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Bangkok, 17-28 January 1983

Volume II. Technical Papers

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

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FOREWORD

The official records of the Tenth United Nations Regional Cartographic Conference for Asia and the Pacific held at Bangkok, Thailand, from 17 to 28 January 1983, 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 and organizations. The papers are grouped according to the agenda item to which they relate.

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EXPLANATORY NOTES

Symbols of United Nations documents are composed of capital letters combined with figures. Mention of such a symbol indicates a reference to a United Nations document.

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

Reference to "tons" indicates metric tons, unless otherwise stated.

The term "billion" signifies a thousand million.

Annual rates of growth or change refer to annual compound rates, unless otherwise stated.

A hyphen (-) between years, e.g., 1984-1985, indicates the full period involved, including the beginning and end years; a slash (/) indicates a financial year, school year or crop year, e.g., 1984/85.

A point (.) is used to indicate decimals.

The following symbols have been used in the tables:

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

A dash (--) indicates that the amount is nil or negligible.

A hyphen (-) indicates that the item is not applicable.

A minus sign (-) before a number indicates a deficit or decrease, except as indicated.

Details and percentages in tables do not necessarily add to totals because of rounding.

The following abbreviations have been used:

AES	- advanced edit system
AGD	- Australian Geodetic Datum
AGDS	- automated graphic digitizing system
AHD	- Australian Height Datum
AIS	- Automated Information System
AISME	- Association of Indonesian Survey and Mapping Enterprises
AMG	- Australian map grid

APR	- airborne profile recorder
APTS	- Aerial Profiling of Terrain System
ARS	- Attitude Reference System
ASEAN	- Association of South-East Asian Nations
BAKOSURTANAL	- Badan Koordinasi Survey dan Pemetaan Nasional (National Co-ordination Agency for Surveys and Mapping, Indonesia)
BMR	- Bureau of Mineral Resources (Australia)
BCGS	- Bureau of Coast and Geodetic Survey (Philippines)
CAD/CAM	- computer-aided design and manufacture
CCD	- charge coupled detectors
CCT	- computer-compatible tape
CDMS	- Command and Data Management System
CIDA	- Canadian International Development Agency
CNES	- Centre national d'études spatiales (National Centre for Space Studies, France)
COSPAR	- Committee on Space Research (International Council of Scientific Unions)
CRT	- cathode-ray tube
CSIRO	- Commonwealth Scientific and Industrial Research Organization (Australia)
DBMS	- Data Base Management System
DCAD	- digital cartographic applications data
DFAD	- digital feature analysis data
DFVLR	- Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (Aerospace Research Establishment, Federal Republic of Germany)
DEM	- digital elevation model
DGFI	- Deutsches Geodätisches Forschunginstitut (Geodetic Research Institute, Federal Republic of Germany)
DGK	Deutsche Geodätische Kommission (Geodetic Commission of the Federal Republic of Germany)
DLG	- digital line graph
DLMS	- digital landmass system
DMA	- Defense Mapping Agency (United States of America)
DMAAC	- Defense Mapping Agency Aerospace Center (United States of America)
DMAHTC	- Defense Mapping Agency Hydrographic/Topographic Center (United States of America)
DOS	- Directorate of Overseas Surveys (United Kingdom of Great Britain and Northern Ireland)
DTED	- digital terrain elevation data
DTM	- digital terrain model
EAHC	- East Asian Hydrographic Commission
EDC	- EROS Data Center (United States of America)
EDM	- electronic distance measurement
EDP	- electronic data processing
ERS-1	- ESA Resources Satellite-1 (European Space Agency)
ERTS	- Earth Resources Technology Satellite (now LANDSAT)
ESA	- European Space Agency
FGCC	- Federal Geodetic Control Committee (United States of America)
FIG	- Fédération internationale des géomètres (International Federation of Surveyors)

GCP	- ground control point
GEBCO	- General Bathymetric Chart of the Oceans
GLSS	- graphics line symbolization system
GMA	- geodetic model of Australia
GNIS	- Geographic Names Information System (United States of America)
GPS	- Global Positioning System
GSFC	- Goddard Space Flight Center (United States of America)
GSI	- Geographical Survey Institute (Japan)
GSJ	- Geological Survey of Japan
HBDS	- hypergraph-based data structure
HDB	- hydrographic data base
HDDT	- high-density digital tape
IAG	- International Association of Geodesy
IAP	- instrument approach procedure (aeronautical)
ICA	- International Cartographic Association
Ifag	- Institut für Angewandte Geodäsie (Federal Republic of Germany)
IFOV	- instantaneous field of view
IGN	- Institut géographique national (France)
IGS	- interactive graphics system
IHG	- International Hydrographic Bureau
IHO	- International Hydrographic Organization
IMW	- International Map of the World on the Millionth Scale
ISPRS	- International Society for Photogrammetry and Remote Sensing
ISRO	- Indian Space Research Organization
IUGG	- International Union of Geodesy and Geophysics
JICA	- Japan International Co-operation Agency
KSC	- Kennedy Space Center (United States of America)
LADS	- laser airborne depth sounder (Australia)
LED	- ligth-emitting diode
LFC	- large-format camera
LIS	- Land Information System
LOTS	- land ownership and tenure system (Australia)
LRDC	- Land Resources Development Centre (Overseas Development Administration, United Kingdom of Great Britain and Northern Ireland)
MESSR	- multispectral electronic self-scanning radiometre
MLA	- multispectral linear array
MMU	- mass memory unit
MSL	- mean sea-level
MSS	- multispectral scanner
MMS	- multi-mission modular spacecraft
MOMS	- modular opto-electronic multispectral scanner
MOS	- Marine Observation Satellite
MRSE	- microwave remote-sensing experiment
NASA	- National Aeronautics and Space Administration (United States of America)
NASDA	- National Space Development Agency (Japan)
Natmap	- Division of National Mapping (Australia)
NBMS	- National Bathymetric Map Series (Australia)
NGS	- National Geodetic Survey (United States of America)
NMC	- National Mapping Council (Australia)

NMD	- National Mapping Division (of United States Geological Survey)
NNSS	- Navy Navigation Satellite System
NOAA	- National Oceanic and Atmospheric Administration (United States of America)
NOS	- National Ocean Survey (United States of America)
NRSA	- National Remote Sensing Agency (India)
NTMS	- National Topographic Map Series (Australia)
ODA	- Overseas Development Administration (United Kingdom of Great Britain and Northern Ireland)
OEEPE	- Organisation européenne d'études photogrammétriques expérimentales (European Organization for Experimental Photogrammetric Research)
OMB	- Office of Management and Budget (United States of America)
OPIT	- Opération interministérielle de télédétection (France)
pixel	- picture element
POCC	- Payload Operation Control Centre (NASA, Houston)
RAN	- Royal Australian Navy
RCU	- remote control unit
rms	- root mean square
RBV	- return-beam vidicon
SAR	- synthetic aperture radar
SIAT	- special image annotation tape
SLAR	- side-looking airborne radar
SLF	- standard linear (or segment-noded) format
SLRS	- satellite laser-ranging system
SPOT	- Système probatoire d'observation de la Terre (France)
TDRSS	- Tracking and Data Relay Satellite System
TM	- thematic mapper (on LANDSAT 4)
UNDP	- United Nations Development Programme
USGS	- United States Geological Survey
UTC	- universal time co-ordinates
UTM	- Universal Transverse Mercator (projection)
VBLI	- very long baseline interferometry
WGS 72	- World Geodetic System 1972

TECHNICAL PAPERS

PRESENTED TO THE CONFERENCE

AGENDA ITEM 4

Country reports and progress made since the Ninth Conference

REPORT ON ACTIVITIES BY AUSTRALIA, 1980-1982*

RESUME

Le réseau géodésique a été renforcé et développé. Une nouvelle étude du modèle géodésique de l'Australie a été entreprise et on a étudié le géoïde de la région. On a effectué des observations géodésiques à diverses fins et commencé à développer des installations de télémétrie par satellite.

Les activités de photographie aérienne ont été poursuivies par cycle et complétées pour la cartographie, comme il était demandé. En photogrammétrie, l'utilisation d'enregistrements numériques et d'ajustements par faisceaux, de même que la photogrammétrie terrestre, a été développée. Les installations d'étalonnage ont continué d'être étendues et un profilographe aéroporté perfectionné a été mis en place pour l'établissement de cartes. De nouvelles orthophotocartes contrastées ont été produites.

Uns installation au sol LANDSAT a été mise en place. Les données LANDSAT ont permis d'établir des cartes des récifs et du couvert végétal ainsi que des levés pour les différentes sciences de la Terre.

L'utilisaiton de systèmes et de données cartographiques numériques a été étendue et on a commencé à prendre des mesures pour assurer une normalisation appropriée.

La carte topographique de base de l'Australie est maintenant établie à 75 pour cent. De grands progrès ont été réalisés dans l'établissement de cartes de certaines régions à moyenne échelle. On met au point de nouvelles spécifications uniformes pour la cartographie topographique à toutes les échelles.

Les bases de données à petite échelle pour la cartographie thématique ont été améliorées. Trois atlas régionaux ont été achevés et la production de deux atlas nationaux a été poursuivie. Des faits nouveaux

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, on behalf of the National Mapping Council, appeared as document E/CONF.75/L.37.

sont intervenus en ce qui concerne l'établissement de cartes de la végétation et de cartes géologiques, géophysiques et touristiques. Les cartes de district pour le recensement de 1981 ont été numérisées et on a commencé à établir de nouvelles cartes pour celui de 1986.

On a continué à produire des cartes cadastrales et des cartes urbaines en série. On a entrepris la compilation numérique de détails cadastraux. Un plan cadastral indiquant la délimitation des terres des tribus aborigènes a été établi. On a continué à développer des systèmes d'information foncière automatisés et on envisage de mettre au point des normes nationales.

L'établissement de cartes marines initiales de la région de l'Australie est maintenant terminé à 60 pour cent; l'automatisation des techniques et l'accroissement des effectifs permettent d'accélérer la production de nouvelles cartes. L'établissement d'un levé bathymétrique du plateau continental est maintenant achevé à 40 pour cent. Deux systèmes d'information marine sont actuellement mis au point et un système de sondage aéroporté deviendra opérationnel en 1985.

Parmi les faits nouveaux intervenus dans la présentation des cartes et les méthodes d'impression, on mentionnera les orthophotocartes contrastées, l'impression par le procédé quatre ou cinq couleurs, les cartes repliées et l'impression d'orthophotocartes sans écran.

L'Australie a fourni une assistance technique et des services de formation en cartographie à dix pays de la région dans le cadre des programmes de coopération en matière de défense, de programmes de l'Organisation des Nations Unies et d'accords d'assistance bilatéraux.

The mapping of Australia is a co-operative enterprise, most of which is shared by the major federal (Commonwealth) and state map-making organizations represented on the National Mapping Council (NMC) (see annex).

The individual mapping responsabilities of each organization are determined by the needs of their respective governments. In the case of the basic mapping cover for civilian purposes, it has led to a broad Commonwealth-state division of responsibility at 1:100,000 scale, with the various states concentrating mainly on larger scales within their respective borders. 1/

Co-ordination of these activities in order to avoid duplication of effort and to make arrangements for co-operation is the primary task of NMC.

In 1981, the Commonwealth arrangements for surveying, mapping and charting the country and its waters were examined in considerable detail by the Government, and it was decided that there should be no merger of the Commonwealth organizations that undertake surveys or mapping.

It was recognized that the existing machinery for co-ordinating hydrographic programmes was satisfactory, that the Hydrographic Office of the Royal Australian Navy (RAN) would continue to be the national charting authority and that the Division of National Mapping (Natmap) would continue to be responsible

for the bathymetric mapping of the Australian continental shelf. Original surveys carried out by the RAN Hydrographic Service and by Natmap will therefore continue to be exchanged and used both for detailed nautical charting and for more general bathymetric mapping as required by each organization.

It was also recognized, however, that mapping programmes could benefit from further consultation between Commonwealth organizations, and the Commonwealth Co-ordinating Group on Mapping, Charting and Surveying (CCGMCS) was established. The first report by CCGMCS was expected to be made to the Government by early 1983.

The present report is an overview of the progress of mapping by Australia during the period 1980-1982. It places in context the other papers presented to the Tenth Conference by Australia and summarizes the main work reported by the organizations listed in the annex, from which more details can be obtained. Consolidated lists of most of the non-topographic maps produced are contained in recent issues of the Thematic Mapping Bulletin, published annually by Natmap.

GEODETIC SURVEY

The Australian geodetic network was strengthened with more electronic distance measurement (EDM) and Doppler satellite observations and was increased where necessary to provide control for new maps and cadastral surveys, using Doppler, airborne laser-profiling and photogrammetric surveys as well as conventional ground surveys. Programmes to preserve existing geodetic survey marks were continued, and a computerized national data base was established. 2/

Recognizing the considerable strengthening of the network since 1966, when it was adjusted by program VARYCORD to produce the Australian Geodetic Datum (AGD), and the parallel developments in computing, NMC decided to re-examine the geodetic model of Australia (GMA), in a project designated GMA82. All available observations were rechecked, and some multi-station Doppler and high-precision EDM surveys were done. All of these data will be adjusted together by CHAOS, a program developed from the Canadian program HAVOC by the University of New South Wales, and NMC will use the results in assessing the future adequacy of the AGD66 co-ordinates.

Many Doppler satellite observations were made in neighbouring countries and these, together with observations made previously or by other countries, were used in empirical studies of the geoid in the region. 3/

Special-purpose geodesy included crustal movement surveys, maintenance of the precise national time-scale--UTC (AUS)--and observations in support of the GEOS, SEASAT and Global Positioning System (GPS) projects, a very long baseline interferometry (VLBI) experiment and international studies of Earth's rotation and polar motion.

A co-operative project was begun with the National Aeronautics and Space Administration (NASA), United States of America, to upgrade the lunar laser ranger near Canberra for ranging to artificial satellites. 4/

AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRY

Cyclic rephotography was continued, typically ranging from wide-angle scales 1:5,000-1:16,000 every two or three years for metropolitan areas to super-wide-angle scale 1:60,000-1:85,000 every 10 or 15 years for the least developed areas. This work was supplemented as necessary to meet individual mapping requirements, typically 1:40,000 scale photographs for 1:25,000 scale mapping and 1:50,000-1:85,000 scale photographs for 1:50,000 and 1:100,000 scale mapping. Ultra-high-altitude photographs at 1:140,000 scale were also taken for 1:50,000 scale military orthophotomaps.

In photogrammetry, the trend towards digital output and computer-assisted editing and plotting continued, but most topographic map compilation was done by analogue methods. Most of the aerotriangulation was done by independent model block adjustment, but there was an increase in the use of bundle adjustment.

The use of terrestrial photogrammetry increased, reflecting the growing interest of Australia in its historic buildings and sites.

A new laboratory calibration service for cameras was established, 5/ and a photogrammetric test range was further developed. 6/ An improved airborne laser-profiling system was introduced in order to provide photogrammetric control for 1:50,000 scale mapping. 7/ No new 1:100,000 scale orthophotomaps were made, but in response to increasing acceptance by users, there was a marked increase in the production of enhanced orthophotomaps at larger scales. 8/

SATELLITE IMAGERY

The Australian LANDSAT station, which receives, processes and distributes image data transmitted by United States satellites, came into full operation in 1980. Modifications to suit the LANDSAT-4 multispectral scanner (MSS) data are in hand, and the upgrading of facilities for a thematic mapper and data from the Système probatoire d'observation de la Terre (SPOT) is under consideration.

Satellite imagery is being used in the compilation of nautical charts, particularly in areas of complicated reef structures where no regular hydrographic surveys exist or are likely to be carried out in the foreseeable future. It is only possible where the ground control is sufficiently precise to rectify the imagery, but it has been found that considerable detail of reef and shoal delineation is possible, even though depths cannot yet be inserted. Areas charted from satellite imagery but not supported by hydrographic surveys will be indicated as "unsurveyed" on the chart and reference made to caution under the chart title.

In topographic mapping, LANDSAT imagery was used--where it was the best available source date--to depict reefs at 1:100,000 scale and vegetation at 1:250,000 scale. 9/ LANDSAT imagery continued to be used in determining land cover for thematic maps at 1:1,000,000 and smaller scales.

Methods were developed for analysing the topography of the Great Barrier Reef using LANDSAT. 10/ Digital image-processing systems were used for ground-

water studies, geological map revision and reconnaissance, pasture assessment and the analysis of land-cover changes, such as flooding and timber felling.

COMPUTER-ASSISTED MAPPING AND CHARTING

Digital systems using locally written computer programs are currently often used for cartographic products, ranging from large-scale maps and plans 11/ to urban social altlases. 12/

The application of systems based on the Canadian AUTOMAP software for topographic mapping--AUTOMAP 13/ and AUTOCHART--is being extended.

Australian marine navigation chart production is predominantly computer-aided and the AUTOCHART system is an integral component of chart compilation and production procedures. The generation of final reproduction material for printing from the digital compilation files is almost totally automated since only minor text fount structure remains to be defined.

Digital topographic data have made possible not only automatic drawing of maps and charts but analytical hill-shading 14/ and automatic control of ortho-photo projection.

The need for standardization of digital data, brought about by these developments, has not been overlooked. An Australian standard (AS 2482 of 1981) has been adopted for the exchange of feature-coded digital mapping data, and NMC is reviewing its standard specifications for topographic mapping with the aim of achieving commonality of data bases as well as depiction of data.

TOPOGRAPHIC MAPPING

The compiling of topographic data at 1:100,000 scale with 20-m contours was continued, and the programme for first cover of Australia is now about 75 per cent complete. The disposition of mapping resources is currently being reviewed, and this programme is likely to be accelerated in order to complete it by about 1986. The number of published 1:100,000 scale maps from these compilations increased to about 1,500; the area covered by the maps is currently equivalent to nearly half of the area of the country. The derivation of new 1:250,000 scale maps with 50-m contours from the 1:100,000 scale compilations (to replace the old series of maps with heights in feet completed in 1968) continued, and 140 of the 544 maps needed to cover the country have now been published.

Most of the 1:250,000 and 1:100,000 scale maps published comprise the National Topographic Map Series (NTMS), but many are produced to specifications differing slightly from NTMS in order to meet specific military or regional administrative requirements.

In such a long-term project as NTMS, it is difficult to maintain complete consistency in the face of changing user requirements. Recent examples of consequent changes to NTMS are in the selection of topographic names 15/ and the classification of roads.

The spatial accuracy of NTMS maps continued to be monitored, and progress was made in improving techniques for doing this. 16/

Topographic mapping at 1:50,000 and larger scales proceeded at a much higher rate. New 1:50,000 scale maps published covered about 660 fifteen-minute quads. New 1:25,000 scale maps published covered the equivalent of about 675 seven and one-half minute quads: this included a new programme begun in Tasmania, in which the maps are being published in 20 x 20-km grid rectangles.

Good progress was made in the mapping of urban areas and selected development areas at 1:10,000 or larger scale, often published with an orthophoto base. By way of example, an additional 4,400 km^2 of urban area in New South Wales was orthophotomapped at 1:4,000 scale.

A draft standard specification for topographic mapping in Western Australia at all scales (WATSAS) was produced, and NMC is considering it as the basis of a new national standard specification.

SMALL-SCALE AND THEMATIC MAPPING

Recognizing the importance of accurate small-scale maps not only for general reference but as bases for thematic maps, a set of national base maps ranging in scale from 1:5,000,000 to 1:30,000,000 was prepared and is being maintained, and a programme to produce a digital data base at 1:1,000,000 scale was begun.

A related programme, 17/ to further rationalize the collection and management of data on the country's various resources in order to simplify the task of producing small-scale thematic maps, also was begun.

Atlases of the states of Queensland and Victoria were produced, publication of the Atlas of Population and Housing (1976 Census) was completed; and the first two volumes of the 10-volume third edition of the Atlas of Australian Resources, which will contain many innovations, 18/ were published. Production of the BMR Earth Science Atlas at 1:10,000,000 scale continued, and three more of the maps were published.

The World Conservation Strategy recognizes the importance of accurate resource inventories in management for sustainable development, and many projects to record natural resources are already in hand in Australia. Some of these projects record vegetation cover on series of maps at 1:1,000,000 or larger scales, and a project to consolidate vegetation data at 1:1,000,000 scale was begun. 19/

The standard series of geological maps at 1:250,000 scale continued to be revised and extended, but the emphasis was shifted towards special and regional maps at various scales for selected areas of geological importance, for example, 1:25,000 scale maps of the Broken Hill area and a 1:1,000,000 scale map entitled "Continental shelf sediments - Tasmania and Bass Strait".

Aeromagnetic and radiometric survey maps, gravity maps and marine geophysical maps are now mainly produced by computer-assisted processes.

Other major thematic mapping programmes include tourist mapping, for which NMC is now investigating a standard set of symbols; the regular revision of aeronautical charts, generally at 1:1,000,000 scale; and forestry mapping.

CENSUS MAPPING

The population census held in Australia every five years involves two important mapping tasks. Before each census, many thousands of maps at various scales (depending upon local population density) defining planned census collection district boundaries are produced for the use of collectors. After each census, the actual boundaries are digitized to allow subsequent merging with statistics for a host of planning applications. The 1981 census collection district boundaries have thus been digitized, and a project to update base mapping and aerial photography for defining collection districts for the 1986 census was begun.

CADASTRAL AND URBAN MAPPING

Rural cadastral mapping is done in series at 1:250,000, 1:100,000, 1:50,000 or 1:25,000 scale, depending upon the density of the cadastral network. The form of publication adopted by each state or territory varies: approaches include monochrome printed maps or dye-line copies, combination with selected topographic features for printing in three or four colours and overprinting on standard topographic maps.

In urban areas, cadastral and topographic mapping is done in series at 1:5,000 and larger scales; orthophotomaps are commonly used. Some areas of urban growth or other intensive development are being mapped at 1:10,000 scale.

Cadastral mapping conventionally uses manual graphical methods on a standard topographic or orthophoto base map, but the emphasis is now shifting to digital compilation of the cadastre for eventual use in computerized land information systems.

An interesting development in cadastral surveying was the application of surveying and photogrammetric techniques to the delineation of Aboriginal clan boundaries in the Northern Territory. 20/

COMPUTERIZED LAND INFORMATION SYSTEMS

Over the past decade, significant steps have been taken by land administration authorities in the various Australian states and territories towards the computerization of records relating to land. A computerized land ownership and tenure system (LOTS) was commenced in 1980 as the first stage of a land information system (LIS) for the State of South Australia, and most other states and territories now have systems that are partially implemented or under development.

Progress has also been made in digital cadastral systems to provide spatial referencing of land information systems, and the State of Western Australia commenced the digital recording of its cadastre in 1982. 21/

Recognizing the potential need to merge data from the various land information systems being established, the Standards Association of Australia began to study where standards for these systems might be appropriate.

HYDROGRAPHIC CHARTING AND BATHYMETRIC MAPPING

The Australian charting area extends from the equator through Papua New Guinea, New Britain and New Ireland waters to Antarctica, incorporating large regions of the Indian Ocean, The Southern Ocean and the south-west Pacific Ocean. Some 350 of the planned initial coverage of approximately 600 charts have been produced. Chart production capacity is first applied to the chart revision and maintenance programme. Staff restrictions in the past few years have limited new chart production; nevertheless, computer-aided charting techniques and a recent increase in manpower will accelerate new chart production within the region. Some emphasis is being directed towards aid programmes for charting in the south-west Pacific region. This support is in the form of training and assistance in nautical chart production and maintenance.

A joint charting agreement between Australia, New Zealand and the United Kingdom of Great Britain and Northern Ireland ensures that there should be no duplication of effort in areas formally charted in the British Admiralty series. Weekly Notices to Mariners published by the Royal Australian Navy Hydrographic Office in order to promulgate necessary corrections to charts and publications include appropriate extracts from New Zealand and United Kingdom notices.

The contour mapping of the continental shelf continued. Of the 287 sheets in the 1:250,000 National Bathymetric Map Series (NBMS), the number completely surveyed rose to 113 and the number published to 68. Bathymetric surveys at Macquarie Island and the Australian Territory of Heard Island and the McDonald Islands--all in the Southern Ocean--were carried out in conjunction with other mapping and scientific activities.

Two computerized marine information systems are under development. Digital information for use in preparing nautical charts in the Australian series continues to accrue in magnetic tape, which is stored in the RAN Hydrographic Office at Sydney. Definitions of the requirements for the digital hydrographic data base (HDB), which will hold all hydrographic survey information in digital form, is proceeding in anticipation of installation during 1984. The data base is being developed in parallel with the planned deployment of digital field survey systems, in particular the laser airborne depth sounder (LADS), 22/ which, it is hoped, will become operational in 1985.

The Australian Oceanographic Data Centre is the national archive for oceanographic data covering the waters surrounding Australia, including the Indian Ocean and the Southern Ocean. The data bank currently contains some 133,000 temperature profiles and expansion of this facility to encompass other data parameters is well advanced.

DEVELOPMENTS IN MAP STYLES AND PRINTING METHODS

Cartographically enhanced, simulated colour orthophotomaps were produced instead of conventional line-mapping for many 1:25,000 and 1:50,000 scale topographic maps. 23/

The trend towards printing topographic maps in fewer colours--for greater economy--continued. Most of the maps at 1:100,000 and 1:250,000 scales are now printed in only five colours, which represents a considerable saving; 1:250,000 scale maps for military purposes, for example, used to be printed in nine colours. 24/ For line maps at 1:50,000 and 1:25,000 scales, conventional printing procedures predominated, but four-colour process printing was introduced in Tasmania and continued in New South Wales.

Covers were printed on the edges of more maps, and most new civilian maps are now made available in folded form to users.

A screenless printing technique was developed in order to maintain resolution in orthophotomaps at 1:50,000 scale. 25/

ASSISTANCE TO OTHER COUNTRIES

Australia provided mapping, charting and geodesy support to Fiji, Indonesia, Papua New Guinea, Solomon Islands and Tonga, through defence co-operation programmes. 26/ Mapping assistance under these programmes comprised 517 maps on the scales 1:250,000, 1:100,000, 1:50,000 and 1:25,000.

In Papua New Guinea, the Royal Australian Survey Corps continued to provide support for field surveys, topographic mapping and aeronautical charting. Highlights have been the completion of first edition coverage at 1:100,000 scale in 1980 and subsequent completion at 1:250,000 scale in 1982.

In Indonesia, the Royal Australian Survey Corps and the Royal Australian Air Force provided assistance for the acquisition of aerial photography and mapping control in Irian Jaya and Maluku provinces. Technical support was given for aerotriangulation. A feature of this work has been the successful completion of a systematic network of airborne profile recording (APR) over the province of Irian Jaya, covering rugged tropical terrain ranging from coastal mangrove swamps to glacier-covered mountains.

The RAN Hydrographic Service is providing direct hydrographic assistance to Solomon and Fiji Islands. In the latter, a hydrographic surveyor is on secondment for two years to assist in local hydrographic organization. In addition, a deep-water hydrographic survey is being carried out in the Indispensable Strait by a unit embarked in the Department of Transport MV Cape Pillar. In Fiji, an officer is on exchange with the Fiji Hydrographic Service, while a Fijian receives training and practical experience in RAN. An extension of this co-operative programme is anticipated in future years.

The Royal Australian Survey Corps also provided equipment and technical support to Fiji, Solomon Islands and Tonga to assist in fixing control points for the determination of exlcusive economic zones, and undertook systematic rephotography in Fiji.

Two officers from the Division of National Mapping participated in United Nations programmes; one expert in cartography to work with the Government of the Philippines; the other to work in the Department of Lands, Fiji, on a bathymetric mapping project.

The Commonwealth Surveyor-General joined a mission that examined the programme and procedure for the issuance of land titles in several areas of Thailand.

In September 1981, staff seconded from the Australian Survey Office completed the cadastral surveys of approximately 50,000 acres of sugar lands in Fiji. 27/ During the project, 26 trainees nominated by the Government of Fiji received surveying and drafting training experience in Australia.

The Australian Survey Office also completed mapping and engineering surveys for the Tanjungkarang-Telukbetung and Kotabumi water-supply projects in Indonesia, and the Tarawa sewerage project in Kiribati. An officer visited Samoa in order to investigate and report on photographic and mapping requirements.

The Bureau of Mineral Resources (BMR) has been engaged in a joint project of the Australian and Indonesian Governments, to assist Indonesia in undertaking systematic and comprehensive geoscientific surveys in Irian Jaya and in producing 1:250,000 scale maps of the area. The project, to cost about 6 million Australian dollars ($A), will continue for about 10 years and involves 10 BMR geologists, geophysicists and support staff. The field programme is currently being amended: field training will be moved to another province, probably Kalimantan.

The Royal Australian Survey Corps arranged on-the-job training or formal courses at the School of Military Survey for 38 civilian and military personnel from Fiji, Indonesia, Malaysia, Papua New Guinea, the Philippines, Singapore, Solomon Islands and Thailand, in a wide range of mapping skills. Study visits by officials from Indonesia, Malaysia, Singapore, Solomon Islands and Vanuatu covered many specialized topics, including analytical aerotriangulation mehtods and automated cartography with AUTOMAP.

The RAN Hydrographic School at Sydney alos provides training for oversea students at the basic hydrographic officer level, and has been granted a Class B certificate by the International Hydrographic Organization/Fédération internationale des géomètres (IHO/FIG) for this course. Courses at the surveying technician level are also available.

Natmap provided on-the-job training in photolithography and map-draughting to two officers from teaching institutions in Papua New Guinea; in general mapping to two officers from the Department of Lands, Fiji; and in astronomical techniques and precise time and frequency measurement to two government officers from the Philippines.

Notes

1/ See "Map production and map revision in New South Wales", under agenda item 5(e).

2/ See "The national geodetic data base", under agenda item 5(a).

3/ See "A geoid for South-East Asia and the Pacific", under agenda item 5(a).

4/ See "The Natmap laser-ranging system", under agenda item 5(a).

5/ See "Camera calibration in the Division of National Mapping", under agenda item 5(b).

6/ See "Lake Hume photogrammetric test range", under agenda item 5(b).

7/ See "Airborne profile recording", under agenda item 5(b).

8/ See "Simulated colour for orthophotomap production", "Cartographic enhancement of orthophotomaps" and "Orthophotomapping for the market-place: the Queensland experience", under agenda item 5(b).

9/ See "Use of LANDSAT imagery to supplement conventional imagery in medium-scale and small-scale mapping and charting", under agenda item 5(c).

10/ See "LANDSAT: its application to marine park management of the Great Barrier Reef", under agenda item 5(c).

11/ See "A system for computer assistance in large-scale map production" and "Automated cartography, computer mapping and digital terrain models", under agenda item 5(d).

12/ See "Use of computers to prepare urban social atlases", under agenda item 5(d).

13/ See "Digital topographic mapping in the Division of National Mapping" and "Automation in computer-assisted cartography: AUTOMAP 2", under agenda item 5(d).

14/ See "Analytical hill schading", under agenda item 5(d).

15/ See "Selection of topographic names for the national map series", under agenda item 5(e).

16/ See "Map-accuracy surveys by the Division of National Mapping", under agenda item 5(e).

17/ See "Development of data bases for small-scale and thematic mapping in the Division of National Mapping", under agenda item 5(f).

18/ See "Innovations in the national atlas", under agenda item 5(f).

19/ See "Mapping of present vegetation", under agenda item 5(f).

20/ See "Hermannsburg Aboriginal land grants in the Northern Territory", under agenda item 5(g).

21/ See "Development of a cadastral digital capture for the Western Australia land information system, covering the period from January 1981 to September 1982", under agenda item 5(g).

22/ See "The laser airborne depth sounder", under agenda item 5(i).

23/ See note 8.

24/ See "Five-colour process printing of line mapping", under agenda item 5(j).

25/ See "Production of orthophotomaps using a duotone, random-dot technique", under agenda item 5(j).

26/ See "Technical assistance in Asia and the Pacific" and "Technical assistance to the National Mapping Bureau of Papua New Guinea", under agenda item 7.

27/ See "Completion of the Sugar Lands Surveying Project in Fiji", under agenda item 7.

Annex

SOURCES OF ADDITIONAL INFORMATION

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REPORT ON THE PROGRESS OF SURVEYING AND MAPPING BY CHINA, 1980-1982*

Paper submitted by China

RESUME

Le rapport décrit les travaux accomplis par les services cartographiques de la Chine entre 1980 et 1982 et fait le point des activités réalisées dans les domaines de la géodésie classique et de la géodésie par satellite, des levés topographiques, de la cartographie et de la formation de personnel. Il montre les moyens cartographiques considérables dont dispose la Chine et les possibilités de coopération scientifique et technique qui existent avec d'autres pays dans le domaine de la cartographie.

Compte tenu des besoins de l'économie, de la défense et de la recherche scientifique, les services cartographiques de la Chine ont élargi la gamme de leurs activités au cours des dernières années. Certains des programmes de base mis en train il y a trois ans sont terminés ou sur le point de l'être. Parallèlement aux activités cartographiques de base, on a établi des cartes à grande échelle devant servir principalement à l'agriculture et à la mise en valeur des ressources énergétiques, au développement des communications et à l'urbanisme. On a continué à établir et publier divers atlas et cartes à petite échelle pour toutes les catégories d'usagers. On a régulièrement étendu la portée des activités cartographiques.

This report reviews the work completed by the surveying and mapping departments of China during the period 1980-1982, including the achievements made in classic geodesy and satellite geodesy, topographic mapping, cartography and personnel training. It shows the country's considerable surveying and mapping capability and the possibility for scientific and technical co-operation on surveying and mapping between China and other countries.

In recent years, the surveying and mapping departments in China have engaged in an even broader range of surveying and mapping activities in order to meet the requirements of national economic and defence construction and scientific research. Some of the basic programmes initiated three years ago have been completed or nearly completed. While the basic surveying and mapping work was in progress, the emphasis in large-scale mapping was on providing map service for assistance to agriculture, energy resources and communications and for the planning of cities and towns. All types of small-scale maps and atlases were continuously prepared and published, and small-scale geographical base maps and large atlases also were compiled and published for numerous purposes and population groups. The service scope of surveying and mapping has been steadily broadened.

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GEODESY

On the basis of the work during the past 30 years, the main emphasis in recent years has been to strengthen and improve the accuracy and densification of the terrestrial horizontal control networks and vertical control networks. Meanwhile, the technique of satellite geodesy has been applied.

The batch adjustment of the national astrogeodetic net has been completed. Research and experiment on the scheme for adjustment of the national astrogeodetic net began in the 1960s and was continuously improved along with the development of science and technology. Since 1978, the scheme for batch adjustment of the entire net has been worked out, and some 50,000 points of all first- and second-order points (with a small number of tertiary points) of the triangulation chains and nets have been adjusted as a whole. In 1982, the adjustment was successfully computed on its first run. To ensure the accuracy of the results through a mutual check and verification, the batch adjustment was carried out separately on two different computers with two different schemes and programs. After the results were compared and analysed, it was found that the greatest difference of the same horizontal co-ordinate point obtainable with these two schemes was 4.8 cm.

The layout of the national first-order levelling net has been basically completed and the overall adjustment is under preparation. The field layout ot the first-order network, with more than 90,000 km of levelling lines throughout the country, was completed in 1981; and the field-work is estimated to be finished in 1983 after the local check measurement and resurvey have been made. Meanwhile, research and experiment on the technical scheme for the overall adjustment of the national first-order levelling network has begun.

The layout of the national second-order levelling network was begun in 1982, and the total length of the net is planned to be more than 100,000 km.

The old national secondary triangulation nets are being reformed. The national secondary triangulation network established before 1958 with a mean square error of angle measurement of $\pm$ 2.5", also called the "old secondary fill triangulation net", was mainly distributed in the economically developed areas in south-eastern China. As large-scale mapping was carried out progressively in those areas, the accuracy of the old secondary triangulation net was proved to be relatively low and unable to meet the requirements. Therefore, the reformation of the net has been in progress. In order to find a more economical and reasonable reformation programme several alternative methods to increase the accuracy of geodetic net are under experiment: an additional survey of special traverses, layout of Doppler nets and points; and a supplementary survey of a moderate amount of initial sides.

The combined measurement of the local co-ordinate system of the Xisha Islands and the geodetic network of the continent was carried out with two CMA-722B Doppler Georeceivers in 1978; and a Doppler geodetic network of 37 stations, with an average interval of some 800 km, has been established throughout the country since 1982. The network was divided into several districts for observations and more than two common points in every district were connected. Every point in each district was observed simultaneously with MX-1502 Georeceivers and at least 100 qualified satellite passes at each point were obtained.

Data processing was done with a single-point positioning program using "broadcast" ephemeris. Currently, experiments are being made on the adjustment of the entire net using the short-arc mode. The purpose of establishing the national satellite Doppler geodetic network was to study the possibility of strengthening and reforming the astrogeodetic network with the satellite geodetic method.

In order to develop further research and experiment on the application of space techniques to geodesy and geodynamics, an experiment satellite observation station is under construction at Beijing.

There have been new developments also in gravity measurement in recent years. On the basis of the existing national gravity results, the $1^{o} \times 1^{o}$ national mean gravity measurements were completed by additional survey and supplementary survey. The average accuracy of the gravity anomaly was expected to be better than 3-5 megagals.

To meet the needs of the transformation of the height system, gravity measurements were taken along the first-order levelling lines, and measurements along the second-order levelling lines are scheduled.

In co-operation with Italy, 11 absolute gravity stations were established in the eastern part of the country, which created a better situation for the reformation of the old gravity control network.

As investigation and maintenance of survey targets and marks were carried out all over the country, the maintenance of survey targets and bench-marks was improved and their important role was enhanced.

TOPOGRAPHIC MAPPING

To meet the needs for the economic construction of China, topographic mapping has been carried out in more varieties and at larger scales. Aerophotogrammetry has become the main means of making and revising maps at various scales. In the light of the specific conditions in China, plane-table survey still played a certain role in large-scale engineering mapping on small areas. The work accomplished in recent years is described below:

(a) To provide the large-scale topographic maps need for larm-land development and the investigation and division of agricultural natural resources, topographic maps at 1:10,000 scale and image maps were made at a relatively high speed. Moreover, topographic mapping at 1:25,000 scale also was carried out to satisfy the demands of resource exploitation and construction;

(b) The revision of the basic topographic maps at 1:50,000 scale was conducted progressively. With the rapid development of the socialist economic construction of the country, the geographical picture changed greatly. To maintain current status in map production, it has become an important task to revise and update the basic topographic maps at 1:50,000 scale. With the relatively high accuracy of the first-generation topographic maps and the application of photo-interpretation combined with field-checking, the field work-load was greatly decreased and map revision proceeded at an accelerated pace;

(c) The development of construction at large and medium cities and towns, factories, mines and other enterprises, as well as key water-control projects, gave rise to an urgent need for producing topographic maps at 1:2,000, 1:1,000, 1:500 and larger scales. In the past, topographic mapping at such scales had been carried out by surveying and mapping forces in the departments of economic construction. As the mission was constantly increasing, a considerable part of the surveying and mapping forces in the National Bureau of Surveying and Mapping was also involved in topographic mapping at 1:2,000, 1:1,000 and 1:500 scales. Topographic mapping at 1:2,000 and 1:1,000 scales was accelerated through the use of aerophotogrammetric techniques;

(d) In the investigation of natural resources and other work, remote-sensing information provided by satellite imagery was extensively used. With the support of United Nations Interim Fund for Science and Technology for Development, the Information Department of China National Remote Sensing Centre was set up in the National Bureau of Surveying and Mapping. The Information Department provides appropriate satellite imagery in black and white and in colour to various departments throughout the country;

(e) Non-topographic photogrammetry was adopted in the observation of ancient architectures, distortion of large dams, volume of large containers, deformation of docks, moving orbit of flying bodies etc. This marks the application of non-topographic photogrammetry in the engineering departments of China;

(f) Attention has been paid to the use and development of new techniques and equipment.

In applying aerophotogrammetry, analytical aerial triangulation was extensively adopted, and programmes of large-format and small-scale photogrammetric mapping and of direct scribing of all the map elements on polyester sheets in one step were gradually extended in order to speed up topographic mapping.

For the purpose of developing large-scale mapping, in the light of practical conditions in China and on the basis of full utilization of the existing instruments and equipment, great efforts have been made to improve such instruments and equipment and to produce prototype instruments suited for large-scale mapping, such as precise point-pricking devices, automatic-recording stereo-comparators, precise stereoplotters and automatic co-ordinatographs. These instruments are all used in production for tests.

The Chinese research and education institutions for surveying and mapping have been making efforts to do research on digital and automatic photogrammetric systems. Thus far, progress has been made on the development of a digital control mapping system; this refers to the success on the relief drawing part and a pass of examination on it. A further advanced digital mapping system is at a research stage, with the objective of developing an automatic digital photogrammetric system with full functions, good adaptability and high efficiency.

CARTOGRAPHY

In recent years, to satisfy the demand of national economic construction

and scientific research, besides the continuous preparation of national series of large and medium-scale topographic maps, the surveying and mapping departments of China have enhanced the work for compilation and publication of small-scale topographic maps and atlases, various thematic maps and a series of school maps and atlases. Furthermore, a large atlas is under preparation.

Topographic maps at 1:200,000 and 1:500,000 scales have been compiled, and a new edition of 1:1,000,000 scale topographic maps has been completed. The major features of the latter maps are highlighted with more current status and in more detail, compared with the past editions. The publication of these maps will provide the economic planning departments of the country with reliable fundamental information.

A large number of thematic maps were published, such as various types of tourist maps, forest maps and land-use maps.

The compilation of provincial and regional general atlases has been completed in many provinces and autonomous regions. These atlases mainly describe the physical and geographical conditions and the social and economic development situation in the area, and introduce the achievements attained over the years. They will constitute a good reference for governmental organizations and local cultural and educational departments.

The Historical Atlas of China is being printed and will be published publicly at home and abroad. The atlas describes the fundamental and general situation of the territory limits, administrative divisions and nationality distributions in each historical period of Chinese society before 1840. It is a record of important historical events and provides the history circles with an important historical atlas for their studies of the Chinese feudal dynasties of past years.

The preparation of the National Atlas of the People's Republic of China is under way. The atlas consists of five volumes concerning: general topics; physical subjects; agriculture; energy resources; and historical topics. After the completion of these volumes, the atlas will be published in a popular edition, a Chinese phonetic alphabet edition and foreign language editions, respectively, in the light of specific conditions. The atlas will vividly depict the physical and geographical, social and historical, and economic and cultural situation of the country, as well as the achievements of the socialist construction of new China. It provides the Government with important fundamental information used for general planning, arrangement of industrial and agricultural production, exploitation of resources and transformation of nature. Moreover, it is a basic job for economic work and study of earth science.

PERSONNEL TRAINING

The Wuhan College of Geodesy, Photogrammetry and Cartography in China is one of the key national institutes of higher learning with the aim of training senior surveying and mapping personnel. The college is entitled to confer doctoral degree in some courses and specialities.

In order to accelerate the training of mid-level technicians for strengthening the forefront of surveying and mapping production, the Zhengzhou Technical School for Surveying and Mapping was recently established at Zhengzhou, Henan Province, under the supervision of the National Bureau of Surveying and Mapping. The school began to enroll students throughout the country in 1982. Moreover, surveying specialities are offered in some institutes of higher learning, and surveying and mapping classes are attached to the polytechnic schools in ministries of geology, metallurgy etc., which train high- and mid-level surveying and mapping personnel for the industrial departments.

To sum up, further progress has been made in surveying and mapping in China over the years. In developing surveying and mapping, there is constant adherence both to the policy of independence and self-reliance and the policy of opening to the outside world; and great importance is attached to learning advanced experiences and technology of surveying and mapping from other countries. While paying attention to developing new surveying and mapping technology, the work is based on the use of conventional instruments and methods. Full play is given to the functions of the existing equipment and there is much concern about the economic benefits, so as to provide better services to create a new situation in all fields of socialist modernization in China. There is a willingness to make greater contributions together with colleagues from all countries to the development of surveying and mapping for science and technology.

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

Paper submitted by Cyprus

Comme 40 pour cent de la partie septentrionale de Chypre est encore occupée par l'armée turque, les progrès dans le domaine cartographique ont été minimes et les activités limitées aux zones contrôlées par le Gouvernement.

ZONES COUVERTES PAR DES CARTES TOPOGRAPHIQUES

Ces trois dernières années la Direction britannique des levés outre-mer (Directorate of Overseas Surveys) et le Service foncier et topographique de Chypre ont poursuivi le programme commun d'établissement de cartes topographiques du territoire national au 1:5 000. Des cartes ont été dressées pour près de 800 km^2. Au total 113 feuilles ont été produites. Il ne reste plus à couvrir qu'environ 900 km^2 au centre de la partie libre de Chypre. On prévoit que cette zone sera photographiée au cours du premier trimestre de 1983. Une fois les cartes dressées, le programme national d'établissement de cartes topographiques à l'échelle de 1:5 000 sera achevé pour l'ensemble de la partie libre de Chypre.

