1908 and the New Zealand Survey Board in 1928. The establishment of the Board of Examiners had the effect of setting up a uniform standard of entry to the surveying profession throughout New Zealand which had previously not been the case. In the system which evolved admission to practice was by means of academic and practical examinations set by the Board after a period of cadetship with a registered surveyor. Initially there was no institution where candidates could obtain tuition for the Board examinations. Candidates were forced to study privately with the result that failure rates were high. Eventually, however, the Technical Correspondence Institute was prevailed upon to offer correspondence courses in the subjects of the examination and pass rates improved.

The need for university education for professional surveyors was first felt in 1908 when moves were made

by the New Zealand Institute of Surveyors to obtain the establishment of a Department of Surveying, Geodesy and Municipal Engineering at Victoria College in Wellington. These moves came to nought and further attempts in the period between 1925 and 1952 met with a similar fate. Finally, in 1962, the efforts of the Institute were crowned with success and a Department of Surveying was established at the University of Otago in Dunedin. The first students were enrolled in 1963.

At the time, the University of New Zealand was the only body with the power to grant degrees but the creation of a new degree was a lengthy and uncertain process beset with difficulties. The steering committee therefore recommended that a three-year Diploma course in Surveying be established, designed in such a way that it could be converted into a four-year degree course at an appropriate time. Concurrent with the establishment of the Diploma course the Minister of Lands approved changes which brought to an end the system of cadetship. This move had the effect of establishing the University of Otago surveying course as the only academic qualification for registration as a surveyor.

In 1968 the Diploma was supplemented with a Bachelor of Science degree in surveying. The curriculum of the Bachelor of Science course was essentially the same as that of the Diploma course but with the addition of advanced courses in mathematics. Both the Diploma and the Bachelor courses suffered from the disadvantage that the academic load imposed upon candidates was unreasonably heavy. The situation was remedied in 1976 with the introduction of a four-year course leading to a Bachelor of Surveying degree which replaced both the Diploma and the Bachelor of Science degree in Surveying.

The structure of the Bachelor of Surveying degree at the University of Otago is similar to that of other professional degrees in New Zealand. It consists of an intermediate year followed by three professional years. The intermediate year and examinations can be taken at any university in New Zealand but the three professional years can be taken only at Otago. The curriculum has been designed to meet the educational requirements of the statutory authority in surveying, namely, the New Zealand Survey Board. The immediate objective of the degree is to prepare candidates for entry to the surveying profession; thus the course is a broad one because of the wide field in which the New Zealand surveyor operates. However, its scope extends beyond these minimum requirements. It attempts to lay the foundations of surveying and land development in its widest sense and attempts to produce graduates who are equipped to respond to the challenges of the future.

The intermediate year consists of courses in mathematics (three papers, namely, in algebra, calculus and statistics), physics and either geography or geology. This year provides a general introduction to the three professional years. The number of candidates admitted annually to the first professional year is restricted to 33 because of limitations of space and equipment. The course is popular and the number of applications for admission received annually is usually well in excess of the places available, and thus a selection procedure is necessary. Selection is based upon academic merit as evidenced by performance in the intermediate examination. Unsuccessful candidates are able to proceed to Bachelor of Science degrees in either mathematics, physics, geology or geography.

The detailed curriculum for the three professional years together with details of the breakdown of the course into general subject areas and the course prescriptions are set out in annex I.

During their three professional years, in addition to the academic course, candidates must attend full time, for a total of not less than eleven weeks, practical field camps arranged by the Surveying School. Candidates are also required to carry out at least 100 days of suitable practical work under the supervision of a registered surveyor or engineer before they may graduate. This work is usually carried out during the university vacations at the end of the first and second professional years. It is thus apparent that there is a very strong component of practical field-work prescribed for the degree.

After graduation, candidates who wish to register as surveyors are required to complete two years satisfactory experience under the supervision of a registered surveyor, pass a written examination set by the Survey Board in the law relating to surveying, and satisfy the Survey Board in an interview of their professional competence.

Professional education is the joint responsibility of the academic institutions and the professional body concerned. It is the responsibility of the university to provide the academic education and a small component of practical training but it is the responsibility of the profession to provide the practical training and the practical experience for the graduate in his pre-registration years. The dual nature of the responsibility for surveying education is recognized and accepted by the New Zealand Institute of Surveyors.