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* The original text of this paper appeared as document E/CONF.75/L.84.

ZONES COUVERTES PAR DES CARTES THEMATIQUES

On a continué à dresser des cartes à petite échelle aux fins de la révision de la carte routière et administrative de l'île, de l'établissement et de la révision du plan de la ville de Limassol et de la révision du plan de la ville de Nicosie.

Au cours de la période considérée, le Service foncier et topographique de Chypre a dressé et publié ces deux nouvelles cartes ci-après.

a) La carte touristique de Chypre au 1:250.000, imprimée en couleurs avec au verso les plans des quatre villes libres de Chypre accompagnés de notices historiques. Cette carte est publiée uniquement en anglais;

b) La carte nautique de Chypre au 1:250 000 dressée en 1982, que le Gouvernement chypriote a présenté à la troisième réunion de la Commission démographique pour la Méditerrannée et la mer Noire, tenue en avril 1982 à Monte Carlo. Des exemplaires de cette carte, qui est conforme aux spécifications de l'Organisation hydrographique internationale, sont exposés.

NOMS GEOGRAPHIQUES

Le Comité permanent chypriote pour la normalisation des noms géographiques a fini de réunir, normaliser et transcrire les principaux noms géographiques de l'île et de publier le répertoire succint de Chypre. Ce répertoire a été présenté à la quatrième Conférence des Nations Unies sur la normalisation des noms géographiques tenue en août dernier à Genève. Il peut être consulté à l'exposition et on peut en obtenir des exemplaires en s'adressant au Comité permanent. La nomenclature des cartes publiées à l'avenir à Chypre suivra le répertoire. Chypre présente une étude spéciale sur cette question au titre du point 6 de l'ordre du jour.

PROGRAMME ULTERIEUR

En même temps que la Chypre s'efforce de terminer l'établissement de cartes topographiques à l'échelle de 1:5 000, la mise à jour de ses cartes topographiques et cadastrales représente une tâche gigantesque. Ces huit dernières années, l'aménagement foncier de la partie de Chypre, contrôlé par le Gouvernement, a été spectaculaire. La Chypre manque de personnel spécialisé ainsi que, bien entendu, de moyens financiers. Elle sera heureuse de recevoir des offres d'assistance technique dans ce domaine, des pays qui disposent des moyens nécessaires.

Because 40 per cent of the northern part pf Cyprus is still under occupation by the Turkish army, overall progress in the cartographic field was not substantial during the period under review. All cartographic activities were confined to the areas under control of the Government of Cyprus.

TOPOGRAPHIC MAP COVERAGE

National topographic mapping at 1:5,000 scale, carried out jointly by the

United Kingdom Directorate of Overseas Surveys and the Department of Lands and Surveys of Cyprus, has continued during the past three years. An area of about 308 square miles has been mapped, and 113 sheets were produced. The only area that has not been mapped covers about 350 square miles in the centre of the free part of Cyprus. It is anticipated that this area will be photographed in the first quarter of 1983. When the mapping of this area is completed, the entire free part of Cyprus will be covered by national topographic mapping at 1:5,000 scale.

THEMATIC MAP COVERAGE

Small-scale mapping has also continued, with the revision of the Administration and Road Map of the Island, the revision and production of the town plan of Limassol and the revision of the Nicosia town plan.

Two new editions of maps were prepared and published by the Department of Lands and Surveys during the period under review:

(a) Tourist map of Cyprus at 1:250,000 scale. It is a multicoloured edition, at the back of which maps of the four free towns of Cyprus are printed with historical notes. The edition is produced in English only;

(b) Cyprus nautical chart at 1:250,000 scale. The chart was prepared in 1982 and was presented by the Government of Cyprus at the Third Meeting of the Mediterranean and Black Sea Hydrographic Commission, held at Monte Carlo in April 1982. The specifications of the chart meet the requirements of the International Hydrographic Organization.

GEOGRAPHICAL NAMES

The Cyprus Permanent Committee for the Standardization of Geographical Names has now completed its work on the collection, standardization and transcription of the main geographical names of the island and has published the Concise Gazetteer of Cyprus. The gazetteer was submitted to the Fourth United Nations Conference on the Standardization of Geographical names, held at Geneva in August 1982. It may be inspected at the exhibition and copies may be obtained on application to the relevant committee in Cyprus. The nomenclature on future map publications of Cyprus will be based on the new gazetteer. A special paper on the subject was submitted by Cyprus under agenda item 6 (see "Geographical names").

FUTURE PROGRAMME

In addition to the efforts made to complete the topographic mapping of the island at 1:5,000 scale, there is the colossal task of updating both the topographic and cadastral series of maps. During the past eight years, land development in the part of Cyprus under government control has been tremendous. There are shortages both of trained staff and, of course, financial resources. Offers of technical assistance in this field from countries that have the means to assist Cyprus will be welcome.

COUNTRY REPORT OF THE FEDERAL REPUBLIC OF GERMANY*

Paper submitted by the Federal Republic of Germany

RESUME

En République fédérale d'Allemagne, les administrations cadastrales des Länder et certains organismes nationaux (fédéraux) sont responsables de l'exécution des travaux officiels de levé topographique pour coordonner leurs activités, leurs méthodes de travail et leurs résultats d'où a été constitué un groupe de travail (Arbeitsgemeinschaft). Ses comités s'occupent de la recherche-développement appliquée à leurs domaines de travail respectifs. Les structures sont les mêmes pour les organismes chargés de l'amélioration et du remembrement des terres et leur groupement.

Tous ces organismes et leurs bureaux locaux font des travaux officiels de topographie, de cartographie et de cadastre. Ils bénéficient du concours de géomètres experts, qui travaillent à leur compte mais sont tenus de conformer aux lois et décrets en vigueur. Ces géomètres exécutent également toutes sortes de levés d'étude.

La recherche scientifique dans tous les domaines relatifs à la cartographie est assurée principalement par le Deutsche Geodätische Kommission (Commission géodésique de la République fédérale d'Allemagne) qui s'occupe notamment de lancer les projets de recherche, d'appliquer en République fédérale d'Allemagne les recommandations de l'Association internationale de géodésie et de participer à la contribution de ce pays à des projets internationaux. La Commission fait appel pour cela aux services de Deutsches Geodätisches Forschungsinstitut (Institut de recherches géodésiques).

La formation technique et la recherche relèvent des universités et des écoles polytechniques, qui offrent également des cours de perfectionnement sous forme de colloques et de conférences scientifiques sur des questions d'actualité et de cours d'initiation sur des sujets nouveaux. Ces réunions sont souvent organisées en collaboration avec des associations à caractère technico-scientifique dont l'objectif est également de fournir une formation complémentaire à leurs membres.

In the Federal Republic of Germany, the survey administrations of the Länder and some national (federal) authorities are responsible for official surveying and mapping. An Arbeitsgemeinschaft (working committee) co-ordinate their tasks, their methods and their results. Working groups of the committee are concerned with application-oriented research and development in their specific fields of work. The same applies to the land improvement and land consolidation authorities and their working committee.

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* The original text of this paper, prepared by the Institut für Angewandte Geodäsie, Frankfurt am Main, appeared as document E/CONF.75/L.43.

All these authorities and their local offices carry out work in national surveying, in official cartography and in the property cadastre. They are assisted by registered surveyors who, although working on a free-lance basis, must conform to the relevant laws and decrees. These surveyors also perform all types of engineering surveys.

Scientific research in all fields of cartography is primarily the task of the Deutsche Geodätische Kommission (DGK, Geodetic Commission of the Federal Republic of Germany). Its work includes, among other things, the initiation of research projects, the realization in the Federal Republic of Germany of the recommendations of the International Association of Geodesy (IAG) and assistance in the national contribution to international projects. For the performance of these tasks, DGK avails itself of the facilities of the Deutsches Geodätisches Forschungsinstitut (DGFI, Geodetic Research Institute).

Research and technical education are the responsibility of technical universities and polytechnics, which also provide profession-oriented further education in the form of scientific colloquia, lectures on current subjects and introductory courses on new topics. Often these meetings are held together with scientific-technical associations, whose objective also is the provision of supplementary education to their members.

PRACTICAL WORK

National surveying activities include, above all, renewal of the horizontal and vertical control survey networks by means of modern survey systems, using electronic data-processing for the evaluation.

In the horizontal control survey net, a scientific diagnosis is currently being performed which includes 354 stations (277 determined astronomically), 2,760 directions (observed in 804 sets) and 901 triangle sides (with 14,127 single distances). The adjustment (1,518 unknowns) will presumably be completed in 1983.

In the vertical control survey net, the renewal of the first-order net was begun in 1980. The work is expected to take about six years. For all projects, the automatic flow of data is envisaged, beginning with the field survey and ending with the control station data file. Apart from this, the extension of the vertical control survey nets of the Länder is continuing as far as possible.

The extension of control of the primary gravity network is being executed up to about one station for each 4 km^2.

National topographic surveying by means of aerial photogrammetry and--if necessary--tacheometric procedures are reflected in the topographic maps at 1:5,000 scale (for the south of the Federal Republic of Germany, they are also at 1:2,500). So far, only part of this series has been completed. Because of the large scale and the non-generalized representation of planimetry and heights, this map series, supplemented by an orthophoto series, is ideally suited to serve as the basis for a multitude of applications.

Pending the completion of the basic map series at 1:5,000 scale, the topographic changes are incorporated in the topographic map at 1:25,000 scale. This map series, which is fully available, serves for the time being, in most cases, as the basis for the production and revision of the official map series at smaller scales.

Apart from the basic 1:5,000 map, the following official map series are published by the survey departments of the Länder: (a) topographic map at 1:25,000 scale (2,095 sheets); (b) topographic map at 1:50,000 scale (560 sheets); (c) topographic map at 1:100,000 scale (151 sheets). Of the 1:100,000 map series, 89 sheets are currently available as final editions and 56 as provisional editions.

The following approximate numbers of new sheets are produced each year: 15 at 1:25,000 scale; 2 at 1:50,000; and 5 at 1:100,000. The following approximate numbers of revised sheets are produced each year: 300 (20 with computer assistance) at 1:25,000 scale; 100 at 1:50,000; and 17 at 1:100,000.

The Institut für Angewandte Geodäsie (IFAG, Institute of Applied Geodesy) publishes, by order of the federal Administration and the survey departments of the Länder, the general topographic map at 1:200,000 scale (44 sheets), the general map at 1:500,000 scale (4 sheets) and the International Map of the World on the Millionth Scale (2 sheets), as well as maps for air traffic control and military purposes.

In pursuance of the recommendations of a working group set up by the Arbeitsgemeinschaft and charged with the examination of the map contents for possible work simplification, the map specifications for the official map series at scales from 1:5,000 to 1:200,000 have been revised. The new version of the map specifications for the topographic map series at scales from 1:25,000 to 1:200,000 were published in 1980 and 1981. The new version for the basic map of the Federal Republic of Germany is under way. First editions of the map specifications for the general map at 1:500,000 scale and the International Map of the World on the Millionth Scale are being prepared.

Based on the above-mentioned map series, the survey departments of the Länder and IfAG produce special maps, such as combined sheets and maps representing the immediate surroundings of towns etc., administrative maps and general maps, as well as hiking, cycling and recreational maps. By order of the Military Geographical Service of the Federal Armed Forces, the survey departments of the Länder derive and print, from the civilian sheets of the topographic map at 1:50,000, a military edition.

Other technical administrations use the official map series as the basis for the production of special maps of their own (e.g., geological maps, forestry maps or planning maps). A great number of different maps, such as town and city maps, road maps and hiking and recreational maps, as well as atlases and globes, are produced by private publishing houses.

For automation of the property cadastre, the survey administrations decided upon a nominal concept for the cadastral register (1973) and for the cadastral plan (1975). Financially supported by the Federal Ministry for Research and Technology, they have been engaged in the automation of the cadastral map since 1977, their objective being that the property boundaries and other important planimetric data related to the real properties are now stored both graphically

(analogously) and digitally through electronic data processing. In this process, a data file of co-ordinates and planimetry will be compiled, as well as a data file of the measuring elements.

The programming work of the automated maintenance of the cadastral register has been completed to such an extent that the practice-related test run can be begun. This applies to the autonomous solution (Baden-Württemberg, Nordhein-Westfalen) as well as to the integrated keeping of the property and cadastral register. Because of system-independent application programming and the development pf compatible interfaces, the procedure of different manufacturers (e.g., International Business Machines (IBM) and Siemens) can be used with different data base-management systems.

Considering that the work on the automation of the property cadastre has reached different stages in the individual Länder and is still continuing, the planned integrated maintenance of the cadastral register and the cadastral plan is reserved for a later extension of the programming system.

SCIENTIFIC RESEARCH

In the past few years, the research topics described below have been given priority.

In geodesy, the use of earth satellites for geodetic purposes has been the main objective. A Sonderforschungsbereich (special research unit) attached to the Technical University at Munich co-ordinates the work. The satellite observation station at Wettzell in the Bavarian forest is currently being extended to a fundamental station.

In addition to the stationary laser satellite observation system, Doppler equipment and a mobile laser system will be in use as of 1983. A radio telescope for interferometric measurements is under construction. Also, the high-precision time service has been improved.

Another Sonderforschungsbereich, which is attached to the Technical University at Hannover, is concerned with procedures of surveying and remote sensing in coastal and marine areas; partial projects include exact positionings by satellite measurements and scanning of the sea-bottom. In the realization of these projects, the staff of the Sonderforschungsbereich co-operates with the staff of the scientific institutions of the federal Government and the Länder that include surveying and remote sensing in their activities.

At Bad Homburg vor der Höhe, near Frankfurt am Main, a new earth-tide observation station has been installed. It is operated and maintained by IfAG. A super-conducter and two modified La Coste and Romberg gravity meters are running in parallel; measurements with an absolute gravity meter are in preparation.

At Schiltach in the Black Forest, an earth-tide observation station is operated jointly by the universities at Karlsruhe and Stuttgart. Several instruments (e.g., gravity meters and extensometers) are permanently recording.

In photogrammetry, the availability of image data from space and new image processing and evaluation systems has led to new research projects.

Part of the research work is done by means of international co-operation, in particular within the scope of the Organisation européenne d'études photogrammétriques expérimentales (OEEPE, European Organization for Experimental Photogrammetric Research).

A current task is the production of photomaps--for the time being prepared from remote-sensing data--for that part of Antarctica where scientists of different disciplines from the Federal Republic of Germany are carrying out research work.

In cartography, priority has been assigned to the introduction of computer-assisted procedures in the various operations of map-making.

The problems of graphical data captured by scanning have been solved in principle; the instrumental realization of the procedure has already reached a very promising stage. Results have also been obtained in the reduction of data for the representation of scanned features by their minimum point quantity.

Part of the graphical output is, among other things, the computer-assisted placement of the topographic feature, which can, by display and digitizer, be moved interactively to the desired position and can then be exposed with a phototypesetter. Electronic data-processing methods have also been applied to the production of the Gazetteer of the Federal Republic of Germany.

OTHER ACTIVITIES

Apart from institutions of scientific research and the public administration, the scientific and technical associations also contribute their share to the development of surveying and mapping in the Federal Republic of Germany.

Their main objective is the advancement of science and practice in their specific fields and the cultivation of international co-operation. Their activities embrace the publication of technical journals; the organization of annual meetings, each devoted to a current topic and serving the establishment of scientific, practical and public contacts; the holding of professional meetings (courses, symposia); the exchange of the most recent findings and experiences within working groups, which often also conduct investigations of their own; and co-operation with the corresponding commissions of foreign and international associations.

Every year, advanced training courses on interrelated subjects of topical interest are held by universities, polytechnics and the corresponding associations; they receive an enthusiastic response at home and abroad.

Emphasis is also placed on the further education of foreign specialists and top executives, in particular those from developing countries. Individual advanced training is provided by nearly all scientific institutions and authorities.

Further particulars of the development and progress made in surveying and mapping are given in the numerous publications issued at regular intervals by scientific institutions, authorities and associations.

A detailed information paper entitled "Surveying and mapping in the Federal Republic of Germany: co-operation with other countries" is available. Requests for copies should be addressed to IfAG.

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CARTOGRAPHIC ACTIVITIES IN INDONESIA, 1979-1982*

Paper submitted by Indonesia

RESUME

On trouve dans le rapport une description mise à jour des activités cartographiques pour la période 1979-1982.

Des progrès ont été réalisés dans les domaines des levés Doppler de l'établissement de cartes et de la photographie aérienne au moyen d'appareils couplés.

Le rapport signale également le premier cours pilote de formation à la toponymie pour la région de l'Asie du Sud-Est et du Pacifique (zone sud-ouest).

Divers projets cartographiques à petite et moyenne échelles intéressant le programme de migrations internes, la planification urbaine, des projets agricoles, les activités géologiques et minières, à la sylviculture, les levés cadastraux etc. ont été vigoureusement entamés.

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* The original text of this paper, prepared by Badan Koordinasi Survey dan Pemetaan Nasional (BAKOSURTANAL, National Co-ordination Agency for Surveys and Mapping), Jakarta, appeared as document E/CONF.75/L.92.

This report updates the cartographic activities of Indonesia since the Ninth Regional Cartographic Conference for Asia and the Pacific, covering the period 1979-1980.

MAPPING ORGANIZATIONS

There is no change in the government mapping organizations in Indonesia as previously reported.

The number of private firms in survey and mapping, organized in the Association of Indonesian Survey and Mapping Enterprises (AISME), has increased significantly with the increase of volume of work in various government development projects. A separate report in this respect, "The growth of domestic survey firms in support of mapping the country", is presented under agenda item 5(b).

GEODETIC ACTIVITIES

Doppler surveys

In Irian Jaya, 134 Doppler stations were positioned to form a basic framework for mapping of the area at 1:100,000 scale; and during the period 1979-1981, a total of 198 Doppler stations were established in the Maluku Archipelago for mapping at 1:50,000 scale (see figure 1). These stations were observed by single-point positioning mode using a precise ephemeris.

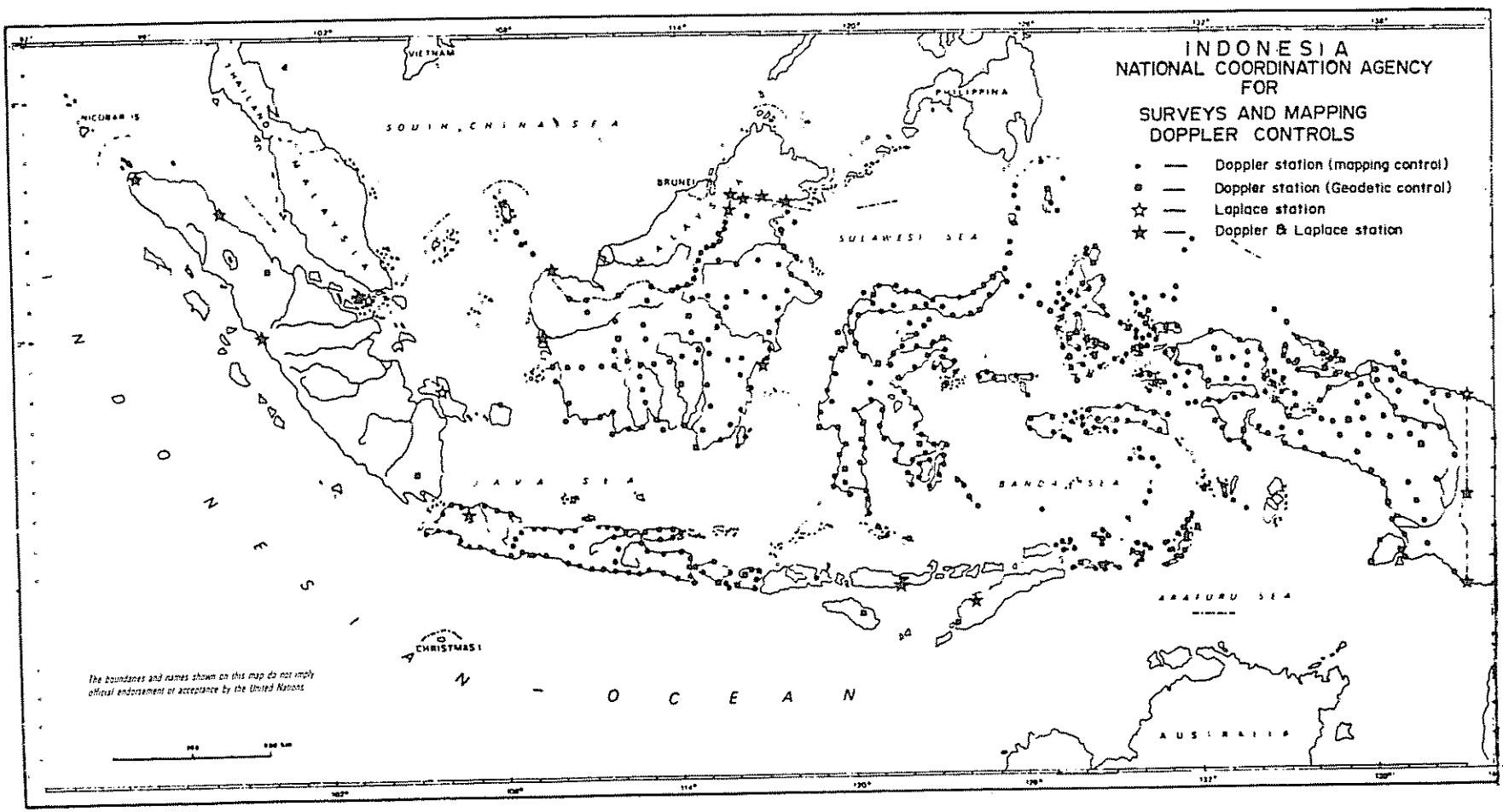
In Kalimantan, Sulawesi and the Nusa Tenggara Islands, 238 Doppler stations were established during the 1979-1981 survey seasons. The Doppler stations were observed using seven Indonesian CMA-751 Doppler receivers in the multi-station mode of operation, with two known Doppler base stations on precise ephemeris while the five roving stations were observed simultaneously with the base stations on broadcast ephemeris.

That work was undertaken by a Canadian survey company in co-operation with counterpart personnel from Badan Koordinasi Survey dan Pemetaan Nasional (BAKOSURTANAL, National Co-ordination Agency for Surveys and Mapping), in the framework of the Canadian assistance to Indonesia. At the end of the project, all 10 Doppler receivers were turned over to Indonesia, and BAKOSURTANAL is continuing the Doppler survey in Lombok, Bali and Jawa to provide control for 1:25,000 topographic mapping. In all, 76 stations are being established.

For the survey and demarcation of the international land boundary between Indonesia (Kalimantan) and Malaysia (Sabah/Sarawak), 40 Doppler stations, selected at salient points on the watershed boundary, were fixed in 1979-1980. (See "Joint demarcation and survey of the international land boundary between Indonesia and Malaysia", under agenda item 5(a).

Doppler positioning techniques will also be utilized in the joint survey and demarcation of the international boundary with Papua New Guinea. It is planned to position 27 Doppler stations, beginning in 1983.

Figure 1. Indonesia: geodetic control surveys, 1979-1981



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Vertical control

Beginning in 1980, precise relevelling of the Jawa network has been undertaken; and up to the present report, 850 line km in western part of Jawa have been completed (figure 2).

Another 1,200 line km will be carried out in 1983, covering western Jawa and part of central Jawa. In total, 801 bench-marks were planted.

In conjunction with precise levelling, tide-gauge observations are being made at two stations, at Cilacap on the southern coast of Jawa and at Surabaya on the north-eastern coast. A new height datum for Jawa will be defined when analyses of the current tidal observations are completed.

Vertical control for topographic mapping of Sulawesi and Kalimantan at 1:50,000 scale using airborne profile recording is in preparation.

MAP PRODUCTION

Topographic base maps of the 1:50,000 series were published for the following areas (previously reported numbers are given in brackets): Sumatera, 293 sheets (231 sheets); Kalimantan, 144 sheets (144 sheets); Irian Jaya, 57 sheets, published as interim line-maps without field-checking (see figure 3).

In 1983, 84 sheets of Sumatera will be printed in full colour, and 163 sheets will be prepared as provisional maps. These provisional maps are printed directly from plotting, thus bypassing fine-drawing for production of repromats so as to speed up the output.

For areas where aerial photography and Doppler control are available from the previous Resources Evaluation Aerial Photography (REAP) project (see section on aerial photography) but still lacking vertical control, planimetric photomaps are to be prepared, particularly for areas of high priority for regional development in Kalimantan.

A computer cartographic hardware system, including a flat-bed plotter, was installed at BAKOSURTANAL, and digitizing of information from existing 1:250,000 maps is being undertaken to create a data bank for a resources information system. The computer-assisted cartographic hardware system will be linked with the stereoplotters in order to overcome the bottle-necks in manual fine-drawing in the production of repromats.

Reprinting the maps at 1:1,000,000 scale, consisting of 30 sheets covering the whole of Indonesia, is expected to be completed at the end of March 1983. About 50 per cent of the maps at 1:500,000 scale (43 sheets) were printed during the period covered in this report.

The national base mapping programme has been rescheduled to conform with the existing capacities of BAKOSURTANAL and the Army Topographic Services to complete the programme, which comprises the 1:50,000 base mapping of Sumatera, Kalimantan, Sulawesi and Maluku; the 1:100,000 base mapping of Irian Jaya; and the 1:25,000 base mapping of Jawa, Bali and Nusa Tenggara Islands. According

Figure 2. Indonesia: precise levelling net of Jawa

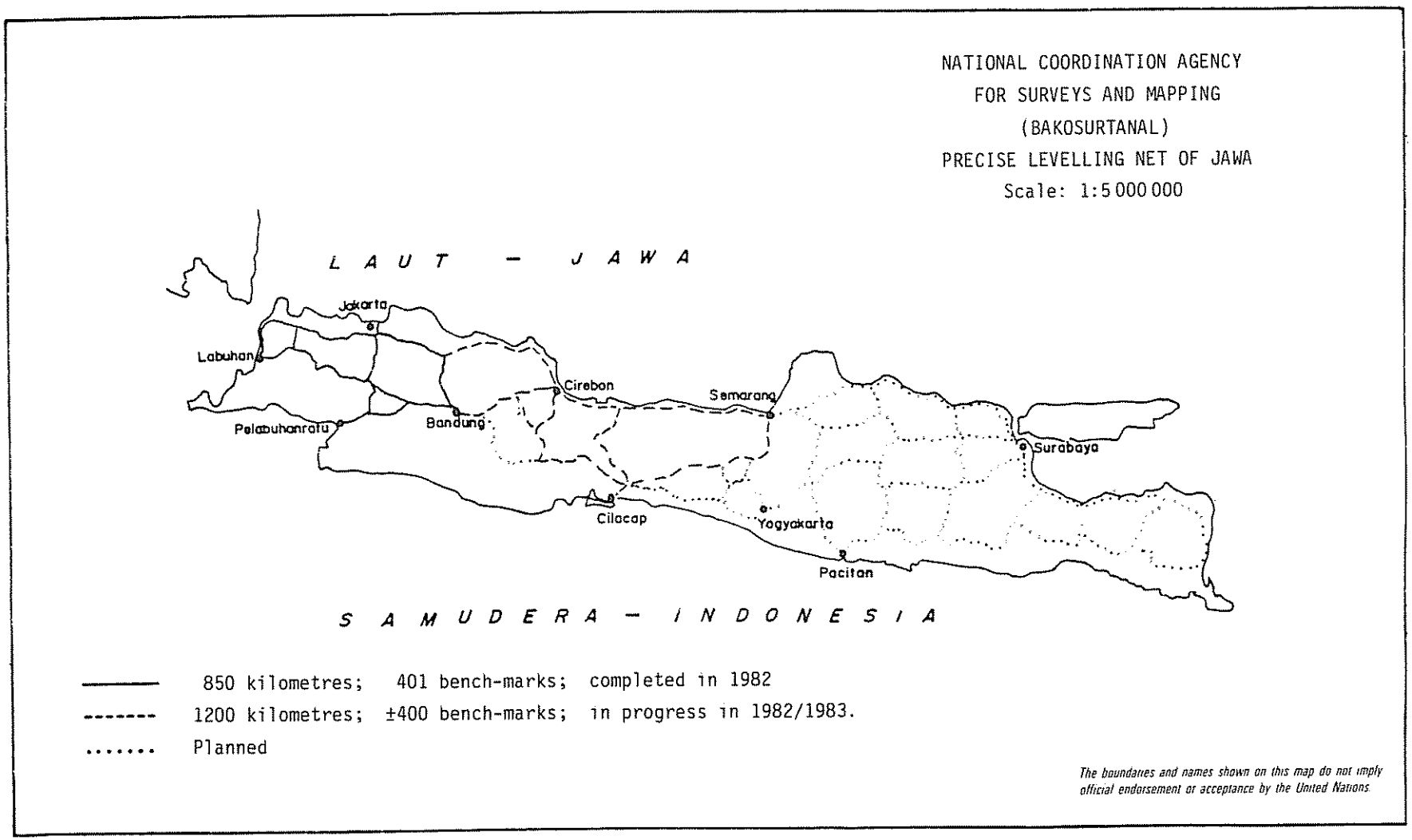

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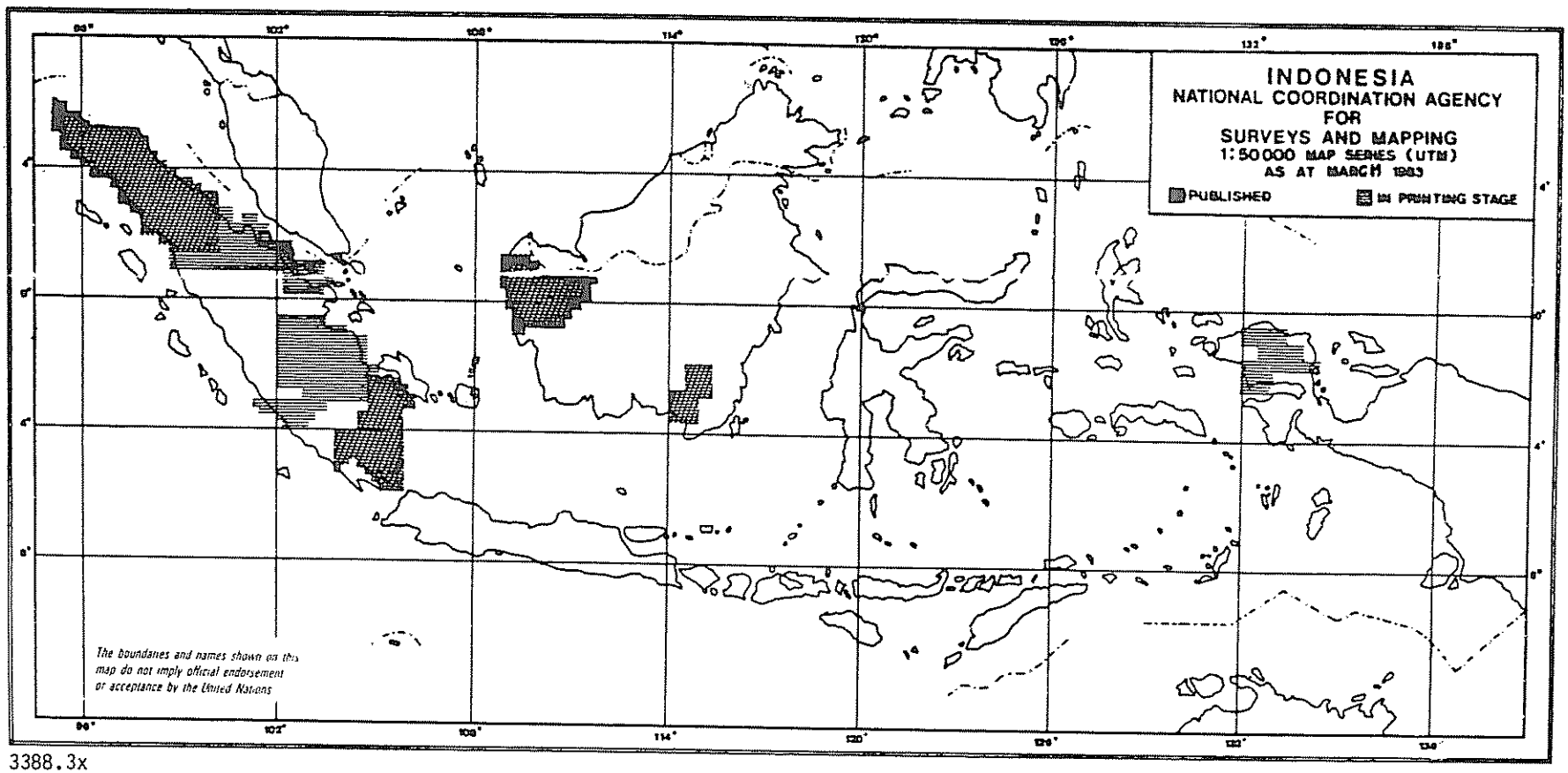
Figure 3. Indonesia: mapping at 1:50,000 scale as at March 1983



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to the new schedule, the photogrammetric compilation is expected to be completed by 1993. To meet this target, two shifts of work are suggested, with a production of 270 sheets per year commencing in 1983.

AERIAL PHOTOGRAPHY

The aerial photography coverage for the base mapping programme is shown in figure 4. The results of the dual-camera aerial photography, carried out in the REAP project under a Canadian International Development Agency (CIDA) loan agreement, are: Kalimantan, 68 per cent; Sulawesi, 84 per cent; Jawa and Madura, 98 per cent; Nusa Tenggara Islands, excluding the island of Sumbawa, 100 per cent; Sumbawa Island, 95 per cent.

The contract for this aerial photography, carried out by a Canadian contractor, was terminated at the end of November 1982; and the two Taurus King Air aircraft were handed over to BAKOSURTANAL for further utilization.

Extensive aerial photography for the transmigration programme has been carried out since 1980 by domestic aerial survey firms, covering an area of 145,340 km^2 on the scale 1:20,000.

Aerial photography for urban mapping at 1:5,000 scale also is being done by domestic private firms, and 48 cities in Jawa were covered in 1982. This undertaking is part of an urban project funded by the World Bank, of which urban mapping is one of the components.

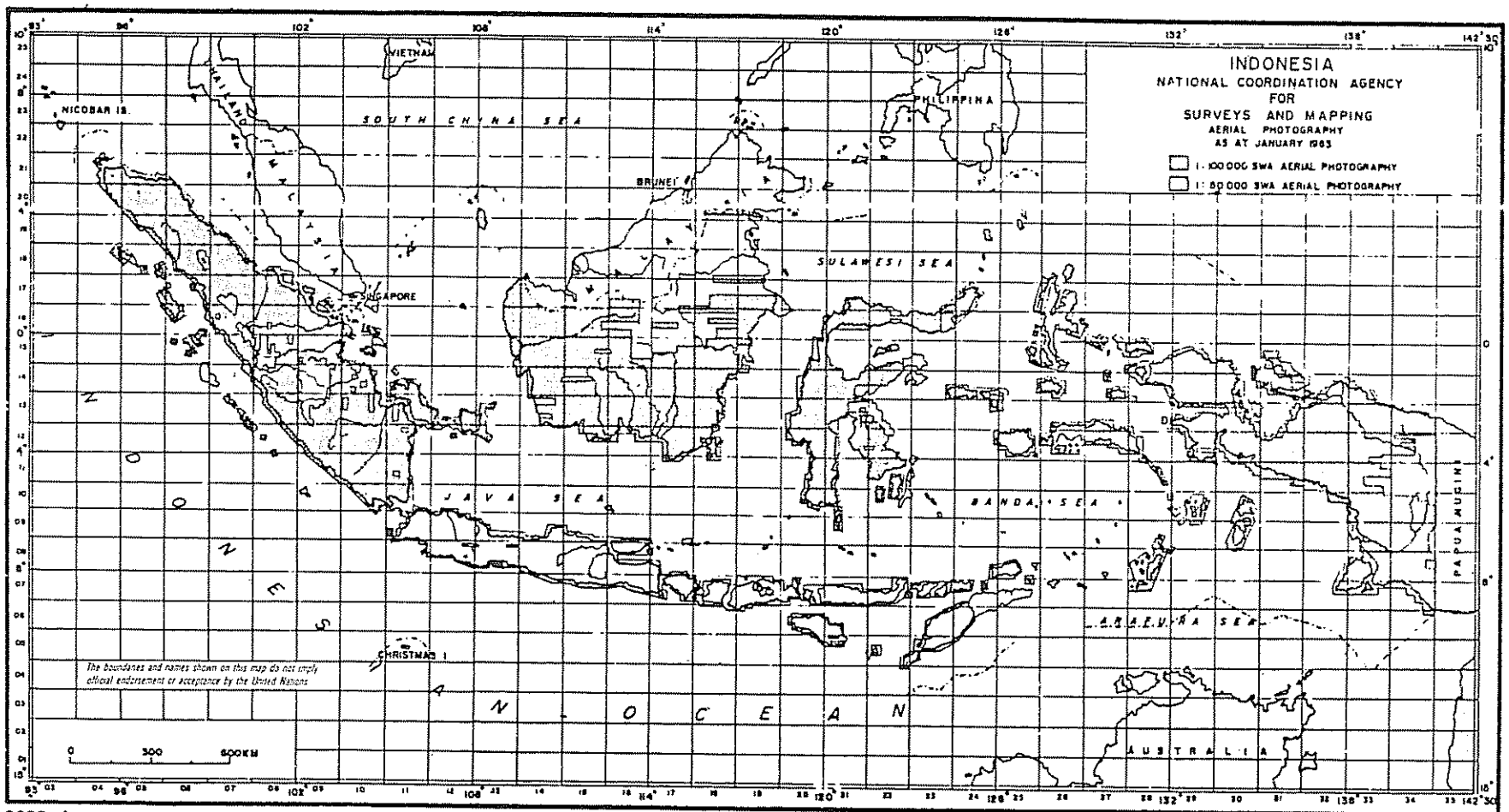
GEOGRAPHICAL NAMES

Since the Government of Indonesia has not yet established a national committee on geographical names, the chairman of BAKOSURTANAL continues to act on its behalf and takes care of matters pertinent to this subject. Efforts to inform and convince the Government of the importance of such a committee are continuing. In this relation, the National Working Group on Geographical Names was set up.

In addition to the National Gazetteer on Geographical Names published earlier in 1978, a new Gazetteer on Geographical Names was published in 1982, covering names extracted from the new 1:50,000 topographic map of Aceh Province (North Sumatera). Gazetteers of this type will progressively be issued synchronously with the completion of the 1:50,000 base mapping.

A pilot training course in toponymy was held at Cisarua, a hill town south of Bogor, from 7 to 18 June 1982, organized by BAKOSURTANAL and sponsored by the United Nations Group of Experts on Geographical Names and its Asia South-East and Pacific South-West Division. The Group of Experts recruited lecturers from Australia, the Federal Republic of Germany, Hungary, the Netherlands, the United Kingdom of Great Britain and Northern Ireland and the United States of America. Trainees were from countries in the division: Indonesia; Malaysia; Nepal; the Philippines and Thailand. There were 40 participants.

Figure 4. Indonesia: aerial photography as at January 1983



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During the course, all participants and instructors resided in bungalows in this hill town with its beautiful surroundings, so that there was a close contact between participants and lecturers, and discussions were even held at night. Field exercises took place in the vicinity of the training site.

This toponymy course was the first of this type; and it is considered successful, due to the untiring efforts of Mr. Ormeling, Chairman of the Working Group on TRaining Courses, of the Group of Experts on Geographical Names. The course was conducted pursuant to resolution 15 C of the Eighth United Nations Regional Cartographic Conference for Asia and the Far East (now Asia and the Pacific).

LARGE-SCALE AND MEDIUM-SCALE MAPPING

Large scale and medium-scale mapping are required for various development projects/programmes. These survey and mapping works were carried out by Indonesian private firms, either individually or in the form of consortia. The following programmes/projects show the scope and magnitude of the effort.

Transmigration programme

In the third national five-year development plan (PELITA) 500,000 families are being resettled from densely populated Jawa and other islands in the vicinity to sparsely inhabited Sumatera, Kalimantan, Sulawesi, Maluku Utara and Irian Jaya. To prepare sites for the resettlements, physical data are among the most needed items for planning purposes. Prospective areas should be flat, with a maximum slope of 8 per cent to prevent soil erosion and thereby make dry-land food-cropping feasible.

The topography, drainage pattern, land utilization and soil condition should be mapped. Uncontrolled mosaics at the original photo scale of 1:20,000 are used for preliminary study; they can be prepared as soon as aerial photographs are available. For actual planning for site development, topographic maps at larger scales (1:10,000 and for specific areas, 1:5,000) are prepared.

Extensive aerial photography is being carried out (see table 1) including a programme for the coming fourth national plan, which begins in 1984, with a view to overcoming bottle-necks at the planning stage. Unfavourable weather conditions, limited time and widely scattered location of the sites to be surveyed are constraints which can only be overcome by unified management of available capacities.

Table 1. Aerial photography for transmigration programme, Indonesia

Fiscal year	Number of sites	Total area (hactares)
1980/81	124	2 497 370
1981/82	69	1 870 560
1982/83	427	10 166 450
	620	14 534 380

Urban mapping project

Cities play an important role in the socio-economic and political life of a country. One out of six Indonesians is a city-dweller, and this situation is changing rapidly because of increasing urbanization.

The Government has decided to improve conditions of the cities. For the first phase, 100 cities are included in the programme. Up-to-date large-scale map coverage of the cities is indispensable. Therefore, orthophoto or line maps on the scale 1:1,000 will be prepared. The maps will be used for urban planning, which includes betterment of low-income residential areas, improvement of drainage systems, provision of clean water and general city planning. Land registration, fiscal cadastre and city inventory will benefit from the availability of the new maps.

The project is financed by the World Bank and the Government of Indonesia, and it is to be completed within three years. Foreign firms are being involved as mapping consultants to supervise the work carried out by domestic firms.

Agricultural projects

The Indonesian economy was fully agrarian in nature until national development brought about changes in its structure. Although the agricultural sector contributed only 31.7 per cent to the national gross domestic product (GDP) in 1981, the majority of the people depend upon this sector. Self-sufficiency in rice production has been the main national concern, but production of industrial crops, such as rubber, palm-oil, coffee and tea, together with establishment of agro-industries, is gaining more importance in the economy of the country.

Rehabilitation and extension of irrigation networks, as well as the construction of dams, have been considered priority projects since the beginning of PELITA. Extension of irrigated rice-fields is one important way to raise productivity.

Orthophotomaps at 1:5,000 or 1:1,000 scale with contour lines and spot heights (derived from ground survey) are widely used in planning main and secondary irrigation channels as well as dams. Terrestrial survey is applied for more detailed measurements, for example, in construction planning for tertiary irrigation ditches.

This "tertiary programme" plays a major role in increasing production, for example, by increasing the harvest from once to twice a year. In the third PELITA, the Government's goal for the tertiary programme is 800,000 ha.

Another important programme is land development to open up new rice-fields in the sparsely populated regions in conjunction with transmigration, with a target of 300,000 ha by the end of the third PELITA (1984).

As a result, rice production has been increasing and self-sufficiency was attained when the harvest reached 23 million tons in 1982. Survey and mapping have contributed to the achievement of this major goal.

Replanting and extension of industrial crops in connection with growing agro-industries significantly increase the demand for survey and mapping services, especially aerial photography and terrestrial surveying.

National systematic soil mapping has been done since the first PELITA. The actual mapping is done by the Department of Agriculture, but it is contracting out acquisition of aerial photography to domestic firms.

Geology and mining

Increasing activities in oil and mining industries give rise to an expanding need for geological surveys and topographic mapping.

A large portion of the archipelago is covered by side-looking airborne radar (SLAR) and synthetic aperture radar (SAR). SAR surveying is more widely applied. These radar images are used for preliminary exploration for oil, coal and ores. The medium-scale (1:40,000-1:50,000) conventional aerial photogrammetric method is used in preparing topographic maps, either for planning or for site development.

The large mining firms have their own capability for assessment of mining potential using aerial survey methods. Detailed terrestrial surveys provide data and terrain information to support engineering activities.

Systematic regional geological mapping has been undertaken since the beginning of PELITA. The goal of this programme is to produce geological maps for the entire country (for Jawa, at 1:100,000 scale and for the outer islands, at 1:250,000). For this purpose, the Government is using its in-house capacity, but it obtains the photographs from survey firms.

Forestry

The development of forest industries has become even more important in the economy of Indonesia since implementation of Government policy to boost wood-based industries and to restrict exportation of round logs. To supply logs for the industries, consistent forest management should be applied. To avoid depletion of forest resources, reforestation and regeneration programmes have been carried out by the Government and industries.