Education and training of technician surveyors

The first move to provide an academic qualification for technician surveyors took place in 1951 with the introduction of the Public Service Survey Assistants' Examination. This examination was intended primarily for the staff of government departments. Tuition was almost entirely by correspondence backed up by on-the-job practical training.

In 1966, the Technicians' Certification Authority of New Zealand, an examining body, introduced a Technicians' Certificate (Survey) in order to provide academic training for technician surveyors in the private sector. It consisted of a three stage part-time course extending over three years. The Public Service Survey Assistants' Examination was discontinued in 1968 in favour of the Technicians' Certificate (Survey).

In 1973, in response to a demand for a higher level of academic training, the Technicians' Certification Authority introduced a New Zealand Certificate in Land Surveying. The certificate consists of five part-time stages extending over a five-year period. For three of the five years candidates must be engaged on employment of a surveying nature. The New Zealand Certificate in Land Surveying is not an extension of the Technicians' Certificate (Survey) and cannot be gained by two years' additional study. However, because of common subjects between the two courses it is possible to obtain both qualifications in six years.

Tuition for both certificates is offered on a part-time basis by many of the seventeen technical institutes or polytechnics spread throughout the country. Tuition by correspondence is also offered. Candidates who are unable to obtain tuition locally or who prefer to undertake a period of full-time study in place of part-time study or correspondence may opt to do a 12-week full-time sandwich or block course at one of the institutions offering such courses. Details of the New Zealand Certificate in Land Surveying and the Technicians' Certificate (Survey) are set out in annexes II and III respectively.

In the regulations for the Bachelor of Surveying degree at the University of Otago provision is made for candidates who have obtained, with sufficient merit, the New Zealand Certificate in Land Surveying, Engineering or Draughting, and who have passed additional courses in mathematics to be exempted from up to two years of the degree course. In practice they are usually granted exemption from the intermediate year and certain of the courses of the first professional year, so that they spend three years at the University.

TRENDS AND DEVELOPMENT

New Zealand has an important role to play in the development of the Pacific region and this is nowhere more apparent than in the field of surveying education. In Sarawak and the Solomon Islands, New Zealand has played a major role in the establishment and staffing of schools for the training of technician surveyors. In the professional field it has also played its part, and many professional surveyors in South-East Asia and the Pacific region received their academic training at the University of Otago.

Owing to shortages of equipment and accommodation the annual intake of new candidates at the Surveying School of the University of Otago is restricted. However, the New Zealand University Grants Committee has recently given its approval to the planning of a new building for the Surveying School to house 150 undergraduates and 15 post-graduate students. When completed, the facilities available will allow the annual intake of the school to be increased from 33 to 50. On completion of these developments the school will be in a much stronger position than at present to service the needs of the Pacific region with regard to professional surveyors.

In the field of postgraduate education the University of Otago makes provision for a Master of Surveying degree. Holders of the Bachelor of Surveying degree, or an equivalent qualification, are eligible for admission as candidates for this degree. The degree is of two years' duration. Course work at an advanced level is prescribed for the first year and research work, on an approved topic, for the second year. The results of the research work are presented in the form of a thesis which must provide evidence of competence in methods of research appropriate to the subject. There is no set curriculum for the course of advanced study, but it is adapted to the needs of individual graduates and their fields of specialization. The objectives of the course of advanced study are to advance the knowledge and experience of a graduate in a given field of specialization in Surveying or Land Planning and create an awareness of advanced work which is being carried out in the field.

A higher degree, that of Doctor of Philosophy, is available for candidates who, after obtaining a Master of Surveying degree, wish to continue further with studies in a given field.

In summary it may be stated that the system of surveying education in New Zealand grew up to meet the demands placed upon it by the community. It developed and was adapted to meet changing conditions and changing demands. The university degree in surveying consolidated and extended the process by providing graduates with the background and expertise to deal not only with the current situation but with situations which may be expected to materialize in the future.

Annex I

BACHELOR OF SURVEYING DEGREE, UNIVERSITY OF OTAGO: PROFESSIONAL YEARS

1. CURRICULUM

First professional year				*Second professional year*				*Third professional year*			
Course	*L*	*P*	*A.W.*	*Course*	*L*	*P*	*A.W.*	*Course*	*L*	*P*	*A.W.*
Semester 1				*Semester 3*				*Semester 5*			
212 Plane Surveying 1	3	6	4	311 Plane Surveying 2	3	4	2	[a]431 Subdivisional Design 2	1	3	4
213 Surveying Computations	3	0	3	312 Photogrammetry 2	2	4	2	[a]432 Engineering Surveying	2	0	3
214 Cadastral Draughting	2	4	0	313 Engineering 2	5	0	2	[a]433 Photogrammetry 3	1	2	2
215 Civics and Administration	3	0	3	314 Town Planning	3	0	1	[a]201 Computer Science 201	2	1	—
216 Calculus of Observations	3	0	1	315 Geodetic Surveying 1	3	0	3	411 Geodetic Surveying 2	5	0	3
	14	10	11		16	8	10	412 Cadastral Law	3	0	1
									14	6	13
Semester 2				*Semester 4*				*Semester 6*			
211 Engineering Surveying 1	3	6	3	321 Valuation	3	0	2	[a]431 Subdivisional Design 2	1	3	4
222 Photogrammetry 1	2	3	2	322 Cartography	3	4	2	[a]432 Engineering Surveying 2	2	0	3
223 Engineering 1	3	2	3	323 Land Studies 1	3	0	1	[a]433 Photogrammetry 3	1	2	2
224 Engineering Graphics	1	2	3	324 Cadastral Surveying 1	3	3	3	[a]201 Computer Science 201	2	1	—
225 Astronomy	3	0	3	325 Subdivisional Design 1	2	4	4	421 Land Studies 2	3	0	2
								422 Cadastral Surveying 2	3	0	2
								423 Professional Practice	2	0	1
	12	13	14		14	11	12		14	6	14

Key
L: Hours of lectures per week.
P: Hours of practical work or tutorials per week.
A.W.: Hours of assigned project work per week.
A semester comprises 12 weeks of academic work.
[a]Subjects extending over semesters 5 and 6.

2. STRUCTURE OF COURSE

Subjects						
General surveying	*Cadastral*	*Geodetic*	*Engineering*	*Cartographic and Mapping*	*Land Planning and Development*	*General*
Plane Surveying 1 (9)	Cadastral Surveying 1 (6)	Astronomy (3)	Engineering Graphics (3)	Photogrammetry 1 (5)	Subdivisional Design 1 (6)	Land Studies 1 (3)
Plane Surveying 2 (7)	Cadastral Surveying 2 (3)	Geodesy 1 (3)	Engineering 1 (5)	Photogrammetry 2 (6)	Subdivisional Design 2 (8)	Computer Science (6)
Engineering Surveying 1 (9)	Cadastral Draughting (6)	Geodesy 2 (3)	Engineering 2 (5)	Photogrammetry 3 (6)	Town Planning (3)	Geodesy 2 (2) (Geology)
Engineering Surveying 2 (4)	Cadastral Law (3)			Cartography (7)	Valuation (3)	
Surveying Computations (3)	Professional Practice (2)				Civics (3)	
Calculus of Observations (3)	Land Studies 2 (3)					
Hours per annum						
385 (25 per cent)	253 (17 per cent)	99 (6 per cent)	143 (9 per cent)	264 (17 per cent)	253 (17 per cent)	121 (8 per cent)

NOTE: Numbers in parentheses refer to the number of hours per week per semester devoted to the course. Figures are based on an 11-week semester and not a 12-week semester to allow for wastage due to public holidays.

Summary
Total course = 1,518 hours
Survey Camps = 11 weeks
Vacation Work = 100 days

3. COURSE DESCRIPTION

Plane Surveying 1 (SURV 212)

One paper. Three lectures and six hours practical work per week for one semester. Basic survey techniques and instrumentation; surveys for topographical and cadastral purposes; computations associated with these techniques.

Surveying Computations (SURV 213)

One paper. Three lectures per week for one semester. Various computing techniques and aids; mechanical and electronic computing, survey documentation.

Cadastral Draughting (SURV 214)

One paper and continuous assessment. Two lectures and four hours practical work per week for one semester. Draughting materials, plan preparation, data searching, planimetry.

Civics and Administration (SURV 215)

One paper. Three lectures per week for one semester. Concepts of land and the general law relating to administration by central and local government.