The industries are obliged to provide forest and topographic maps at 1:20,000 scale for their respective concessions.

Reconnaissance forest type mapping has been begun; it will provide a preliminary basis for forest evaluation and planning. Similar to the above-mentioned regional geological survey, the Government is active in conducting the inventory with the help of aerial photographs carried out in part by the private sector.

Cadastral surveys

Cadastral surveys are by law under full control of the Government. Certain

stages of the survey, however, are often contracted out to the survey firms. As mentioned previously, urban maps prepared by these firms will be utilized, e.g., to support cadastral mapping. Provision of aerial photographs of rural areas for the same purpose is tendered to the domestic firms.

Other engineering projects

The demand for large-scale engineering maps, prepared by way of aerial photogrammetry, is increasing. They are needed for planning of road construction, improvement and extension of runways at the provincial cities and towns to meet increasing demand for air transport, development of industrial sites, planning for electrical transmission lines and microwave networks, oil and water pipeline construction and other purposes.

Hydrographic and related marine surveys

Since the "oil boom" in the early 1970s, the oil and gas industry not only has made crude oil, the primary export item for Indonesia, but has introduced advanced technology for offshore exploration and exploitation. This advanced technology has in turn stipulated higher requirements and broader scope of survey activities compared with those for navigational charting, which previously was the main activity.

The oil industry projects include positioning surveys for marine seismic exploration and drilling rigs, drill-site hazards surveys, crude-oil pipeline routes, control surveys for pipe-laying operations, control surveys for offshore structure maintenance programmes; and surveys for miscellanous offshore construction, such as flow stations and gathering platforms.

Feasibility studies for establishing large new ports will be made in the fourth PELITA (1984-1989). In addition, small ports will be established by Pertamina, the State-owned oil company, for their refinery products distribution network, and by the Government to meet increasing interinsular shipping. It is expected that a significant amount of cable-laying will take place to link the smaller islands to larger centres.

COMPUTERIZED RESOURCES INFORMATION SYSTEM

Three aspects must be considered in the development of a computerized resources information system: (a) hardware and software; (b) flow of data; (c) use of the information.

In 1979, BAKOSURTANAL selected the Comarc design system for its computerized information system. The hardware configuration consists of a Data General computer system of 1,024 kilobytes, a number of digitizer subsystems, on-line graphical terminals, cathode-ray tube (CRT) display interactive terminals, a line-printer, a drum plotter and a flat-bed plotter.

The Comarc software package for resource management and planning--the Comarc Planning Information System (COMPIS)--was installed and accepted in

March 1980. A pilot project for the resources information system was created and the province of Lampung (South Sumatera) was chosen as a sample area. In this pilot project area, the following thematic information was digitized: geology; hydrology; forest cover; land cover; topography; rainfall; and commodities. This demonstration showed how various thematic data could be integrated through the use of a computer and how integrated information could be presented.

The installation of a computerized georeferenced resource information system is a vehicle for channeling sectoral resource data and information to the central authorities, thereby making them available for intersectoral use, and above all for the presentation of spatial planning alternatives. This system will be further developed for the establishment of a national network, directly linking information-producing agencies (in this case, thematic mapping agencies) and information-using agencies (planning offices at various levels).

There are, however, two main problems facing a computerized information system:

(a) There is an abundance of resources data but often they are not compatible. Incompatibilities are caused by different methodologies, different scales, different projection systems or different purpose of data acquisition;

(b) Available information cannot be released as there is still a tendency to consider the data at least restricted, if not classified.

Currently, data can flow smoothly if mutual understanding between agencies exists. Another step to be taken is the proper classification of data to facilitate availability and accessibility. Data stored in the computerized information system, as well as maps, aerial photographs and remote-sensing images, are to be used by government agencies to support decision-making and planning. An important step that still has to be done in the use of the computerized information system is to define the data requirements of various potential users.

ATLAS OF INDONESIAN RESOURCES

To give comprehensive visual information of the resources of Indonesia, BAKOSURTANAL compiled and published the Atlas of Indonesian Resources and the Atlas of Indexes of, among others, "Remote-sensing image coverage", "Topographic map coverage" and "Thematic map coverage".

The Atlas of Indonesian Resources consists of two types of atlases: (a) a comprehensive resources atlas of all of Indonesia at 1:7,500,000 scale; and (b) a more detailed resources atlas, visualized island by isalnd, for example, the Resources Atlas of Sumatera and the Resources Atlas of Sulawesi, at 1:500,000 scale.

Table 2 shows the status of production of the resources atlases, as well as the themes covered. The status of production of the Atlas of Indexes as of January 1983 is given below:

1. Index of LANDSAT coverage;
2. Index of aerial photography, 1955-1969;
3. Index of aerial photography, 1970-1974;
4. Index of aerial photography, 1975-1980;
5. Index of photo maps;
6. Index of geological maps (unpublished);
7. Index of geological maps at 1:2,000-1:100,000;
8. Index of geological maps at 1:200,000-1:600,000;
9. Index of geological maps at 1:750,000-1:3,000,000;
10. Index of forestry maps based on aerial photo-interpretation;
11. Index of hydrographic maps at 1:25,000-1:75,000;
12. Index of hydrographic maps at 1:100,000-1:200,000;
13. Index of hydrographic maps at 1:250,000-1:4,000,000;
14. Index of aerial navigation maps;
15. Index of land-use maps;
16. Index of soil maps;
17. Index of topographic maps at 1:25,000-1:63,000;
18. Index of topographic maps at 1:100,000-1:200,000;
19. Index of topographic maps at 1:250,000;
20. Index of topographic maps at 1:300,000-1:1,000,000;
21. Index of SLAR images.

MANPOWER DEVELOPMENT

In the early years of PELITA--the national five-year development plan--an imbalance between availability of and need for survey personnel caused serious problems in survey and mapping to support the development programmes. Because most survey activities had previously been carried out by the Government, most survey personnel were public servants. As a result, newly established private firms were faced with a major disadvantage in performing their activities, while existing training institutions provided survey technicians and junior technicians solely to their respective government organizations. This in-service training cannot be expected to alleviate the situation of the private firms. Professionals with university degrees in geodesy and other earth sciences, as well as applied sciences, are needed in survey and mapping, although in a limited number.

As the demand keeps growing more rapidly than the supply of various categories of surveying personnel, both the Government and the private sector have experienced many difficulties in carrying out their respective tasks. The shortage of qualified technologists, technicians and junior technicians was more serious, compared with that of professionals. To solve the problem, several survey firms organized informal training for survey technicians, draughtsmen and photogrammetric operators.

As reported at the Ninth Conference, several technical training schools that are offering formal programmes in photogrammetry, cartography, surveying and image interpretation and integrated survey, have been providing needed technicians for both the Government and private firms. Furthermore, through these technical training schools, a number of surveyors who have completed in-service training in various companies can fulfil the requirements of formal training and therefore can be qualified as survey technicians in their

Table 2. Status of production of Atlas of Indonesian Resources

Themes	Indonesia, 1:7,500,000 scale			Sulawesi, 1:1,500,000 scale		
	Data collection and completion	Manuscript	Printing	Data collection and completion	Manuscript	Printing
Administrative boundary	C	C	C	C	C	C
Geomorphology	C	C	C	C	C	C
Geology	C	C	C	C	C	C
Soil	C	C	C	C	C	C
Mineral deposits	C	C	C	C	C	C
Land cover	..	..	..	C	C	C
Forest cover	C	C	C	C	C	C
Main food crop	C	C	C	..	..	..
Population	C	C	C	C	C	C
Plantation	..	..	..	..	..	..
Industry	R	R	O	..	..	..
Road network	C	C	C	C	C	C
Fishery	..	..	..	..	..	..
Animal husbandry	..	..	..	..	..	..
Mean monthly cloudiness, rainfall and rainy days (12 months)	C	C	..	..	..	..
Topography	R	R	P	C	C	C

Table 2 (continued)

Themes	Sumatera, 1:2,500,000 scale			Kalimantan, 1:2,250,000 scale		
	Data collection and computation	Manuscript	Printing	Data collection and computation	Manuscript	Printing
Administrative boundary	C	C	C	C	C	O
Geomorphology	C	C	C	R	R	O
Geology	C	C	C	C	C	O
Soil	C	C	C	C	C	O
Mineral deposits	C	C	C	C	C	O
Land cover	C	C	C	..	..	..
Forest cover	..	..	..	..	..	..
Main food crop	C	C	C	C	C	O
Population	C	C	C	C	C	O
Plantation	..	..	..	C	C	O
Industry	R	R	..	C	C	O
Road network	C	C	C	C	C	O
Fishery	..	..	..	C	C	O
Animal husbandry	..	..	..	C	C	O
Mean monthly cloudiness, rainfall and rainy days (12 months)	..	..	..	..	..	..
Topography	C	C	P	C	C	O

Table 2 (continued)

Themes	Jawa and Madura, 1:1,500,000 scale			Bali, 1:250,000 scale		
	Data collection and computation	Manuscript	Printing	Data collection and computation	Manuscript	Printing
Administrative boundary	C	C	O	C	O	O
Geomorphology	P	P	O	..	O	O
Geology	C	P	O	C	O	O
Soil	C	P	O	C	O	O
Mineral deposits	C	C	O	C	O	O
Land cover	C	P	..	C	O	O
Forest cover	..	..	..	..	..	..
Main food crop	C	P	O	C	O	O
Population	C	P	O	C	O	O
Plantation	C	O	O	C	O	O
Industry	C	P	O	C	O	O
Road network	C	R	O	C	O	O
Fishery	P	O	O	C	O	O
Animal husbandry	P	P	O	C	O	O
Mean monthly cloudiness, rainfall and rainy days (12 months)	..	..	..	..	..	..
Topography	P	O	O	P	O	O

Note: O = not yet executed; P = in process; C = completed; R = revised.

respective specialized fields. See also "Training and education in surveying and mapping", under agenda item 8.

CARTOGRAPHIC WORK IN JAPAN, 1979-1981*

Paper submitted by Japan

RESUME

Au Japon des travaux de géodésie sont exécutés principalement par l'Institut de levés géographiques et le Département d'hydrographie qui par ailleurs produisent diverses cartes en collaboration avec l'Agence nationale du territoire, le Ministère de l'agriculture, des forêts et des pêches et l'Institut japonais de levés géologiques.

Les principaux travaux réalisés récemment portaient sur le levé géodésique précis en vue de réviser du canevas existant et de détecter les mouvements tectoniques pour la recherche sur la prévision des séismes; le nivellement géodésique des zones de subsidence; des observations géodésiques par satellite pour préparer le réseau de triangulation et déterminer la position d'îles isolées etc.; des observations astronomiques pour établir des stations de Laplace et préparer des almanacs et des éphémirides marins; des mesures gravimétriques pour établir des cartes des anomalies de la gravité pesanteur; des observations géomagnétiques pour dresser des cartes géomagnétiques.

Ces trois ou quatre dernières années ont été marquées pour l'installation du système de mesure de la gravité absolue à l'Institut de levés géographiques en 1980 et du système hautement performant de poursuite des satellites par laser au Département d'hydrographie au début de 1982. Ces systèmes devraient permettre de normaliser le réseau gravimétrique japonais et de raccorder le canevas géodésique japonais au système géodésique mondial.

En cartographie, les travaux suivants ont été entrepris récemment au Japon: des cartes topographiques de base au 1:25 000 ont été préparées sous la direction de l'Institut de levés géographiques pour la quasi-totalité du territoire à l'exception de quelques îles isolées; celui-ci a publié en outre des cartes topographiques à d'autres échelles du 1:2 500 au 1:3 000 000 et produit des cartes thématiques, par exemple sur l'occupation des sols, l'état des terrains etc.

L'Agence nationale du territoire a effectué des levés cadastraux et établi des plans cadastraux à l'échelle 1:250 et 1:5 000.

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* The original text of this paper appeared as document E/CONF.75/L.109.

Le Ministère de l'agriculture, des forêts et des pêches dirige la production des cartes pédologiques des terres cultivées et forestières et la totalité des forêts nationales a été cartographiée.

L'Institut japonais de levés géologiques a établi des cartes géologiques au 1:50 000 ainsi que des cartes géologiques et sédimentologiques du plateau continental à l'échelle 1:200 000.

Le Département d'hydrographie a publié diverses cartes marines, des cartes indiquant les courants de marée etc. et en 1981 il a publié la liste des noms géographiques figurant sur les cartes japonaises se conformant presque entièrement aux résolutions de la Conférence des Nations Unies sur la normalisation des noms géographiques.

Most of the cartographic work in Japan is carried out under the Survey Law to co-ordinate efficiently and standardize in accuracy and to avoid overlapping work.

It is classified into two categories: (a) the fundamental survey, which is nation-wide and executed by the Geographical Survey Institute (GSI); and (b) the public surveys for particular projects or local governmental projects, which are carried out by other governmental or public organizations, such as the Forestry Agency, the Geological Survey of Japan (GSI) and the National Land Agency. Various types of hydrographic charts are prepared by the Hydrographic Department, Maritime Safety Agency.

GEODETIC WORK

Geodetic work in Japan is principally executed by GSI and the Hydrographic Department. Since completion of the geodetic networks, composed of 39,000 first-, second- and third-order triangulation points with a total length of 20,000 km of precise levelling throughout the islands of Japan, revision surveys have been carried out twice on the first-order triangulation network and six times on the precise levelling routes.

Fourth-order triangulation and second-order levelling are in progress for large-scale mapping.

Those operations have been carried out by GSI.

Precise Geodetic Network Surveying Project

GSI began the Precise Geodetic Network Surveying Project in 1974, in order to switch over from its old geodetic data by conventional methods to more precise new geodetic data by trilateration using optical electronic distance measurement (EDM). The geodetic framework in the project is classified into two networks: a primary precise geodetic network composed of 6,000 first- and second-order triangulation points; and a secondary precise geodetic network composed of 32,700 third-order triangulation points. The new data can serve not only as a revised framework for mapping but as basic data for earthquake prediction and research on crustal movement of the country.

Levelling

In addition to the revision survey, GSI is undertaking 1,000 km of relevelling every year in the specified observation areas and in the intensified observation areas designated in the National Earthquake Prediction Project. Furthermore, in co-operation with local governments, GSI is doing 12,000 km of relevelling annually in and around ground-subsidence areas along the coast.

The Coastal Movement Data Centre has 105 tidal stations registered, and all the tidal data obtained at those stations are compiled and published each year.

The Hydrographic Department is carrying out sea-crossing levelling and the observation of vertical deflection every year around the Izu Syoto area, which is a tectonically active area in the seas around Japan, providing data for elucidation of crustal structure in this locality.

Satellite positioning

After a year of lead-off time, GSI received a Navy Navigation Satellite System (NNSS) Doppler observation system with JMR for practical application in 1976. The system is applied as follows: (a) to control the precise geodetic network; (b) the determine the geodetic co-ordinates of islands isolated from the mainland; (c) to study the geoidal height; and (d) to connect the geodetic network of Japan to those of other countries. The Hydrographic Department also is engaged in satellite positioning using NNSS to determine the geodetic co-ordinates of off-lying islands.

At the beginning of 1982, the Hydrographic Department installed a laser-ranging system using artificial satellites and put it into practical use for connecting the Tokyo Datum with the World Geodetic System. Since April 1982, the system has been in operation.

Astronomical observation

The Geographical Survey Institute is establishing Laplace stations in the primary precise geodetic network and observing the astronomical latitudes and longitudes of those points. The vertical deflections also are calculated. Astrolabes equipped with electronic transit detectors developed by GSI are used in these observations.

The Hydrographic Department is conducting the observation of occultations at three hydrographic observatories as well as at Tokyo headquarters. In 1980, the total solar eclipse in Kenya was observed. The results are being used for compilation of nautical almanacs and ephemerides.

Gravity survey

Gravity surveys are carried out on land by GSI and at sea by the Hydrographic Department. GSI is repeating fundamental and first-order gravity surveys at fundamental and first-order gravity stations with a La Coste and Romberg gravity meter.

Until 1979, the fundamental survey had been operated with pendulum apparatus developed by GSI. In 1980, GSI introduced an absolute gravity measuring system from France; it is still at the experimental stage.

GSI is also continuing the second-order gravity survey at levelling and triangulation points. Those data are concentrated on the preparation of Bouguer anomaly and free-air anomaly charts at 1:2,000,000 scale and are provided for study of geoidal heights and around the islands of Japan.

Gravity measurement at sea is being conducted as part of the survey for the Basic Map of the Sea on the Continental Shelf Areas. The results are published as free-air gravity anomaly charts of the Basic Map series and used for the determination of the geoid in the north-west Pacific area.

Geomagnetic survey

GSI is conducting an repetitional geomagnetic survey at 105 first-order geomagnetic stations at appropriate intervals with portable geomagnetic meters developed by the Institute. An aeromagnetic survey is being carried out on land by GSI at the adjacent seas of the islands of Japan by the Hydrographic Department. In 1979 and 1980, the Department conducted land and aerial magnetic surveys throughout Japan and its surrounding waters. the results are used to show the accurate magnetic compass on the chart and to revise magnetic charts in the adjacent seas of Japan.

The data obtained by GSI are used for the compilation of magnetic charts at 1:2,500,000 scale for the D components and at 1:4,000,000 for the H, I, Z and F components.

GSI was preparing to publish D, H, I, Z and F component charts in 1982, using the data obtained during the period from 1952 to 1980, which were reduced to the common epoch 1980.0. In addition to these charts, one sheet of a total intensity chart for 1975.0 was to be published in the same year with the results obtained by the GSI aeromagnetic survey during the period from 1967 to 1981.

Observation of absolute and variations of geomagnetism formerly was conducted at three GSI observatories and one Hydrographic Department observatory. In March 1978, however, the facilities of the Simosato Hydrographic Observatory were moved and re-established at Hatizyo Sima, because of the deterioration of the observation environment. Hence, Hatizyo Hydrographic Observatory is newly registered as part of the world magnetic observation network.

The geodetic work for the period from 1979 to 1981 is given in table 3.

TOPOGRAPHIC MAPPING

Medium-scale topographic maps

As the national base map series covering the entire country of Japan, topographic maps at 1:50,000 scale began to be prepared in 1982, and the maps covering the entire country were completed in 1925.

Table 3. Geodetic work in Japan, 1979-1981

	1979	1980	1981	Total
Primary precise geodetic network	594	875	890	2 359
Secondary precise geodetic network	156	151	153	460
Fourth-order triangulation	1 430	1 534	1 438	4 422
Satellite Doppler positioning				
Inland	GSI:4	GSI:4	GSI:6	GSI:14
Island	GSI:3 HD:10	GSI:2 HD:10	GSI:2 HD:10	GSI: 7 HD: 30
Others (Republic of Korea)	GSI:1	-	-	1
Laplace stations	2	2	2	6
Astronomical observations	8	8	8	24
Gravity survey				
Fundamental	5	3	4	12
First-order	11	10	10	31
Second-order	295	264	256	815
First-order geomagnetic survey	42	40	40	122
Aeromagnetic survey on land (square kilometres)	86 100	39 200	38 300	163 600
Precise levelling (kilometres)	3 693	3 570	3 581	10 844

Note: GSI = Geographical Survey Institute; HD = Hydrographic Department.

About 40 years later, the 1:25,000 scale topographic map was taken up as the national base map to replace that at 1:50,000, under a medium-scale topographic map development programme. It has now been completed to cover all of the country except some remote islands.

GSI is conducting the revision survey and the recompilation of those maps under the following principles:

(a) The revision of the 1:25,000 map is conducted at intervals of 3 (urban areas), 5 (intermediate) or 10 (mountainous areas) years, depending upon the extent of unit charge in the map-sheet;

(b) Simultaneously with revision of the 1:25,000 scale topographic maps, the corresponding 1:50,000 sheets are revised. Accordingly, the revision work of topographic maps at 1:25,000 scale is carried out in units cooresponding to the borders of the 1:50,000 sheet;

(c) The work to determine the changes is made by the Regional Survey Departments of GSI, which are located at 10 places throughout the country.

National large-scale topographic mapping

In 1960, GSI began national large-scale topographic mapping to cover 190,000 km^2 of flat areas. At the same time, the Forestry Agency also has promoted a project in mountainous areas for the purpose of producing a forest basic map as the core of forest surveying. The project in mountainous areas was completed in 1980.

Table 4 shows the amount of large- and medium-scale topographic mapping work undertaken in the past three years.

Table 4. Large-scale and medium-scale topographic mapping, Japan, 1979-1981 (square kilometres)

Scale and edition	1979	1980	1981
1:2,500			
New edition	659	369	311
Revision	135	61	41
1:5,000			
New edition	1 446	1 964	1 510
Revision	253	108	227
1:5,000			
Photomap	-	180	190
1:25,000			
New edition	269		2
Revision	29 779	30 653	31 422
Recompilation	12 811	10 612	7 711
1:50,000			
Revision		280 sheets	
Recompilation		90 sheets	

Table 5 shows the basic forest mapping work in the same period.

Table 5. Basic forest mapping, Japan, 1979-1981
(square kilometres)

Type and scale	1979	1980	1981
Contour map, 1:5,000	12 730	12 730	-
Photomap, 1:5,000	3 000	3 000	3 000

Small-scale maps

Small-scale maps published by GSI as of the end of 1981 are shown in table 6.

Table 6. Status of small-scale map preparation,
Japan, end of 1981

Type and scale	Number of sheets	Size	Number of colours	Remarks
Regional map, 1:200,000	129	46 x 58 cm	6	-
District map, 1:500,000	8	788 x 1 091 cm	9	Layered edition
District map, 1:500,000	8	788 x 1 091 cm	4	-
IMW, 1:1,000,000	3	788 x 1 091 cm	12	Layered edition, Hill-shading edition
NIPPON, 1:1,000,000	3	788 x 1 091 cm	4	-
Japan and surroundings, 1:3,000,000	1	788 x 1 091 cm	12	Layered edition, Hill-shading edition
Composite map, 1:100,000	2	788 x 1 091 cm	4	Tokyo and vicinity, Shikotsu, Toya and vicinity

Note: IMW = International Map of the World on the Millionth Scale.

The International Map of the World on the Millionth Scale (IMW) is compiled by using the international standard map symbols. Preparation of this map requires close co-operation with the various countries in the world so that the map symbols, method of preparation etc., are studied carefully in compliance with the request of the United Nations, to reflect the results of the study in the international map of Japan.

CADASTRAL SURVEYS

The cadastral survey in Japan is being carried out by the National Land Agency in conformity with the National Land Survey Act.

The location, boundary, owner, number and land use of each parcel are ivestigated, and the boundary and acreage of them are surveyed in the cadastral survey.

The cadastral survey in Japan was initiaded in 1951, when the National Land Survey Act was introduced. The prefectural or municipal governments have actually performed the cadastral survey under the control of the National Land Agency since then. The results accomplished so far in Japan are as follows: (a) cadastral survey, 73,621 km^2 (1951-1981); (b) control point survey, 41,606 points (1951-1981).

The system of cadastral survey is divided into the following processes: the cadastral supplementary control system; investigation of parcels; cadastral detail survey; measuring the acreage of parcels; and making cadastral maps and books. The cadastral supplementary survey is based on the control point survey, which is carried out by GSI.

The scale of cadastral maps is 1:250, 1:500, 1:1,000, 1:2,500 or 1:5,000, depending roughly upon the mean acreage of parcels. The accuracy is also divided into six classes, depending upon the land-use pattern.

Copies of cadastral maps and books are sent to registry offices after getting approval from the Minister of the National Land Agency or prefectural governors. The old registers are then amended on the basis of the new cadastral survey results.

Since 1962, the planning for cadastral surveys has been based on the legislation of the National Land Survey Promotion Act. The Third Ten-Year National Land Survey Plan (1980-1989) is currently being performed as follows: (a) cadastral survey, 60,000 km^2 (1980-1989); (b) control point survey, 25,000 points (1980-1989).

In addition to the cadastral survey itself, an edited cadastral map, in which several cadastral maps are connected on smaller scales, such as 1:1,000, 1:2,500 or 1:5,000, has been prepared since 1977.

The cadastral surveys carried out during 1979-1981 are shown in table 7.

Table 7. Cadastral surveys, Japan, 1979-1981

	1979	1980	1981
Cadastral survey (square kilometres)	3 803	3 910	3 903
Control point survey (square kilometres)	1 403	1 534	1 458
Edited cadastral map (wards)	20	20	20

THEMATIC MAPPING, 1979-1981

GSI is engaged in various types of thematic mapping in co-operation with other governmental organizations. Table 8 lists those maps prepared and published by GSI during the period 1979-1981.

Table 8. Thematic maps produced in Japan, 1979-1981

Type	Scale	Number of sheets
Land use map	1:25 000	156
Land classification map	1:50 000	120
Land condition map	1:25 000	15
Land condition map	1:10 000	1
Land condition map of coastal areas	1:25 000	11
Lake chart	1:10 000	9

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, Forestry and Fisheries.

A 1:50,000 scale series of soil types and their products has been prepared for cultivated lands by the Agricultural Administration Bureau since 1959; and the entire area of cultivated land, 6,000 km^2, is already covered by this series.

A 1:20,000 scale series of soil types for national forets has beem prepared by the Forestry Agency since 1947. The entire area of national forests, corresponding to 75,000 km^2, was covered by this series by 1978. The Agency also has prepared a 1:50,000 scale series of soil types for private forests.

GEOLOGICAL MAPS

Geological maps of Japan are mainly produced by the Geological Survey of Japan, Agency of Industrial Science and Technology.

The preparation of a series of basic geological maps at 1:50,000 scale has been carried out since 1952 by GSI, and 69 sheets with explanatory texts have been published. The coverage of 1:50,000, 1:75,000 and 1:100,000 geological maps is 719 out of the total of 1,267. Nine sheets of a 1:200,000 scale series of edited geological maps were published during the period 1979-1981. In addition to those basic maps, GSI has prepared many types of geological and geophysical maps:

(a) Three hydrogeological maps on a scale of 1:50,000;

(b) One geological map of Kagoshima, at 1:500,000;

(c) Four geological maps of Japan, at 1:1,000,000;

(d) Five marine geological and sedimentological maps, as a marine geological map series, at 1:200,000 and 1:1,000,000;

(e) Two geological maps of valcanoes at 1:25,000;

(f) Two maps of volcanoes of Japan at 1:200,000;

(g) One neo-tectonic map each at 1:200,000 and 1:500,000;

(h) One distribution map each of hydrothermal alteration haloes and hot-spring deposits, known geothermal fields and heat discharge by hot springs in Japan at 1:2,000,000;

(i) Five mineral deposits maps at 1:2,000,000 scale, classified into the following catagories: (i) lead and zinc; (ii) copper; (iii) manganese; (iv) gold, silver, antimony, mercury and arsenic; (v) sulphur, iron sulphide, gypsum and barite;

(j) Six geophysical maps, four gravity anomaly maps at 1:50,000 and two airborne magnetic maps at 1:200,000 scale;

(k) Six cruise reports around Japan and the central Pacific.

MARINE GEOLOGICAL RESEARCH ACTIVITIES

GSI is engaged in marine geological and geophysical investigations in the seas around Japan and in the central Pacific area.

The main purpose of the project is to prepare geological and sedimentological maps of the continental shelves and slopes off the Pacific coast of the Japanese islands at 1:200,000 scale. During the ongoing project, the geology of the entire continental margin around Japan has been outlined, and the results have been published as several sheets of reconnaissance geological map on a scale of 1:1,000,000. During the period from 1979 to 1981, five sheets each of 1:200,000, and 1:1,000,000 and three cruise reports were published.

HYDROGRAPHIC WORK

Hydrographic surveys and charts

Nautical charts

During the past 10 or so years, the development of commercial ports, fishing harbours and their hinterlands has been steadily progressing. Consequently, littoral topography, the shape of coastlines and the aspects of vessel traffic have been greatly changing.

For the safety of navigation, it is necessary to publish new charts and to revise existing charts as well as to issue chart corrections to incorporate the changes which have occurred so as to make updated charts available.

The quantities of various types of charts on issue as of Octobre 1982 are given below:

Nautical charts:

General chart	26
Sailing chart	124
General chart of the coast	191
Coast chart	276
Harbour plan	399
Total	1 016

Miscellaneous charts:

Current chart	11
Tidal current chart	19
Meteorological chart	8
Chart showing positions of set-net fisheries	17
Position plotting sheet	32
Pilot chart	12
Others	32
Total	131

Basic Map of the Sea:

Basic Map of the Sea in the Continental Shelf Areas	301
Basic Map of the Sea on Coastal Areas	179
Others	61
Aeronautical chart	21
Total	562
Grand total	1 709

The numbers of various types of hydrograpgic surveys conducted up to fiscal 1981 are given in table 9.

The amount of nautical charting work up to fiscal 1981 is shown in table 10.

Table 9. Hydrographic surveys, Japan, 1979-1981

Type of survey	1979	1980	1981
Harbour survey	4	5	10
Updating survey	180	195	235
Passage survey	-	-	-
Coastal survey	-	-	1
Oceanic survey	-	-	1
Survey for the Basic Map of the Sea at 1:50,000 scale	8	8	8
Survey for the Earthquake Prediction Programme	1	2	2

Table 10. Charting activities, Japan, 1979-1981

Type of chart	1979	1980	1981
New charts:			
Nautical chart	26	16	13
Miscellaneous chart	1	1	1
Basic Map of the Sea	43	50	40
Aeronautical chart	1	-	-
New editions:			
Nautical chart	35	42	59
Miscellaneous chart	14	2	-
Basic Map of the Sea	-	-	-
Aeronautical chart	2	4	5
Reprint	3	13	7
Total	125	128	125

Tidal current charts

In Japan, there are a number of narrow straits, archipelagos and bays of intricate shapes where tidal streams are strong and complicated. Information on tidal currents is indispensable for coastal navigation.

For those areas where tidal current information is important for safe navigation, the Hydrographic Department publishes tidal-current charts which contain diagrams of directions and velocities of tidal currents for every hour before and after slack water in the locality. Altogether, 19 charts have been published since 1964. Two of them were published in 1980 and one in 1981. Another is scheduled to be published in 1982.

Gazetteer of Japanese coast

In 1981, the Hydrographic Department published a gazetteer listing those existing geographical names appearing on the Japanese charts, almost in line with the resolutions made by the United Nations Conferences on the standardization of geographical names. The publication will facilitate the standardization of place names as well as the location of such names by the user.

Publications of Japan Hydrographic Association

The Japan Hydrographic Association has also been publishing charts and books for referential use by mariners, as shown in table 11.

Table 11. Miscellaneous charts and books published by the Japan Hydrographic Association, 1971-1981

Type of chart or book	1971-1978	1979	1980	1981
Maritime traffic information chart	4	5	4	4
Fishery chart	5	-	9	3
Small-craft chart	5	-	-	-
Yachting chart	2	2	-	1
Reference chart showing qualities of the sea-bed at shelters	-	1	-	-
Reference chart showing qualities of the sea-bed at anchorages	-	-	1	-
Guidebook for small craft	8	2	2	2
Marine environmental atlas	3			
Total	27	10	16	10

Application of hydrographic techniques

Bathymetric charts

The Hydrographic Department has published bathymetric charts of the adjacent seas of Japan on the scale 1:1,000,000.

The sea-bottom topography is represented by principal isobaths at 100-m depth intervals. Printed in nine colours, the chart is constructed on a Lambert conformal conical projection. One sheet each was published in 1980 and 1981. Two sheets are to be issued in 1982. Eventually, the five sheets of the chart will cover all of the waters around Japan. These charts are compiled by using all the results of the surveys for the Basic Map of the Sea in the Continental Shelf Areas at 1:200,000 scale which have already been completed, and the General Bathymetric Chart of the Oceans (GEBCO) plotting-sheets on the scale 1:1,000,000 in ocean areas.

To cope with the new maritime régime and to provide basic data for ocean development, the Basic Map of the Sea in Coastal Waters series has been published since 1974. A set consists of a bathymetric chart and a submarine structural chart, each at 1:50,000 scale, compiled from entirely new survey results.

About eight sets have been published every year. This 1:50,000 scale map series will cover all the coasts of Japan; and up to 1982, 16 per cent had been covered.

As an experiment accompanying this map series, sonographs compiled from side-scan sonar records have been prepared for small areas on a map for use by the coastal fishing industry. This has attracted attention by fisheries.

Hydrographic surveys, including precise bathymetric surveys, have also been conducted to provide basic data for earthquake prediction and estimation of submarine volcanic activities. The survey results have been compiled into detailed bathymetric charts issued since 1978. The outline of the Basic Map of the Sea series is shown in table 12.

REPORT ON CARTOGRAPHIC ACTIVITIES IN NEW ZEALAND, 1980-1982*

Paper presented by New Zealand

RESUME

On trouvera dans le présent rapport un résumé des activités de cartographie entreprises en Nouvelle-Zélande au cours des trois dernières années par le Département de cartographie, le Bureau hydrographique de la Marine, le Service des forêts et le Département de la recherche scientifique et industrielle.

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* The original text of this paper, prepared by the Department of Lands and Survey, appeared as document E/CONF.75/L.39.

Table 12. Basic Map of the Sea series, Japan

Series	Scale	Coverage	Size	Type
Basic Map of the Sea in Coastal Areas	1:10 000 and 1:50 000	Coastal areas within 12 nautical miles of the coast	Full	Bathymetric chart; submarine structural chart
Basic Map of the Sea in the Continental Shelf Areas	1:200 000	Continental margin	Half	Bathymetric chart; subamrine structural chart; total magnetic intensity chart; gravity anomaly chart
Basic Map of the Sea in Ocean Area[a/]	1:500 000	Ocean	Full	Bathymetric chart; submarine structural chart; total magnetic intensity chart; gravity anomaly chart

a/ Commencing in 1983.

Le rapport contient des informations sur les opérations dans les domaines ci-après: canevas des points géodésiques, cartographie topographique et cadastrale, plans topométriques, photographie aérienne, orthophotocartes, télédétection, établissement de cartes aéronautiques, cartes générales et cartes répondant à des fins déterminées, cartographie assistée par ordinateur, établissement de cartes hydrographiques, cartes scientifiques et assistance technique.

CARTOGRAPHIC ACTIVITIES OF DEAPRTMENT OF LANDS AND SURVEY

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

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

(b) Triangulation and urban and rural control surveys, including precise levelling and selected earth deformation surveys;

(c) Topographic mapping for engineering purposes as well as for basic mapping;

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

(e) Aeronautical charting;

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

The Department of Lands and Survey is strongly decentralized, with 12 district offices and four suboffices spread throughout New Zealand. Attached to the Head Office are three branches providing specialized services in photogrammetry, cartography and computing, as well as a 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 (DSIR) the organization responsible for the preparation and publication of geological, geophysical, oceanographic and soil survey maps, as detailed in a subsequent section.

Mapping work related to forestry and forest management in New Zealand is undertaken by the New Zealand Forest Service, while hydrographic surveys and hydrographic charting are carried out by the Hydrographic Branch of the Royal New Zealand Navy, as detailed below.

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 landholders.

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 copy-cards. To meet the increasing use of computers and electronic distance measurement (EDM) equipment, regulatory standards are continuously under investigation. All new survey data approved are 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 geodetic control in areas lacking reliable modern control and the revision of older triangulation are continuing activities. Considerable use is made of modern EDM equipment in this control and in the extensive urban and rural control traverses carried out for cadastral surveys and large-scale mapping.

Several major control extensions, as well as numerous small extensions, have been completed. A major survey completed in 1982, with a transalpine triangulation connection, was the second-order triangulation of the Westland region of the South Island.

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.

Precise levelling is also being extended along the west coast of the South Island and around the east coast region of the North Island.

Under the earth deformation study programme of the Royal Society of New Zealand, which co-ordinates geodetic, geological and geophysical research into crustal deformation, the Department has been responsible for establishing and surveying a series of first-order triangulation and trilateration networks and of first-order precise-level circuits and routes across the main tectonic structures of the country. These projects included resurvey and relevelling of major portions of the original first-order triangulation network and existing precise levelling. All seven long networks and four regional networks of triangulation and all four major precise-level projects proposed by the Royal Society in 1973 have now been completed. Resurvey and monitoring of these networks and circuits on a 10-year cycle will commence in late 1985-1986.

The availability of satellite position-fixing equipment on a loan basis in New Zealand has resulted in 15 stations being occupied, as well as a further

four in the Chatham Islands. In general, the pattern complies with the International Union of Geodesy and Geophysics (IUGG) Commission 10 requirements of stations 200 km apart. The work was done in conjunction with a GEOS team from the United States of America, who are stationed in New Zealand, and by courtesy of the agents for Magnavox Limited, who made their MX 1502 equipment available.

Following the purchase of astronomical theodolite and timing equipment and initial trials, procedures and equipping for first- and second-order astrogeodetic control have been developed. So far, 11 first-order reciprocal Laplace azimuths for the orientation control of some of the earth deformation networks, and four second-order Laplace azimuths to control the Westland second-order triangulation have been observed (see table 13).

Table 13. Triangulation and control surveys, New Zealand, 1980-1982

	1980	1981	1982
Triangulation (square kilometres)	17 169	24 366	19 039
Rural control traverse (kilometres)	1 039	1 254	972
Urban control traverse (kilometres)	520	609	420
Precise levelling (kilometres)	466	361	1 082

Basic topographic mapping

Metric mapping specifications for an integrated series of topographic maps and cadastral records designed 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 20-m contour intervals for the 1:50,000 series and 5-m intervals for the 1:10,000 series. The 1:50,000 scale map-sheets cover an area 30 x 40 km and are bled to the edge north and east.

The new maps are patterned on the New Zealand map grid, which permits both the North Island and South Island maps to be compiled on a single projection and co-ordinate system. Some 122,000 km^2 of new photogrammetric mapping has been completed at 1:125,000 scale, and fair-drawings have been completed for maps at both 1:50,000 and 1:250,000 scales. Sixty-eight sheets have been printed and published.

Engineering mapping

Most engineering project mapping requirements for all government agencies are now produced by photogrammetric methods. Scales range from 1:500 to 1:10,000; and the form of presentation may be contoured orthophotographs, line maps or digital terrain data. Since the most recent report in 1980, the special emphasis on power investigation and irrigation schemes has continued. A microprocessor-

assisted stereoplotter was installed in May 1982 and three existing analogue plotters have been fitted with semi-automatic co-ordinatograph tables.

Cadastral maps

New Zealand has full cadastral map coverage and has found value in having a counterpart cadastral map to match the metric 1:50,000 scale topographic series. The cadastral record map at 1:10,000 scale and its breakdown in urban areas to 1:2,000 and 1:1,000 scales are available as up-to-date plan prints. Successful trials have been completed for the production of these record maps by computer-aided methods.

Orthophotomaps

There has been a positive response to a survey of potential users of a 1:10,000 scale orthophoto series. A number of trial maps have been produced to determine the best production methods and the visual effects of additional data on the photo-image. Production is likely to be in priority development areas.

Aerial photography

The Department of Lands and Survey co-ordinates aerial photography for all government needs and with full coverage achieved; the objective in recent years has been to recover 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 and public agencies. The Department holds copies of all Crown and private copyright photography. The photography scale for basic mapping is 1:50,000; those for resource and interpretation photography; 1:50,000 and 1:25,000; and for urban areas, 1:10,000. Special surveys at various scales are flown for miscellaneous purposes.

Remote sensing

Investigations are continuing on the application of remote-sensing techniques, utilizing both satellite and aircraft-borne sensing systems.

LANDSAT imagery is being used in the mapping organization as an aid to relief shading; to assist definition of vegetation boundaries, shapes of hydro-electric 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 continuing on land-use mapping, within New Zealand, from satellite imagery. The Department of Lands and Survey is the distribution agency in New Zealand for all LANDSAT products and there is a steady demand for 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 the Royal New Zealand Air Force. The large volume of joint civil and 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 on the scales 1:1,000,000 and 1:2,000,000 (New Zealand) and 1:3,000,000 and 1:6,000,000 (Pacific) are revised when required.

Six specially designed charts at 1:250,000 scale have been published, derived from the topographic map series at the same scale. Two more are in preparation.

A digital data bank of aeronautical information is being compiled and maintained in order to assist production in this essential cartographic service.

A topographic aeronautical chart of the Fiji Islands group, on the scale 1:500,000, has been published.

Administrative series

The pilot sheet for a new administrative series is under preparation. This series will be based on the 1:250,000 scale topographic map detail and sheetlines, and will show regional, local authority and administrative boundaries as well as various categories of parks, reserves and lands administered by the Crown.

Tourist and recreation maps

Twenty-four tourist and recreation maps were produced showing national parks, state forest parks and tourist areas on scales between 1:10,000 and 1:25,000. The maps vary in scale and size to suit the area of interest and emphasize tourist and recreational information on specially drawn topographic bases.

Resource mapping

For the New Zealand land inventory at 1:100,000 scale (NZMS 290), the areas being mapped are generally major study areas and show a variety of themes for each area, according to planning needs, incorporated in the following topic maps: (a) land tenure and holding; (b) existing land use; (c) wildlife; (d) soils; (e) rock types; (f) indigenous forest.

The main effort, 11 sheets, has been in the Northland region of the North Island. To date, all topics have been published except indigenous forest, and it is well advanced. Transparent overlays displaying land slope have been printed and work has commenced on suitability overlay mapping of a further four themes.

Work is also progressing on a study of the Waitaki Basin area of the central South Island. This study basically comprises five sheets of three themes plus suitability overlays. As a base for the wildlife map of the Waitaki study and to provide a geomorphology representation, specially processed LANDSAT imagery will be used.

General and special-purpose maps

The programme of large-scale mapping in the south-western Pacific has progressed; final drawings of a number of islands are in preparation and some have already been printed. The Atlas of the South Pacific was published in 1979.

A map defining the exclusive economic zone of New Zealand has been published.

A new 1:1,000,000 scale metric topographic map has been drawn to specifications of the International Map of the World on the Millionth Scale (IMW), and a 1:2,000,000 scale map is in preparation. The map at 1:4,000,000 scale has already been published.

A major change has been made to the street map specifications and production methods have been simplified. There is a continuing programme of redrawing, based on the New Zealand map grid.

Coastal Resources Atlas

A survey of coastal resources at 1:500,000 scale has been published. It comprises 15 sheets to cover the country, and it was compiled to assist in the identification and location of areas of potential damage from oil spillages at sea.

Computer Mapping Unit

The Department's Computer Mapping Unit, established in 1978, has now developed programs for the production of digital metric cadastral record maps from data derived from manually drawn imperial-scaled sheets. A pilot study area of some 30,000 land parcels has been collected on scales of 1:1,000 for urban areas and 1:10,000 for rural areas, and full production is expected to commence by 1985.

Development work is also being undertaken in the production of scribed data for aeronautical charting. This work includes the development of a data base of navigational aids and air space linked to a graticule plotting routine and a digital coastline of New Zealand at 1:500,000 scale.

Under research and development, a suite of programs is being developed for the drawing of survey plans from new field data. The results of this work will be tested in early 1983.

Oversea aid

New Zealand continues to provide aid in surveying and mapping to South Pacific and South-East Asian neighbours, by the short- and long-term secondment

of New Zealand personnel and by providing training within New Zealand and expertise for aid investigations. Specific activities have been the long-term secondment of surveyors to Papua New Guinea, a surveyor to the Joint Sarawak/Sabah Survey Training School, a surveyor and draughting Officer to the Regional Survey School at Honiara, Solomon Islands, survey staff to Samoa, and an investigation and report on the survey and mapping requirements of Fiji. Survey and draughting staff from Brunei Darussalam, Fiji, Hong Kong, Papua New Guinea and Sarawak have spent varying periods in New Zealand receiving additional experience in their particular fields.

CARTOGRAPHIC ACTIVITIES OF THE NEW ZEALAND FOREST SERVICE

The New Zealand Forest Service produces maps to service the Department's administrative, planning, scientific and publicity requirements in seven Conservancy Offices, the Forest Research Institute and the Head Office. To maintain national cartographic standards and to avoid duplication, the New Zealand Forest Service works in close co-operation with the Department of Lands and Survey.

Basic mapping at 1:10,000 scale

Maps produced in terms of the New Zealand map grid and prepared for dye-line reproduction are the base topographic mapping for most forestry requirements. Prepared from topographic photoplots produced by the Department of Lands and Survey, they show contours, streams, roads, vegetation, forest compartments and forest boundaries. Final compilation is undertaken in the local Conservancy Office, which also updates the information using photogrammetric plotters.

Slope maps at 1:10,000 scale are produced to satisfy local requirements and to show slope areas in categories of 0°-15°, 15°-20°, 20°-30°, 30°-40° and over 40°. Slope information is produced from contours using a line-enhancement system and then overprinted on a topographic base.