Calculus of Observations (SURV 216)

One paper. Three lectures per week for one semester. Introduction to the process of measurement and the propagation of errors. Appli-

cation of least squares and arbitrary adjustment techniques to surveyed networks.

Engineering Surveying 1 (SURV 221)

One paper. Three lectures and six hours practical work per week for one semester. Survey for collection of data for engineering purposes; setting out engineering works and all associated computations.

Photogrammetry 1 (SURV 222)

One paper. Two lectures and three hours practical work per week for one semester. Aerial cameras and optics, geometry of photogrammetry. Elementary plotting methods and height determination.

Engineering 1 (SURV 223)

One paper. Three lectures and two hours practical work per week for one semester. Road design, hydraulics of flow in pipes and channels, soil mechanics, introduction to elastic stress analysis.

Engineering Graphics (SURV 224)

One paper. One lecture and two hours practical work per week for one semester. Engineering draughting and plan presentation. Elementary projections, perspective and illustrated sketches. Calculation of quantities. Planes, lines and points in space.

Astronomy (SURV 225)

One paper. Three lectures per week for one semester and a two-week practical course. Spherical astronomy, field observations for azimuth, latitude, time and longitude; investigation of errors; computations.

Plane Surveying 2 (SURV 311)

One paper. Three lectures and four hours practical work per week for one semester. Electronic distance measurement processes and instrumentation for horizontal and vertical control surveys.

Photogrammetry 2 (SURV 312)

One paper. Two lectures and four hours practical work per week for one semester. Heighting, co-ordinate transformations, basic design and operation of plotting machines, photo maps, rectification, ground control.

Engineering 2 (SURV 313)

One paper. Five lectures per week for one semester. Engineering materials, more advanced soil mechanics, urban services, concrete mix design and concrete in simple reinforced structures, water supply, sewage disposal systems, contracts.

Town Planning (SURV 314)

One paper. Three lectures per week for one semester. Planning terminology. Planning in the New Zealand situation related to the economic background and the determination of social goals—the town planning legislation.

Geodesy 1 (SURV 315)

One paper. Three lectures per week for one semester. Introduction to geodesy and geodetic surveying. Geodetic reference systems and projections with particular application to New Zealand. Adjustment and error analysis of triangulation and height networks.

Valuation (SURV 321)

One paper. Three lectures per week for one semester. Concepts of value, the preparation of valuations and effects of land values in land use decision-making in both urban and rural areas.

Cartography (SURV 322)

One paper. Three lectures and four hours practical work per week for one semester. Advanced techniques. Plan reproduction. Cadastral draughting. Cartographic projections. Map reproduction. New Zealand mapping system, preparation for map production. Automated cartography.

Land Studies 1 (SURV 323)

One paper. Three lectures per week for one semester. Land use in New Zealand and its interrelationships with animals, soils and climate. Productivity and its maintenance. Competition for land and single and multiple use. Water quality and supply.

Cadastral Surveying 1 (SURV 324)

One paper. Three lectures and three hours practical work per week for one semester. The New Zealand cadastral system. The concept of land title surveys and associated computations.

Subdivisional Design 1 (SURV 325)

One paper. Two lectures and four hours practical work per week for one semester. The elements of the suburban area, requirements in roading and other facilities, statutory and planning requirements.

Subdivisional Design 2 (SURV 431)

One paper of four days duration. One lecture and three hours practical work per week throughout the year. Advanced subdivisional design projects; critical path analysis; cash flow analysis; co-ordination and management of development.

Engineering Surveying 2 (SURV 432)

One paper. Two lectures per week throughout the year. Surveys for construction projects. Precise measurement of deformations. Underground surveys. Hydrographic surveys. Survey economics and pre-analysis.

Photogrammetry 3 (SURV 433)

Continuous assessment. One lecture and two hours practical work per week throughout the year. Design of instruments; camera calibration; aerotriangulation; specifications; terrestrial photogrammetry; engineering and other applications; flight planning.

Geodesy 2 (SURV 411)

One paper. Five lectures per week for one semester. Introduction to the theory of plate tectonics. Results of tectonic plate movement. Studies of New Zealand plate tectonics. First order determination of length, direction and height. First order position determination by triangulation, trilateration, traverse and earth satellite. Standard error of position.

Cadastral Law (SURV 412)

One paper. Three lectures per week for one semester. Statute law relating to land, its subdivision and use in New Zealand.

Land Studies 2 (SURV 421)

Continuous assessment. One lecture and two tutorials per week for one semester. Resource surveys. Land-based data banks. Land tenure systems. Land tenure in New Zealand and the South-West Pacific region. Fragmentation of land holdings. Consolidation of fragmented holdings.

Cadastral Surveying 2 (SURV 422)

One paper. Three lectures per week for one semester. Principles of land registration. Torrens system. Comparative cadastre studies. Case studies of cadastral problems encountered in New Zealand.

Professional Practice (SURV 423)

One paper. Two lectures per week for one semester. Professional ethics and conduct, history and structure of the profession, professional relationships, office organisation, overseas practice.

Annex II

NEW ZEALAND CERTIFICATE IN LAND SURVEYING

CURRICULUM

Stages 1 and 2

1006	Communication English
1011	Mathematics
2018	Mathematics
1013	Physics

1005 Drawing
2019 Physics or 2036 Science
Two optional courses

Stage 3

3031 Mathematics
3011 Survey Drawing
3041 Survey Practice

Stage 4

4120 Cadastral Survey
4122 Survey Law
4110 Survey Practice
4121 Land Development Engineering

Stage 5

5177 Photogrammetry
and two of the following:
5175 Land Classification and Utilization
5174 Land Development Engineering
5176 Geodetic Surveying

Annex III

TECHNICIANS' CERTIFICATE (SURVEY)

CURRICULUM

Stage 1

1006 Communication English
1011 Mathematics
1005 Drawing
1013 Physics

Stage 2

2018 Mathematics
2047 Elementary Surveying
2048 Elementary Cadastral Survey

Stage 3

3085 Mapping
3011 Survey Drawing
3097 Land Survey Engineering

NEW ZEALAND'S TECHNICAL TRAINING ASSISTANCE IN THE PACIFIC AND SOUTH-EAST ASIA COUNTRIES*

Paper presented by New Zealand

RÉSUMÉ

Le document expose divers aspects du rôle de la Nouvelle-Zélande dans la formation de personnel originaire de pays du Pacifique et de l'Asie du Sud-Est dans les domaines de la cartographie et de l'établissement de levés.

L'examen de la question a été subdivisé en trois rubriques :

1. Création de centres de formation en dehors de la Nouvelle-Zélande.
2. Détachement de personnel néo-zélandais dans des pays d'outre-mer.
3. Formation en Nouvelle-Zélande de personnel originaire de pays d'outre-mer.

New Zealand's record in providing technical assistance and training in survey and mapping to Pacific and Asian territories is fairly extensive, and for the past 25 years in particular, the Department of Lands and Survey has actively participated in training projects. Seven Pacific territories, eight Asian countries and three African nations have taken advantage of the training available which has taken various forms, including in-house training, secondment of staff to home territories, investigation and implementation of systems and establishment of training programmes.

This paper will describe some of the training schemes.

ESTABLISHMENT OF TRAINING CENTRES OUTSIDE NEW ZEALAND

Joint Sarawak/Sabah Survey Training School, Kuching, Sarawak, East Malaysia

The Kuching School was established under the Colombo Plan in 1962, following a request from the then Crown colonies of Sarawak and North Borneo. In the offing at that time was the Malaysian merger and the need to make greater effective utilization of the lands of British Borneo. Because the economy was dependent on an intensification of land development, top priority was placed on the establishment of local survey training facilities, and this was negotiated successfully by New Zealand's Surveyor General. A joint survey school was proposed to provide a 2-year course for an annual intake of 12 survey assistant trainees. The objective was to produce survey assistants fully competent to undertake all surveys and associated work with minimal supervision. The school buildings were the responsibility of Sarawak, while New Zealand met the cost of technical equipment, furniture and transport and supplied two qualified surveyors as instructors. Necessary local practices were incorporated into the syllabus and greatest emphasis was placed on practical application of academic and instructional work, though it was known full well that with a ratio of 1 professional surveyor to 30 survey technicians operating in Borneo, on-the-job training was not feasible and neither was effective supervision. The school continued under New Zealand sponsorship and tutors until 1972 when local instructors took over. Reports indicate complete satisfaction with the training received and the authorities have been impressed with the efficiency and versatility of students, some of whom have subsequently risen to positions of considerable responsibility, both within government service and private practice.