Orthophotomaps at 1:10,000 scale are produced by the Department of Lands and Survey; and specific overlay requirements, such as compartment boundaries, are added in Conservancy Offices.

Administrative mapping

Administrative mapping at medium and large scales includes maps for species distribution, fire control, communications and roading. The scale varies from 1:10,000 to 1:1,500,000. Small-scale administrative maps include forests of New Zealand at 1:1,000,000 and 2,000,000 scales and regional conservancy maps at 1:250,000 scale, produced for general use by the Forest Service, local councils and ad hoc authorities.

Scientific mapping

Seventeen of a 27-sheet forest class map series at 1:250,000 scale have been published, nine with accompanying texts. A variety of forest-type maps

are also produced in response to specific scientific issues. A large selection of graphs, maps and diagrams are produced to accompany scientific bulletins, displays and reports published by the Forest Research Institute.

Public information maps

Forest brochures are prepared in conjunction with the Department of Lands and Survey, and small maps are regularly produced to accompany public information pamphlets and for inclusion in magazines and reports. Of the 18 Forest Park maps, five have been published, four are nearing completion and drawing has commenced on a further five.

Aerial photography

Vertical aerial photography is utilized in most aspects of forest planning, inventory and management. For many purposes, the small format (70 mm) is more suitable and economic than the larger format normally associated with photogrammetric mapping. This 70-mm photography is acquired and processed on a regional basis using hired aircraft with departmental camera operators and navigators. Local processing ensures the quick service essential to forest managers. Most photography is on black-and-white panchromatic film, with colour becoming of value for indigenous forest interpretation. Experimental work, with colour infra-red film, has achieved acceptable results and this film is gaining importance for special-purpose work.

Remote sensing

LANDSAT imagery has been evaluated for mapping the indigenous forest areas in the central North Island of New Zealand. This evaluation has shown that imagery could be used to map indigenous areas nationally, with 80-90 per cent savings over conventional methods. 1/

Aircraft scanner multispectral data have also been evaluated for plantation forest management and although the higher resolution (10-15 m), compared with LANDSAT (80 m), indicated values in areas of intensive forest management, the high acquisition costs and terrain relief and scanner distortions of data made it less attractive. With future satellites planned to give greater resolution, data from this source should be of more value to forestry.

HYDROGRAPHIC ACTIVITIES

The Hydrographic Office of the Royal New Zealand Navy is responsible for:

(a) Hydrographic surveys of New Zealand coastal waters and adjacent ocean areas;

(b) Preparation and publication of navigational charts;

(c) 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 (IHO) General Bathymetric Chart of the Oceans;

(d) Production of international charts for areas of the South Pacific Ocean;

(e) Issue of weekly Notices to Mariners and promulgation of long-range navigational warnings (NAVAREA 14);

(f) Distribution of New Zealand charts throughout the world and British Admiralty and Australian charts on an agency basis;

(g) Maintenance of national hydrographic and tidal archives;

(h) Records and preparation of definitive charts showing baselines, territorial waters, fishing zones and exclusive economic zones, and publication of charts illustrating territorial sea and fishing zones, and 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, capacity for collection of selected geophysical data and additional capacity for oceanographic work. (Coring, sampling, current, temperature etc. measurement and underwater photography were added in the latter half of 1980.)

The major and ongoing hydrographic survey task of HMNZS Monowai is the re-surveying, for new chart purposes, of the area and approaches to Foveaux Strait and Stewart Island. This survey, which was commenced in 1980, was placed in abeyance for the duration of the Auckland-Nordfolk Island-Sydney-Suva-Hawaii-Vancouver (ANZCAN) cable route survey, carried out in late 1980 and early 1981, and was recommenced in 1982. Other surveys undertaken in the period were:

(a) 1980: West Coast, South Island (small-scale offshore);

(b) 1981: reef entrance survey, Funafuti; Jackson Bay sketch survey; and Milford Sound approaches and deep water basin;

(c) 1982: Apia Harbour survey, Samoa; Fiji, Vanua Levu inner-reef survey (Yangganga Island to Ravi Ravi); and Tonga Ridge seamount survey (under way).

Inshore survey craft

Since becoming operational in early 1980, the two new inshore survey craft, HMNZ Tarapunga and HMNX Takapu, have completed the following coastal surveys in New Zealand waters:

(a) 1980: approaches to Napier and Napier roads survey;

(b) 1982: Manukan Harbour bar and channel survey and Nelson Harbour check survey.

Both ships are now currently part way through a larger scale resurvey of Foveaux Strait for new chart purposes.

During the three-year period, the Hydrographic Office published 24 new charts and new editions and revised and reprinted 158 charts. Metrication of fathoms charts continued to progress; 12 charts were converted. A new series of 10 charts at 1:1,250,000 scale covering the New Zealand exclusive economic zone was completed and published. Two British Admiralty charts were withdrawn in favour of New Zealand charts.

As a consequence of the extension of the area of New Zealand charting responsibility, preliminary work has been done for a scheme of small-scale charts covering the souht-west Pacific Ocean, in conjunction with the British and Australian hydrographic authorities.

International chart specifications, formally adopted by the Twelfth International Hydrographic Conference, are now being progressively introduced into New Zealand charts.

Exclusive economic zone maritime boundaries between the Cook Islands and Samoa and Tokelau and American Samoa were calculated and illustrated for the Governments of Cook Islands and Tokelau.

The introduction and implementation of the International Association of Lighthouse Authorities (IALA) maritime buoyage system in New Zealand waters during 1982 has required numerous amendments to navigational charts and associated publications.

A correction service is maintained to ensure that all charts are corrected from Notices to Mariners up to the date of issue. Charting and notices to mariners are co-ordinated with Australia and the United Kingdom in order to maintain integrated world cover. Cartography is in accordance with the requirements of this arrangement and generally in agreement with International Hydrographic Organization resolutions.

Reproduction material for selected charts is supplied to the United Kingdom Hydrographic Department under the terms of the Charting Arrangement, and internationally for those charts produced under the small-scale international chart scheme.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

The Cartographic unit in the Science Information Division of the Department of Scientific and Industrial Research has significantly altered in character and approach over the past three years. The staffing level has remained fairly constant at about 22, as has the approach to traditional scientific multicoloured mapping and illustrative cartography. However, computer technology is permitting a thrust forward into a more rapid-response mode which essentially views cartographic information as timely for developmental use. This trend is becoming particularly evident in, for example, soil mapping. A future is seen in which ongoing information based on earth science investigations will be rapidly put into accurate graphical form through computer technology, as part of the information transfer chain, rather than solely a long-term "end-product" map.

Traditional multicoloured lithographed mapping and charting is produced for the following DSIR agencies: Geological Survey; Soil Bureau; Oceanographic Institute; Geophysics Division; and Botany Division. Nearly all of the maps produced are at metric scales and are based on the New Zealand grid projection; and, where possible, they comply with the standard sheetlines.

Approximately 150 multicoloured maps have been produced and published over the past three years, ranging in complexity from A1-size, three-colour lake bathymetry charts to 850 x 1,250 mm geological maps with up to 10 colour plates.

Approximately 3,000 small monochrome maps and figures illustrating scientific texts are produced annually for science editors in the Science Information Division and DSIR.

The Cartographic Unit has recently acquired a small-dimension computer-graphics array to assist in the production of these small monochrome figures and it is already producing work of publication standard. Software development is proceeding, which will later be applicable to the larger dimension multicoloured mapping when larger high-quality plotting facilities are available. A major secondary use of the computer-graphics array is as a training tool and all cartographic staff have taken a one-to-one introductory course on the equipment, followed by specified project work.

Concurrently, there has been a greater involvement of cartographic staff in field familiarization and planning work of earth scientists, leading to a much enhanced understanding of the graphical portrayals required.

The Cartographic Unit has full darkroom facilities for producing a large volume of transparency and paper prints for field use and for processing (including combining and screening) map fair-copy up to the plate-making stage. The photo-typesetting facility is diminishing in use as more names and map texts are processed on floppy discs and then sent to the Government Printer's high-speed typesetting facility.

The activities of the Cartographic Unit are increasingly integrated with DSIR divisions, particularly as concerns computer graphics. A number of other divisions also have this capability; and in future there will be an increase of joint projects as all units have direct access to the DSIR VAX computer facility. The Cartographic Unit is also represented on a DSIR body set up to examine future options for scientific data bases.

Note

1/ Details of the results are contained in N. P. Ching, "Forest inventory from satellite imagery", Wellington, New Zealand Forest Service.

COUNTRY REPORT ON THE PHILIPPINES*

Paper submitted by the Philippines

RESUME

Après la dernière conférence, les Philippines ont déployé beaucoup d'efforts et accompli des progrès considérables dans divers secteurs de la cartographie:

a) Géodésie. Le canevas géodésique établi au début du siècle a été mis à jour et densifié dans les années 50 et 60. Il a ensuite été complété dans les années 70 à l'aide d'équipements électroniques tels que les systèmes spatiaux EDM et JMR. Tous les points de contrôle ont été ajustés pour former un niveau de référence philippin unique, basé sur le sphéroide de Clarke de 1866. Toutefois, il est prévu de continuer à mettre à jour, renforcer, resserrer, densifier et ajuster le canevas pour l'accorder avec le système géodésique mondial;

b) Cartographie topographique. Les Philippines possèdent des cartes topographiques représentant au total 1 051 feuilles au 1:50 000, 1:250 000 et à d'autres échelles. Ces cartes sont constamment révisées. A la fin des années 70 le Gouvernement philippin avec l'aide du Japon et du Programme des Nations Unies pour le développement (PNUD) a établi des cartes topographiques au 1:25 000. Le Japon a collaboré à l'établissement de la carte topographique de la vallée de Cagayan et le PNUD a fourni des experts, des bourses et du matériel et a assuré la formation de personnel;

c) Cartographie cadastrale. On procède actuellement dans l'ensemble du pays à des travaux accélérés de cartographie cadastrale à l'aide de matériel et de méthodes très modernes;

d) Géomagnétisme. Les Philippines possèdent plusieurs observatoires de géophysique. Le principal est l'observatoire magnétique national de Muntinlupa (Rizal) et les autres sont des observatoires privés installés à Manille, Baguilo et Davao. Situées en des points stratégiques répartis dans toutes les îles, des centaines de stations magnétiques sont observées tous les cinq ans;

e) Cartographie générale. A l'instar d'autres pays en développement les Philippines ont amélioré leurs capacités en matière de cartographie du point de vue des méthodes et des instruments utilisés. On utilise l'IHSS en hydrographie, la photogrammétrie pour l'établissement des cartes topographiques et cadastrales, l'informatique, les systèmes EDM et les systèmes spatiaux Doppler pour les levés de contrôle. Toutefois, les progrès restent lents en raison de l'exode des cadres et de l'insuffisance des ressources.

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* The original text of this paper appeared as document E/CONF.75/L.81.

During the period following the Ninth Conference, the Philippines exerted efforts and made substantial gains in various aspects of cartography and the progressive development of surveying and mapping. Instrumental in this endeavour are various agencies of the Government, such as the Bureau of Coast and Geodetic Survey (BCGS), AFP Mapping Centre, National Cartographic Authority, Bureau of Lands and the National Resources Management Centre. Mention should also be made of the active participation of the private sector in aerial photography, cadastral surveying, exploration and geophysical surveys.

GEODESY

On of the imperative input items in mapping, surveying, exploration and engineering research projects is geodetic controls. These controls are the basis for production and evaluation of engineering and infrastructure plans, cadastral and topographic maps, nautical charts and exploration plans.

The existing geodetic control network was mainly established in the first quarter of the twentieth century, when it consisted of a triangulation network of the second and third orders. Subsequently, during the 1950s and 1960s, the network was expanded, controls were established using electronic distance measurement (EDM) and the JMR satellite Doppler method.

All these networks were adjusted to conform to one Philippine datum (Luzon datum) based on Clarke Speroid 1866. The controls established to date by government agencies, according to BCGS records, are listed below:

(a) Horizontal: JMR satellite stations, 47; second-order stations, 1,518; third-order stations, 2,792; astronomical stations, 101;

(b) Vertical: first-order bench-marks, 5,295; second-order bench-marks, 1,082; other (tides), 158; gravity stations, 426.

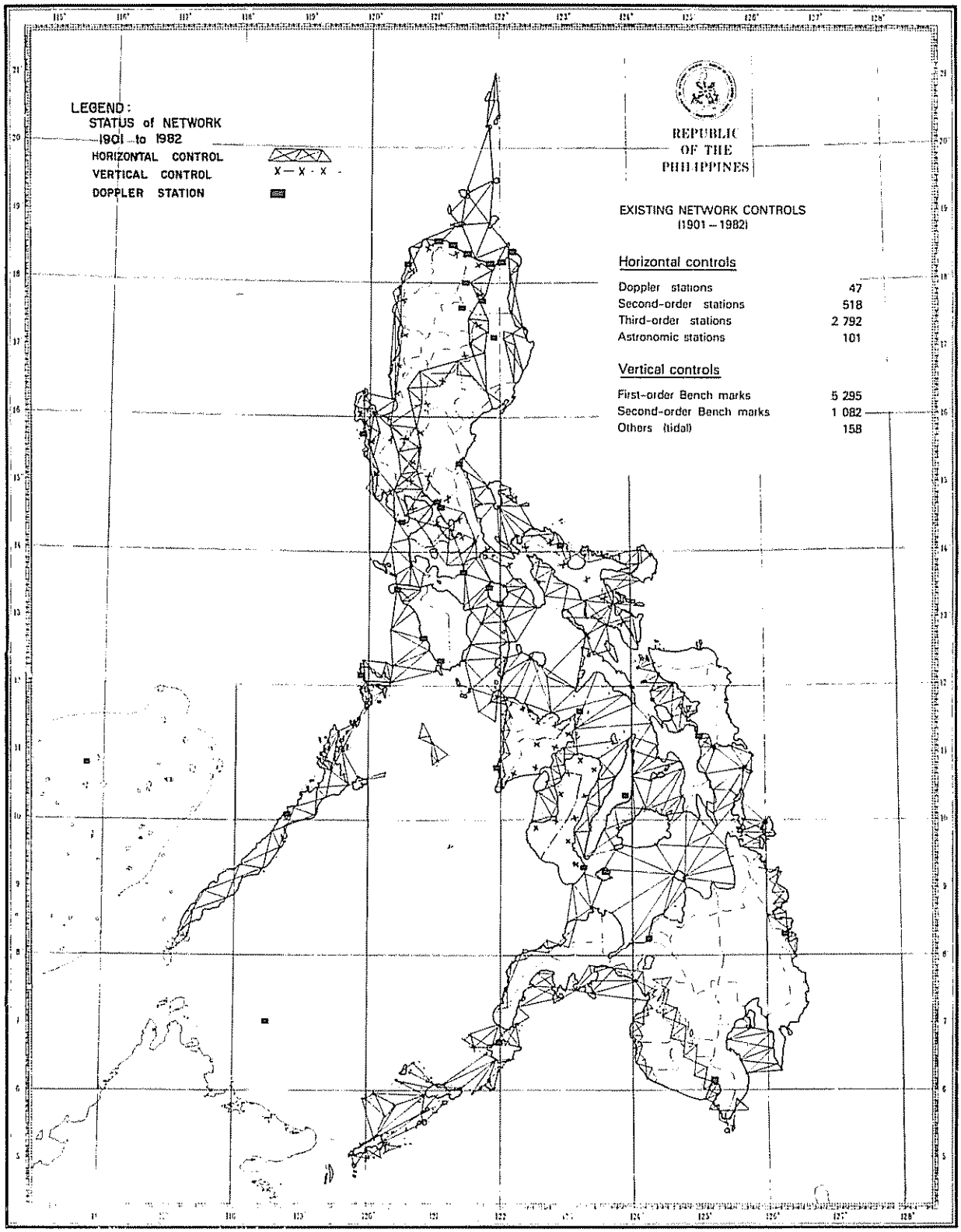
The private sector has accounted for the following controls: JMR stations, 25; second-order stations, 127; third-order stations, 126; astronomical stations, 4; second-order bench-marks, 628; third-order bench-marks, 361.

It is planned to further strenghten and densify the existing network: 200 JMR Doppler stations, located about 50 km apart, will be established throughout the country; Laplace azimuth will be observed on these JMR stations in addition to connection to the first-order levelling net; and gravity stations will be augmented. It is also planned to readjust these networks, including the old ones, to conform to the World Geodetic System. These plans are only waiting for funding support to be implemented.

GEOMAGNETISM

The Philippines is maintaining a few geophysical observatories. Foremost is the Government Magnetic Observatory at Muntinlupa, Rizal; and the others are private observatories located at Manila, Baguio and Davao. Scattered strategically in the island chain are hundreds of magnetic repeat stations

Figure 5. Philippines: status of geodetic network, 1982



3388.5x

and magnetic stations. The observations of the epoch of 1980 have been completed and observations for the 1985 epoch are about to commence.

TOPOGRAPHIC MAPPING

Topographic maps are another important input to national development. The Philippines is maintaining stocks of maps in the following series: (a) 1:50,000 scale, 976 sheets; (b) 1:250,000 scale, 55 sheets; (c) various scales, 30 sheets (see figure 6).

Topographic mapping at 1:25,000 scale was begun in the late 1970s in selected areas. This project was pursued with the assistance and co-operation of the United Nations Development Programme (UNDP) and the Government of Japan. Five new sheets covering western Pangasinan had been printed. In the near future, 72 topographic map-sheets of medium scale covering the Cagayan Valley region in northern Luzon will be made available. Orthophotomaps will also be available in urban areas in the region under this project. This mapping project in Cagayan Valley was a joint co-operative effort by the Philippines and the Government of Japan.

All map-sheets are revised continuously, in particular, the 1:50,000 and 1:250,000 series. Other ongoing topographic mapping programmes are Metro Manila, Ilocos Norte, Zamboanga del Sur and Bohol. These maps are on various large scales ranging from 1:4,000 to 1:25,000.

NAUTICAL CHARTS

Nautical charts are not only an indispensable instrument to marine navigation but a valuable tool to marine resources inventories, considering that the Philippines has an approximate water area of 780,000 square nautical miles including its exclusive economic zone.

The country is maintaining over 170 charts covering the entire archipelago on various scales (see figure 7). Some of these charts have recently been metricated. Important water areas and channels are being resurveyed for metrication. It is envisioned to publish bathymetric charts in the near future.

CADASTRAL MAPS

Cadastral maps are an instrument of national progress. A cadastral plan can be easily converted to funds to be used to finance the wheels of progress.

To hasten the democratization of wealth in the countryside, land titling has been accelerated in recent decades, due to active support of the Government in cadastral surveying and mapping.

Figure 6. Philippines: index of topographic maps

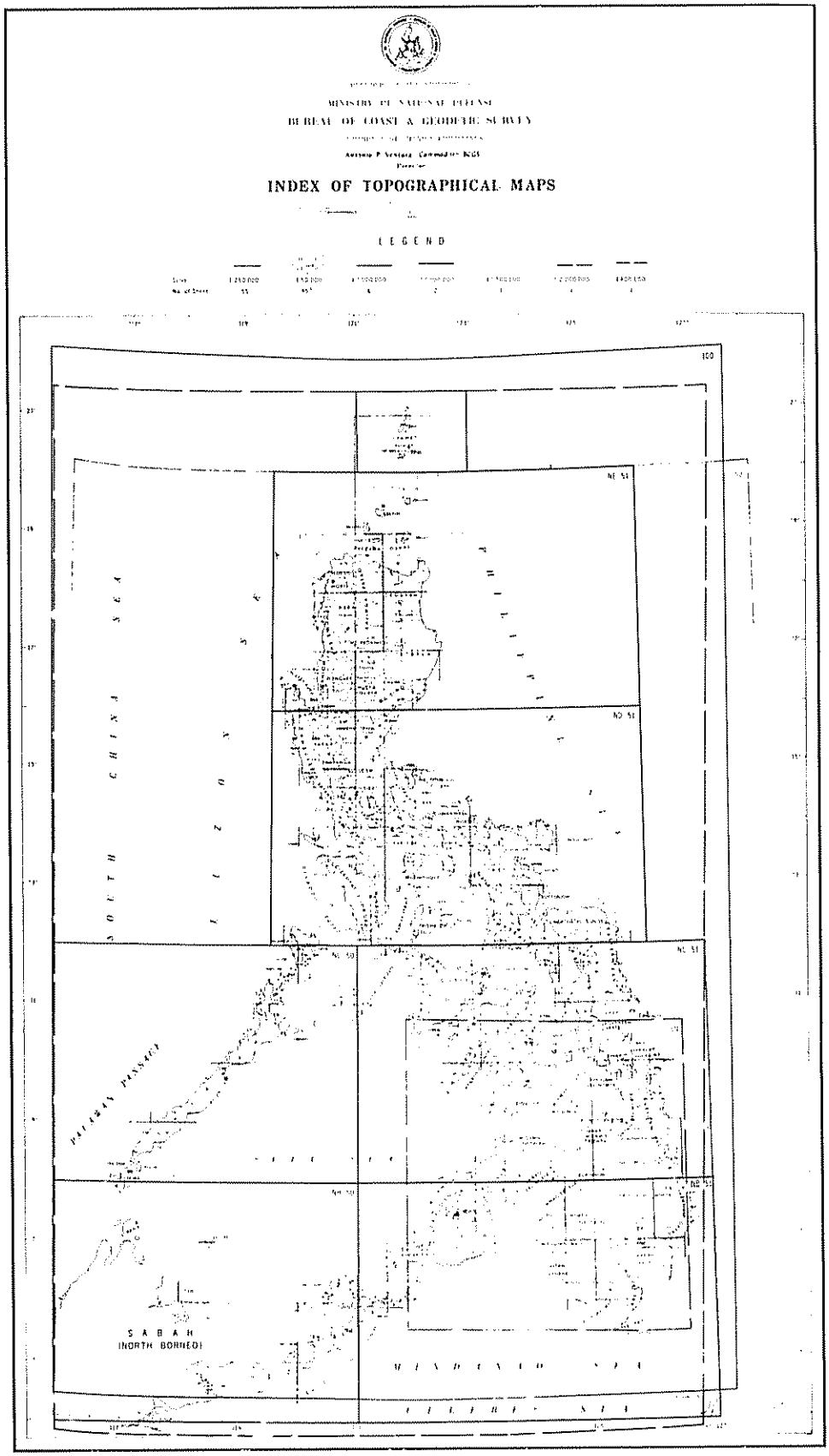
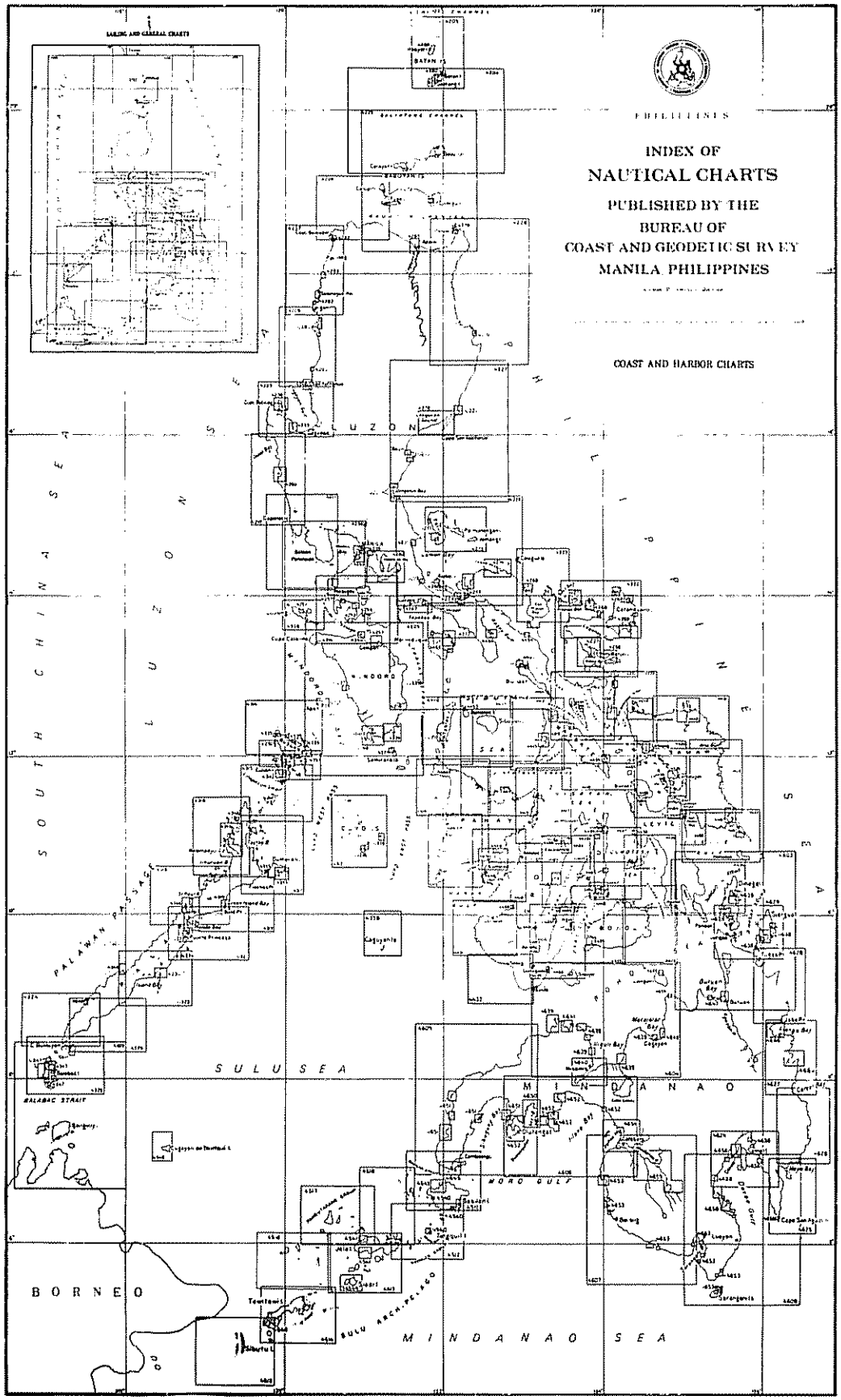


Figure 7. Philippines: index of nautical charts



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CARTOGRAPHY IN GENERAL

During the pas decade, the Philippines has joined other developing countries in the advancement of cartography. Foremost is the coming of an era in the country of semi-automated cartography.

Aerial photography has been used extensively in topographic and cadastral surveying. Accelerated hydrographic survey is made possible through the use of the Integrated Hydrographic Survey System. Control network is made easy in the usage of EDM and the JMR satellite system. Data processing, adjustments and analyses are accelerated through the use of computers. Remote sensing is being utilized in inventories of natural resources. A new agency, the National Cartography Authority, has been solely mandated with the furtherance of cartography in the Philippines. Training programmes have been established for cartography, photogrammetry and geophysics.

However, these efforts have been set back due to brain drain and limited resources. Because of the intensive demand in the Middle East for these types of expertise, the Philippines has suffered a brain drain of such magnitude that it adversely affects progress in surveying and mapping.

It is hoped that in future the Philippines will be able to join the developed countries in the advancement of cartography.

COUNTRY REPORT AND PROGRESS IN THE FIELD OF MAPPING IN THE REPUBLIC OF KOREA*

Paper submitted by the Republic of Korea

RESUME

Au cours des 10 dernières années, le secteur gouvernemental a obtenu des résultats remarquables en géodésie et en cartographie.

Une carte de base du pays au 1:25 000, une carte topographique au 1:50 000 ainsi que diverses cartes thématiques et cartes spécialisées ont été dressées. Par ailleurs, on établit actuellement des cartes à grande échelle au 1:5 000 pour diverses activités d'aménagement du territoire aux niveaux national et régional.

Les services de cartographie ont en outre entrepris des opérations de trilatération en vue d'obtenir des points géodésiques nationaux plus précis, tout en exécutant des levés astronomiques, magnétiques, gravimétriques et Doppler.

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* The original text of this paper, prepared by the National Geography Institute of the Ministry of Construction, appeared as document E/CONF.75/L.80.

Dans les 10 années à venir, on prévoit d'introduire un système géo-informatique permettant de convertir les résultats des levés en base de données et d'acquérir le matériel nécessaire pour la cartographie automatisée.

L'Institut géographique national projette de terminer prochainement ses activités d'établissement des cartes au 1:5 000 et de production de l'atlas national.

Il prévoit également d'exploiter le système géo-informatique dont la base de données englobera toutes les cartes publiées par lui-même et par d'autres organismes cartographiques et aussi d'installer un système de cartographie automatisé destiné à renforcer l'efficacité des activités d'établissement et de mise à jour des cartes.

During the past decade, the Government of the Republic of Korea and its agencies have made remarkable advances in the fields of geodesy and mapping.

In mapping they completed the national base map at 1:25,000 scale and the topographic map at 1:50,000. Large-scale mapping at 1:5,000 is in progress for various national land and regional planning. Moreover, various thematic and special-purpose maps have been produced.

In geodesy, they have embarked on trilateration to enhance the accuracy of he national control points, while simultaneously implementing such surveys as astronomical, magnetic, gravity and Doppler.

During the coming decade, it is expected that a geo-information system will be initiated to transform all the survey results into data base and that the necessary equipment for automated cartography will be introduced.

GOVERNMENT MAPPING ORGANIZATIONS

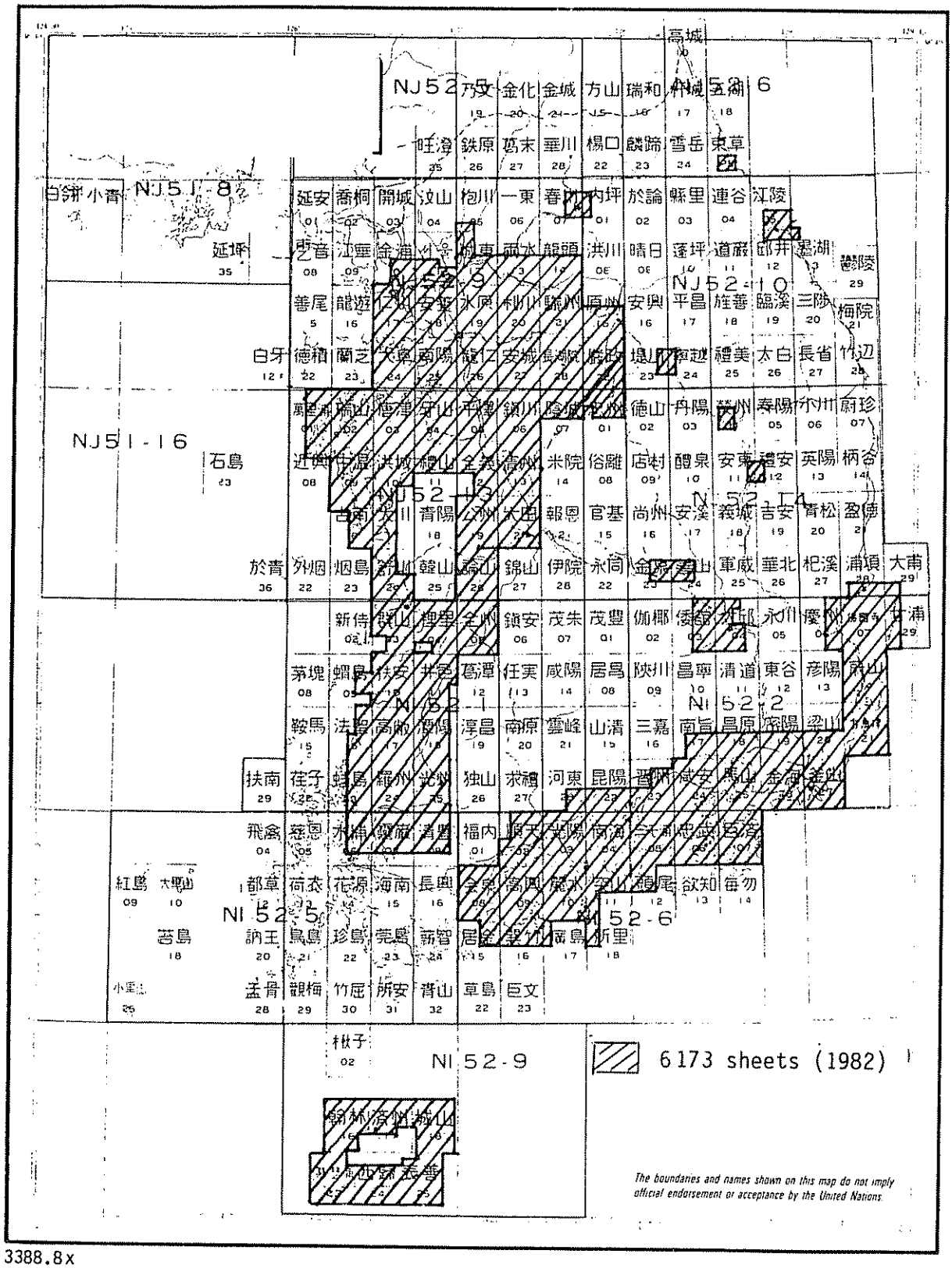
Major mapping organizations are responsible for mapping in the Republic of Korea. As provided in the survey law, the National Geography Institute (NGI), in the Ministry of Construction, has full responsibility for all geodetic survey and topographic mapping; the Hydrographic Office, in the Ministry of Transportation, is in charge of bathymetry and marine chart production.

National Geography Institute

By 1974, NGI had completed the production of topographic maps on the scales of 1:50,000, 1:250,000 amd 1:1,000,000 as well as the 1:25,000 national base maps. It then immediately began 1:5,000 large-scale mapping and has now covered about one third of the entire territory (figure 8).

For large-scale mapping at 1:5,000 and further for periodic revision of the existing maps, NGI has annually photographed about 20,000 km^2, a portion of it repeatedly, at 1:20,000 scale.

Figure 8. Republic of Korea: topographic mapping at 1:5,000 scale, 1982



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The 1:5,000 map, using a format of 1'30" x 1'30" requires about 15,000 sheets to cover the country, with a 5-m contour. It is being supplied for public use in diazo, monocolour and multicolours according to demand.

Apart from the routine mapping projects mentioned above, NGI is engaged in producing a number of special maps:

(a) Orthophotomap at 1:5,000 scale. This map (see figure 9) is being produced for large metropolitan and new development areas at an annual rate of about 100 km^2. Map-sheets are organized in such a way that there should be no direct joining with adjacent sheets, with a small portion of area overlapped, since the sheets are formed by model. In addition, roads and rivers are over-printed in brown and blue colours, respectively, thereby making interpretation much easier. (For technical reasons, this map could not be reproduced in colour in this volume);

(b) Land-use map at 1:25,000 scale. This map is based on the 25,000 national base map with grey-colour line map details, including geographical names, and land-use classification expressed in 12 groups and 45 subgroups using colours and symbols. The entire territory has been represented with this map, which is useful for land-use planning with legal validity for future development;

(c) Small-scale land-use map at 1:250,000. Efforts had been made to produce this land-use map through visual interpretation of LANDSAT imagery, beginning in 1972. This attempt, however, was not very successful, because of the complexities of land use in the Republic of Korea and problems with the resolution power of the imagery. In 1979, a computerized method of imagery analysis was adopted in co-operation with the Korea Advanced Institute of Science and Technology (KAIST). This method has begun to produce better results, and it will continue to be used to keep track of changes in nation-wide land use;

(d) National Atlas of Korea. NGI is planning to compile the National Atals of Korea for completion by 1986. Compilation work has been based on all the pertinent data and information prepared by relevant government agencies. The most recent status of territory, economic and social phenomena and culture of the Republic of Korea is displayed in 110 sheets. Thus far, 17 sheets have been published, for example, population distribution, motor-vehicle traffic volume, railway passenger transportation, paved-road ratio, and exports and imports;

(e) Coastal fundamental map. The Republic of Korea is a peninsular country surrounded by the sea on three sides, with a well-developed continental shelf along its shallow south-western coastal waters. Exploration of this continental shelf is of vital value to the country. NGI is currently implementing detailed surveys of the coastal waters up to the depth of 20 m and is in the process of making a bathymetric map on the scale 1:25,000. Out of the total plan of 11,000 km^2, approximately 4,000 km^2 have been surveyed. The coastal survey will be completed by 1986 (see figure 10).

(f) Production of other maps. NGI is also engaged in the production of other maps required by the Government and its agencies, for example, route maps (1:1,200-1:5,000) needed for highway design and construction, a special topographic map (1:1,200) for farm-land adjustment and a situation map (1:5,000) for a dam site.

Figure 9. Republic of Korea: orthophotomapping at 1:5,000 scale, 1982

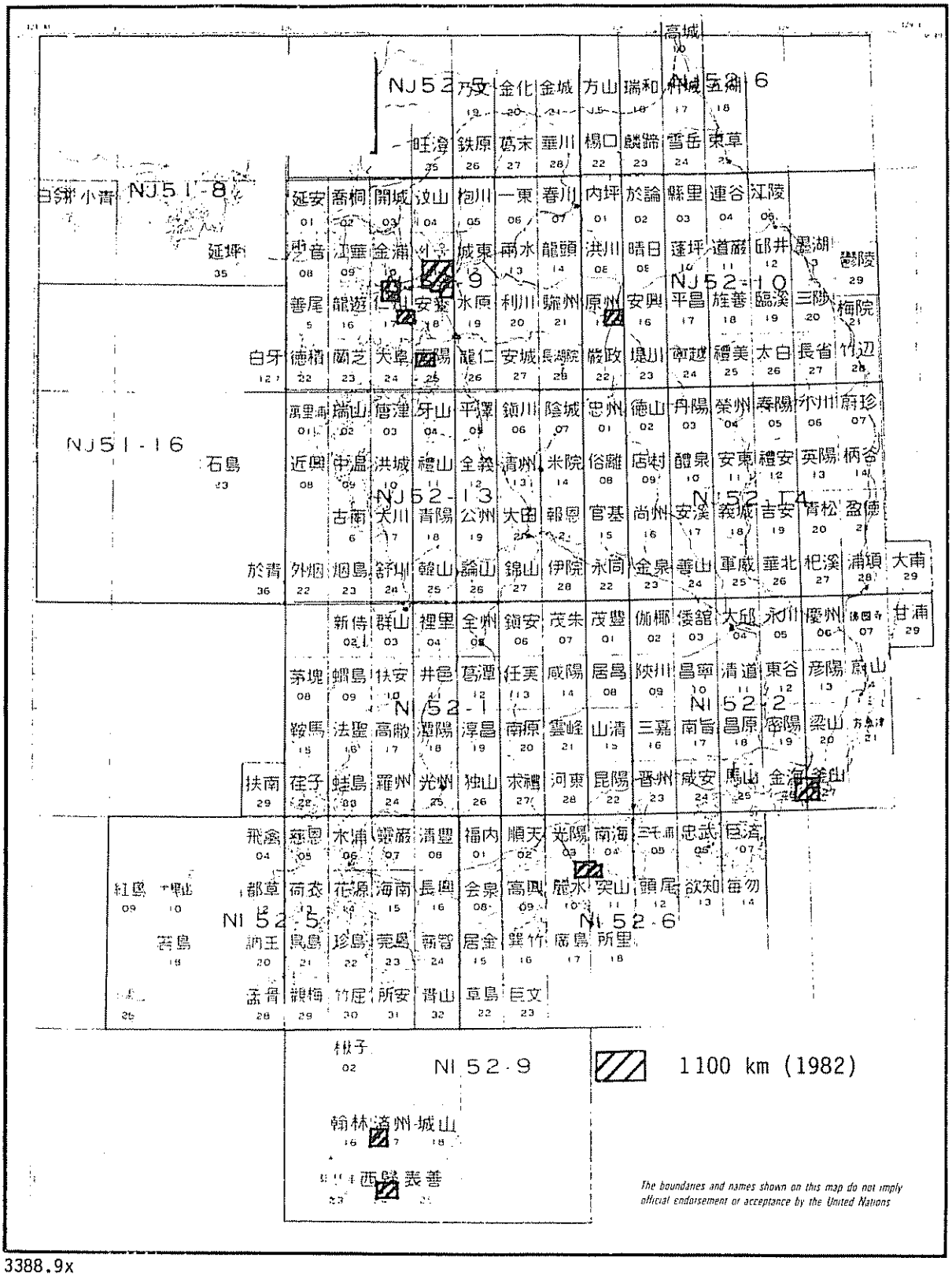

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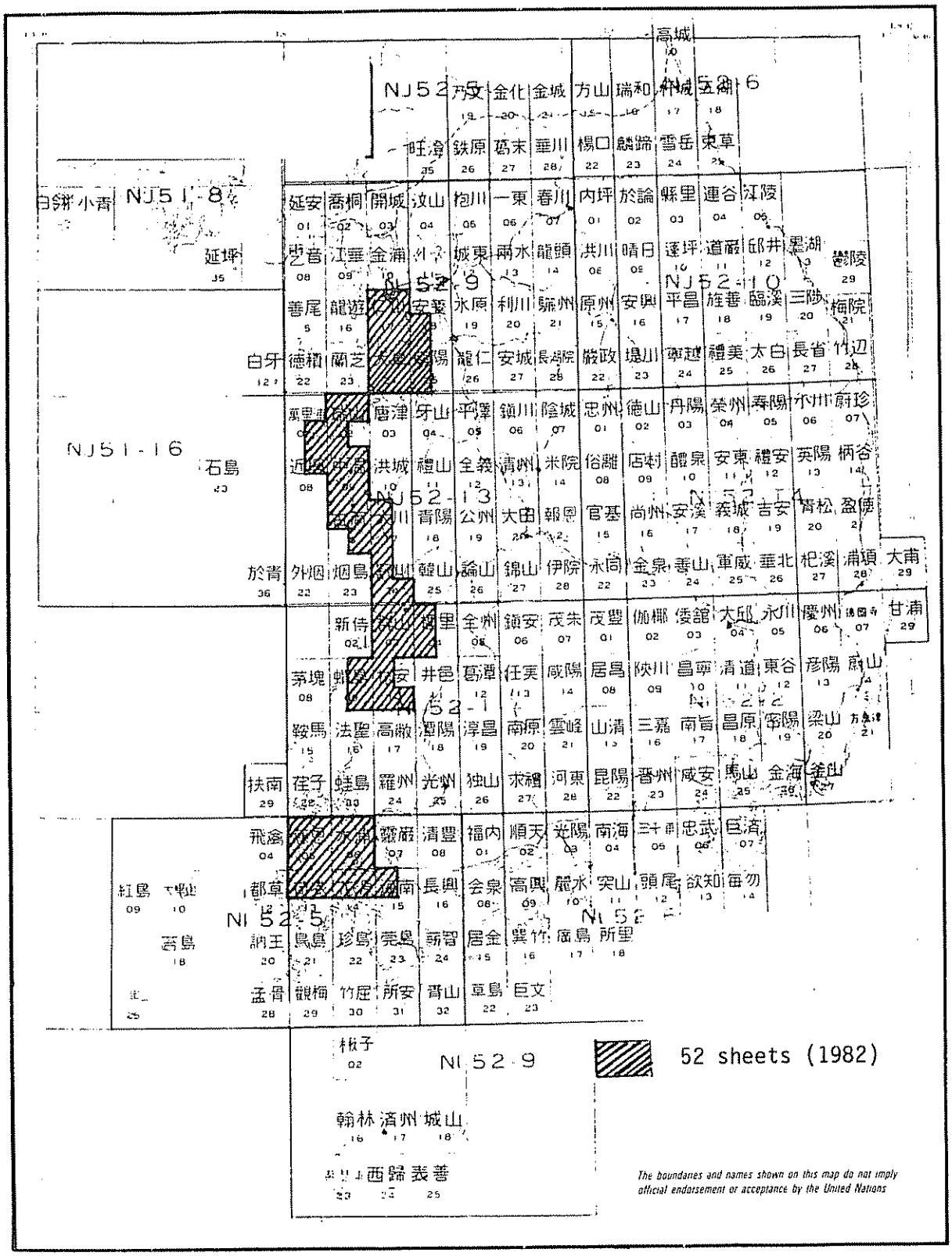
Figure 10. Republic of Korea: coastal fundamental map at 1:5,000 scale, 1982



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Hydrographic Office

The Hydrographic Office publishes nautical and bathymetric charts, notices to mariners and various nautical publications. The nautical charts are compiled from the field survey data covering information essential for the safe navigation of vessels. The coverage and scales of the charts are determined by such factors as coastal features, location of harbours, navigational needs and user convenience. The Office produces the charts in different series, such as general charts, sailing charts, coastal charts and harbour charts at different scales.

The charts and publications issued by the Hydrographic Office are constantly revised and updated for Notices to Mariners. It has published as many as 248 different types of charts since 1949; and annual production of new editions, revision and reproduction comprises about 45 types, on the average. The nautical publications issued by the Office are compiled directly from the various maritime agencies and countries throughout the world. For instance, the sailing direction describes in detail information that is not shown on the charts but is essential for safe navigation.

Other mapping organizations

In addition to the organizations mentioned above, a few others publish thematic maps, using the NGI 1:50,000 and 1:25,000 topographic maps as base maps.

The Forest Research Institute, Office of Forestry, is producing a forest type map (1:25,000), a forest land-use planning map (1:25,000) and a forest soil map. The Korea Institute of Energy and Resources is producing a geological map (1:50,000), and the Plant Environment Research Institute produces soil maps (1:50,000).

FUTURE PLANS IN MAPPING

In the near future, NGI intends to complete all the 1:5,000 large-scale mapping and national atlas production, both currently in progress. It also plans to operate the geo-information system with data base covering all the maps being published by itself and other mapping organizations and, furthermore, to introduce an automatic cartography system intended to enhance efficiency in the work of mapping and updating.

REPORT ON SURVEY AND MAPPING ACTIVITIES IN SINGAPORE, 1980-1982*

Paper submitted by Singapore

A Singapour, les organismes gouvernementaux chargés des travaux topographiques sont:

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* The original text of this paper, prepared by the Mapping Unit and the Survey Department, appeared as document E/CONF.75/L.114.

a) Le Service de cartographie, responsable de l'établissement des cartes topographiques;

b) Le Département des levés responsable des levés cadastraux.

D'autres organes officiels et les géomètres experts indépendants répondent à la demande du public en ce qui concerne les levés fonciers et les levés d'étude. La formation des géomètres et topographes est assurée à l'Ecole polytechnique de Singapour.

CARTES TOPOGRAPHIQUES

Les séries de cartes de Singapour au 1:50 000, 1:25 000 et 1:10 000 sont continuellement mises à jour. Toutefois, une grande partie des travaux porte sur l'établissement de cartes par photogrammétrie pour répondre aux besoins de développement. On peut citer notamment l'établissement de cartes au 1:500 et au 1:1 000 pour l'aménagement du couloir proposé pour transports en commun. En effet, les techniques photogrammétriques et les photographies aériennes sont de plus en plus largement utilisées pour les projets techniques.

Etant donné le rythme accéléré du développement souvant la cartographie topographique classique ne suffit pas à satisfaire à la demande. Un des autres procédés utilisés est la production d'orthophotocartes, en particulier pour l'aménagement urbain.

TRAVAUX GEODESIQUES

Pendant la période considérée, cinq nouvelles stations ont été ajoutées à la triangulation de premier ordre. Il est prévu d'augmenter encore la densité des points de contrôle.

LEVES CADASTRAUX

Les levés cadastraux sont régis depuis 10 ans par le Conseil des géomètres cadastraux en vertu du Land Surveyor Act (1970).

A ce jour le répertoire cadastral contient 1 396 feuilles de plans au 1:1 000 couvrant l'ensemble de la République. Ces plans constituent les documents cadastraux permanents et complètent les plans certifiés. Tous les changements dans les titres ou les limites de terrain sont enregistrés ce qui permet d'avoir des données à jour sur l'état du cadastre dans l'ensemble de Singapour. Leur mise-à-jour est donc un travail continu. Ces plans sont très utilisés par divers départements et organes officiels pour les travaux de planification ou d'administration et par le grand public à diverses fins.

INFORMATISATION DE LA CARTOGRAPHIE

Des recherches sont en cours en vue d'utiliser l'ordinateur en cartographie. Il est question d'acquérir un système informatisé de données concernant le

territoire. Le Conseil national d'informatique a pris une mesure importante en 1982, en invitant IBM à organiser un séminaire sur le traitement des données géographiques pour sensibiliser les responsables et définir les besoins des services publics et départements gouvernementaux.

FORMATION DES GEOMETRES

L'enseignement occupe une place importante dans la République. Il existe à Singapour des cours de formation et de perfectionnement pour géomètre.

L'Institut polytechnique de Singapour forme des géomètres diplômés et offre également un cours avancé d'arpentage, le diplôme décerné étant une qualification indispensable pour être reconnu officiellement, par le Conseil des géomètres, comme expert.

La Public Service Commission continue à octroyer des bourses d'études universitaires à l'étranger. Entre 1980 et 1982, 10 étudiants ainsi formés sont entrés dans la profession.

Le programme des cours de génie civil de l'Institut technologique de Nanyang a été amélioré. Certains géomètres locaux expérimentés enseignent à temps partiel à l'Institut.

In Singapore, the government organizations undertaking national surveys are: (a) the Mapping Unit, which is responsible for topographic mapping; (b) the Survey Department, responsible for cadastral surveys.

Other statutory boards and the private registered surveyors serve the public needs for both title and engineering surveys. Survey education is avaialble at the Singapore Polytechnic.

TOPOGRAPHIC MAPS

The standard series maps of Singapore at 1:50,000, 1:25,000 and 1:10,000 scales are continuously updated. However, a great proportion of mapping resources is expended on larger scale photogrammetric mapping to meet development needs. The completion, in 1980, of mapping for the proposed mass rapid-transit corridor at 1:500 and 1:1,000 is a major example of such work. There has been a trend towards the acceptance and usage of photogrammetry and aerial photographs in engineering projects.

With the rapid pace of development, conventional topographic maps often cannot be published fast enough. An alternative being pursued is the production of orthophotomaps for urban planners, in particular.

CONTROL SURVEY

Within the review period, the primary triangulation was broken down with the establishment of five additional trig stations. Further densifications of national control points are planned.

CADASTRAL SURVEYS

Cadastral surveys are regulated by the Land Surveyors Board under the Land Surveyor Act (1970), which has been in operation for the past 10 years.

To date, there are 1,396 sheets of cadastral index plans at 1:1,000 scale, covering the entire country. These plans are the permanent cadastral survey records and are complementary to the Certified Plans. All mutations to titles or land boundaries of properties are recorded on these index plans to give an overall and up-to-date cadastral position of Singapore. The updating of these plans is therefore a continuous exercise. The plans are very widely used by various government departments and statutory boards for planning and administration purposes, and also by the public for their various needs.

COMPUTERIZATION IN CARTOGRAPHY

Exploratory tasks are being undertaken to provide a computer-assisted mapping environment. There is interest in the acquisition of a land data information system. An important first step was initiated in 1982 by the National Computer Board when International Business Machines (IBM) was invited to conduct a seminar on geoprocessing to create an awareness of it and to identify the needs of numerous public utilities and government departments.

SURVEY EDUCATION

Education has an important role in Singapore, and facilities are available for training and upgrading skills and knowledge for surveying.

The Singapore Polytechnic provides a technician diploma course in surveying. It also conducts an advanced diploma course in surveying which is accepted as a pre-qualification for professional recognition as a registered surveyor by the Land Surveyors Board.

Scholarships for university education in surveying abroad continue to be available from the Public Service Commission. Ten such surveying graduates were absorbed into the survey profession during the period 1980-1982.

In the Nanyang Technological Institute, the survey content of courses for civil engineering undergraduates has been upgrated. Some local experienced survey professionals were co-opted to teach part-time at the Institute.

NATIONAL REPORT OF SRI LANKA*

Paper submitted by Sri Lanka

RESUME

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* The original text of this paper appeared as document E/CONF.75/L.113.

Le Département de topographie de Sri Lanka existe depuis 1800. A l'origine il effectuait de temps à autre des levés topographiques pour la vente de terres. La première carte topographique du pays date de 1940. La série de cartes topographiques au 1:63 360 fut établie entre 1897 et 1924. La chaîne de triangles a été calculée dans la seconde moitié du dix-neuvième siècle. Le nivellement géométrique a été fait entre 1926 et 1930. Après l'indépendance en 1948, le Département a entrepris d'importants levés géographiques pour des projets de développement. Depuis 1979, ont été produites deux séries de cartes topographiques.

Les activités du Département sont les suivantes:

a) Tous les levés géodésiques sont réalisés à l'aide d'instruments de précision et d'équipement modernes;

b) Cartographie topographique: la série de cartes au 1:63 360 montre la topographie du pays et l'occupation des sols et comporte des courbes équidistantes de 100 pieds. Cette série sera bientôt remplacée par la nouvelle série au 1:50 000 qui est plus détaillée. Une autre série au 1:10 000 est en cours de production;

c) Cartographie pour la réalisation de projets: des levés topographiques à plus grande échelle sont réalisés pour divers projets de développement, (irrigation, détournement de cours d'eau, urbanisme etc.);

d) Cartographie thématique: un Atlas national contenant 45 cartes est en cours de préparation;

e) Cartographie de l'occupation des sols: le Centre de télédétection établit des cartes normalisées de l'occupation des sols pour chacun des 24 districts administratifs, en se basant sur des photographies aériennes et des données satellite;

f) Levés aériens: des photographies aériennes de l'ensemble du pays ont été prises en 1956. Une autre série a été prise à plus grande échelle en 1972. On prend de nouvelles photographies à l'heure actuelle. Elles sont utilisées pour des levés intéressant certains projets. Pour l'établissement de la carte de base agricole et des cartes d'occupation des sols etc.

Quant aux travaux hydrographiques les cartes existantes sont celles qui ont été établies par l'Amirauté britannique au début du siècle. Le Gouvernement poursuit cette activité. Un comité interdépartemental a déjà élaboré les prcédures à adopter;

Les levés aériens géophysiques sont réalisés par le Service géologique. Des levés aéromagnétiques et radiométriques ont été exécutés dans certaines régions du pays en 1957 et 1958. Les résultats sont présentés sous forme de cartes en courbes.

Sri Lanka is participating for the first time in a United Nations Regional Cartographic Conference for Asia and the Pacific. In the circumstances, a brief historical account of the Survey Department is appropriate.

HISTORY OF SURVEY DEPARTMENT

The Sri Lanka Survey Department is one of the oldest government departments in the State Service; it has been in operation for over 180 years.

The first phase, which commenced in 1800 and covered a period of about 50 years, was the survey of scattered allotments of land for sale to private parties. Records show that about 50,000 title plans were issued during that period. These scattered surveys were not tied to a common framework. A map of Sri Lanka on the scale 1:506,880 (8 miles to an inch) was produced in 1822. The topography and delineation of the maritime areas were shown in this map, although a good part of the central districts were blank. A sketch map of the central districts at 1:63,360 scale (1 mile to an inch) and also a map of the entire island at 1:253,440 scale (4 miles to an inch) were completed by 1840.

The observations for the triangulation network were begun in 1857 with the measurement of the Negombo base on the western coast. A second base was measured at Batticaloa on the eastern coast.

In 1863, the Registrar-General's Department was created; and provision was made for the systematic registration of land, on the basis of cadastral surveys, pending the survey and registration of deeds. It was during this period that the scattered surveys were shown, in their relative positions, in a key map.

In 1886, a 1:253,440 scale (4 miles to an inch) map of Sri Lanka was lithoprinted in 16 sections, in colour; it was the first undertaking of this nature in the country. A topographic map on the same scale was completed in 1893.

A complete reorganization of the department was effected in 1897, with the topographic survey of the island and block surveys (i.e., separation of state lands from private lands) as the main objectives. The topographic maps were on the scale 1:63,360 (1 mile to an inch) and the block surveys on the scale 1:3,168 (4 chains to an inch). The topographic series was completed in 1924. The surveys for the demarcation of State-owned lands is now complete, and the planning and execution of land distribution systems have been in operation for a long time.

The observations for the geodetic levelling network commenced in 1926 and was completed in 1930. Close contour surveys of vast areas for development were initiated in 1931. The principle triangulation network was recomputed in 1931, with remeasurement of the two bases and some additional angle observations.

With the declaration of independence in 1948, the land policy and pace of development accelerated, with emphasis on extensive project surveys for development of river basins, irrigation schemes, reservoirs, hydroelectric-power generation, forest management etc. In keeping with the technical advances, the Air Survey Branch was set up in 1955, followed by the purchase of an aircraft and connected equipment in 1956. This department is now fully equipped with fairly modern facilities for all types of land surveys.

The scape of the Resources Survey Unit, established in 1958, has gradually changed. It now functions as the Centre for Remote Sensing.

A system of land reforms was introduced by the Government in 1972. The land surveys connected with this development were one of the heaviest tasks undertaken by the Department. Approximately 500,000 ha, involving thousands of individual scattered parcels of land, had to be surveyed and indexed within a very short period. Then, in 1978, surveys were required for the accelerated Mahaweli Porgramme, a massive multi-purpose development project.

The Department has also commenced the preparation of a base map to cover the entire island on the scale 1:50,000, to replace the 1:63,360 topographic series, under the Agricultural Base Mapping Project. The production of a new 1:10,000 series is also one of the objectives of this project.

CURRENT FUNCTIONS OF SURVEY DEPARTMENT

The Survey Department has expanded considerably from its humble beginnings in 1800, and it is currently engaged in the following activities:

(a) Triangulation and precise levelling;

(b) Precise traversing using electronic distance measurement (EDM) equipment;

(c) Mapping at 1:10,000 and 1:50,000 scales;

(d) Surveys to record and locate state lands and lands conveyed to the state;

(e) Provision of survey plans for the Director of Irrigation, Director of Works, Director of Highways, Town and Country Planner, Commissioner of Local Government, Government Agents in charge of Districts, Land Reforms Commission, Ministry of Plantation Industries and many other departments, corporations and organizations;

(f) Aerial photography and photogrammetry;

(g) Remote sensing, resources surveys and integrated surveys;

(h) Software development and data processing;

(i) Reproduction and printing of maps;

(j) Survey training at technician and higher levels.

The major activities are described below.

Geodetic surveys

To date, the following geodetic control surveys have been completed: two baselines; a principal triangulation network; astronomical azimuth observations at the two bases; and 59 fundamental bench-marks covering 3,840 km of primary levels. In addition, independent precise triangualtion networks for all major development project areas have been completed, using modern first-order theodolites and EDM equipment.

All precise geodetic surveys are undertaken by the Department.

Mapping

Topographic mapping

The current 1:63,360 (1 mile to one inch) topographic map series, comprising 72 maps, covers the entire island; 100-foot contours and the land-use pattern are shown on these maps with reasonable accuracy and provide the basic data needed for planning development projects.

This series will be replaced by the 1:50,000 series produced under the Agricultural Base Mapping Project and will contain much more data concerning land use and land formation. This series will contain 92 map-sheets and production work has just commenced. The contour interval in this series is 10 m in flat areas and 20 m in hilly areas.

The 1:10,000 map series planned under the Agricultural Base Mapping Project is also under production; 25 map-sheets have already been produced on this scale. The 1:50,000 series, however, has been assigned priority; and 1:10,000 mapping is done on a project priority area basis.

Mapping for project requirements at 1:1,000, 1:2,000 and 1:5,000 scales

Many projects in different parts of the island have been completed. One major undertaking is the accelerated Mahaweli River Diversion Project, which commenced in 1978. This integrated development project covers approximately one third of the area of the country. It involved surveys for a massive river diversion, hydropower generation, flood protection, irrigation, canal systems and demarcation of land for settling new farm families. Under this project, the close contour survey of about 500,000 ha at 1:5,000 scale, dam sites and other site surveys covering about 4,000 ha, about 5,500 ha of reservoir bed surveys and about 2,700 km of channel surveys have been completed. The Department is now attending to the blocking-out of allotments to place the allottees in possession. This project was originally planned to be completed in 30 years. Under the accelerated programme, the Government has planned to complete it in six years and the survey activities are well ahead of schedule.

Thematic mapping

The Survey Department has undertaken the production of a National Atlas, containing 45 map-sheets, on the scale 1:1,000,000. Four maps have been produced and 13 manuscript maps are completed. The maps will be issued in loose-

leaf form in the first edition and will be accompanied by a text. On request, the Department also produces various thematic maps at different scales for other departments.

Land-use mapping

Land-use mapping is undertaken by the Centre for Remote Sensing, assisted by a project of the Swiss Government and affiliated by the Survey Department. By district, 24 maps have been taken up and 12 maps are in the process of production. The Department expects to complete the project in two years. The maps will be on a standard scale of 1:100,000 and will be printed in colours. A special map, depicting the forest cover of the island, at 1:500,000 scale has been produced using data obtained from aerial photography and updated by satellite imagery.

Aerial surveys

Aerial photography was first carried out in Sri Lanka in 1950, when foreign contracting firms covered selected areas. The photography of the entire island at 1:40,000 scale and a few selected areas at larger scales were completed in 1956/57, with Canadian aid. A twin-engine Beachcraft Super-18 was procured in 1959. Photography required by several user departments and agencies was carried out, including rephotography of the island in 1972 on the scale 1:20,000.

A new aircraft, Cessna Golden Eagle 421-C, was procured in 1980 for the Agricultural Base Mapping Project. The flying and maintenance of the aircraft are carried out by the Sri Lanka Air Force. Navigation and photography are carried out by Survey Department personnel. About 53 per cent of the island has now been photographed at 1:50,000 scale. The balance is expected to be completed by April of this year. In addition, special areas have been recently flown on the scales 1:20,000 and 1:10,000, at the request of other departments and contracting firms, for urgent development programmes.

Cadastral surveys

There have been systems of maintaining of land records from ancient times. Portugal and the Netherlands continued this in certain areas, and the British introduced a system of registration of deeds from 1863. A pilot project carried out in the 1880s for the introduction of registration of title was abandoned after a few years of operation. Hence, only a system of registration of deeds is in force in the country. The Government of Sri Lanka appreciates the need to introduce registration of titles. The aspect of introducing a systematic cadastre and title registration system has been fully studied, and committee reports and recommendations are now accepted in principle by the Government for phased-out long-term implementation. The delay is due in part to lack of resources and to other constraints.

HYDROGRAPHIC SURVEYS

The existing charts around the island are those prepared by the British Admiralty, based on surveys carried out at the turn of the twentieth century. Minor revisions have been made from time to time.

The Sri Lanka Government is interested in pursuing this activity, in view of its relevance to current needs. Accordingly, under a directive from the Cabinet of Ministers, an interdepartmental committee consisting of the Survey Department, Coast Conservation Division of the Ministry of Fisheries, Ports Authority, Fishery Harbours Corporation and the Sri Lanka Navy, was formed in 1980. A report outlining the procedures to be adopted was submitted to the Government by this committee in 1982.

The Government also established the National Aquatic Resources Agency, for systematic exploitation of marine resources, in 1982. This agency plans to conduct systematic oceanographic surveys in the future.

AIRBORNE GEOPHYSICAL SURVEYS

Airborne geophysical surveys are carried out by the Geological Survey Department. Between 1957 and February 1958, this department carried out aeromagnetic and radiometric surveys with Canadian aid. A total of 35,000 line km was flown, and an area of about 23,000 km^2, mostly in the south-western quadrant, was covered.

The results of the aeromagnetic and radiometric surveys have been presented in the form of contour maps. The former map shows lines of equal total magnetic intensity, and the latter, lines of equal radioactive counts. In all, 113 aeromagnetic maps on the scales 1:63,360 (1 inch to a mile), 1:31,680 (2 inches to a mile) and 1:15,840 (4 inches to a mile) have been completed; 34 separate radiometric maps also have been completed.

PROGRESS REPORT ON CARTOGRAPHIC ACTIVITIES IN THAILAND, 1972-1982*

Paper submitted by Thailand

RESUME

Différents services gouvernementaux de la Thaïlande ont mené des activités cartographiques. Pour récapituler les progrès réalisés depuis la dernière conférence, on a élargi et étendu à la quasi-totalité du pays le réseau de points géodésiques et on a multiplié les stations géophysiques. Les photographies aériennes prises ont été reproduites à différentes échelles. On a réuni de nouvelles données pour compléter un grand nombre de cartes topographiques et établi des cartes marines et aéronautiques. On a délivré plus de 100 000 titres de propriété et plus de deux millions d'extraits de registres fonciers. Le Service central de traitement des données permet au Royal Irrigation Department d'établir, à partir de photographies aériennes, des cartes extrêmement précises. S'agissant de la télédétection, le

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* The original text of this paper, prepared by the Royal Thai Survey Department, appeared as document E/CONF.75/L.70.

Comité national de coordination fournit des services de reproduction photographique d'imagerie LANDSAT et envisage de mettre à la disposition des organismes utilisateurs du matériel et des installations d'interprétation des cartes topographiques, tout en poursuivant la coopération avec certains pays, dont ceux de l'ANASE. A la suite des activités de cartographie thématique conduites par les organismes intéressés, diverses cartes spécialisées ont été publiées et d'autres sont en préparation. Certaines universités et d'autres établissements d'enseignement offrent des programmes de formation aux opérations cartographiques et domaines connexes qui débouchent sur la licence et la maîtrise.

Cartographic activities in Thailand have been performed by various governmental agencies. The responsibility placed on each agency depends upon the requirement of its own mission. The progress made in the field of cartography and related activities during the report period (October 1979-September 1982) is summarized below.

ROYAL THAI SURVEY DEPARTMENT

Geodetic and geophysical survey

During the reporting period, the Royal Thai Survey Department conducted the following geodetic and geophysical surveys:

(a) First-order traverse. The electronic distance measurement (EDM) traverse has been used extensively for establishing first-order horizontal controls. The first-order traverse was chosen in order to ease the difficulty of laying out the triangulation chains. The traverse lines were run and connected to the existing first-order triangulation network in the central and eastern parts of the country. The above-mentioned traverse established 131 additional controls;

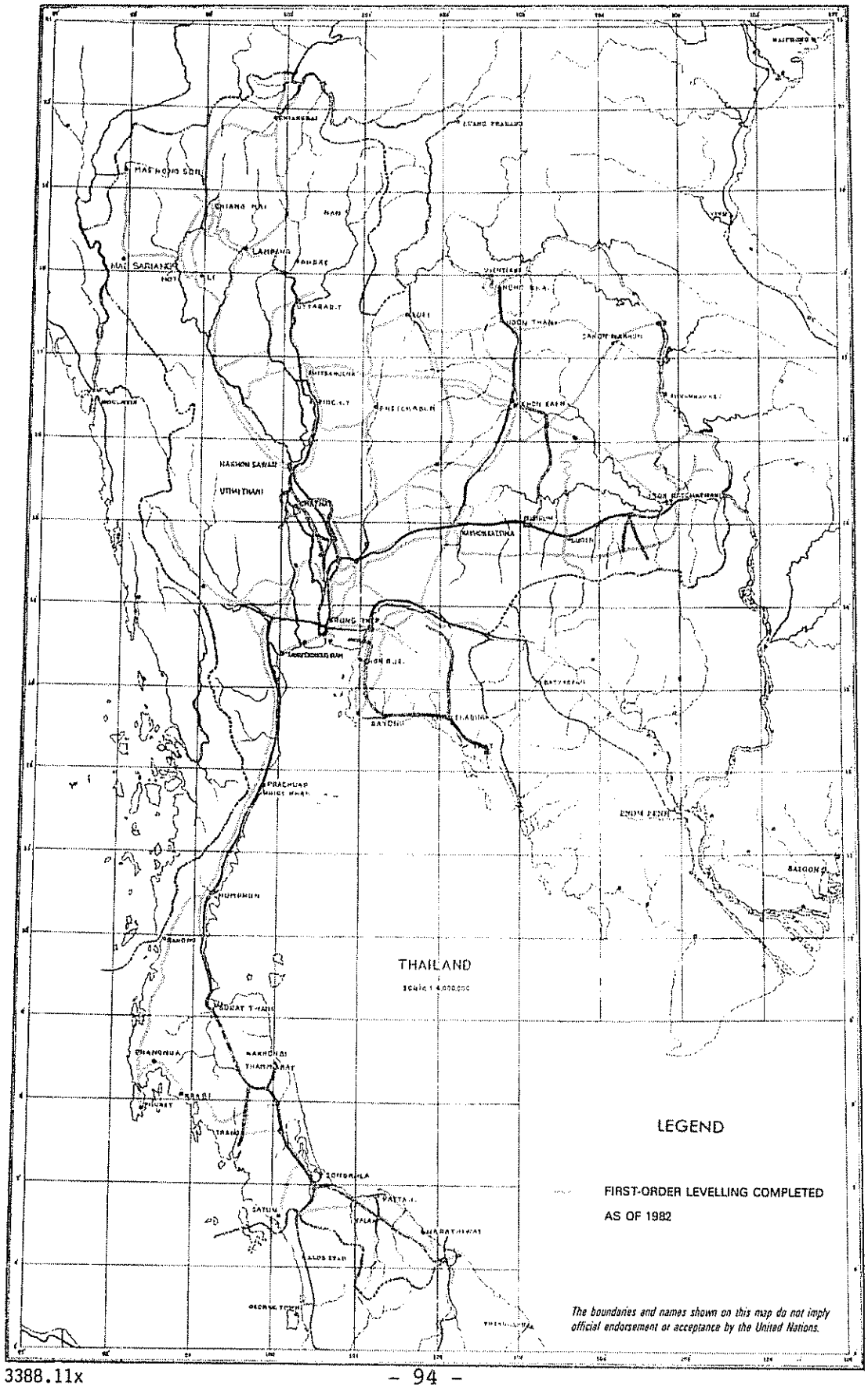
(b) Geodetic astronomy. In order to strenghten the existing geodetic network and to determine the geoid profile, nine Laplace stations were established at the existing first-order traverse and triangulation stations located in the northern, central and north-eastern parts of the country;

(c) Satellite geodesy. The Doppler geodetic point-positioning programme has been undertaken in Thailand since 1971. The receiving signals from transit satellites at various locations will be sent to the Defense Mapping Agency Hydrographic/Topographic Center (DMAHTC) of the United States of America for computation of co-ordinates in the geocentric datum and the local geodetic datum. Eighteen Doppler stations were established during the report period;

(d) Geodetic levelling. Seven lines of first-order levelling were run in order to densify the existing national network (figure 11). A total of 162 first-order bench-marks and 612 second-order bench-marks were established along a distance of 1,280 km;

(e) Land gravity survey. Gravimetric observation was carried out in the northern, central, eastern, north-eastern and southern parts of the country

Figure 11. Thailand: first-order levelling network as of 1982



3388.11x

(figure 12), and 336 stations were established approximately 10 km apart;

(f) Geomagnetic survey. The geomagnetic survey was carried out to reobserve the geomagnetic elements at the existing stations located in the upper central, lower central and southern parts of the country, in order to provide data for the geomagnetic variations. In all, 51 stations were reobserved (figure 13).

Aerial photography

Aerial photography for mapping and national development projects conducted by the Royal Thai Survey Department consisted of the following activities:

(a) Aerial photography for 25 different mapping projects was flown at scales ranging from 1:10,000 to 1:40,000. The areas covered totalled about 67,106 km^2;

(b) Aerial photography to meet requirements of 28 other governmental agencies was flown on scales ranging from 1:7,000 to 1:40,000, covering about 70,500 km^2.

Mapping

Standard topographic maps

The bilingual topographic map series L 7017 at 1:50,000 scale, covering some parts of the country, was recompiled to improve the accuracy of the existing maps. To date, 160 map-sheets covering certain areas in the north-eastern and northern parts of Thailand have been recompiled; of these, 108 sheets have been published.

Because some of the Thailand border sheets had not been included in series L 7017, but in series L 7015 (Lao People's Democratic Republic) and L 7016 (Democratic Kampuchea), it was decided that those 58 border sheets were to be added to the existing series L 7017, bringing the total of the series to 830 sheets. The 58 border sheets have already been published.

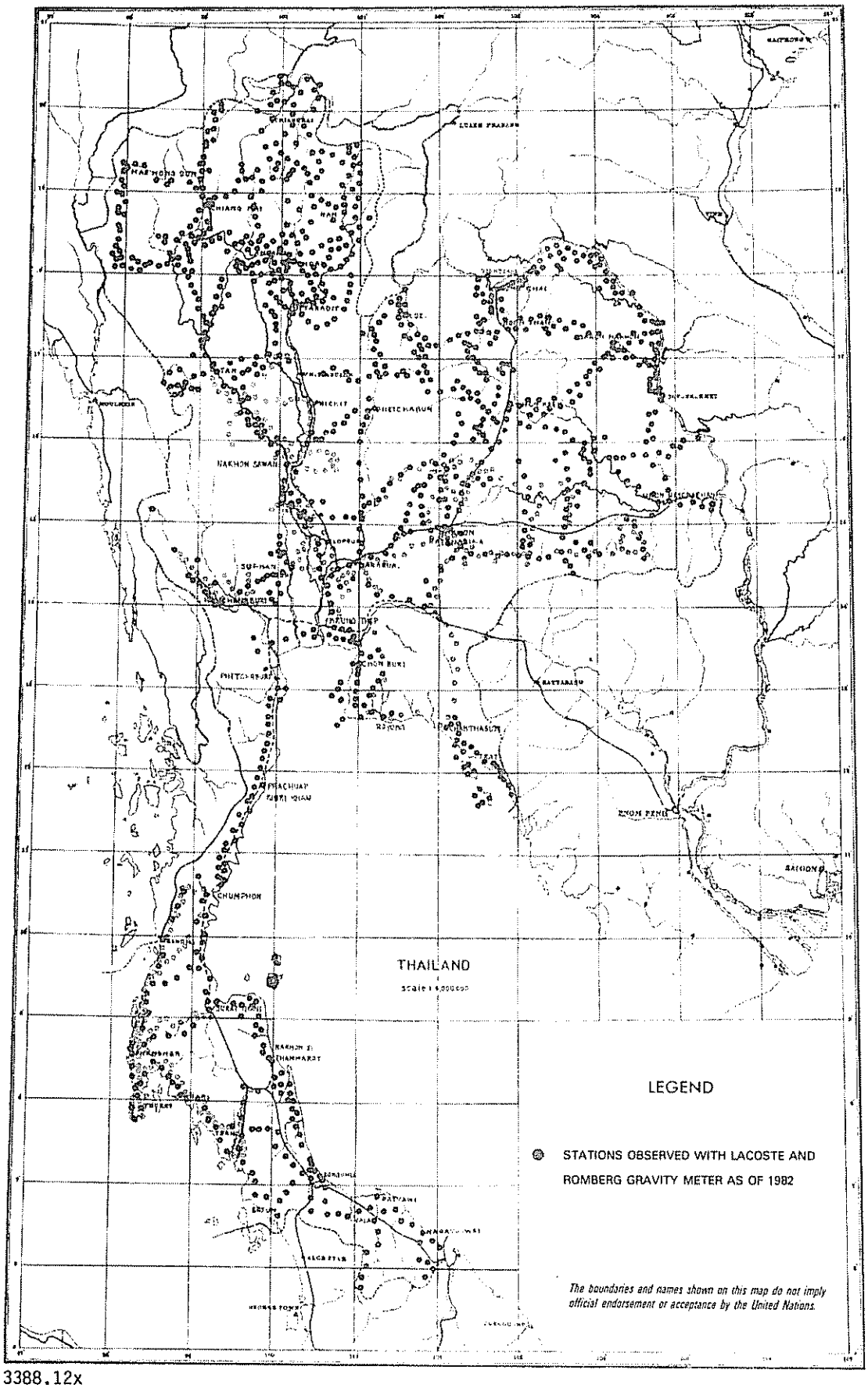
Other topographic maps

During the reporting period, 20 sheets of 1:25,000 bilingual topographic maps covering some particular areas of Thailand were published. Currently, 273 sheets are available for military use.

A bilingual city map at 1:12,500 scale has been published; it covers the urban areas in 153 sheets. These maps have been updated from time to time; and 35 revised sheets have been published, while 10 sheets are in revision.

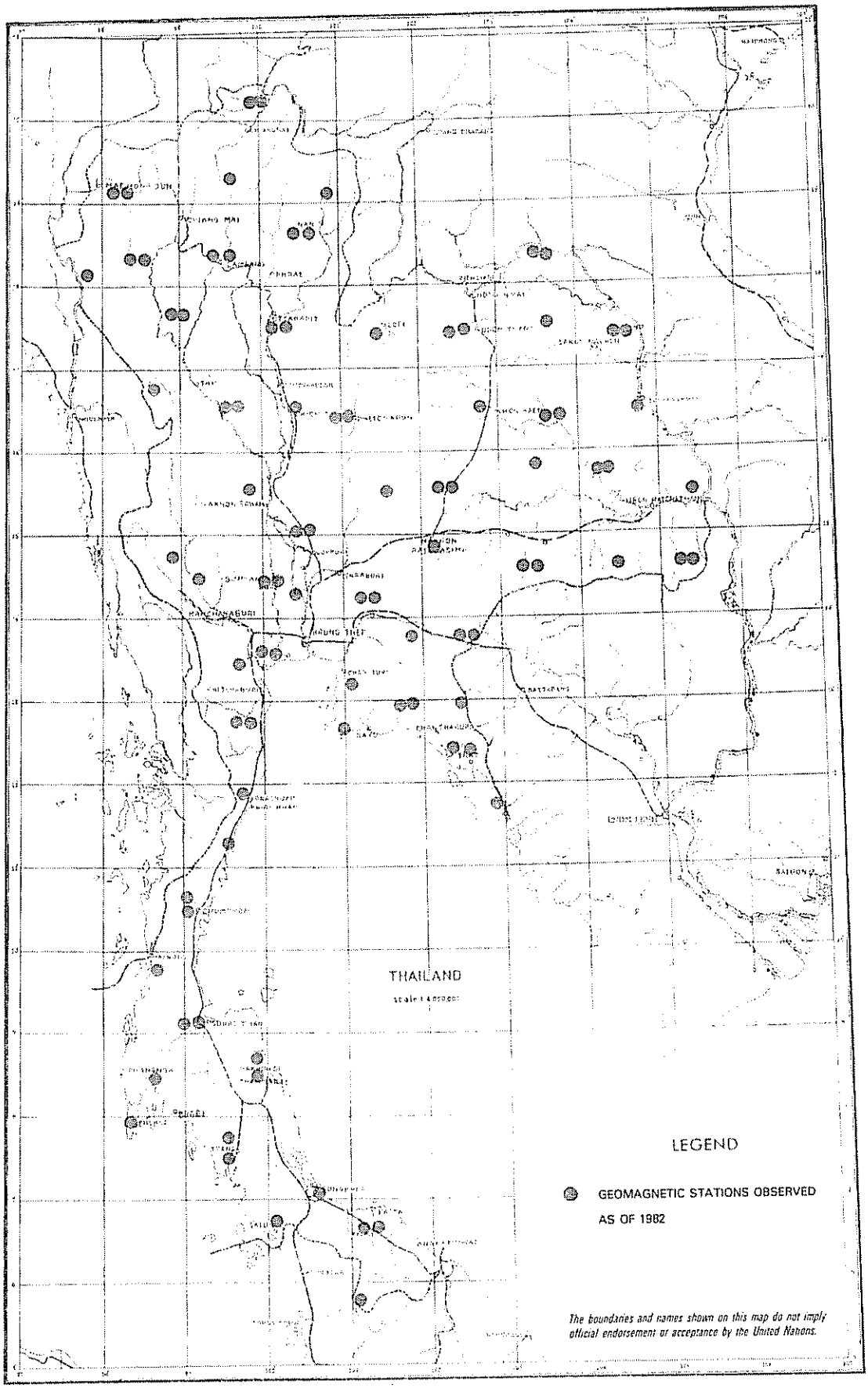
Fifty-two sheets of bilingual topographic maps at 1:250,000 scale, series 1501, 1501A and 1501S (for public use) covering the entire area of Thailand, have been revised from time to time.

Figure 12. Thailand: gravimetric stations observed as of 1982



3388.12x

Figure 13. Thailand: geomagnetic stations observed as of 1982



3388.13x

Thematic maps and atlases

(a) National Resources Atlas of Thailand. Of the 51 topics to be produced as first planned, 45 topics have already been published;

(b) Topographic Atlas of Thailand. Of the 114 sheets to be produced as first planned, 110 sheets have been published. The bilingual texts, however, are at the drafting stage.

General-purpose maps and road maps

Twenty sheets of the city plan of Bangkok Metropolis on the scale 1:20,000 have already been published.

A road map at 1:2,000,000 scale, showing road networks throughout the country, was revised and published.

Map reproduction

During the reporting period, 4,250,000 copies of various types of maps, 78 per cent of which were compiled by the Department, were printed. The rest were compiled by other governmental agencies.

Geographical names

The preliminary name list obtained from 52 sheets of map series 1501 as whole, referred to in the report to the Ninth Conference, has been completed and sent to DMAHTC for the compilation of the gazetteer based on that series.

An officer of the Royal Thay Survey Department attended the Pilot Training Course in Toponymy held in Indonesia from 6 to 19 June 1982.

Map Information Centre

During the report period, the Map Information Centre received 411 sheets of various types of maps from nine countries.

Education and training

Various courses have been offered by the Survey School of the Royal Thai Survey Department:

(a) Three classes of a five-year survey engineering course for military cadets;

(b) One class of a 26-week advanced survey engineering course for senior commissioned officers;

(c) One class of a 26-week associated surveying course for junior commissioned officers who have never attended a five-year survey engineering course;

(d) One class of a 26-week aerial cartography and survey navigation course for commissioned officers;

(e) Three classes of a two-year basic surveying course for non-commissioned officers;

(f) Two classes of a 26-week advanced surveying course for master sergeants;

(g) One class of a 24-week associated surveying course for non-commissioned officers who have never attended a basic surveying course for non-commissioned officer students;

(h) One class of a nine-week cartographic draughting course for non-commissioned officers;

(i) One class of a 12-week surveying instrument course for non-commissioned officers.

During the reporting period, scholarships were granted to personnel of the Royal Thai Survey Department. As a result, Master's degrees from universities in Thailand and in the United States of America were conferred upon 6 officers, 5 officers have undertaken Master's degree programmes in Thailand and Australia, 3 officers accomplished three different post-graduate courses at the International Institute for Aerial Survey and Earth Sciences in the Netherlands, 6 officers completed six different courses in the United Kingdom of Great Britain and Northern Ireland and the United States, and 14 officers were trained abroad in 10 courses.

HYDROGRAPHIC DEPARTMENT

Hydrographic surveys

The areas of the Gulf of Thailand from Tao Island to Kra Island and from Kra Island to the southernmost part of Changwat Narathiwat were surveyed for the production of the small-scale nautical chart.

Nautical and aeronautical charts

Three new nautical charts were published, and 10 charts were revised.

Two new aeronautical charts were published, and seven existing charts were revised.

DEPARTMENT OF LANDS

As stated in the country report submitted to the Ninth Conference, a photogrammetric procedure was selected to produce a series of graphical cadastral photomaps for the issuance of land titles and certificates of land use to landowners. During the reporting period, the Department of Lands issued 104,215 land titles to landowners, covering a developed area of 686,687 rai (1,098.7 km^2);

issued 2,593,833 certificates of land use, covering a developed area of 20,109,161 rai (32,174.7 km^2); and completed aerial triangulations covering 8,880 km^2.

ROYAL THAI FOREST DEPARTMENT

The Royal Thai Forest Department, under the Ministry of Agriculture and Co-operatives, is responsible for producing various types of forest maps. Recently, due to political, economic and social pressures, the forest condition has consistently deteriorated . Thus, there is an urgent need to use modern techniques of remote sensing for surveying and mapping the forest resources in order to solve these problems.

Specific work done since the Ninth Conference includes:

(a) Forest type and land-use maps of eastern 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 scale and overprinted on maps series L 7017. During the report period, the Royal Forest Department published 52 sheets of type map in four colours, covering approximately 37,908 km^2;

(b) Existing forest maps of central, north-eastern and southern Thailand. These maps were produced by means of LANDSAT-2 imagery covering an area of about 306,968 km^2;

(c) Maps of forest land use in selected watershed areas of northern Thailand. These maps were produced by using four-band photographs obtained from the Royal Thai Survey Department. The objectives of this project are to select prime areas for initiating crop-replacement efforts by the hill tribes and to encourage these tribes to utilize wasteland instead of converting existing forest by shifting cultivation. The project began in 1980; and thus far, 15 watershed areas in northern Thailand, covering an area of about 750 km^2, have been surveyed and maps were produced as a useful tool for setting the policy of land-use planning in this region.

ROYAL IRRIGATION DEPARTMENT

The progress of the Royal Irrigation Department in the field of cartography and related activities during the report period is described below.

Aerial triangulation

The Royal Irrigation Department has improved its mapping activities in the field of photogrammetry. Aerial triangulation, which is the bottle-neck of the method, has been carried into the block adjustment through use of independent models. With the assistance of the United Nations Development Programme and the Food and Agriculture Organization of the United Nations, the Royal Irrigation Department was able to establish the Central Data Processing Unit for Photogrammetry in Thailand in late 1979. The PAT-M43 computer software developed by Stuttgart University was purchased and installed at the IBM 370/145 and the UNIVAC 1100/60. Input data were prepared from both an analogue plotter (Wild AMH) and an analytical plotter (Traster 77).

Since the establishment of the Central Data Processing Unit, the Royal Irrigation Department produced maps covering over 20,000 km^2 from the aerial photographs on scales 1:15,000 and 1:10,000 with highly satisfactory accuracy.

Topographic line maps

The Topographic Survey Division is responsible for making topographic maps, usually at 1:10,000 scale with 1-m contour interval, for feasibility study, planning and design of irrigation projects. In general, the photogrammetric method is employed for large and medium-sized projects. For small projects, topographic maps are prepared by surveyors attached to the regional irrigation offices, using the conventional terrestrial survey method.

During the report period, the Division produced topographic line maps covering approximately 15,200 km^2, of which 11,500 km^2 were done by means of the photogrammetric method.

Photomaps

The Topographic Survey Division has produced both rectified photos and orthophotos, mostly at 1:4,000 scale. Approximetaly 9,900 km^2 were covered by photomapping during the report period.

Cadastral survey

Photomaps at 1:4,000 scale efficiently facilitate the property boundary survey in the field. The area of lands is computed on an electronic co-ordinate reader equipped with a programmable calculator. About 1,930 km^2 were covered during the report period.

Spot height survey

The design and construction of on-farm development projects require photomaps at 1:4,000 scale with an 0.25-m contour interval. To achieve such high altimetric accuracy, dense spot heights must be surveyed in the field. These spot heights are usually selected from well-identified points on photomaps.

During the period under review, approximately 4,900 km^2 were covered by the spot height survey.

LAND DEVELOPMENT DEPARTMENT

In the Land Development Department, the Land Classification Division and the Soil Survey Division are responsible for cartographic activities.

Land Classification Division

Maps produced by the Land Classification Division are described below.

Land-capability classification maps

Land is classified into capability and suitability classes according to agricultural uses, e.g., upland crops, paddy, rubber, orchard and pasture. It is divided into three categories:

(a) General land-capability map of Thailand. The map scale is 1:250,000; it is printed in both multicolours and black and white. For the time being, only the black-and-white edition is available;

(b) Provincial land-capability map. This map at 1:100,000 scale is classified as "land capability and upland crops" and "land suitability for paddy-field". It is reduced from the 1:50,000 topographic map and printed in black and white; land-capability and land-suitability boundaries are overprinted in red lines;

(c) Project plan land-capability maps. For the project area that needs more detail data, 1:15,000 aerial photographs are interpreted and the data obtained are used in producing different types of maps at 1:20,000 scale covering: land capability for upland crops; land suitability for paddy-field; land suitability for rubber; land suitability for orchard; land suitability for pasture.

Current land-use maps

The land-use maps currently produced include:

(a) Regional land-use maps. There are two series of maps at 1:500,000 scale. The first series was produced from satellite imagery and was published in black and white in 1977. These maps were used as the base while the land-use boundaries were interpreted and overprinted in red lines. The second series was area symbols printed in black and white on topographic maps. It is expected that regional land-use maps will be produced every three years;

(b) Provincial land-use maps. Base maps at 1:100,000 scale were reduced from 1:50,000 topographic maps and printed in black and white. Land-use boundaries obtained by means of aerial photograph interpretation were overprinted in red lines. To date, provincial land-use maps covering 32 provinces have been published.

Provincial land-use planning maps

Natural resources and socio-economic data are used in land planning. The provincial land-use planning maps showing suitable uses of land with recommendations for soil improvement and alternative uses of land were produced for that purpose.

Landholding maps

After the completion of cadastral surveys, maps are produced on two scales, provincial scale 1:12,500 and project plan scale 1:5,000, to show the lad tenure and the current landholding condition of the farmers. They also provide information concerning topographic details, water distribution, infrastructure and communication systems etc.

Land type classification maps

This multicoloured map, printed in 1971 on the scale of 1:250,000, shows different land types according to the Cabinet's solution 17 years ago. The map was reduced to this scale from 1:50,000 to indicate the approximate boundary of the land types, e.g., permanent forest, settlment area, public pasture and paddy-field.

Soil Survey Division

During the report period, the Soil Survey Division of the Land Development Department reproduced the maps described below.

Soil-suitability maps for rubber-growing

The general soil maps of the southern and souht-eastern regions of Thailand were prepared and used as a basic information for interpreting soil suitability for growing rubber. Three suitability classes have been recognized: class I soil suited for rubber; class II soil poorly suited for rubber; class III soil unsuited for rubber.