In response to a request early in 1979 for a New Zealand surveyor to alleviate staffing problems at the

*The original text of this paper, prepared by D. G. Jeffery and D. R. Rinckes, Department of Lands and Survey, appeared as document E/CONF.72/L.17.

school, the Government of New Zealand agreed to the secondment of a New Zealand surveyor to the school for the 1979/80 school year to upgrade the syllabus and incorporate training on new equipment and techniques.

Draughting Training School, Kota Kinabalu, Sabah, East Malaysia

In the early 1960s a draughting training school was established in what was then known as Jesselton. For a period of six years it was staffed by experienced senior draughtsmen from New Zealand.

Pacific Regional Survey School, Honiara, Solomon Islands

The training course for survey technicians at the Honiara Technical Institute in the Solomon Islands was established as a New Zealand Aid Project in 1975. It followed an investigation in 1975 by two experienced New Zealand surveyors representing the New Zealand Government and the New Zealand Institute of Surveyors into regional requirements and training facilities for survey staff in the South-West Pacific. The choice of Honiara was influenced by an existing facility already catering for Pacific needs in other trades and the fact that a survey training course had recently been functioning at the Institute. The New Zealand Government approved the provision of tutors, equipment, materials and bursaries to suitable students as its contribution to the project which would provide a study programme over two years.

The objectives of the course are basically the same as developed for Kuching, that is, to produce good practical survey technicians competent to undertake most survey activities with minimal supervision. Here again, emphasis has been placed on practical experience.

Each year since January 1976, 10 to 12 bursaries have been made available to students who are selected from various Pacific countries. However, it became clear that an annual output of 12 survey technicians would be difficult to maintain, so it was decided that during 1979 and 1980 the two-year survey course would be replaced by two one-year draughting courses if support for such courses was forthcoming. Good support in fact was given and 12 students received training in 1979 and a further 12 have been nominated for 1980.

All survey and draughting instructors have been drawn from New Zealand, and at the end of 1979 three two-year survey courses and one one-year draughting course have been completed.

The school obtains excellent co-operation from the local Survey Department, which provides a variety of practical tasks that benefit the Solomon Islands as a whole and the students in particular by work-related experience.

SECONDMENT OF NEW ZEALAND PERSONNEL TO OVERSEAS COUNTRIES

Long-term secondment

Generally speaking, not a great deal of this kind of secondment is now taking place since the necessary skills are being acquired, more and more, by local personnel. However, over the years a good deal of secondment on the longer term did take place.

Western Samoa. Because of work pressures or lack of experienced surveyors or draughtsmen in some areas, requests were received to provide personnel to undertake long-term assignments. Such a situation occurred in Western Samoa in 1953 when, following short-term assignments to provide mapping control, the post of Director of Lands was filled by New Zealand departmental surveyors. This continued for 10 years until sufficiently experienced local staff were available. Since then, senior surveyors and survey technicians have continued to provide long-term assistance and train local staff.

The post of Chief Draughtsman was similarly filled by a New Zealand draughtsman and latterly an experienced officer has been seconded as a Co-ordinating Draughtsman to organize training and to develop standards and procedures.

Cook Islands. Between 1954 and 1966, New Zealand has provided Chief Draughtsmen as well as experienced draughtsmen to maintain standards and institute training programmes.

A senior survey technician has been seconded for the past 7 years and has been responsible for much of the field survey operations and local training.

Fiji. In a country of growing population and limited land resources the rationalization of planning and subdivisional practices is essential if development is to proceed on a planned basis. To assist in this an experienced New Zealand surveyor has for the past four years been assisting in developing town planning procedures and processing applications to subdivide land. Fiji's internal education and training programme for survey students has been supported by the provision of experienced tutors well versed in writing and disseminating course material to enable students to achieve local registration. A further recent appointment has been a Survey Supervisor to provide survey services and training in surveying to an exotic timber industry which has been established. Experienced survey draughtsmen have taken up posts for varying periods as training draughtsmen to establish and co-ordinate survey draughting and cartographic operations and initiate staff training.

Short-term secondment

Indonesia. The Chief Photogrammetrist of the Department of Lands and Survey spent a year in Indonesia during 1971/72. The purpose of this project was to assist in the establishment of a photogrammetric mapping unit at Bandung as well as in the training of the necessary personnel in operating the plotters and preparation of flight plans.