After the soil in these regions had been interpreted, the suitability map for rubber-growing in the southern and south-eastern areas was published at 1:100,000 scale. In addition, the acreage and proportional extent of each suitability class were shown in the legend.

Potential land-use maps in reserved forest

Although the forest in Thailand has been registered as the national reserved forest, parts have been cleared for wood extraction and for shifting and permanent cultivation. For the purpose of forest reclassification, the potential land use in the reserved forest in each physiographical region in Thailand was prepared and published at 1:1,000,000 scale. The potential land-use maps were then superimposed on the reserved forest maps. Within each reserved forest, the potential of the land for agricultural production was delineated.

Maps showing unsuitable agricultural uses of land

Because parts of various soils in Thailand have not been used in accordance with their suitability for common crops, maps were produced in order to show areas where farmers have used the soil incorrectly. By superimposing the potential land-use map on the current land-use map, the boundary of unsuitable uses of land was delineated. This type of map was prepared at 1:100,000 scale for each physiographical region. The maps will be used for agricultural planning and land improvement.

Detailed soil maps for various projects

Most of the detailed soil maps for various projects were also published at 1:20,000 scale for: (a) the water-pumping project; (b) rain-fed agricultural development in north-eastern Thailand; (c) small-scale irrigation in north-eastern Thailand.

Soil salinity maps of north-eastern Thailand

The data for the soil salinity maps were compiled from the provincial soil maps, hydrological and geological maps and LANDSAT imagery. Field-checks have been performed in 15 north-eastern provinces during the dry season. The published map scale is 1:250,000.

Maps for Agricultural Land Development Project

Most of the maps for the Agricultural Land Development Project in northern Thailand were compiled from existing aerial photographs at 1:15,000 scale by PG II stereoplotter and are on the scale 1:10,000 with a 5-m contour interval. Soil, land capability, current land use and land tenure are shown in these maps.

Geomorphological maps

In addition to soil survey work, geomorphological study and mapping of some regions of Thailand have been conducted as a continuous project. Most of these maps were printed at 1:100,000 scale. To date, the geomorphological maps of certain parts of some provinces, namely, Changwat Kamphaeng Phet, Tak and Nakhon Ratchasima, have been published.

AGRICULTURAL LAND REFORM OFFICE

The Agricultural Land Reform Office (ALPO) under the Ministry of Agriculture and Co-operatives is responsible for public and private land reform for a total area of 5,121,069 rai (819,371 ha). Two main types of maps are prepared: maps for the planning stage; and those for the implementation stage. The basic maps for planning were almost completed during the period 1977-1979, and the major tasks remaining constitute mapping for implementation.

Maps for planning

During the report period, two types of maps for planning were produced:

(a) A topographic map on scales 1:10,000 or 1:5,000, with a 1-m contour interval, covering 1,316,632,865 rai (2,106.6 km^2);

(b) A cadastral map at 1:5,000 scale in which the ownership and area for each plot of land in the project were determined and registered; it covers 176,534 rai (about 282.5 km^2).

Maps for implementation

The suitable alternative routes of roads, waterways and other infrastructure were planned by engineers on the cadastral and topographic maps at 1:5,000 or 1:10,000 in which the proposed reallotment of farmers' plots will be designed. Furthermore, a new method of reallotment in public land has been introduced to prevent complete movement of the farmers who occupied the lands, by dividing the existing plots that exceed the average plot area considered by the committee

from the Agricultural Land Reform Office and leaving engineering development for a later stage. During the reporting period, reallotment maps covering 435,913 rai (almost 70 km^2) were produced.

The survey and mapping completed by ALRO for various projects during the period 1980-1982 are listed in table 14.

NATIONAL ENERGY ADMINISTRATION

The Surveying and Mapping Branch of the National Energy Administration is under the Investigation and Planning Division. The duty of the Branch is to collect all information related to the topography of the energy resource development project areas. The surveying and mapping works on scales ranging from 1:5,000 to 1:10,000, with contour intervals ranging from 1 to 5 m, have been produced using aerial photogrammetry. The other topographic maps of dam sites, resource deposits, power-plants, access roads, transmission lines and power routes, and the hydrographic map for navigational improvement of the International Mekong Project carried out by the Branch are accomplished by usual surveys. The photogrammetric instruments are two Kern PG 2, one of which is connected with Kern ER 2 and Digital Decwriter II and one Laser Transmark B point-marker. The final products distributed to other departments are in blueprints.

NATIONAL RESEARCH COUNCIL

Remote-sensing activities in Thailand

The national remote-sensing programme of Thailand was established in 1971 by Cabinet decision, as a step towards peaceful uses of space technology. Thailand was later accepted by the National Aeronautics and Space Administration (NASA) of the United States of America to participate in LANDSAT-1, Skylab EREP and LANDSAT-2 investigation programmes. As a result, up-to-date and accurate information was available to meet the needs of various government agencies concerned with planning for development and management of natural resources at the national level

The co-ordination centre of the remote-sensing programme was reorganized in 1977 as the Remote Sensing Division under the National Research Council (NRC) of the Ministry of Science, Technology and Energy. Apart from carrying out administrative work and co-ordination functions of the national co-ordinating committee, the Division provides user services in photographic reproduction of LANDSAT imagery and lends interpretation equipment and facilities to user agencies. There is a small technical library, and a quarterly newsletter is being issued. Research grants totalling $50,000 are provided each year to various agencies concerned with the applications of remote-sensing data. International co-operation, aside that maintained with the United States, was initiated and NRC currently has co-operative research programmes with France and Japan. Similar projects are being planned with members of the Association of South-East-Asian Nations (ASEAN).

Table 14. Survey and mapping work completed by the Agricultural Land Reform Office, Thailand, 1980-1982

Type of map and scale	Area covered			
	1980	1981	1982	Total
Maps for planning				
Topographic maps, 1:5,000 or 1:10,000	939 134.8 rai	105 172.5 rai	272 325.5 rai	1 316 632.8 rai
Cadastral maps, 1:5,000	92 813 rai	77 591 rai	8 130 rai	176 534 rai
Maps for implementation				
Road survey	24 km	446.15 km	297.96 km	768.10 km
Canal survey	8 km	590.56 km	57.2 km	655.76 km
Reservoir map, 1:1,000, 1:2,000	3 125 rai	14 538.8 rai	1 578.1 rai	19 241.9 rai
Maps for land and water conservation, 1:1,000	-	1 175 rai	12 809.7 rai	13 984.7 rai
Village map, 1:1,000	985.57 rai	28 174.37 rai	6 274.06 rai	35 434.00 rai
Reallotment map	119.937 rai	255 974 rai	60 002 rai	435 913 rai

Note: 625 rai = 1 square kilometre.

Applications of LANDSAT data

LANDSAT data have been applied in various disciplines, including agriculture, forestry, land use, geology, oceanography, hydrology and environmental monitoring. The multidisciplinary nature of LANDSAT data has brought resource managers, decision-makers and technicians together in the joint effort for a common goal. Several projects have attained quasi-operational status. Research and development in digital processing of LANDSAT data is increasing, although visual analysis of LANDSAT imagery still constitutes the major research and development effort. Some of the significant results are described below.

Agriculture

The greatest contribution of Earth resources satellite LANDSAT to Thailand is probably in agriculture. Research has been conducted in crop calendar and practices, with particular emphasis on economic crops, in assessing paddy-fields throughout the country and estimating coconut and rubber plantations along the eastern coast; and in some southern provinces, in monitoring the changes in cultivated land. Economic study has found that LANDSAT data are very cost-effective.

Forestry

LANDSAT data have been applied in the assessment of existing forest land, classification of forest cover types, and identification of shifting cultivation and watershed areas, as well as areas of cut forest. Changes due to land use in forest areas are also observed periodically.

Land use

A regional land-use map of Thailand using LANDSAT imagery has been carried out in a wide variety of classifications, such as: urban land; agricultural land; forest; water resources. The up-to-date information obtained is used as a basis for policy and design of national development planning of Thailand.

Geology

Experience to date has shown the many advantages of LANDSAT data over conventional aerial photography in locating large faults and fractures and in the preparation of tectonic maps. Several rock types can also be identified from LANDSAT imagery.

Oceanography and fishery

Remote sensing provides information on potential fishing areas. Certain fish stocks may also be located by identifying their habitats on the imagery. Repetitive coverage in coastal areas is useful in determining major changes in rates of pollution, sedimentation and erosion.

Hydrology and meteorology

Hydrological information acquired from satellites is very useful to water resources management.

Monitoring of floods and assessment of flood damage can be assisted by LANDSAT data, and real-time data from meteorological satellites will be needed for flood forecasting and flood warning.

Current research and development projects include:

(a) Application of machine-processing to plant acreage assessment and yield forecast of major crops, such as rice, sugar-cane and corn;

(b) Study of the relationschip between soils and geomorphological features by remote-sensing techniques;

(c) Use of satellite imagery to study changes in forested area, using both manual interpretation and digital processing;

(d) Mapping of agricultural land-use patterns using LANDSAT data;

(e) Use of satellite data to map the geological structure of Thailand;

(f) Applications of LANDSAT imagery to soil erosion pertaining to poor cultivation practices in northern and eastern Thailand;

(g) Determination of water yield in relation to rainfall and deforestation by using remote-sensing techniques;

(h) Study of environmental changes of Bangkok using LANDSAT data;

(i) Study of mineralization around Chiangmai Basin using satellite data;

(j) Study of muddy-water plume caused by offshore mining in southern Thailand using LANDSAT imagery;

(k) Land resource survey of the Central Plain of Thailand by remote-sensing technique;

(l) Evaluation of satellite remote-sensing imagery for geomorphological mapping of north-eastern Thailand;

(m) Development of a software package for geometrical correction of LANDSAT multispectral scanner digital data;

(n) Study of changes in mangrove areas in Thailand using LANDSAT imagery.

(o) Evaluation of the reforestation programme in northern Thailand using LANDSAT data.

Thailand LANDSAT/METEOSAT ground receiving station

The LANDSAT/METEOSAT ground receiving station completed in November 1981 has the capability to provide up-to-date and timely data both from Earth resources satellite LANDSAT and from meteorological satellites, such as NOAA and TIPOS-N and GMS. The GMS high-resolution picture transmission part of the station was installed and commissioned in early June 1981. The main station is located at a site just outside Bangkok. Sixteen countries or distinct geographical

territories could be wholly covered and six others partially covered by the Thailand station. Therefore, the Thailand LANDSAT/METEOSAT ground receiving station will be able to serve data needs of users of the region, especially those of ASEAN.

DEPARTMENT OF MINERAL RESOURCES

The Department of Mineral Resources is responsible for geological tasks. Surveying and mapping in connection with those tasks are performed by the following divisions:

(a) Geological maps of Thailand on various scales are prepared and published by the Geological Survey Division;

(b) Mineral distribution maps are compiled by the Economic Geology Division;

(c) Hydrogeological maps are prepared by the Ground-water Division;

(d) Levelling and cadastral surveying for mineral prospecting and mining concessions are mapped by the Survey Division.

Systematic geological mapping of the entire country at 1:250,000 was initiated in 1966. The basic standard topographic maps at 1:50,000 scale, produced by the Royal Thai Survey Department, were used as the data-base maps.

The mineral distribution maps were printed at 1:2,500,000 and show 14 mineral deposits in Thailand. Two sheets of the geochemical map at 1:250,000 scale were also compiled by the Economic Geology Division.

In 1976, six sheets of the above-mentioned maps were printed by the Royal Thai Survey Department. The next seven sheets were printed by the Federal Republic of Germany during the period 1976-1981, under the joint effort of the Geological Mission Programme of the Federal Republic of Germany, which was initiated in 1972.

In 1980, the Geological Survey Division established the printing unit to print all maps produced by the divisions. Despite the establishment of the printing unit, limitation of budget and equipment made it necessary to acquire help from the Royal Thai Survey Department whenever a large number of maps had to be produced.

The following maps were prepared during the report period: (a) 1 sheet of the geological map of Thailand at 1:1,000,000 scale; (b) 5 sheets of the geological map of Thailand at 1:500,000; (c) 34 sheets of the geological map of Thailand at 1:250,000; (d) 1 sheet of the lineament map of Thailand at 1:1,000,000; (e) 1 sheet of the tectonic map of South-East Asia at 1:2,500,000; (f) 3 sheets of the geochemical map at 1:250,000; (g) several other topics of thematic maps.

DEPARTMENT OF SURVEY ENGINEERING, CHULALONGKORN UNIVERSITY

The Department of Survey Engineering was founded in 1955 within the Faculty of Engineering of Chulalongkorn University. The objective of the Department is to provide the theoretical principles and practical techniques on surveying and mapping necessary for various engineering and development projects. Courses offered in the Department, in both the undergraduate (Bachelor's degree) and Master's degree programmes, cover broad fields of surveying, photogrammetry and remote sensing, cartography and geodesy.

Bachelor's degree programme

The structure of the curriculum in the Bachelor's degree in survey engineering is:

(a) General education (conformed to the University Bureau resolution): 21 semester credits comprising 6 credits in social studies, 6 credits in humanities and 9 credits in English;

(b) Engineering core courses: 48 semester credits comprising 14 credits in mathematics, statistics and computer, 15 credits in physics and chemistry, and 19 credits in basic engineering courses;

(c) Civil engineering and geology: 27 semester credits;

(d) Department core courses: 40 semester credits comprising 11 credits in surveying and mapping, 6 credits in applied mathematics and adjustment computation, 8 credits in photogrammetry and remote sensing, 10 credits in geodesy and astronomy, and 5 credits in cartography;

(e) Electives: 8 semester credits.

Total credits for graduation are 144 semester credits, which would take eight semesters. A minimum average grade point of 2.00 from a 4.00 scale is required for graduation.

Master's degree programme

A total of 48 semester credits, of which 30 credits are for course work and 18 credits for a research thesis, are required. The minimum average grade point for graduation is 3.00.

Researches and projects

The Department of Survey Engineering has done a number of research projects in large-scale mapping and surveying, and terrestrial photogrammetry for conservation of historical sites.

In 1982, The Department set up a horizontal control network of 250 stations in the north-eastern part of the Greater Bangkok Metropolitan area for the Land Department. Its aim is to set up control for photogrammetric block adjustment

to be used for cadastral mapping. Earlier, in 1979, a levelling network of 124 bench-marks was established by the Department for the Bangkok Metropolitan Authority, to be used as vertical control for various engineering purposes.

The Department also organized the first national-level Surveying and Mapping Conference, which was held from 3 to 5 September 1980 and was attended by about 250 participants. Thirty-five technical papers also were presented at the conference.

Current status

The Department of Survey Engineering has 13 faculty members, 90 undergraduate students and 26 graduate students. In 1981, the Bachelor of Engineering degree was awarded to 17 students. In 1982, two Master of Engineering and 17 Bachelor of Engineering degrees were awarded.

REPORT ON SURVEYING AND MAPPING IN THE UNION OF SOVIET SOCIALIST REPUBLICS*

Paper submitted by the Union of Soviet Socialist Republics

RESUME

Le document décrit les principales orientations des travaux de levé et d'établissement des cartes menés en URSS. Il contient des renseignements sur les progrès réalisés dans l'automatisation de certaines phases de ces travaux, sur les nouveaux types d'objectifs des caméras aéroportées, les appareils de restitution photogrammétriques, le logiciel de la triangulation analytique, l'utilisation des techniques spatiales et des images spatiales, les cartes topographiques des plateaux continentaux, les progrès de la cartographie thématique, etc.

Surveying and mapping continued to be carried out in the Union of Soviet Socialist Republics, to meet the requirements of national economic development and scientific research in accordance with the economic and social development plans of the country.

Large scale surveys, sea-bottom surveys in shelf areas and bottom surveys in lakes, as well as map revision, constitute the main part of surveying activities. Topographic surveys were performed on the scales 1:25,000, 1:10,000, 1:5,000 and 1:2,000; and map revision was done on all scales up to 1:100,000.

In producing maps, atlases and other cartographic materials, the maps and atlases produced for schools in all languages of the republics of the Soviet Union took priority.

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* The original text of this paper appeared as document E/CONF.75/L.96.

To further increase production efficiency and to improve quality, new instruments and technologies are being developed. Special attention is being paid to the development of a computer-aided mapping system, AKS, which utilizes the software for the universal system of EC series computers and computer-driven EC-7054 automatic plotters. This system is currently being used primarily for the smallest scales (1:2,500,000-1:1,000,000) and large scales (1:500-1:2,000), as well as for layout of highways and irrigation system projects. Another task is data bank development, mainly for towns and cities.

In the field of aerial survey, cameras with high-level illumination lens power are being developed, along with automatic exposure correction units for use in the new aerial survey cameras. Panoramic aerial survey cameras and photogrammetric equipment for panoramic images are being tested to improve the quality of image interpretation and for use in revising topographic maps.

The development of a computer-aided mapping system is closely related to such problems as introducing the following instruments into production: electronic tacheometers; automatic data-recorders; digitizers with automatic line-tracing; computer-driven plotters with light tracing of symbols; and display units.

A new NT stereo-marking instrument has been developed for analytical network densification. It marks the points on images with scale differences up to 15 times within a mean square error of 2 metres per kilometre. A new stereoscope also has been developed and tested; it has a special marking device to mark points on the images in the field.

In co-operation with the MOM Enterprise in Hungary, serial production of SC stereoplotters, image size 18 x 18 cm, was initiated.

Analytical triangulation programmes developed in the USSR encompass processing of stereocomparator data, aerial camera calibration data obtained by images over test-fields, build-up and adjustment of strips and blocks, calculation of co-ordinates of digital terrain models and initial data for photogrammetric instruments.

The software for the universal system of EC series computers is widely used, and the complex of computer programs has been broadened. Although new software will be developed over several years, its separate links will be used as soon as they become available.

Methods of strict photogrammetric network adjustment, which account for systematic errors, are being developed in order to increase the accuracy of photogrammetric nets.

Stereocomparators produced in the German Democratic Republic are used to prepare data for analytical net densification, and there is broad co-operation with that country also in development of new photogrammetric instruments. In addition, there is broad use of instruments coupled with the IZOT automatic data-recorder made in Bulgaria.

In the USSR, space imagery is used for compilation of thematic maps for various purposes, as well as for map revision, beginning with scale 1:200,000 and smaller scales.

The volume of large-scale surveys of the bottoms of seas, lakes and major rivers has increased in recent years. For hydro-acoustic measurements, echo-sounders and panoramic-view hydro-locators are used. For survey vessel position-fixing, radio-geodetic positioning systems are used. Technologies of shelf mapping are continuously improved, and a system of symbols for shelf topographic maps that is in full agreement with ground surface symbols has been developed.

Sea-bottom topographic surveys are considered to constitute a single entity with ground surveys. Unlike bathymetric charts, topographic maps of sea and lake bottoms have the same altitude system as terrain maps; and the topography is plotted by contour lines. The maps are in Gauss projection, with the same map-sheet division for all scales. Thus, one can study terrain and sea-bottom structures as a whole, as well as plot all the communication lines for exploitation of sea resources and--first of all--for pipelines for sea oil and gas.

In the Soviet Union, thematic mapping is being developed for environmental monitoring, planning, management and scientific research. Maps are prepared for different planning and management levels. Special attention is given to production of maps for short- and long-term planning.

Currently, in addition to the general thematic maps for the entire country, such maps are being prepared for investigations preceding planning and decision-making, and for planning and management on the level of republics, regions and provinces, as well as regional complexes. These thematic maps are used for planning and construction of new objectives of the national economy, earth resources planning and rational utilization, environmental protection and forecasting of environmental changes resulting from human activities. A large volume of map-making is carried out for agriculture and land management.

In thematic atlases, environmental aspects are predominant among the topics. Regional atlases of planning and management for the Baikal-Amur Railway and for the north-west and the north-Caucasus regions of the USSR are being published. Work on fundamental cartographic editions also is continuing; for example, an atlas on "Snow and glacial resources of the world" is being prepared.

As concerns international co-operation, the Soviet Union is participating in preparation of the Linguistic Atlas of Europe, the Atlas of European Highways and the Atlas of COMECON Countries. Furthermore, revision of the International Worl Map at 1:2,500,000 scale has begun.

Another major trend in cartographic activities in the USSR is a complex cartographic inventory of natural resources using imagery from space.

In the field of map graphical art, a new technology for production of plastic globes is being developed.

In map production, the most modern and efficient methods of map and atlas printing introduced include use of a standard triad of colours rather than 6-10 colours using photomechanical and electronic colour separation and multi-colour map-printing in four colours instead of 8-12 colours or more.

The developments described above have increased labour productivity.

The density and accuracy of the national geodetic network satisfies the requirements of mapping programmes and civil engineering in the Soviet Union. However, the necessary steps are being taken to rebuild, densify and preserve the network so that it can respond to modern requirements. New methods of mathematical adjustment of control networks using modern computers have been developed. These methods are designed to solve tens of thousands of normal equations, using the multi-group solution method developed in the 1940s by Soviet scientist Pranis-Pranevitch.

In accordance with the 1977 programme for the levelling network, modernization and densification are carried out, in particular for studies of vertical movements of the Earth's crust. Work on new maps of contemporary movements of the Earth's crust has been continued, using geodetic data. More than 300,000 km of repeated levelling lines will be used in compiling the maps. At the end of the 1970s, the geodesists of the USSR celebrated the hundredth anniversary of the high-precision levelling network, which they consider unique in world geodetic practice because of the volume of data used and the vastness of the terrain covered. The manual of first-order and second-order levelling, summarizing both USSR and foreign long-term experience, was prepared.

Geodetic instruments meeting modern specifications are now being produced in the USSR for use in extensive survey work. Tests of a domestically produced TA-5 tacheometer also have been conducted successfully. Mass production of the 3SM2 survey range-finder is being prepared; and mass production of the Granat radio range-finder, intended to measure distances of 15-20 km, has begun.

As concerns gravimetry, the tempo of development of the gravimetric networks and surveys has been sustained. Investigations to increase the accuracy of gravimetric determinations have been conducted. The fundamental gravimetric network has an accuracy of better than $\pm$ 0.03 megagal, and the first-order gravimetric network has a random-point error of not more than $\pm$ 0.05 megagal.

Geodynamic investigations to study movements of the Earth's crust and to forecast earthquakes have great social and scientific significance. Geodetic methods to determine the exact locations of mutual positions of points are used extensively in studying deformations of the Earth's crust resulting from earthquakes, as well as those caused by human activities. The rapide development of complex geophysical investigations during the past decade resulted in creation of a number of geodynamic test networks in the USSR; they are developed in seismic areas and in places where high dams, hydropower plants and other engineering installations are located. Both planimetric and vertical control surveys are carried out there at regular intervals and are then analysed with computers.

The significance of applied geodesy in civil engineering, in particular as concerns unique buildings and construction, is constantly increasing. Much attention is given to the problems of automation of civil engineering surveys undertaken to monitor construction and the installation of technological equipment. Photogrammetry is more and more extensively used in applied geodesy.

The utilization of space technology for Earth resources inventory gave rise to a new scientific trend, and space imagery is currently used by many agencies in the Soviet Union. Such imagery is particularly useful in geology, agriculture,

forestry, water resources inventory and land reclamation. The Salyut type of manned space station is expected to carry out a number of experimental works in space--visual and instrumental surveys for inventory of land resources and environmental protection. The ground equipment for processing aerial photographic data and space imagery serves to rearrange the initial data into a form that can be applied in various branches of the national economy. Both the number of types of images for cartographic application and their quality are thereby increased.

The USSR participates extensively in scientific/technical and economic co-operation in the fields of geodesy and cartography, in particular with the member countries of the Council for Mutual Economic Assistance. In the Asia and the Pacific region, there is co-operation with the Lao People's Democratic Republic, Mongolia and Viet Nam, among others.

The USSR provides assistance to many countries of Africa and Asia in educating their engineers and technicians, geodesists, surveyors, photogrammetrists and cartographers. Soviet consulting engineers, geodesists, surveyors and cartographers work in a number of countries; and specialists from those countries are being trained in the Soviet Union, where they study the advanced experience gained in management and planning in surveying and mapping. Thus, in a short period of time, it is possible for these countries to set up new, self-reliant survey agencies that are capable of performing the full complex of survey and mapping work to promote economic and social progress.

REPORT ON ACTIVITIES OF THE UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RESUME

Le rapport porte sur la contribution du Gouvernement du Royaume-Uni de Grande-Bretagne et d'Irlande du Nord et de ses agences aux opérations de levé et d'établissement des cartes des pays et des mers de l'Asie et du Pacifique entre octobre 1979 et novembre 1982.

Les travaux ont été effectués par:

a) La Direction des services cartographiques outre-mer et le Centre de mise en valeur des ressources terrestres, en vertu d'accords réciproques de coopération technique; ces deux agences relèvent de l'Administration britannique pour le développement outre-mer. A partir de 1984, la Direction sera la Division outre-mer du Service géographique du Royaume-Uni, mais continuera à s'occuper de l'établissement des levés et de la formation pour les pays en développement.

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* The original text of this paper, prepared by the Directorate of Overseas Surveys, appeared as document E/CONF.75/L.115.

Les demandes d'assistance devront continuer à être adressées sous couvert de l'Ambassade britannique, du Haut Commissariat ou du British Council, selon le cas;

b) La Direction des levés militaires et le Département hydrographique du Ministère de la défense, à la demande.

Les travaux sur le terrain, la production de cartes, la formation et les affectations d'experts sont également décrits dans le rapport.

During the period between October 1979 and November 1982, government agencies of the United Kingdom of Great Britain and Northern Ireland contributed to the surveying, mapping and charting of countries and seas of Asia and the Pacific as described below. This work and other related activities were carried out by:

(a) The Directorate of Overseas Surveys (DOS) and the Land Resources Development Centre (LRDC), both of which are part of the Overseas Development Administration (ODA). In 1984, DOS will become the Overseas Division of the Ordnance Survey of Great Britain but will continue to carry out survey mapping and training functions for developing countries. Requests for DOS assistance should continue to be channelled to ODA through the British Embassy, High Commission or British Council as relevant;

(b) the Directorate of Military Survey and the Hydrographic Department, Ministry of Defence, on request.

During the period under review, the United Kingdom also presented the following papers to the Fourth United Nations Conference on the Standardization of Geographical Names, held at Geneva, from 24 August to 14 September 1982: "Report of the United Kingdom Division of the United Nations Group of Experts on Geographical Names" (E/CONF.74/L.49); "Report by the United Kingdom" (E/CONF.74/L.50); "Report on national gazetteers" (E/CONF.74/L.51); "The status of the English language" (E/CONF.74/L.54); "Romanization in the context of the United Nations" (E/CONF.74/L.55); "Report by the United Kingdom expert to the Working Group on a Single Romanization System on Each Non-Roman Writing System" (E/CONF.74/L.56); "Toponymic guidelines for cartography in Great Britain" (E/CONF.74/L.57); "The computer processing of geographical names for map and gazetteer production" (E/CONF.74/L.58); "The application of Pinyin spelling for geographical names (E/CONF.74/L.59).

AERIAL PHOTOGRAPHY, FIELD SURVEY, TOPOGRAPHIC AND THEMATIC MAPPING

Aerial photography

The Directorate of Overseas Surveys arranged for aerial photography to be taken of Yemen during October-November 1980, and a further contract was flown in October 1982 for the mapping projects at 1:50,000 scale. In December 1981, aerial photography of the Sundarbans Forest was flown; the photography will be used to prepare up-to-date maps for the Forest Inventory Project, which is

being supported by ODA and its specialist unit, the Land Resources Development Centre, in co-operation with the Government of Bangladesh.

Field survey

Throughout the period, a DOS field-party worked in Yemen, continuing with the establishment of a main survey framework and the observation of control for the 1:50,000 mapping. They also carried out field completion of the photogrammetric plots, adding new tracks, administrative boundaries, and other cultural information, and tape-recording the place names ready for transliteration by the United Kingdom Permanent Committee on Geographical Names.

Since January 1979, the Directorate of Military Survey, in conjunction with their host departments, has observed a total of 51 precise ephemeris Doppler fixes in Bahrain, Brunei Darussalam, Dubai, Hong Kong, Macao, Nepal, Sabah, Sri Lanka and Vanuatu. The work in Vanuatu is of particular interest as it will provide the basis for the definition of its exclusive economic zone in terms of the World Geodetic System 1972 (WGS 72) reference system. Wherever possible, surveyors from the host survey departments have been seconded to the observing teams to learn the new tchnology.

Other geodetic activities in Nepal include gravity transfers from Colombo and Bangkok to Kathmandu and a limited survey in the Kathmandu Valley. Work has begun on the observation of a first-order framework for the Neapl Survey Department which will include several of the Doppler stations.

Topographic mapping

The topographic maps published by DOS are listed in table 15. Topographic mapping was carried out for five countries; DOS completed the 1:5,000 mapping in the joint project with Cyprus, the 1:25,000 series of Kiribati and the photomap series of Tuvalu. Work is continuing on the 1:50,000 Kiribati series (Tarawa and Christmas Island) and on the small-scale administrative map. A two-sheet administrative map of Nepal, with a mosaic base made from LANDSAT imagery, has been completed and copies will be available in January 1983. The first 48 sheets of the new series of Yemen have been published and work is continuing on a further 124 sheets. Preparatory work on Arabic versions of the 1:50,000 series has commenced.

Thematic maps

The thematic maps produced by DOS are listed in table 15. The multicoloured geological maps of the Pakistan Salt Range were produced in collaboration with the Geological Survey of Pakistan and the geologist who undertook the original survey on 1" sheets in the 1920s; he was able to visit Pakistan to update his material where necessary. The 1:100,000 geological series of Oman ophiolite areas (four sheets), produced as part of an ODA-sponsored research project, were completed and the final sheet is currently being printed. A further sheet in the 1:100,000 geological series of Vanuatu was published and source material for the final sheet was received at DOS in October 1982.

Table 15. Summary maps of Asia and the Pacific produced by Directorate of Overseas Surveys, United Kingdom of Great Britain and Northern Ireland, November 1979-Novembre 1982

Country and scale of map	Area covered	Type	Number of sheets
Cyprus			
1:5,000	Southern part of island[a/]	Contoured	75[b/]
Kiribati			
1:25,000	Abemama Abiang, Tamana and Arorae, Aranuka, Nonouti, Onotoa, Tabiteau, Tarawa	Photomaps	17
Oman			
1:100,000	Ophiolite areas	Geological	3
Pakistan			
1:50,000	Salt Range	Geological	6
Tuvalu			
1:12,500	Nanumea and Niotoa	Photomaps	2
	Nui and Nanumanga		
1:25,000	Nukufetau	Photomap	1
1:50,000	Funafuti	Photomap	1
Vanuatu			
1:100,000	Aoba and Maewo	Geological	1
1:1,000,000	Entire country, revision	Administrative	1
Yemen			
1:50,000	South-western Yemen	Contoured	48
1:500,000	Entire country (Arabic version)	Administrative (layered and contoured)	1
1:50,000	Montane Plains	Soils and land suitability	5[c/]

a/ Joint project of the Department of Lands and Surveys, Cyprus; and the Directorate of Overseas Surveys.

b/ Eleven sheets were mapped by the Department of Lands and Surveys, Cyprus; and were fair-drawn and printed in the United Kingdom of Great Britain and Northern Ireland.

c/ For the Land Resources Development Centre.

For the Land Resources Development Centre, DOS produced five sheets of the Montane Plains in Yemen at 1:50,000 scale, using a LANDSAT mosaic image base overprinted with soil and land-suitability information.

In addition, LRDC has produced mapping to accompany reports on projects in Bnagladesh, Cyprus, Indonesia, Nepal, Papua New Guinea and Sri Lanka.

HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING

Hydrographic surveying

For the first three months of 1979, HMS Herald, Hydra, Fox and Fawn were deployed on contract surveys off the coast of the Islamic Republic of Iran. No further surveying was conducted in Asian waters until the latter part of 1981, when HMS Herald undertook surveys in the approaches to Hudaydah, Yemen; and Fujairah, United Arab Emirates; and an executive survey covering 40 miles of the coast of Oman (see table 16).

The hydrographer always views requests for assistance sympathetically but inevitably finance constrains the amount of help that can be offered. Assistance in the form of advice on new ventures can more readily be given and he was pleased to be able to meet such a request from Bahrain. The Assistant Hydrographer visited the country to give advice on plans for surveying and charting, and this visit is being followed up by further advice in planning aerial survey.

It has not been possible to deploy a hydrographic surveying vessel in the Pacific in recent years. An officer has been seconded to head the Hydrographic Survey Unit in Fiji, however, and this assistance will continue to be offered for the foreseeable future.

Nautical charting

Normal maintenance and updating of Admiralty charts of the area have continued. There has also been considerable progress in redrawing of charts in the new format using metric units.

The new charting of the Gulf, including small-scale charts, is now almost complete, with only one chart at 1:1,500,000 scale and a sheet of plans remaining to be published. Metric chart coverage of Singapore is complete; and coverage of Bangladesh, Fiji, India, Solomon Islands, Sri Lanka and Vanuatu is well in hand.

Work is underway to improve the United Kingdom coverage of many other areas of southern and eastern Asian waters, including China, Hong Kong, Japan, the Republic of Korea, Thailand and parts of Indonesia. It is of interest to note that the United Kingdom has published some charting of the new deep-water port of Yanbu on the Red Sea; and, additionally, Saudi Arabia has now contracted to a private firm to survey and chart its entire coastline.

During the past three years, the United Kingdom has progressed with the adoption of the 1:3,500,000 International Charts of the Pacific Ocean, drawn

Table 16. Hydrographic surveys in Asian and Pacific waters by vessels of Royal Navy, United Kingdon of Great Britain and Northern Ireland, 1979-1982

Area	Scale	Year
Gulf of Suez and Red Sea		
Sha'b Abu Nukâs, Strait of Gubal	1:25 000	1979
Felix Jones Patches	1:25 000	1979
Suez Bay	1:20 000	1981
Approaches to Hudaydah	1:25 000	1981
Al Jabanah	1: 5 000	1981
Oman		
Approaches to Fujairah	1:10 000 1:25 000	1981 1981
Approaches to Wudam	1:25 000	1981
Outer approaches to Wudam	1:50 000	1981
Ras Hilf Anchorage, Masirah Island	1:20 000	1982
Southern approaches to Masirah Channel	1:50 000	1982

internationally agreed specifications and produced by Australia, Chile, France, Japan, New Zealand and the United States of America. Five more adopted charts remain to be published in the United Kingdom series. The adoption of Australian and New Zealand charts of their respective waters has continued under the terms of the trilateral charting agreement.

AERONAUTICAL CHARTS

During the period under review, the Directorate of Military Survey produced four Operational Navigation Charts at 1:1,000,000 scale and 13 Tactical Pilotage Charts at 1:500,000. For sheet numbers, see table 17.

TRAINING AND SECONDMENT OF EXPERTS

Training

DOS continued to provide training in cartography and photography. Courses were tailored to meet the needs of individual departments; and trainees were funded by United Kingdom technical co-operation training awards, by United Nations fellowships or by their own Governments. Trainees came from:

(a) Brunei Darussalam: 1979-June1980 (one); August 1980 - August 1981 (one); September 1981 - July 1982 (three);

(b) Fiji: 1979-September 1980 (one);

(c) Iran (Islamic Republic of): May-August 1980 (one);

(d) Iraq: February-April 1980 (one);

(e) Nepal: March-August 1982 (two);

(f) Sarawak: June 1980 - January 1981 (one); and August 1980 - February 1981 (one).

In addition, a number of United Kingdom technical co-operation awards were granted for the pursuance of academic courses in surveying, cartography and printing at universities and colleges in the United Kingdom; and for the special Middle Management Courses for Land Surveyors and Land Officers sponsored by ODA through the British Council, which were held at North East London Polytechnic from February to June 1980 and from April to July 1982. Participants for the Middle Management course included personnel from Solomon Islands and Yemen in 1980, and from Kiribati, Tuvalu and Vanuatu in 1982. A further course is planned for 1984. During 1982, two new courses were formulated that are of direct interest. To meet the need for training in cadastre, a one-year post-graduate diploma course is being introduced at North East London Polytechnic beginning in Ocotber 1983; and a new Master of Science course in remote sensing is to commence in October 1983, run jointly by University College and Imperial College of the University of London. A revised booklet detailing full-time training facilities in the United Kingdom in the fields of land survey, photogrammetry and photo interpretation, cartographic and map production including printing,

Table 17. Production of aeronautical charts of Asia and the Pacific by United Kingdom of Great Britain and Northern Ireland, October 1979 - November 1982[a/]

Series	Scale	Published		In production
Operational navigational charts	1:1 000 000	H5, J6, J7, N17		P 16
Tactical pilotage charts	1:500 000	J6-B, J6-C) J7-A, H5-A) H5-D, H7-D) G4-C)	1980	-
		H5-B, H5-C) J7-C, G4-D)	1981	-
		J7-B, J7-D	1982	

a/ Produced by Directorate of Military Survey.

remote sensing, cadastre, land registration and hydrographic surveying, was produced by DOS to be presented at the Fifth United Nations Regional Cartographic Conference in Africa in February 1982. Further copies of the booklet will be available from DOS.

Hydrographic training was provided for a number of personnel; for details, see table 18.

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, as noted below:

(a) Fiji: hydrographic surveyor, ongoing;

(b) Indonesia, Direktorat Irigasi: land survey adviser, October 1980 - July 1982; land survey adviser, July 1982 - ongoing; surveyor, January 1982 - ongoing; cartographer, June - September 1981 (special short-term appointment to assist land survey adviser);

(c) Indonesia, Direktorat Tata Kota, Dan Kota Daerah: project cartographer, November 1980 - ongoing;

(d) Kiribati: survey officer, August 1982 - ongoing;

Table 18. Training at the Royal Navy Hydrographic School: courses taken by students from Asian and Pacific countries, 1980-1982

Type of course	Country and number of students		
	1980	1981	1982
Officers' Basic Course	-	Pakistan (1)	Malaysia (4) Pakistan (1)
Officers' Long Course	Malaysia (6) Australia (1) New Zealand (1)	Malaysia (2) Australia (1) New Zealand (12) India (1) Pakistan (1)	Malaysia (2) Australia (1) New Zealand (2) India (1) Pakistan (1)
Senior Rating Course	-	Malaysia (6) Pakistan (2)	-

(e) Solomon Islands: chief surveyor, 1979 - July 1980;

(f) Vanuatu: land surveyor, ongoing (chief surveyor from October 1980); land surveyor, April 1981 - ongoing;

(g) Yemen: survey advisers, 1979 - February 1980 and September 1981 - ongoing.

In addition, ODA has continued, at the request of oversea countries, to recruit experts to fill specialist posts and to finance salary supplementation schemes as necessary.

REPORT ON CARTOGRAPHIC ACTIVITIES OF THE UNITED STATES OF AMERICA*

Paper submitted by the United States of America

RESUME

Le document contient un résumé de l'état d'avancement des principaux programmes exécutés par les Etats-Unis d'Amérique dans les domaines de la cartographie et de la géodésie. Durant la période considérée, les Etats-Unis ont poursuivi, dans le cadre de leurs programmes de cartographie, la collecte et la mise à jour de données horizontales et verticales en vue de réorganiser le Programme national de cartographie, compte tenu des besoins croissants et pour utiliser avec plus d'efficacité des techniques de cartographie perfectionnées.

Durant toute cette période, l'importance accrue accordée au perfectionnement et à l'utilisation plus large des techniques et appareils de cartographie informatisée employés à différentes étapes de la production, de la révision et de la mise à jour de cartes nautiques, aéronautiques, topographiques etc., a été déterminante pour l'orientation et l'expansion des activités dans ces domaines.

Le rapport des Etats-Unis contient des informations fournies par les principaux organismes nationaux, notamment par les services de cartographie suivants: United States Geological Survey; National Ocean Survey; Defense Mapping Agency.

The progress and current status of the major mapping, charting and geodesy programmes of the United States of America are summarized in this paper. The report contains information from all of the major national agencies, with significant contributions from the United States Geological Survey (USGS), the National Ocean Survey (NOS) and the Defense Mapping Agency (DMA).

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* The original text of this paper appeared as document E/CONF.75/L.67.

GEODESY

Horizontal control network

The new adjustment of the North American Horizontal Datum (NAD), recommended by a committee of the National Academy of Sciences and the National Academy of Engineering, is well under way. The National Geodetic Survey (NGS) of the National Ocean Survey has worked in close co-operation with Canada, Denmark, Mexico and Central American countries on the NAD project. The Defense Mapping Agency Hydrographic/Topographic Center (DMAHTC) is continuing to validate all geodetic data in Mexico. The constants of the Geodetic Reference System (1980) were adopted at the International Union of Geodesy and Geophysics/ International Association of Geodesy Conference at Canberra, Australia, in December 1979. These values will be used in NAD for definition of the datum.

Vertical control network

In 1978, NGS initiated a programme to resurvey and publish new adjusted elevations for the primary lines of the National Geodetic Vertical Control Network (NVCN). The National Geodetic Vertical Datum (NGVD) programme, currently scheduled for completion in 1987, includes new levelling surveys and replacement of destroyed control marks over 100,000 km of NVCN.

To date, 23,000 km of field levelling surveys have been completed for the NGVD programme, descriptive information for 457,000 vertical control marks has been keyed and edited, geographical positions for 276,000 vertical control marks have been plotted, 617,000 km of archival levelling surveys have been keyed and edited, and 22,000 vertical control mark elevations have been adjusted.

Doppler satellite surveys

To support the new adjustment of NAD, 138 satellite positions were established in the United States, including Puerto Rico, the Virgin Islands and Alaska, primarily in support of the new adjustment of NAD. Four Doppler stations along the border between Canada and the United States were occupied in 1979 for compatibility studies of the Canadian and United States Doppler networks. Doppler observations continued through the reporting period at the Ukiah Latitude Observatory, California, in support of the international polar motion project.

The June 1980 revision to the Federal Geodetic Control Committee (FGCC) publication, Specifications to Support Classification, Standards of Accuracy and General Specifications of Geodetic Control Surveys, contains recommended procedures for Doppler satellite surveys. Because many factors affect the accuracy of positioning by Doppler techniques, the operation of Doppler receivers and the computer reduction programs should be checked by testing the precision of the measurements and by comparing the results with known geodetic control. These calibration surveys will serve to demonstrate, with reasonable assurance, that the required accuracy for a survey can be met.

Gravity

The National Geodetic Survey gravity field-party occupied 561 gravity stations in states east of the Mississippi River, primarily in support of the NGVD project. The gravity field-party also observed gravity along a designated line which is scheduled to become the new Blue Ridge Mountain short-range calibration line. NGS updated and upgrated its gravity data base, which now contains approximately 1.5 million gravity records.

In 1980, the Air Force Geophysics Laboratory observed 11 gravity sites in Massachusetts, New Mexico, Colorado, Wyoming, Montana, California, Maryland and Texas. In 1982, the Joint Institute for Laboratory Astrophysics observed 12 sites in New Mexico, Wyoming, Montana, California, Colorado, Massachusetts and Maryland. Throughout the United States, about 17,000 gravity anomaly stations were observed during the period 1980-1982.

DIGITAL CARTOGRAPHY

There are two principal uses of digital cartographic data. The first is as input for a variety of geographical information systems used by federal, state and local government agencies to support resource and management decision-making processes. A common element in these information systems is the combination of digital cartographic data with other types of data to address resource and management questions.

The second major use of digital data is to expedite and enhance the production of various maps and charts. Many elements of the map production and revision process can be accelerated, improved and made more effective through the use of digital techniques.

The United States Geological Survey is building a digital cartographic data base compatible with the content and accuracy of 1:24,000 scale maps which contains data that serve a wide range of applications, such as:

(a) Evaluating areas as to their suitability for various activities, such as farming, grazing and timber production;

(b) Recording boundary and public-land surveying data;

(c) Computing overburden to evaluate the economic feasibility of extracting subsurface mineral deposits;

(d) Analysing terrain for air pollution and wildlife-habitat studies;

(e) Supporting such scientific efforts as the space programme;

(f) Revising data shown on printed maps and charts.

The files in the data base are in 7.5-minute units grouped into two categories, digital elevation models (DEM) and digital line graphs (DLG). DEMs consist of a sampled array of elevations for a number of grouped positions that are usually at regularly spaced intervals. DLGs consist of line-map information including such linear features as streams, boundaries and transport systems.

During the reporting period, USGS entered about 4,780 DEMs and about 10,080 DLGs into the digital cartographic data base. In addition, USGS digitized 149 maps separates from 1:2,000,000 scale sectional maps in the National Atlas to meet the need for a small-scale digital data base covering the entire United States. The data categories include civil boundaries, federal lands, road and railways, hydrographic features, populated places and such miscellaneous cultural features as airports.