In 1974 a staff member of PN Aerial Survey in Jakarta spent some 6 weeks with New Zealand Aerial Mapping Ltd and the Photogrammetric Branch of the Department of Lands and Survey in order to gain further first-hand knowledge in the aspects of flying and film handling.

Subsequent indications are that the staff at the mapping unit at Bandung has more than doubled while still employing most of those who were trained in 1972.

Afghanistan. In 1969 the Chief Cartographer of the Department of Lands and Survey took up the position as advisor to the Afghanistan Cartographic Institute in Kabul as part of a United Nations aid scheme.

The staff were in need of detailed training in cartographic draughting. In a little over a year a viable working unit was created and in addition a comprehensive

manual on draughting techniques was prepared for the Institute.

In both the long- and short-term secondment schemes there can be no doubt that a good deal of on-the-job staff training has taken place. No one officer would have worked in absolute isolation, and the manner and methods shaped through their training in New Zealand influenced those with whom they were associated.

Training within New Zealand

Many New Zealand surveyors and draughtsmen have worked at one time or another in most of the Pacific territories, and this association may have had some influence in guiding the development of survey and mapping organizations along lines similar to New Zealand's. Be that as it may, when assistance was requested to train staff in New Zealand there was no hesitation in accepting this responsibility.

Professional training for surveyors

Much of the professional training given has been undertaken by the Department of Lands and Survey over periods ranging from three months to five years. It has involved full-time training under the articled cadet system, sponsoring students to obtain university degrees in surveying and subsequent practical training for registration by the Survey Board, and providing extended practical experience to locally trained surveyors. Over the past 25 years the following countries have participated:

Fiji	15
North Borneo, Sabah, Sarawak, Malaysia	32
Western Samoa	2
Thailand	2
Viet Nam	5
Zambia	1
Cook Islands	3
Total	60

Survey technicians

Survey technician training has also been included in aid programmes, and encouragement has been given students to complete the Survey Technicians' Certificate (STC) a three-year correspondence course or latterly the New Zealand Certificate in Land Surveying (NZCLS) a five-year course. Both courses are examined externally by the Technicians' Certification Authority and are recognized by those countries seeking this type of qualification. In addition the New Zealand Department of Lands and Survey runs a survey training school providing courses of three months' intense survey activities, which has been attended by most overseas trainees and tutors. So far training has been provided as follows:

Fiji	5
North Borneo, Sabah, Sarawak, Malaysia	6
Western Samoa	14
Solomon Islands	1
Thailand	3
Tonga	5
Uganda	1
Brunei	4
Cook Islands	2
Gilbert and Ellice Islands	2
Niue	1
Total	44

Draughting, cartography and photogrammetric mapping

The New Zealand Certificate in Draughting (NZCD), a five-year correspondence course, is a recognized qualification which provides formal study in computing, draughting, cartography or photogrammetric mapping. Several Pacific and Asian countries have taken advantage of this course and the practical training that New Zealand can provide. To date training has been provided as follows:

Fiji	18
North Borneo, Sabah, Sarawak, Malaysia	4
Western Samoa	2
Tanzania	1
Thailand	3
Tonga	3
Cook Islands	9
Niue	3
Total	43

It is pleasing to note that many of those persons who have come to New Zealand for training have achieved positions of responsibility and now direct and/or make policies in respect of survey and mapping operations.

Secondary and tertiary education is now becoming available within the region, thus enabling countries to achieve training in technical know-how "at home". Employees thus educated are in great demand to fill supervisory to middle management positions but lack the experience to do so. In order to assist in this respect we now find a need for staff newly qualified overseas to gain experience in New Zealand, covering as wide a field as possible within a particular discipline.

Previously there have been newly registered surveyors from Fiji who spent some time in New Zealand, while last year two graduates from Lae University in Papua New Guinea spent eight months in New Zealand in four different district offices, while extending their experience.

Conclusion

Most of the technical assistance we have looked at has, over the years, changed in nature, ranging from training people within New Zealand through training them in one or two New Zealand established centres overseas to the stage now where overseas graduates are coming to New Zealand for specialist or general experience.