Systems for nautical and aeronautical chart production, maintenance and distribution continue to be developed by NOS. Nuatical charting software has now been developed and installed to perform automated selection of: (a) soundings critical to navigation; (b) background soundings to portray the bottom configuration; and (c) information about natural channels including least depth. Investigation is continuing on contouring algorithms. The current method tends to generalize mode values in areas of great relief.

Work has begun on the interactive editing of soundings and contours by allowing the cartographer to make final selections at the Automated Information System (AIS) work-station.

The Defense Mapping Agency continues to produce digital data products for use in flight simulation. Information on cultural and natural surface features is stored in digital form. Also, information on vertical obstructions to low-level aircraft flight is stored in digital form and displayed as digital graphics.

AERONAUTICAL CHARTING

The aeronautical charting programme of NOS is in direct support of the National Airspace System of the United States and responds to the user requirements generated by the system. As a result, many products, aeronautical charts and related information publications are compiled, printed, and distributed to satisfy various needs of the users (military and civil aviators) and managers (air-route traffic controllers) of the national airspace.

NOS provides reproduction material to the Defense Mapping Agency Aerospace Center (DMAAC) of base charts at 1:500,000 and 1:1,000,000 scales. As required, DMAAC updates the aeronautical information to satisfy military requirements for the conterminous United States, Hawaii and Alaska. DMA also produces Flight Information Publications and Notices to Airmen for use in flight planning and operations.

In fiscal year 1981, NOS began a comprehensive chart reconstruction effort to enhance the quality of information portrayed on aeronautical charts. The reconstruction programme involves a combined total of 150 visual and instrument charts, and will take 10 years to complete. The programme was initiated to reap some of the benefits derived from improved cartographic techniques as well as inroads made by automation. To date, five Sectional Aeronautical Charts and two World Aeronautical Charts have been published under the auspices of the chart reconstruction programme. Three more sectional charts are scheduled for publication in 1983.

The Gulf Coast VFR chart is a new NOS aeronautical charting product. At 1:500,000 scale, it shows offshore mineral leasing areas and blocks, oil-drilling platforms and high-density helicopter activity areas in and around the Gulf of Mexico.

HYDROGRAPHY AND OCEANOGRAPHY

Hydrographic charts

Since January 1980, DMA has published 512 new nautical charts or new editions of nautical charts in the Asia-Pacific area, which would include some modified facsimile reproductions of charts produced by Australia, Indonesia, Japan, the Philippines and the Republic of Korea. Of the total number, 309 charts are categorized as large-scale harbour and approach charts, larger than 1:75,000 scale; 187 are classified as medium-scale coastal charts, from 1:75,000 to 1:6,000 scale; and 16 are small-scale general nautical charts, smaller than 1:600,000 scale.

NOS continues to co-operate with the Canadian Hydrographic Service to chart the Great Lakes and other boundary waters of mutual concern, with the aim of avoiding duplication of effort and of establishing a standard chart format. As part of the co-operative effort, NOS reconstructed the General Chart of Lake Erie in metric format, while the Canadian Hydrographic Service reconstructed the General Chart of Lake Ontario. In addition, NOS constructed confluence charts of the east and west ends of Lake Erie, in back-to-back conventional and metric format. Fifteen additional charts have been identified for co-operative chart production in the future.

NOS continued to develop a programme to produce nautical charts utilizing computer-assisted machine-engraving techniques. To date, seven reconstructed charts and 18 new charts have been issued using automated chart production procedures.

International exchange of charts

Agreements are in effect with Australia, India, Indonesia, Japan, Malaysia, the Philippines and the Republic of Korea, as well as with countries in other parts of the world. These agreements are in accordance with resolutions of the International Hydrographic Bureau (IHB).

Hydrographic surveys

Continued progress has been made in obtaining basic hydrographic survey coverage to provide a data base for nautical charts of the continental shelf and the Great Lakes. Basic hydrographic surveys were conducted by vessels and the National Oceanic and Atmospheric Administration (NOAA) fleet and by hydrographic field-parties in the waters adjacent to Hawaii, Alaska, Washington, Californie, Texas, Louisiana, Florida, Virigin Islands, Georgia, South Carolina, North Carolina, Virginia, Delaware, New Jersey, Pennsylvania, New York, Massachusetts, Michigan, Wisconcin and Minnesota. Wire-drag operations in support of nautical charting were conducted along the coast of the Gulf of Mexico and

the east coast of the United States. Wire-drag surveys of the approach route and the anchorage and maneuvering areas of the Louisiana Offshore Oil Port (LOOP) were completed.

The USNS Chauvenet and USNS Harkness are the major resources available for the collection of coastal hydrographic survey data in support of United States nautical charting needs. Both ships are under the technical control of the Naval Oceanographic Office. The Chauvenet conducted surveys for the Government of Indonesia during part of the report period.

Annual co-operative hydrographic surveys have continued with the Republic of Korea. Special independent operations have been completed in the Cayman Islands; Port-Au-Prince, Haiti; and Guantanamo Bay, Cuba. NOAA ship Mt. Mitchell also surveyed in the Yucatan Channel in the summer of 1980, as did USCGC Evergreen.

A long-term (from six to eight years) co-operative hydrographic programme has just been entered into with the Bahamas. The 67-foot NOAA vessel Virginia Key will be deployed out of Miami to the Bahamas for two-month periods; surveys will be conducted there in unison with Bahamas Lands and Survey personnel.

Tides, water-levels and circulation

Through an internal reorganization in 1979, NOS established a new Office of Oceanography to be the focal point for collecting and evaluating oceanographic, marine navigation and water-level data. The office performs analyses of physical phenomena pertaining to the sea and Great Lakes, including tides, water-levels, currents, dynamics and physical properties of sea water, and shoreline and bottom configuration as they affect waves and current propagation and attenuation. The Office also conducts investigations in wave climatology, offshore water movement, marine environmental assessment and satellite oceanography. The Office is responsible for establishment and operation of networks of tide stations and water-level gauges, for compilation of tide and current predictions for direct use in marine navigation, for application in civil engineering, for solution of environmental problems and for correlation and analysis in scientific research.

The objectives of the tides and water-levels programme are the collection, analysis, prediction and dissemination of tide, water-level and related data. NOS operates the National Tide and Water Level Observation Network to provide timely, cost-effective, quality products to meet the needs of recreational, professional and governmental users. The current network consists of nearly 200 permanent tide and water-level stations located on the Atlantic, Pacific Gulf coasts of the United States and on the coasts of the Great Lakes, Alaska and selected Pacific Islands. In addition, about 300 short-term stations are in operation at any given time.

Nautical publications

In addition to the nautical chart coverage, DMA produces and maintains many special-purpose charts, the weekly Notice to Mariners, pilot charts, light lists, radio aids, Sailing Directions, Monthly Satellite Nodal Crossing Data and the tables for the Loran-A, Loran-C and Omega navigation systems. Products in these categories are the World Port Index, the Sailing Directions, both

planning guides and en route publications that cover the world except for the Arctic and Antarctic basins. These latter basins are being produced for the mid-1980s.

Omega lattice and propagation tables were compiled for eight stations and will be revised and upgraded as data are received from world-wide monitoring sites and ships of opportunity. New revised Loran-C lattice and correction tables are compiled and printed as the navigation system is revised and/or expanded to fulfil the navigator's needs. As with Omega, receipt of data from monitoring sites dictates compilation and printing of revised publications.

TOPOGRAPHIC MAPPING

In 1980, USGS, aware of changes in public expectations and in mapping technology, established the new National Mapping Division (NMD), comprised of the former Topographic Division and elements of the Publications Division and Geography Program. The purpose was to form a broad-based mapping organization, built on the scientific disciplines of cartography and geography and incorporating related technical and physical resources of map printing and distribution.

NMD is charged with implementing the national mapping programme, which is currently focusing on 11 categories of base map data: reference systems; hypsography; hydrography; vegetative cover; non-vegetative features; boundaries; transport systems; geodetic control; survey monumentation; geographical names; and orthophotographic imagery. Other map data of public value may also be incorporated into the programme.

The major products of the programme are:

(a) Line maps. The traditional multi-purpose line map remains an important tool and will continue to be a major item of production. In addition to the standard series now available, two new map scales, 1:50,000 and 1:100,000, are being produced;

(b) Digital data. A primary goal is to supply base map data in digital form for identified uses. Production of a national digital cartographic data base is an ultimate objective;

(c) Orthophotoquads. Orthophotoquads have become an important product. They are produced quickly and inexpensively and provide a wealth of information;

(d) Cartographic data. The availability of base data in graphical form is being expanded. Reproducibles that are feature-seaprated, as well as colour-separated, facilitate the preparation of special-purpose maps.

Standard quadrangle mapping and revision

During the report period (February 1980 - January 1983), 3,522 new standard topographic maps were published, covering 520,965 km^2. Most of the maps were in the 7.5-minute series at 1:24,000 scale (1:63,360 scale in Alaska). There are 16 states with complete published topographic map coverage at 1:24,000 scale. These maps serve as the data source to derive other small-scale and special maps.

As national coverage in the 7.5-minute series increases, maps are periodically reviewed for revision with emphasis on changes in urban areas, coastal zones, airports and other areas of high national interest. Since the beginning of the reporting period, 4,269 revised 7.5-minute maps have been published.

Even though most primary quadrangle maps of the national mapping programme are being compiled in feet, over 2,000 of the 7.5-minute quadrangles are now in work as metric editions. USGS has co-ordinated plans separately with each state and some have opted for metric mapping.

Orthophotoquads are black-and-white photo-image maps in 7.5-minute quadrangle format with little or no cartographic treatment. There continues to be great demand for this product, for use either as an interim map in areas unmapped at 1:24,000 scale or as a companion product to a published line map. Approximately 27,000 orthophotoquads have been prepared by USGS to date; approximately 10 per cent of these have been lithoprinted and the remainder are available either as diazo or photographic reproductions.

Orthophotomaps are coloured photo-image maps having substantial cartographic treatment. They have become the standard 7.5-minute for certain areas of the coutry where the conventional topographic map symbols cannot adequately portray terrain, such as the Florida Everglades and the lakes region of northern Minnesota.

During the period under review, the DMA mapping programme for the United States primarily involved the revision and reformatting of published maps of military installations and training areas. A total of 299 large-scale topographic maps were published.

Intermediate-scale mapping

The intermediate-scale mapping programme continues to be a growing programme for maps on scales between 1:24,000 and 1:250,000. With the continuing emphasis on energy and mineral development, the demand for quadrangle maps at 1:100,000 scale is also expanding. Through the concept of feature-separation scribing, the intermediate-scale map becomes a multi-purpose base map for many users.

Currently, intermediate-scale maps in quadrangle and county format are under production or available for about 60 per cent of the conterminous United States.

During the reporting period, USGS produced 1,015 intermediate-scale maps on the scales 1:100,000 and 1:50,000, which may be used directly in the preparation of other intermediate-scale maps.

Maps in the 1:250,000 series are used by USGS as base copy for preparation of the state base map series, the International Map of the World series; and special small-scale maps, such as the land-use/land-cover series; and for the preparation of geological maps.

The 50 states are completely covered by 626 topographic maps at 1:250,000 scale. Originally prepared by DMA, the series is now maintained by USGS. During the three-year period, 78 revisions of the maps were published.

Terrain date for the maps at 1:250,000 scale are available on magnetic tape at the National Cartographic and Geographic Information Service (NCGIS).

Land-use and land-cover classification and mapping

The Office of Geographic Research, USGS, has been responsible for the development, testing and implementation of a two-level land-use and land-cover classification system for the United States. This classification system has nine level I general categories and 37 more specific level II categories. The classification system was designed for use primarily with remotely sensed data obtained from aircraft or satellites. USGS Professional Paper 964, entitled A Land Use Classification System for Use with Remote Sensor Data, explains the system and gives definitions for each of its catagories.

Aerial photography

During the reporting period, a national high-altitude photography programme was instituted. In this new inter-agency effort, USGS co-ordinates the acquisition of high-altitude aerial photography for the many federal agencies involved in mapping and resource management activities. The programme goal is to complete the photographic coverage of the continental United States in a six-year period. A maintenance programme will follow.

The data base for the programme consists of both black-and-white panchromatic and colour infra-red 23 x 23-cm photographs taken in a two-camera equipped aircraft at 12,220 m above mean terrain. The 1:80,000-scale black-and-white photography is taken with a 153-mm focal length aerial camera. The 1:58,000-scale colour infra-red photography is taken by a second camera with a 210-mm focal length.

About 4,660,000 km^2 of high-altitude coverage over the conterminous United States have been contracted during the report period. Currently, about 70 per cent of that coverage has been flown and is available for all users. During the period, USGS contracted for 953,000 km^2 for conventional mapping photography.

National Cartographic and Geographic Information Service

The National Cartographic and Geographic Information Service locates, organizes and distributes information about the cartographic products of the United States. NCGIS information systems now contain information on 1,400,000 aerial photographs from nearly 200 governmental and private sources, 130,000 current and historical quadrangle maps and their feature separates, and general information on more than 30,000 cartographic products.

Provisional edition maps

A major accomplishment in improving the efficiency of NMD during the period under review was the introduction of provisional editions of primary quadrangle maps of the United States. Provisional edition maps have essentially the same

level of information as the standard topographic map product, but are less costly to produce. The benefits of the edition are to decrease production time and cost of primary quadrangle map data and derivative map products and to expedite completion of topographic map coverage of the conterminous United States.

Circum-Pacific Map

The Circum-Pacific Map, on the scale 1:10,000,000, depicts geological and resource data for the Pacific basin and the peripheral continental areas that were affected by geological phenomena in the development of the basin during the Mesozoic and Genozoic eras.

Of the projected total of 44 map-sheets, 18 were published by the end of the reporting period.

Antarctic mapping

The National Mapping Division of USGS supports the United States Antarctic Research Program by conducting geodetic ground surveys on the continent and compiling topographic maps to support scientific research. To date, 90 maps covering 978,000 km^2 at 1:250,000 scale have been published. USGS currently is compiling 1:250,000 scale maps of the Antarctic Peninsula, Shackleton Mountains and Jones Mountains areas. LANDSAT image maps are being prepared of the Ronne Ice Shelf and Filchner Ice Shelf areas.

Publications

An important book on mapping was published by USGS during the reporting period. Maps for America summarizes the history, work and products of federal mapping organizations. A second edition was published in mid-1982.

Aerial Profiling of Terrain Systems

The concept of executing accurate surveys of the terrain from low-flying aircraft using recent advances in inertial guidance technology and laser ranging is being implemented in the development of Aerial Profiling of Terrain Systems (APTS). The systems include a laser profiler, television camera, intertial measuring unit, laser tracker, computer and magnetic-tape recorder. The project is in the component integration stage and performance evaluation test flights have begun.

Satellite image maps

A variety of planimetric-image maps and mosaics has been produced from LANDSAT multispectral scanner (MSS) data on scales ranging from 1:250,000 to 1:5,000,000. USGS has developed innovative photogrammetric and film-mosaicking techniques for the production of gridded colour image maps and mosaics which result in improved geometrical accuracy and resolution. USGS has also demonstrated that such themes as open water, vegetation and shaded relief can be

extracted from continuous-tone MSS images using density slicing, density clipping and masking techniques to produce colour-separate plates for lithographic reproduction. This technique was used by USGS to produce an image mosaic of Wenatchee, Washington, at 1:250,000 scale. Thematic extractions are also accomplished through computer processing of MSS digital data.

LANDSAT imagery has been found to be an expedient medium for the preparation of image maps in poorly mapped and inaccessible areas. Since USGS has successfully demonstrated unique new methods and techniques that are necessary to compile image maps of optimum details, many requests for assistance have been received from foreign countries. In response to these requests, a number of LANDSAT colour image maps have been produced with assistance of USGS personnel: (a) colour image maps of Pakistan at 1:500,000 scale; (b) colour image maps of parts of Ethiopia, Kenya, the Sudan, Uganda and the United Republic of Tanzania at 1:500,000 scale; and a number of image maps of Saudi Arabia on scales of 1:250,000 and smaller. In addition, USGS and DMA recently produced a 1:500,000 scale map of the Berry Islands, the Bahamas, which combines space imagery with bathymetric data. MSS images of the Berry Islands were digitally and photographically enhanced to emphasize underwater detail. Bands 4, 5 and 7 were combined to form a colour composite; and band 4 was combined with bathymetric details. The resulting map introduces a new concept in the mapping of the Earth's shallow seas.

GEOGRAPHICAL NAMES

The United States has continued to be active in programmes to standardize names of geographical features on a worlwide basis and domestically. These programmes are carried out through the services of the interdepartmental Board on Geographic Names, while technical staff support and publication efforts are provided by DMA and USGS.

To increase capabilities to manage names information, DMA is introducing automated data-processing and related techniques. At the same time, a programme to publish gazetteers, which is under way, is resulting in the publications containing updated information on names of major geographical features.

Another programme si based on collaboration with other countries. Such collaboration will bring about exchanges of information on names, publication of gazetteers for joint use and provision of technical assistance by the United States as required.

The United States is currently co-operating with the Republic of Korea and Thailand in the publication of indexes to names on maps at 1:250,000 scale. The United States has prepared the basic documents, and the other countries are furnishing translations of the introduction and are adding native-script equivalents for the names. Discussions with Indonesia have taken place concerning co-operative work on names. Other gazetteer plans include publications covering Japan, India, Pakistan and the Democratic People's Republic of Korea.

The Geographic Names Information System (GNIS) was developed by USGS in 1975 to meet a need for an automated data base of official geographical names. GNIS is currently capable of providing basic information for about 2 million names used in the United States and its territories. Data in GNIS include:

(a) name; (b) type of feature (city, town, stream, mountain etc.); (c) state and county; (d) geographical co-ordinates; (e) official status of name; (f) elevations; (g) source co-ordinate if linear feature; (h) USGS map number; and (i) variant names, if any. Information from GNIS is available through direct on-line access by a remote terminal; open-file products, such as magnetic tapes, computer print-outs and microfiche; and printed and bound products, such as alphabetical and topical lists.

TECHNICAL ASSISTANCE AND EXCHANGE PROGRAMMES

The United States is currently engaged in the following technical assistance and exchange programmes:

(a) Australia. DMA co-operative mapping, charting and geodesy programmes continued;

(b) China. Programmes with China included:

(i) USGS entered into an Earth Science Protocol with the Chinese Academy of Geological Sciences. Twenty proposals involving the exchange of scientists and information are included in the Protocol. One of the proposals involves exchange visits for small delegations to discuss geodetic, topographic, cartographic and map publication activities;

(ii) Several groups of scientists and engineers representing mapping and cartographic agencies in China visited United States mapping organizations during the period.

(iii) DMA participated with the Chinese National Bureau of Surveying and Mapping in an exchange of visits;

(c) Indonesia. DMA co-operation in aeronautical and hydrographic charting has been established with Indonesian mapping and charting organizations;

(d) New Zealand. DMA co-operative mapping, charting and geodesy programmes continued;

(e) Philippines. DMA co-operative mapping, charting and geodesy programmes continued;

(f) Republic of Korea. DMA co-operative mapping, charting and geodesy programmes continued;

(g) Saudi Arabia. NMD continued to provide assistance to the Saudi Arabian Ministry of Petroleum and Mineral Resources through the United States Geological Survey Mission at Jiddah. Geodetic control is complete on 90 quadrangles of the LANDSAT-image map series at 1:250,000 scale, and 50 maps have been published;

(h) Sri Lanka. NMD personnel provided assistance to the Government of Sri Lanka for two projects during the reporting period. A three-person team of mapping specialists evaluated and prepared a report on the Agricultural Base

Mapping Project. In addition, a consultant was assigned to the Cartography Unit of the Department of Census and Statistics to assist in the reorganization and modernization of that group;

(i) Thailand. DMA co-operative mapping, charting and geodesy programmes continued;

(j) Trust Territories of Pacific. NMD currently is preparing 56 manuscript maps at 1:10,000 scale of the major inhabited islands of the Trust Territories; these are scheduled for completion by the end of 1982. NMD plans to publish a spin-off series of 17 map-sheets at 1:25,000 scale.

REPORT ON THE INTERNATIONAL CARTOGRAPHIC ASSOCIATION*

Paper submitted by the International Cartographic Association

The International Cartographic Association (ICA) was established by 13 founder member countries in 1959 at Bern, Switzerland, at the initiative of Sweden after preparatory conferences were held at Stockholm (1956), Chicago (1957) and Mainz (1958). The first General Assembly took place in Paris in 1960 with 25 member countries present.

The aims of the Association are: (a) to advance the study of cartographic problems; (b) to instigate and co-ordinate cartographic research; (c) to disseminate cartographic knowledge; (d) to organize international conferences, seminars, exhibitions etc.

ICA is a non-governmental organization with a current membership of 59 countries or areas (see annex I), each represented by a single organization, mostly by a national society or committee for cartography. Individuals cannot be admitted as members.

The Association has adopted the following designation of cartography: cartography is the totality of scientific, technical and artistic activities directed to 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. This definition is in accord with that given in the Multilingual Dictionary of Terms in Cartography.

In this sense, cartography is limited to cartography proper, that is, to data presentation up to the reproduction and printing of maps and charts. It will be understood 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 or demography.

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* The original text of this paper appeared as document E/CONF.75/L.57.

The United Nations uses a much wider concept of cartography, dating from 1948, according to which cartography 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 official bodies of ICA are:

(a) The General Assembly of delegates, which normally meets every four years, in which every member country or area has the right to one vote. As a rule, the General Assembly is held in conjunction with a technical conference;

(b) The Executive Committtee, consisting of a president, from five to seven vice-presidents and a secretary-treasurer, all elected by the General Assembly. For the current composition of the Executive Committee (1980-1984), see annex I;

(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) but may be extended by decision of the General Assembly;

(e) The Publication Committee, responsible for the ICA publication programme;

(f) The Committee on Transfer of Technical Knowledge to Third World Countries.

Annex II gives information on the current ICA commissions and working groups (1980-1984) and their terms of reference.

ICA conferences as held every second year (see annex III for the conferences held since 1980 and the themes considered. 1/

Publications of ICA, available and in preparation, are listed in annex IV.

Applications for membership are made by letter to the Secretary-Treasurer and are subject to ratification by the General Assembly upon the recommendation of the Executive Committee.

The annual subscription for the period 1980-1984 is graded into six categories. Member countries are free to select the category into which they wish to be classified. Subscriptions are multiples of $220, depending upon the category selected.

The Association has established working contacts with various international organizations, such as the International Society for Photogrammetry and Remote Sensing/Fédération internationale des géomètres and the International Geographical Union, with which joint working groups on special subjects are in operation. ICA also 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 was prepared under a UNESCO contract, and ICA Task Force activity in third world countries has been sponsored by UNESCO.

In 1976, ICA established a third world strategy. Seminars on computer-assisted cartography, presented by "teaching commandos" of ICA experts, were held at Nairobi, Kenya in 1978; at Jakarta, Indonesia in 1980; and at Wuhan, China in 1981.

Note

1/ For a list of conferences and their topics during the period 1962-1978, see "The International Cartographic Association: information paper", in Ninth United Nations Regional Cartographic Conference for Asia and the Pacific, Wellington, 11-22 February 1980, vol. II, Technical Papers (United Nations publication, Sales No. E/F.83.I.14), annex III.

Annex I

INTERNATIONAL CARTOGRAPHIC ASSOCIATION

A. Member countries or areas (1982)

Algeria
Argentina
Australia
Austria
Belgium
Brazil
Bulgaria
Canada
Chile
China
Cuba
Czechoslavakia
Denmark
Dominican Republic
Finland
France
German Democratic Republic
Germany, Federal Republic of
Greece
Hong Kong
Hungary
Iceland
India
Indonesia
Iran (Islamic Republic of)
Iraq
Ireland
Israel
Italy
Japan
Kenya
Madagascar
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

B. Executive Committee (1980-1984)

President:

F. J. Ormeling
Meijerinksweg 9
7524 AM Lonneker, Netherlands

Secretary-Treasurer:

Olof Hedbom
Flottbrävagen 16, Stora Essingen
S-112 64 Stockholm, Sweden

Vice-Presidents:

Rolf Bohme
Federal Republic of Germany
Deutsche Gesellschaft für Kartographie

A. Ciokosz
Poland
Polish National Committee on Cartography

Byrne E. Goodrick
Australia
The Australian Institute of Cartographers

K. L. Khosla
India
Indian National Cartographic Association

A. M. Komkov
Union of Soviet Socialist Republics
National Committee of Cartographers

Pierre Legris
France
Comité Français de Cartographie

Joel L. Morrison
United States of America
United States National Committee for ICA

C. Past presidents

E. Imhof (Switzerland), 1960-1964
D. E. O. Thackwell (United Kingdom od Great Britain and Northern Ireland), 1964-1968
K. A. Salichtchev (Union of Soviet Socialist Republics), 1968-1972
A. H. Robinson (United States of America), 1972-1976

Annex II

INTERNATIONAL CARTOGRAPHIC ASSOCIATION COMMISSIONS AND WORKING GROUPS, 1980-1984

A. General responsibilities for all commissions

The general responsibilities are:

(a) To disseminate information on their subject-matter to the ICA member countries;

(b) To continue the implementation of the ICA world policy by providing experts for workshops in developing countries when requested;

(c) To co-ordinate activities with commissions of other international commissions whenever possible;

(d) To appoint co-chairmen, who will be able to take over in case of illness etc. of chairmen.

B. Commissions, chairmen and terms of reference

Commission on Continuing Education in Cartography

Chairman: K. H. Meine (Federal Republic of Germany)

Terms of reference:

(a) To study the need for and to recommend ways of promoting continuing education in cartography;

(b) To prepare course outlines and to enhance the value of the Basic Manual of Cartography;

(c) To develop a strategy to encourage the fuller participation of women in education and training programmes in cartography.

Commission on Map Production

Chairman: K. Burmester (Denmark)

Terms of reference:

(a) To develop a technical exchange procedure between the members of the Commission at the research and development project level in order to ensure that the Commission shall stay abreast of state-of-the-art of cartography technology;

(b) To report on computer techniques employed in the production of text, labels and names on maps;

(c) To complete and publish the Manual on Cartographic Techniques, as envisaged in the terms of reference approved by the Fifth General Assembly held in Moscow in 1976;

(d) To complete and publish a review on short-run multicoloured map reproduction, as envisaged by the Fifth General Assembly held in Moscow in 1976.

Commission on Computer-Assisted Cartography

Chairman: Lowell Starr (United States of America)

Terms of reference:

(a) To develop a technical procedure between the members of the Commission at the research and development project level in order to ensure that the Commission does, indeed, stay abreast of the state-of-the-art technology and computer-assisted techniques associated with cartography;

(b) To establish a co-ordinating officer within the Commission to work directly with appropriate Commission representatives from the International Society of Photogrammetry (ISP) a/ and Fédération internationale des géomètres (FIG) to implement the resolutions that were drafted at the joint FIG, ICA, ISP conference held at Zurich in 1979.

Commission on Communication in Cartography

Chairman: C. Board (United Kingdom of Great Britain and Northern Ireland)

Terms of reference:

(a) To complete and publish the Bibliography of Cartographic Communications, as envisaged in the terms of reference, approved by the Fifth General Assembly held in Moscow in 1976;

(b) To prepare a publication on cartographic communication stressing the elements and processes within models of cartographic communication as an essential framework for future research tasks in cartography;

(c) To initiate a publication on the application of the concepts and methods of cartographic communication. This publication is intended to provide guidance on the choice of the various graphical events of map design.

Commission on Thematic Mapping by the Aid of Remote Sensing

Chairman: A. Ciokosz (Poland)

Terms of reference:

(a) To investigate methods of utilizing satellite imagery for the preparation of thematic maps;

(b) To collect literature related to the theme and to publish a relevant bibliography;

(c) To prepare a publication containing selected articles related to the theme.

Commission on History of Cartography

Chairman: Helen Wallis (United Kingdom of Great Britain and Northern Ireland)

Terms of reference:

(a) To complete and publish the English edition of the Glossary of Cartographic Innovations Prior to 1900;

(b) To develop and promote revised foreign language versions of the Glossary.

Commission on Marine Cartography

Chairman: Adam Kerr (Canada)

Terms of reference:

(a) To review coastal zone mapping on a global basis;

(b) To examine cartographic methods of depicting data collected by new data collection methods.

Commission on Census Cartography

Chairman: U. Freitag (Federal Republic of Germany)

Terms of reference:

(a) To review existing procedures for pre-census mapping, especially the delineation of census areas, and to establish guidelines for future work with special reference to the needs of developing countries;

(b) To recommend methods and standards for post-census cartography with special reference to the application of computer-assisted cartography in census map compilation and production.

Commission on Base Maps for International Thematic Mapping

Chairman: J. Carre (France)

Terms of reference:

(a) To make recommendations concerning the requirements for base maps to be used in international thematic mapping. Special attention will be paid to such matters as scales, projections, data collection and presentation, costs and delays. These recommendations should be directed to interested international organizations through the ICA administration;

(b) To prepare a publication on the subject.

Commission on Urban and Urban Planning Cartography

Chairman: Yasu Masai (Japan)

Terms of reference:

(a) To review existing topics in urban and urban planning cartography in order to identify the topics and representations which seem to be generally required for this class of maps;

(b) To prepare a recommended master legend for land-use and planning-restriction maps for urban planning on scales larger than 1:50,000 as an aid to international standardization in cartography;

(c) To identify future research required for planning cartography.

Commission on National and Regional Planning Cartography

Chairman: Mr. Winid (Poland)

Terms of reference:

(a) To survey the specific cartographic aspects of graphical representation and production of national, regional and urban planning maps in view of the dynamic caracter of the various levels of planning;

(b) To prepare and to publish a bibliography of atlases for national, regional and urban planning.

C. Inter-association working groups, 1980-1984

Joint ICA-IGU Working Group on Environmental Atlases

Chair: Vacant

Terms of reference:

(a) To continue the publication of reviews and essays on environmental maps;

(b) To explore the means of presentation of environmental conditions and factors;

(c) To explore the development of data bases for environmental factors;

(d) To establish the exchange of information among International Geographical Union (IGU) and ICA commissions and working groups concerned with similar subjects.

Joint ICA-IFLA Working Group on Documental Aspects of Cartographic Material

Chairman: Helen Wallis (United Kingdom of Great Britain and Northern Ireland)

Terms of reference:

(a) To study the existing International Federation of Library Associations and Institutions (IFLA) rules for the documentation of maps and related documents;

(b) To give recommendations for a revised edition of these rules if necessary;

(c) To study the consequences of the potential implementation of the possible new rules in map production.

Joint ICA-FIG-ISP Working Groups

Chairman: International Cartographic Association

Terms of reference:

(a) To study the classification of features for digital topographic mapping;

(b) To study design and structure of data bases most suited for digital topographic information systems;

(c) To study basic capabilities needed in interactive editing systems for photogrammetric and cartographic applications in digital topographic mapping;

(d) To report on the results of their work to the Eleventh ICA Conference held at Warsaw in 1982 and to the 1982 ISP Commission IV Symposium.

Note

a/ Now called the International Society of Photogrammetry and Remote Sensing.

Annex III

INTERNATIONAL CARTOGRAPHIC ASSOCIATION CONFERENCES AND THEMES, 1980-1984

Year	
1980-Tokyo	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 fields related to mapping Marine resources and maps Modern requirements and experiences in training cartographers

1982-Warsaw	Theory of cartography Advanced data collection techniques and automation in thematic cartography Thematic maps for regional and economic planning Contemporary school atlases History of thematic cartography Revision of topographic maps Standardization of geographical names
1984-Perth (Australia)	The role of cartography in management and planning Coastal zone mapping Computer-assisted cartography Topographic map revision History of cartography Cartographic education

Annex IV

PUBLICATIONS OF THE INTERNATIONAL CARTOGRAPHIC ASSOCIATION AND RELATED PUBLICATIONS

A. Available publications[a/]

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.

Board, Christopher, comp. Bibliography of works on cartographic communication. 1976.
Copies available from C. Board, Department of Geography, London School of Economics.

Csáti, E. comp. Multilingual explanatory dictionary of automation in cartography. Budapest, 1976.
Contains 400-500 terms and definitions in 11 languages. Available upon order from the Institute of Surveying and Mapping, Budapest.

International Cartographic Association. Commission on Automation in Cartography, comp. Glossary of terms in automated cartography. 1976. 76 p.
Copies available upon request. New edition in preparation.

_____. Commission on the Multilingual dictionary of technical terms in cartography. Weisbaden, Federal Republic of Germany, Franz Steiner Verlag, 1973. 573 p.
Contains 1,400 definitions and terms in, respectively, five and nine languages. Second edition in preparation.

International cartographic yearbook. Vols. I-XX (1961-1980). Bonn-Bad Godesberg, Kirschgaum Verlag. ca. 200 p. per volume.

Kerr, Adam and Annette Kordick, eds. Oceanic cartography. 136 p.

Meynen, E., comp. ICA bibliography 1956/1972. 132 p.

van Zuylen, I. L. and R. J. M. J. Bertrand, eds. Automation in cartography. 1975. 400 p.

Wallis, Helen, ed. An historical glossary of map making to 1900; preliminary study.
Copies for sale at the Map Room, The British Library, London.

B. Publications in preparation

1. Multilingual Basic Manual on Cartography
2. Multilingual Dictionary of Technical Terms in Cartography (2nd edition)
3. Definitions 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.

Note

a/ These publications, if not otherwise stated, are available from Rudolf Muller International Booksellers, P.O. Box 9016, Amsterdam, Netherlands.

AGENDA ITEM 5

Review of the latest techniques and recent developments related to various areas of cartography

(a) Conventional and satellite geodesy, ground control (including special-purpose geodesy)

THE NATIONAL GEODETIC DATA BASE*

Paper submitted by Australia

RESUME

La Division de cartographie a mis sur pied une base de données concernant les coordonnées et autres informations pour les 18 000 stations de planimétrie réparties sur le territoire australien, base gérée par un système IMAGE/1000 de Hewlett Packard. On a établi des programmes en vue de l'entrée, de la mise à jour, de la recherche et de la visualisation ou des informations, de même que de la localisation de certaines stations.

BACKGROUND

In 1978, the National Mapping Control of Australia (NMC) decided that a format should be designed "... for recording details of horizontal and vertical control stations in computer storage...". As a result, the Division of National Mapping (Natmap), on behalf of NMC, has implemented the national geodetic data base.

The national geodetic data base is composed of records for more than 18,000 horizontal control stations and the software necessary to manipulate these records in desired ways. The records are stored on discs in a Hewlett Packard (HP 1000) minicomputer.

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* The original text of this paper, prepared by The Division of National Mapping, Canberra, appeared as document E/CONF.75/L.7.

ASPECTS OF DATA BASE

Types of records

For each horizontal control site, the input record contains not only the station's name and numbers, its co-ordinates (either in latitude/longitude or zone/easting/northing) and its height, but a host of additional information of interest to a variety of users.

Data base management

The Hewlett Packard data base management system, IMAGE/1000, controls storage of the data and makes possible the automatic retrieval of information on selected items.

Data input

HOZIN and DBBLD are data input programs which build the data base. HOZIN, developed by Natmap, carries out data-validity checks; and processes, reports on and reformats data to the to the requirements of DBBLD, which loads the processed data into the data base.

A questionnaire is used to gather information, which is keyed in through a visual display terminal.

Verification of data and stock-taking of survey information are undertaken in co-operation with all members of NMC.

Data update

HOZUP, an update program developed by Natmap, allows individual items of information in the data base to be changed. It can check and correct the update data files before an update is performed.

Data retrieval and display

HOZAC and QUERY are information-retrieval programs. HOZAC, written by Natmap, also produces the following reports:

(a) Information summary. This summary shows all of the information on a station held in the data base as well as items computed from the basic information;

(b) Grid list. This list covers all the stations within a 1:100,000 map-sheet, their values in the Australian Geodetic Datum (AGD) and the Australian map grid (AMG), zone number, height, order of station, survev method and horizontal and vertical datum name;

(c) Adjustment section summary. The print-out shows the names and numbers and co-ordinates of all stations in a selected horizontal control adjustment

section. For each station, it also lists the name and serial of the adjustment in which the station first appeared and obtained its co-ordinates, together with the names and serials of all subsequent adjustments in which the station is held fixed on those co-ordinates.

QUERY, a retrieval program supplied by Hewlett Packard, can be used for special inquiries; for example, it can be used to find all the stations in a specified area that have heights determined by level traverse or to which access is by two-wheel drive vehicle.

HOZPL, a Natmap program, will plot the horizontal control obtained by any of the access programs on the HP 7221S graphics plotter, which features four-colour plotting, relative and absolute plotting with addressable moves of 0.025 mm. It will accommodate A3 sheet-paper or perforated roll-paper.

Plotting is not limited to the standard map areas. The many options available include: (a) stations in a nominated horizontal adjustment; (b) stations in a nominated area; for example, between latitudes 25°59' and 26°01', and longitudes 128°59' and 141°01'; (c) stations of a certain order or type; for example, all Laplace stations in Australia or all Doppler stations in the Northern Territory.

A GEOID FOR SOUTH-EAST ASIA AND THE PACIFIC*

Paper submitted by Australia

RESUME

Des membres de la Sous-Commission pour l'Asie du Sud-Est et le Pacifique de l'Association internationale de géodésie ont fourni des données tirées de quelque 600 observations Doppler de satellites effectuées en 23 points de la région, à des stations dont l'élévation au-dessus du niveau moyen de la mer est connue. A partir de ces données, on a dressé une carte donnant, en courbes de niveau de cinq mètres, la séparation géoide/sphéroide.

With the increasing use of space techniques to determine positions on Earth's surface, it has become imperative to determine the shape of Earth and to know the parameters relating local survey systems and space systems.

The latter data give values in three-dimensional space which can also be quoted in terms of latitude, longitude and spheroidal height in relation to the adopted ellipsoid.

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, appeared as document E/CONF.75/L.8.

The terrestrial values also are in relation to an ellipsoid except that the elevation is generally referred to a mean sea-level (MSL) datum. When the transformation parameters between the ellipsoids have been determined, it is possible to transform ellipsoidal co-ordinates from one ellipsoid to the other.

There remains, however, the difference between MSL and the surface of the ellipsoid. This difference is generally known as the geoid/spheroid separation, denoted by N.

MSL is a function of the local gravity field and thus the MSL surface is most irregular. Attempts have been made to define this surface in terms of spherical harmonics by using perturbations of satellite orbits and satellite altimetry as data on terrestrial gravity measurements.

These models include the series of GEM models, with the most recent being dsigned GEM 10C.

Geoid/spheroid separations calculated from these models still exhibit regional biases when the model is checked against separations obtained from terrestrial measurements.

DETERMINATION OF THE GEOID

Since a knowledge of the geoid is required to transform spatially derived co-ordinates into local ellipsoid and MSL elevations, it can be seen that such models as GEM 10C are of major interest. This is particularly so in South-East Asia and the Pacific, where integrated geodetic networks are not generally available and the need for control for mapping purposes is accelerating dramatically.

Against this background, the International Association of Geodesy (IAG) Sub-commission for South-East Asia and the Pacific requested that an evaluation of the GEM models should be undertaken and that an improved geoid map of the area should be prepared.

A preliminary study was carried out by J. S. Allman of the University of New South Wales, Australia, using the GEM 10B model.

The model separations were compared with the differences between Doppler-derived ellipsoidal heights and known MSL elevations at some 298 stations scattered throughout the region bounded by Antarctica, Pitcairn Island, Hawaii, Japan, Thailand and the Cocos Islands.

These data were collected by A. G. Bomford, the Australian representative and President of the IAG Sub-commission (now retired), and were provided by members of the Sub-commission and others with responsibilities in the region.

The differences confirmed that there were regional biases in the GEM 10B model and a correction surface was calculated. This surface was then added to GEM 10B and table of separations at 1-degree intervals was prepared.

From the table, contour maps of the geoid/spheroid separations were prepared; and the results were presented at the Symposium on Geodetic Networks and Computations, held at Munich in September 1981.

In the intervening period, the GEM 10C model became available. Since the model incorporates satellite altimetry, it must improve on the resolution of the previous models.

A further increase has also taken place in the number of stations in the area for which Doppler-derived spheroidal heights and terrestrially measured MSL elevations have been collected.

The entire project has been repeated using GEM 10C, the 602 Doppler stations and the separations based on the World Geodetic System 1972 (WGS 72) ellipsoid. The resulting geoid has been designated as JSA 82.

Once again, regional biases were obvious and ranged between -10 and +10 metres. A correction surface was again computed and added to the GEM 10C model at 1-degree intervals.

The data distribution, although still sparse, is fairly representative; it is given below:

Location	Number of stations
Antarctic Territories	32
Australia	235
Brunei	1
Caroline Islands	1
Fiji	17
Guam	4
Hawaii	14
Hong Kong	1
Indonesia	64
Japan	8
Johnston Island	1
Malaysia	14
Marshall Islands	23
Midway Island	1
New Zealand	19
Papua New Guinea	111
Philippines	10
Phoenix Islands	1
Pitcairn Island	1
Singapore	1
Solomon Islands	6
Thailand	27
Vanuatu	10

The JSA 82 geoid map is plotted with 5-m contours. Copies are available from the Division of National Mapping, P.O. Box 31, Belconnen, ACT 2616, Australia.

Although this map is beneficial when examining trends over the entire region, it should not be used for small regions. For those regions, 1-m contour plans can be prepared on a much larger scale by Mr. Allman on request, provided that their use is restricted to the design criteria--that is, the provision of mapping control. There is no suggestion that this geoid can give the fine solution that can be obtained through local gravimetric or other surveys.

References

Allman, J. S. and J. B. Steed. A preliminary geoid for South-East Asia and the Pacific. Paper submitted to the Symposium on Geodetic Networks and Computations, Munich, September 1981.

Lerch, F. J. and others. Goddard earth model development for oceanographic applications. Paper submitted to the Marine Geodesy Symposium, Miami, Florida, October 1978.

Allman, J. S. A geoid for South-East Asia and the Pacific. Australian journal of geodetic and photogrammetric survey, 36:59-64, June 1982.

THE NATMAP LASER-RANGING SYSTEM*

Paper submitted by Australia

RESUME

La Division de cartographie at la NASA (Etats-Unis d'Amérique) coopèrent à la construction près de Canberra (Australie) d'une station de poursuite de la lune et des satellites et de télémétrie laser haute précision. Le novueau système comprend plusieurs sous-systèmes - télescope, laser, chronomètre, récepteur et ordinateur - et il recevra des données permettant de mesurer la rotation de la Terre et le mouvement des pôles, de déterminer les coordonnées de la station et d'améliorer les éphémérides de la Lune et des satellites.

The Division of National Mapping (Natmap) of Australia and the United States National Aeronautics and Space Administration (NASA) are co-operating in the development of a high-precision lunar and satellite laser-ranging facility at Orroral, near Canberra, Australia. The new system, know as the Natmap laser-ranging system (NLRS) will be capable of obtaining ranges to satellites with 3-cm precision and of ranging to retroreflectors on the moon with 5-cm precision.

NLRS will replace existing separate lunar and satellite laser ranging facilities in the Orroral Valley region with a single system of greater productivity and precision. The laser data will be used in global programmes of earth rotation, polar motion, geodynamics and plate tectonics.

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, appeared as document E/CONF.75/L.9.

SYSTEM DESCRIPTION

NLRS determines range by measuring the time-of-flight of a very short duration laser pulse to the target and back. Thus, NLRS consists of several subsystems: (a) telescope; (b) laser; (c) timing system; (d) receiver; (e) computer system.

The telescope used is a 1.5-m aperture astronomical telescope in an XY (alt-over-alt) mount, driven by high-precision/high-power torque-drive motors. The telescope is capable of tracking even low orbit satellites with less than 4 arc second error.

The laser is an extremely high-power neodymium-YAG laser which has been frequency doubled to operate in the visible spectrum at 532 nanometres. It can develop pulses of 10^{-10} seconds duration with peak powers in excess of 2×10^{12} W at a repetition rate of 10 pulses per second. The large aperture telescope is used to reduce beam-spreading between the ground and the target and to reduce the intensity of the transmitted signal beam.

The timing system is based on the short-term performance of a high-quality crystal oscillator whose long-term behaviour is controlled by feedback from a clock ensemble which includes five caesium-beam frequency standards. Epoch of events can be logged to 1-microsecond precision in relation to Universal Transversal Co-ordinates (UTC). The travel time of the light to the target and back is measured with 200-picosecond precision.

The receiver is a high-efficiency, high-speed photon-detector system capable of detecting single photons. Sub-nanosecond rise-times are maintained throughout the receiver- and signal-processing system in order to minimize timing errors.

The entire system is controlled by a Hewlett Packard minicomputer system which is capable of maintaining the telescope on track with high precision; controlling the laser, receiver and timing system; and logging all the data in real time at laser shot rates in excess of 10 hertz.