Most if not all of these schemes are government inspired and executed by government departments. However, the private sector of the surveying fraternity has over the years also shown interest and been actively involved in aspects of technical training. Most of this involvement has been channelled via the offices of the Commonwealth Association of Surveying and Land Economy. Participation by individuals from New Zealand and other countries at regional seminars helps not only in identifying problems, with a free exchange of ideas, but also fosters a foundation for healthy and strong regional associations of various technical skills in the surveying, mapping and allied fields.

THE PROPOSED REGIONAL INTERNATIONAL PERIODICAL ON PHOTOGRAMMETRY AND REMOTE SENSING FOR ASIA AND THE PACIFIC*

Paper presented by the International Society for Photogrammetry

RÉSUMÉ

La Société internationale de photogrammétrie et télédétection (SIP) a adopté, lors de son XIIIe Congrès tenu à Helsinki en 1976, une résolution relative aux périodiques internationaux régionaux. Les motifs et les objectifs de cette résolution sont décrits ci-après.

La plupart des pays ont actuellement des activités dans le domaine de la photogrammétrie et de la télédétection, et un nombre assez important d'entre eux sont en mesure d'apporter une contribution substantielle aux progrès dans ce domaine en mettant au point des techniques nouvelles. Ils ont donc besoin de moyens de publication appropriés et internationalement reconnus. La création de nouveaux périodiques nationaux n'est pas une solution appropriée, étant donné qu'il existe déjà une surabondance de documentation sur cette question.

Les articles concernant la photogrammétrie et la télédétection qui sont produits dans les différents pays sont répartis sur un trop grand nombre de périodiques, ce qui entraîne comme conséquence que les gestionnaires qui sont responsables de l'introduction des nouvelles techniques dans les procédures opérationnelles ne peuvent pas obtenir tous les articles de fond. C'est pourquoi l'écart technologique entre les pays industrialisés et les pays en développement s'élargit au lieu de se combler.

Il est donc nécessaire de réduire le nombre des périodiques existants, tout en fournissant à tous les pays leur propre tribune afin de leur permettre de publier leurs apports créateurs aux progrès dans ce domaine.

The International Society for Photogrammetry (ISP), at its XIII Congress, held in Helsinki in 1976, adopted a resolution concerning regional international periodicals. The reasonings and objectives are described below.

Most nations, nowadays, practise photogrammetry and remote sensing, and quite a number of countries are in a position to contribute substantially towards progress by developing new technologies. They need appropriate and internationally recognized means for publication. Establishing new national periodicals is not a suitable solution as an overflow of printed material already exists.

Papers on photogrammetry and remote sensing originating in various countries are spread over too many periodicals, with the result that managers, who are responsible for transferring new developments into operational procedures, cannot obtain all substantive articles. As a consequence, the technological gap between industrialized and developing nations becomes wider, instead of being narrowed.

It is necessary, therefore, to reduce the number of existing periodicals, while providing all nations with their own forum to publish their creative contributions towards progress.

The proposed Regional International Periodical (RIP) is designed to accomplish this goal. There should be one such periodical for each region: Asia and the Pacific, Africa, Latin America, Northern America, Eastern Europe and Western Europe.

Successful functioning of an RIP necessitates a Statute. This Statute has been prepared and will be submitted for approval to the General Assembly of the XIV Congress of ISP to be held in 1980 in Hamburg. The outline is given in annex I.

Some features of the RIP, as incorporated in the Statute, are:

(*a*) Any nation wishing to do so may participate;

(*b*) Participating national societies subscribe for all their members;

(*c*) Participating national societies are themselves responsible for the periodical, and themselves decide on policies and procedures and on appointment of officers of the periodical;

(*d*) The periodical shall be attractive to as many members of national societies of photogrammetry and remote sensing of a geographic region as possible.

An Initiator is required to study the feasibility of such a periodical, and if it is confirmed, to start the *Regional International Periodical for Asia and the Pacific.* The terms of reference of the Initiator (§ 16 of the Statute) are attached (annex II). The Initiator will be appointed by the General Assembly of the International Society for Photogrammetry to be held in Hamburg in 1980. The ninth United Nations Regional Cartographic Conference is requested to propose nominations for an Initiator to the Chairman of Working Group VI/6 of the Society.

*The original text of this paper, prepared by Jürgen Hothmer, Chairman, Working Group VI/6, International Society for Photogrammetry, appeared as document E/CONF.72/L.99.