APPLICATIONS

The principal applications of lunar laser-ranging will be:

(a) Earth rotation (UTI) measurement;

(b) Station co-ordinate determination;

(c) Improvement to the lunar ephemeris and verification of cosmological theories;

(d) In conjunction with other stations, baseline measurements and polar motion;

Satellite laser-ranging will provide information for:

(a) Polar motion and length of day;

(b) Station co-ordinates and interstation baselines;

(c) Satellite ephemeris improvement.

Near-simultaneous observations of centimetre precision at several sites will provide direct measurements of crustal motion and will assist in the establishement of a conventional terrestrial reference system of points on Earth's surface for which relative positions and motions are very accurately known.

The relative merits of lunar and satellite laser-ranging against other techniques with similar aims, such as very long baseline interferometry (VLBI), Doppler satellite-positioning and classical astronomical methods, will be determined by an intense observational programme in the year 1983/84 to Monitor Earth Rotation and Intercompare Techniques (MERIT). NLRS, because of its proximity to VLBI, astronomical and Doppler facilities, will be a prime instrument used in this campaign.

CONTRIBUTIONS TO VERY LONG BASELINE INTERFEROMETRY*

Paper submitted by the Federal Republic of Germany

RESUME

Depuis 1979, des plans sont exécutés en vue d'installer un radiotélescope géodésique pour la radiointerférométrie à très longue base et l'interférométrie par satellite. Les succès obtenus par divers groupes de recherche au Canada, aux Etats-Unis d'Amérique et dans certains pays européens dans leurs études de géodésie ont contribué à cette décision. En 1981, des contrats ont été signés concernant la construction d'un radiotélescope de 20 mètres.

Son installation est prévue pour 1982 à la station d'observation par satellite de Wettzell (République fédérale d'Allemagne). Les premières observations commenceront dans le courant de 1983. L'installation d'une station de référence géodésique et géodynamique, avec des stations analogues dans d'autres parties du monde, contribuent, dans une large mesure, à étendre les canevas continentaux aux réseaux mondiaux.

GENERAL REMARKS

Since the early 1970s, geodetic satellite tracking efforts in the Federal Republic of Germany have been concentrated at the satellite observation station at Wettzell, which is operated mainly by the Institut für Angewandte Geodäsie (IfAG), Frankfurt am Main, acting within the Special Research Group on Satellite Geodesy of the Technische Universität München (SFB 78). Within this community of satellite geodesists, the research efforts of about 40 experts from several institutions have been joined together.

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* The original text of this paper, prepared by the Institut für Angewandte Geodäsie, Frankfurt am Main, appeared as document E/CONF.75/L.28.

Thus far, the activities at Wettzell have been concentrated on satellite laser-ranging with a short-pulse neodymium-YAG laser system, Doppler measurements and C-band radar observations during the GEOS-III campaign, and also on optical observations with a ballistic camera.

During the past years, efforts have commenced to modify the satellite laser-ranging system to add lunar laser-ranging capability by installing additional hardware and software. To satisfy the needs of all the tracking systems, a dedicated precise time service with four rubidium and three caesium frequency standards has been established.

By means of radio-interferometry, large continental and intercontinental distances between different stations can be surveyed with the same quality as short ones, i.e., with cm-repeatability. Therefore, it was recognized in 1979 that it would be necessary to carry out observations with a suitable radio-telescope (see figure 14). These observations would permit participation in international geodynamic programmes.

REALIZATION OF THE PROJECT

The concept of a fundamental observation station within very long baseline interferometry (VLBI) facilities was accepted by the Deutsche Forschungsgemeinschaft (Research Council of the Federal Republic of Germany) in December 1980. The necessary funds for the equipment--about 6.5 million deutsche mark--were included in the budgets of the Institut für Angewandte Geodäsie and the Deutsche Forschungsgemeinschaft for the years from 1981 to 1984. The technical specifications of the future radio-telescope were worked out in 1981, defining characteristic features, such as geometric data, margin of error, kinematic data and scope of supply. For example, the Cassegrain on-axis configuration will have an f/d ratio of 0.45 at an elevation over azimuth mount. The frequency range will be approximately 2-25 GHz. The maximum slewing speed is 3 degrees per second in azimuth and 1.5 degrees per second in elevation.

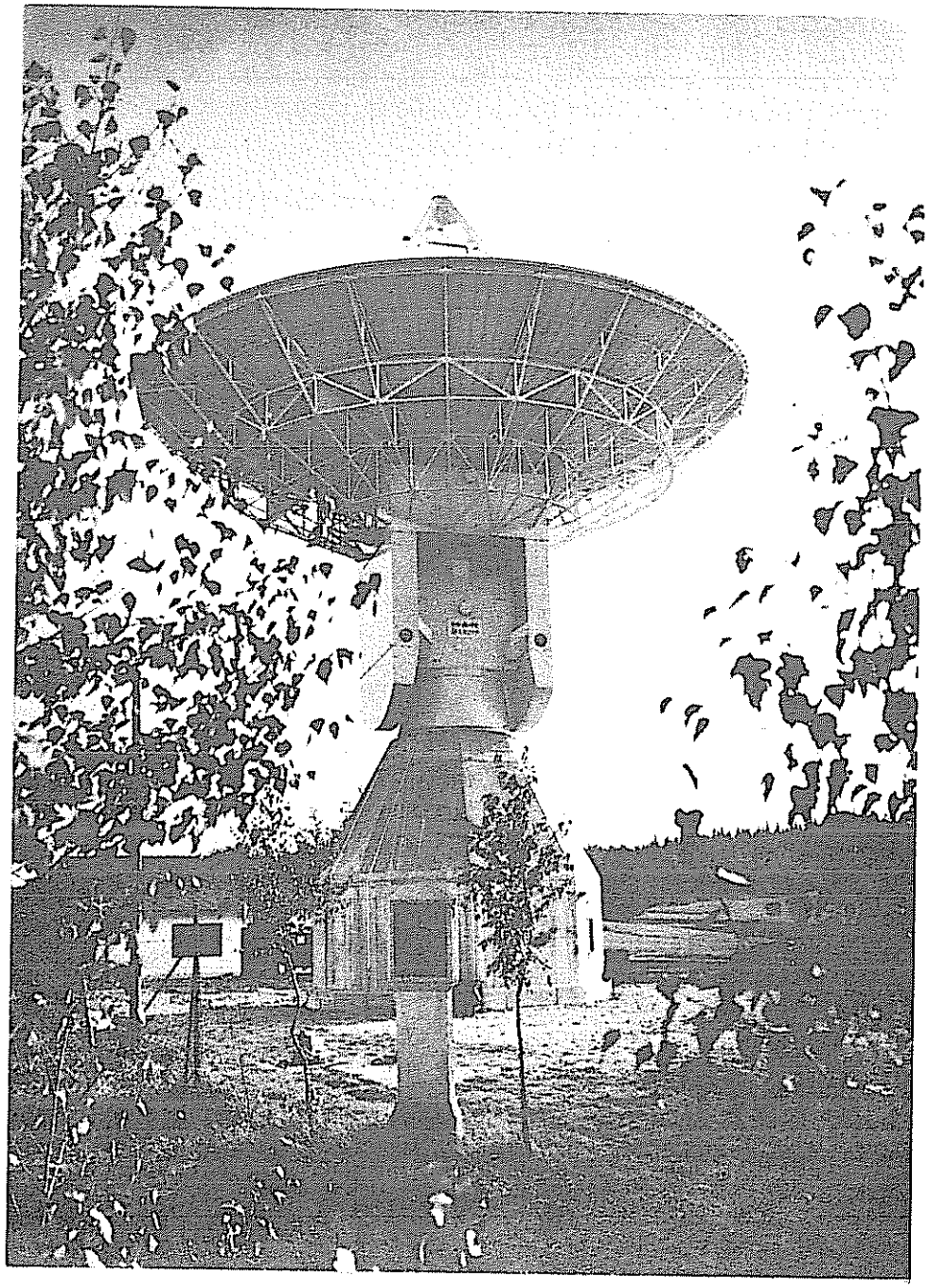
The necessary foundation in the form of a concrete tower depending upon the type of antenna, as well as the specific electronic equipment, the feed horns, the receivers, one of the antenna control computers and the data-recording equipment were delivered under separate orders.

The specifications had to consider the main requirements of IfAG and allow the supplier to apply his special design and expertise. In 1980, they were submitted to nine competent antenna manufacturers in Europe, Japan and the United States of America. Up to September 1980, quotations from seven firms had been received.

A turning-head type of antenna with a main reflector diameter of 20 m was accepted. The accepted design meets or exceeds the requirements claimed.

The construction of a special operation building was begun at the same time as construction of the antenna. The building includes: (a) the antenna control centre where the antenna control board, the control terminal, the Hewlett Packard 1000-F computer and the MARK III data acquisition system will be installed; (b) a conference room and a small library; (c) six offices for the staff of the radio-telescope; and (d) sanitary rooms.

Figure 14. Federal Republic of Germany: 20-metre radio-telescope for very long baseline interferometry and satellite interferometry for satellite observation station at Wettzell



FUTURE ACTIVITIES

In order to define the feed system, several concepts have been considered, such as dual S/X-band concentric horns, S/X-band hybrid horns and a very ambitious three-frequency design to cover also the European 5 GHz-band without being forced to exchange the horn. This would have facilitated the operation of the Cassegrain on-axis configurated telescope. Meanwhile, however, the design for a special S/X-band feed was received from the Jet Propulsion Laboratory (JPL) of the National Aeronautics and Space Administration (NASA) (United States of America).

At first, the operations will be performed with a dual-frequency receiver for S-band and X-band, following the scheme developed at NASA matching with the VLBI Mark III data-acquisition system. The front end will contain two low-noise, two-stage amplifiers in a dewar at 20° K, one for S-band and one for X-band, followed by two other low-noise, three-stage amplifiers at a physical temperature of 70° K. The mixers and the broad-band IF-amplifiers will be operated at stabilized room temperature. The local oscillators for the two frequencies will be operated under phase coherent control of the hydrogen maser.

A MARK III data-acquisition system was ordered to be delivered early 1983. In order to make use of the field-system software already developed, a computer system will be ordered to be installed in 1983.

The time service of the satellite observation station at Wettzell comprehends three caesium standards (Oszilloquartz) and three rubidium standards (Rhode and Schwarz), together with the corresponding time generators, counters, phase micro-steppers and oscilloscopes. A computerized time-comparing device is interrogating all the station clocks every three hours. Time comparisons are performed by flying clocks travelling to the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig; to the Bureau international de l'heure and to the United States Naval Observatory. A time-transfer experiment between PTB and Wettzell via METEOSAT is under preparation. The time comparison every three hours is expected with a resolution of about 30 nanoseconds. A hydrogen maser EFOS-1, developed by Oszilloquartz, Neuchâtel, Switzerland, was delivered in 1982. This hydrogen maser is being installed at Wettzell and integrated into the time and frequency system of the station.

A noise-adding radiometer and a S/X-band phase delay calibration system will be installed in 1983. Concerning the water-vapour radiometer, it has still to be investigated which type will be procured in the course of the following years.

The new radio-telescope is an important addition to the available observation techniques for satellite ranging. Efforts are ongoing to make lunar laser-ranging operational. Co-operative programmes are planned between the Polaris stations of the United States and the stations at Wettzell, such as taking part in the MERIT campaign schduled to commence in 1983. Keeping in mind that all this equipment will be linked to the same precise time service, it will in future be possible to operate one of the fundamental geodetic and geodynamic reference stations necessary to fulfil the aims of future global international geodynamic programmes.

Reference

Schneider, M. and others. Concept and realization of a 20 m radiotelescope for the satellite observation station Wettzell. Paper submitted to the International Association of Geodesy, Tokyo, May 1982.

A MOBILE LASER-RANGING SYSTEM AND ITS APPLICATIONS FOR THE DETECTION OF EARTH PLATE MOTIONS*

Paper submitted by the Federal Republic of Germany

RESUME

Le présent document a trait à un télémètre mobile à laser et porte sur une campagne visant à détecter les mouvements de l'écorce terrestre en Méditerranée orientale.

Deux systèmes identiques sont en construciton à l'Institut néerlandais de physique appliquée TNO-TH à Delft, l'un étant destiné à l'Institut de géodésie appliquée de Francfort-sur-le-Main (République fédérale d'Allemagne) et l'autre à l'Université de technologie de Delft (Pays-Bas). Ces deux systèmes doivent permettre de procéder à des observations à un niveau de bruit de 1 à 2 cm jusqu'à un maximum d'environ 12 000 km et comprennent une énergie d'impulsion de 10 à 15 mJ, avec une largeur de demi-impulsion de 200 p/sec. et une fréquence de répétition de 10 Hz.

Le document décrit brièvement le programme d'observation entrepris par la NASA dans le cadre du projet relatif à la dynamique de l'écorce terrestre en Méditerranée orientale.

The Institut for Angewandte Geodäsie (IfAG) at Frankfurt am Main, acting as a member of the Special Research Group on Satellite Geodesy, and the University of Technology at Delft are co-operating with the Institute of Applied Physics TNO-TH at Delft to develop identical mobile systems for satellite laser-ranging. The completion and preliminary test measurements of the two units, described below, are planned for 1983. The first significant field applications in the eastern Mediterranean are planned to commence in 1984, as part of the projected WEGENER activities.

The systems are designed to be capable of observing at the 1-2-cm noise level to a maximum range of approximately 12,000 km and include a pulse energy of 10-15 microjoules with a half-energy pulse-width of 200 picoseconds and a pulse repetion rate of 10 hertz.

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* The original text of this paper, prepared by the Institut für Angewandte Geodäsie, Frankfurt am Main, appeared as document E/CONF.75/L.29.

SYSTEM SPECIFICATION

A single telescope is designed for use both as optical transmitter and receiver. 1/ Laser and detector packages are attached in fixed positions at the base of the mount and are readily accessible to the operator. The detection system is designed to permit rapid signal identification for observation at the single photo-electron level. A quadrant detector serves to permit adjustment of the pointing in order to maximize signal return at the main PMT and multiple-stop timing is used to facilitate signal recognition and subsequent adjustment of the return signal to the single photo-electron level. An echelle grating is used in place of the customary narrow-band interference filter.

The overall measuring system is under the control of two 8-bit Motorola 6809 microprocessors slaved to a 16-bit HP 1000 model 5 microcomputer. A fast floating-point processor is included to speed up the computation procedure controlling the prediction and pointing, with a direct data feedback link between the formatter and prediction processors; and 2 x 270 kilobytes of disc storage is available to supplement the 128 kilobyte core, and a graphics terminal is included to provide visual feedback to the observer. A TI-Silent 765 keyboard - send and receive (KSR) terminal will be used as an input-output channel for communicating orbital updates and quick-look results between the system and the outside world.

The telescope, mount, laser (including power-supply and cooling) and detector are configured together on a separate cart, which is loaded into the vehicle for road transport and run out to a position adjacent to the ground-marker for ranging operations (see figures 15 and 16). The system will be operated from its own independent power-supply. In an air-freight configuration, the total measuring system fits on to a single standard freight pallet.

Some of the main characteristics of the system, which costs about 2.8 million deutsche mark, are:

(a) Coudé mount, approximate weight, 500 kg;

(b) Diameter of combined transmitter/receiver objective, 40 cm;

(c) Neodymium-YAG laser with oscillator plus one amplifier;

(d) Output doubled to give 539 manometres;

(e) Pulse energy, 10 microjoules;

(f) Half-energy pulse-width, 200 picoseconds;

(g) Pulse repetition rate, 10 hertz;

(h) Pulse-by-pulse calibration;

(i) Multi-stop counter and four-quadrant detector for signal acquisition;

(j) Echelle grating - band-width tuned to laser wavelength to better than $\pm$ 2 Å (Ångström);

Figure 15. Federal Republic of Germany: mobile laser-ranging system on the road

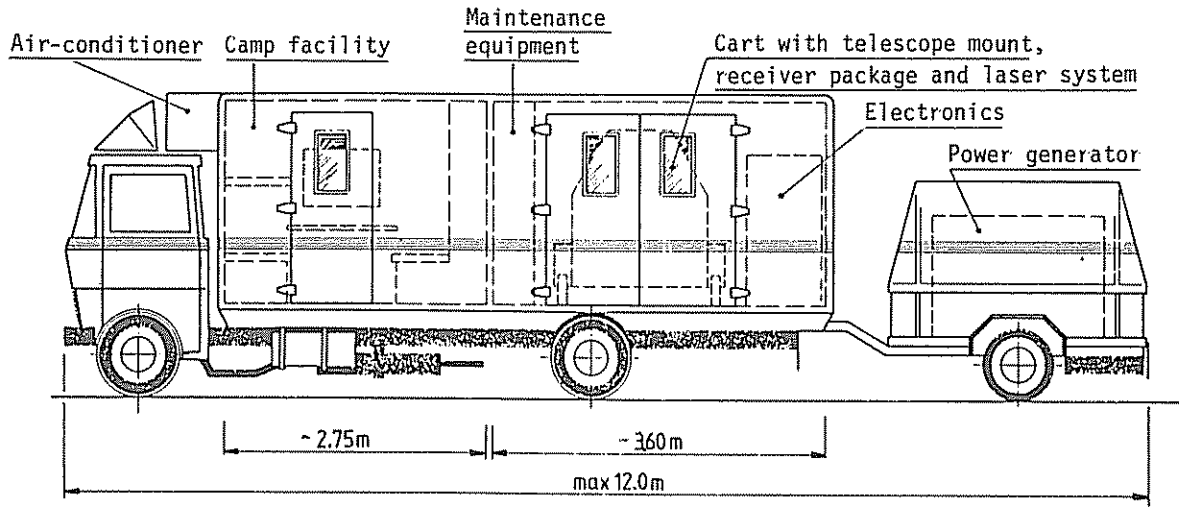
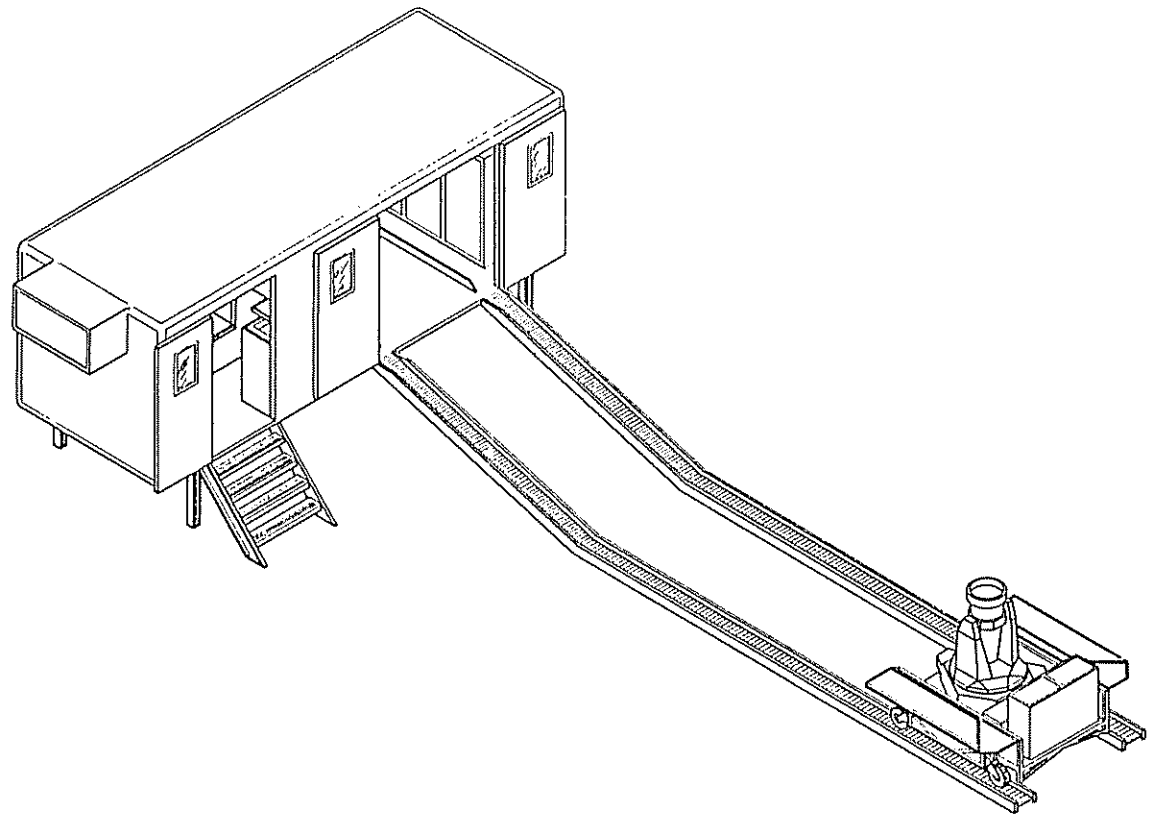


Figure 16. Federal Republic of Germany: operational configuration of mobile laser-ranging system



(k) Normal point range accuracy, 1-2 cm;

(l) Terrestrial ranging;

(m) Operating personnel, two.

The dimensions of the system's modules permit its transfer from point to point by road, rail, sea or commercial air-freight. As a result, it is adaptable for either mobile operations or stationary deployment (see figures 15 and 17). The system will be operated by two engineers.

OBSERVATION PROGRAMME IN THE EASTERN MEDITERRANEAN

It is anticipated that use of the two systems of IfAG and the Delft group will be co-ordinated in projects of common interest, particularly in the field of crustal dynamics and earthquake research, such as that inaugurated by the United States National Aeronautics and Space Administration (NASA). A brief summary of a proposed work plan, which was developed in discussions involving geodesists, geologists and seismologists from several countries, is given below.

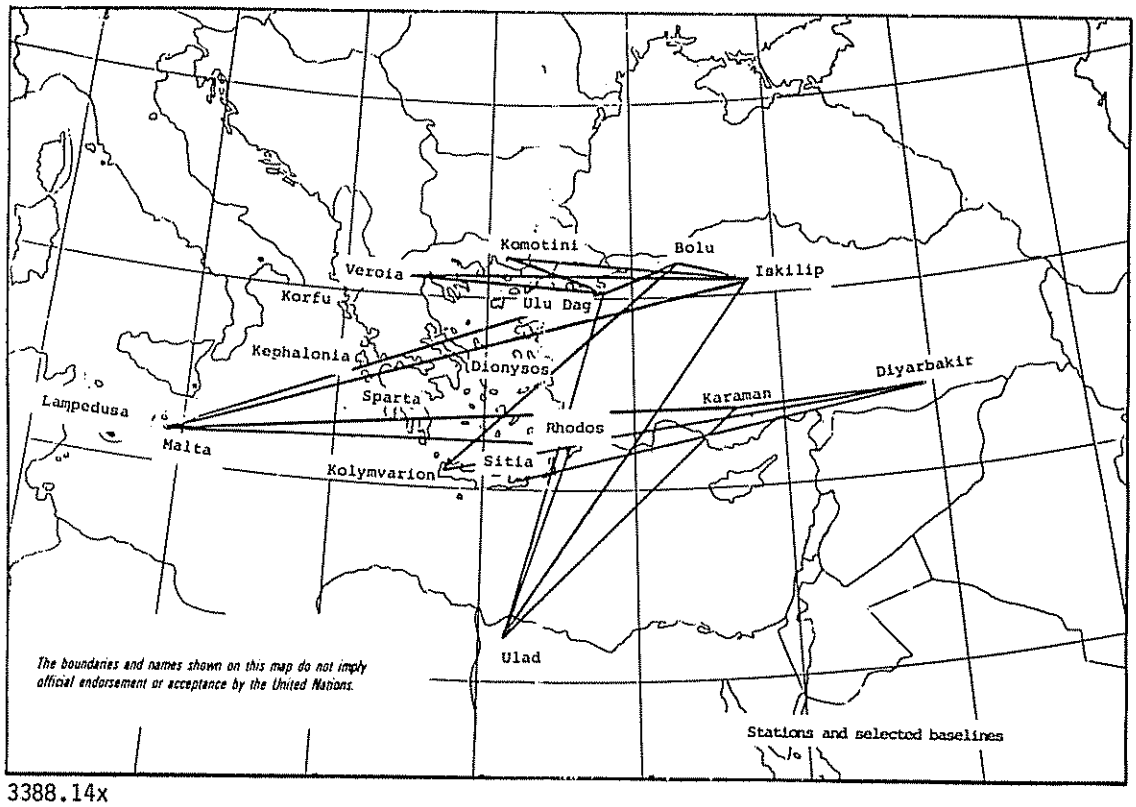
The circum-Aegean region, as part of the boundary between the African and Eurasian plate, is tectonically the most active area of Europe, with a complex pattern of platelets and belts of deformation. Relative motion rates of up to about 5 cm per annum may occur in the area. Space techniques are ideally suited to help define the extent of these platelets and the relative motion vectors with respect to one another and with respect to the distant stable areas of central Europe and north Africa. In addition to providing observed evidence of current rates of change along selected baselines, thereby testing the validity of different kinematic models, the proposal will also provide information of value to earthquake research and hazard assessment throughout the areas of Greece and Turkey covered by the network of points.

Large seismic gaps have been recognized in these countries, especially along the east Anatolian and the Hellenic arc plate boundaries. The expectation that these gaps may be ruptured by large earthquakes in the not too distant future adds an element of urgency to the execution of this study.

It is proposed that a large-scale network of about 14 laser-ranging stations should be established in the eastern Mediterranean area, capable of measuring accurately (± a few centimetres) distances between them which range from 200 to 1,000 km. It is proposed that mobile laser-ranging stations should be brought to bench-marks from which precise ranging would be performed to the satellite LAGEOS. These observations would be performed over a period adequate to ensure a good position determination in relation to those stations occupied simultaneously. Depending upon weather conditions, the observation period at each site can be expected to last up to four weeks.

Since it is planned that several systems will be available for use in the area to be covered, special attention must be paid to the choice of sites selected for parallel occupation. It can be anticipated that the baseline distances between these points will be calculated with greater accuracy than the distances derived from the general station position solutions. Special numerical techniques are being developed to exploit this capability.

Figure 17. Federal Republic of Germany: stations and selected baselines for observation programme in eastern Mediterranean



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Furthermore, supporting observations are planned, throughout the field campaign, from fixed ranging observatories which will act as reference points for the network. Such stations exist at Grasse, France; Kootwijk, Netherlands; and Wettzell, Federal Republic of Germany. The new observatory at Graz, Austria, should be operational by the time field observations commence in 1984.

The upgrated Dionysos system, visualized to be operational at that time, will be of utmost importance, since it can serve as a reference position situated at the heart of the network. Further reference stations are possibly required on the African plate.

It is hoped that NASA will participate in this project with mobile field equipment.

Note

1/ P. Wilson, "Das mobile Laserentfernungsmess system des SFB 78 und sein geplanter Einsatz in Rahmen der internationalen Arbeiten zur Geodynamik", Nachrichten aus dem Karten- und Vermessungswesen, vol. 90 (Frankfurt am Main, Reichsamt für Landesaufnahme, 1982).

ACTIVITIES IN THE FIELD OF GEODETIC CONTROL NETS*

Paper submitted by Hungary

RESUME

Le document donne un aperçu des canevas planimétriques et altimétriques de la Hongrie. Il décrit les réseaux utilisés à l'heure actuelle et expose les activités visant à les perfectionner.

Il montre que les canevas géodésiques hongrois non seulement répondent aux besoins courants mais également permettent une étude scientifique poussée du territoire.

Il convient de signaler en particulier que l'on a utilisé avec succès les techniques de géodésie par satellite dans le contexte des canevas planimétriques. L'expérience acquise par la Hongrie en matière d'application des techniques Doppler pourrait être utilisée avec profit dans d'autres pays.

It has been long known that for any cartographic activity, including even most engineering works, timely execution depends upon the availability of a contiguous, homogeneous geodetic network of adequate reliability for the area in question, be it a country, region or continent.

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* The original text of this paper, prepared by Istvan Joó, National Office of Lands and Mapping, appeared as document E/CONF.75/L.91.

In Hungary, this has been the prevailing point of view for a long time. Thus, for planning geodetic-cartographic works and allocating financial and technical resources, the establishment, maintenance and development of the horizontal and vertical control nets have always been given high priority.

During the 10-15 years following the end of the Second World War, completely new horizontal and vertical control nets were set up in Hungary. Subsequently, greatly increased users' demand, on the one hand, and realized scientific programmes (geoid determination, geodetic confirmation of geodynamic experiments), on the other, have led to much greater requirements for geodetic networks. In the light of these needs, further development of the existing horizontal and vertical control nets was begun in Hungary at the end of the 1960s.

Naturally, the execution of this work has been extensively supported by improvement of geodetic instruments development of completely new methods of positioning and the spread of computers.

This paper describes the fundamental horizontal and vertical geodetic control nets, respectively, and then discusses those works currently in progress designed to update the geodetic control network, using the most recent equipment and methods.

HORIZONTAL GEODETIC CONTROL NETWORK

Review of the network

Principal data of the first-order triangualtion network, shown in figure 18, are:

(a) Average side length, 25-27 km;

(b) Number of first-order points, 140;

(c) Number of first-order triangles, 284;

(d) Number of first-order measured direction, 900;

(e) Number of Laplace points, 59;

(f) Number of measured lengths, 27.

Of these caracteristics the lengths of seven sides were determined by the classical method, on the one hand, but all 27 sides also were measured by electro-optical distance meter, with a mean square error of

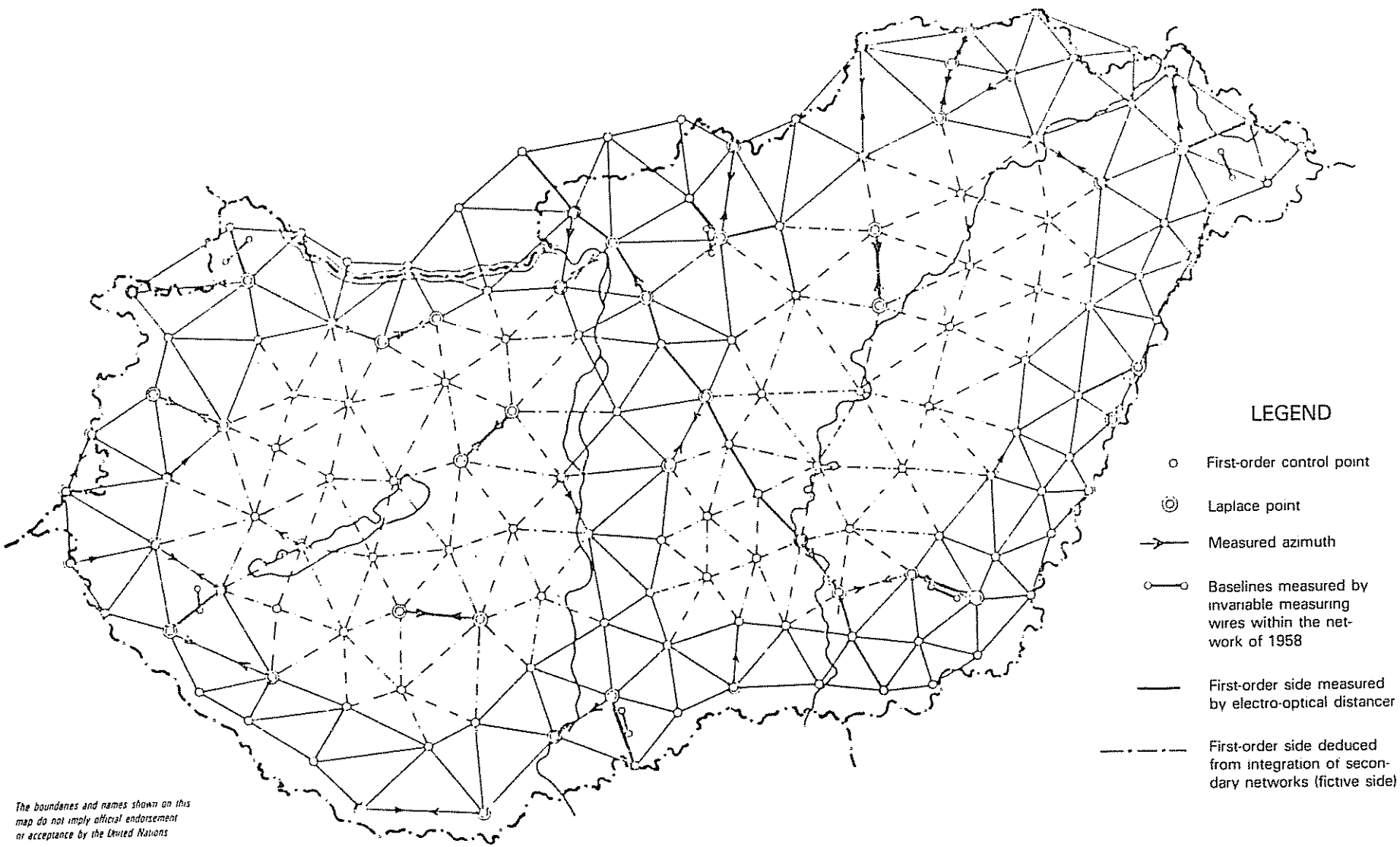
$$\mu_D = \pm 3.6 \text{ mm},$$

which means a relative error of

$$1/7 \text{ million}, \quad \text{with } D_{average} = 25\text{-}27 \text{ km}.$$

Astronomical positionings are characterized by the mean square errors given below:

Figure 18. Hungary: astrogeodetic network



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$$\mu_{\varphi,\lambda} = \pm 0.08"$$

$$\mu_{\alpha} = \pm 0.12"\text{-}0.15"$$

Reliability of the angular measurements are characterized by the following:

$$\mu_{\text{Ferrero}} = \pm 0.403"$$

and

$$\mu_{\text{o-direction}} = \pm 0.434",$$

received from the adjustment, and which equals ± 63 mm, with lengths of 27 km, corresponding to a relative error of 1/475,000.

No second-order network has been established in Hungary.

Principal features of the third-order network are: (a) 6-7-km average side length; (b) 2,116 third-order points; (c) $\mu_{\text{angle}} = \pm 0.46"$; (d) linear mean square error, received from the adjustment, is ± (1.5-2.5) cm, corresponding to a relative error of 1/300,000.

Based on the fundamental net, establishment of the fourth-order net is also under way; its point density is 0.5 km^2 per point for populated areas; and 2-3 km^2 per point for agricultural areas. Linear reliability of the points is ± (2-3) cm, corresponding to a relative error of 1/50,000-1/60,000.

At the end of 1982, the fourth-order net was complete for 68 per cent of the area of Hungary. Completion of the programme is expected by 1992.

From the viewpoint od the survival of the first-order network, construction of reinforced concrete towers on 100 first-order points is important. Measurements from these towers can be performed at any time. The average height of the towers is 20.8 m; the highest is 30 m. Currently, the reinforced concrete towers are completed on 74 points; the rest of the work will be completed by 1990.

Continued development of horizontal control net

Shortly after finishing the work of the fundamental network, was finished its control, consisting of the following works, was begun:

(a) Detailed critical examination of the measurement data;

(b) Complementary measurements (angular and distance measurements, astronomical positioning).

These investigations resulted in the homogeneity and great reliability of the established fundamental net. Despite all these qualities, however, a plan

has been worked out for refinement of the network by satellite geodetic methods. It involves satellite Doppler measurements, on the one hand, and application of stellar triangulation, on the other.

The satellite Doppler positionings (on 14 points) were completed in 1981/82 by multi-location technique (see figure 19), using JMR 1A and JMR 4A instruments. Processing of the measurement data is under way. Experts of the Budapest Institure for Geodesy and Cartography have achieved considerable results in improving the computer programs of satellite Doppler measurement data. Based on the experiences of the 1981 Doppler measurements, a mean square error of about $\pm$ (0.2-0.3) m is expected for the co-ordinates.

The planned stellar triangulation programme is shown in figure 20. It may be seen that the net of seven points consists of 11 sides (with average side lengths of 160-200 km), only two of them measured so far. It is expected that an approximate reliability of $\pm$ 0.3" will be achieved by this technique.

After all planned measurements are completed, the readjustment (probably spatial) of the first-class astrogeodetic net will take place between 1985 and 1990, using the old angular and distance measurements, as well as the satellite Doppler and stellar triangulation measurements.

VERTICAL CONTROL NETWORK

Review of the network

Since the second half of the nineteenth century several national levellings have taken place in Hungary. The third national levelling was carried out after the Second World War (1948-1964). This task was necessitated by the loss or damage suffered by many of the control points during the war.

As a result of these efforts, the entire first-, second- and third-order network has been completed. The total length of the first-, second- and third-order lines is 26,612 km. The first-order network is shown in figure 21. This net consists of 33 loops, with a total linear length of 6,542 km. The average levelling error, received from the adjustment, was $\pm$ 0.80 mm. The same errors for the second- and third-order nets were $\pm$ 0.97 mm and $\pm$ 1.50 mm, respectively.

This is the vertical control network currently used in Hungary.

Improvement of the net

During the 1970s--primarily in connection with the scientific programmes--increasingly firm demands were surfacing with regard to the need to establish a levelling network with special monumentation and extreme accuracy. Of special significance in this question were considerations relating to the recent vertical crustal movements. In view of that situation another levelling programme was initiated in 1973, eventually permitting extensive investigations into the crustal movements through the first-order net.

Figure 19. Hungary: Doppler points on the triangulation network

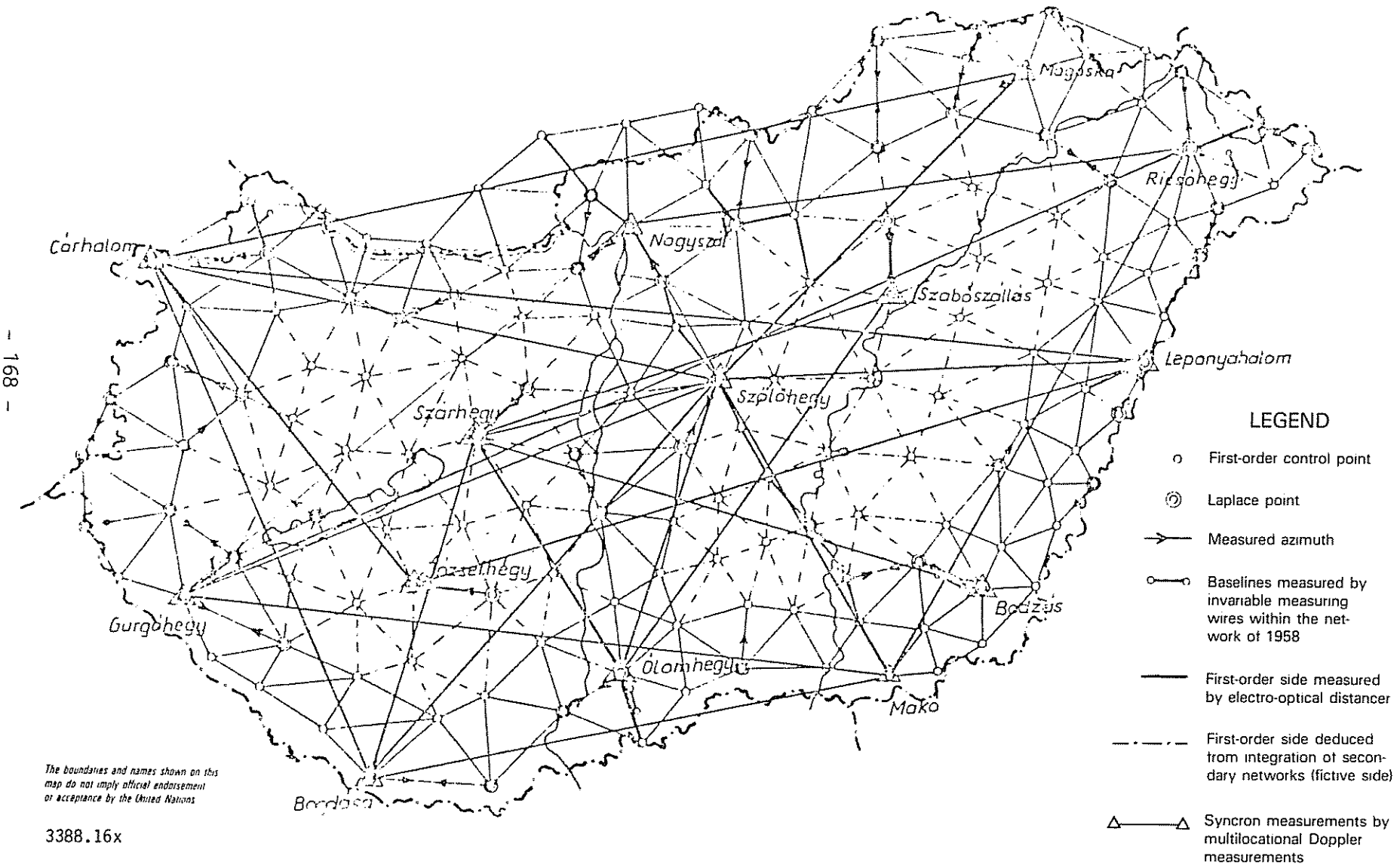

Figure 20. Hungary: stellar triangulation network

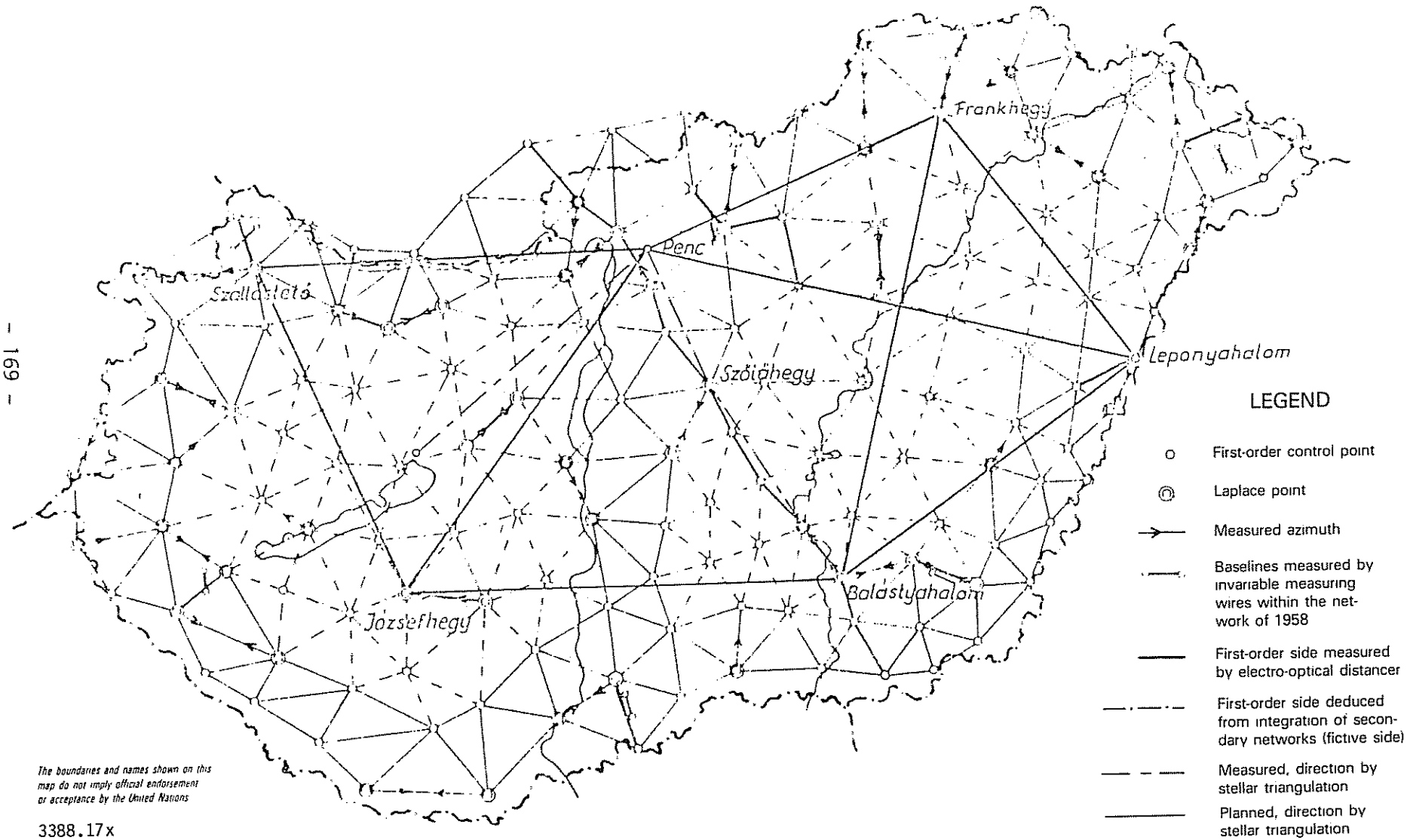

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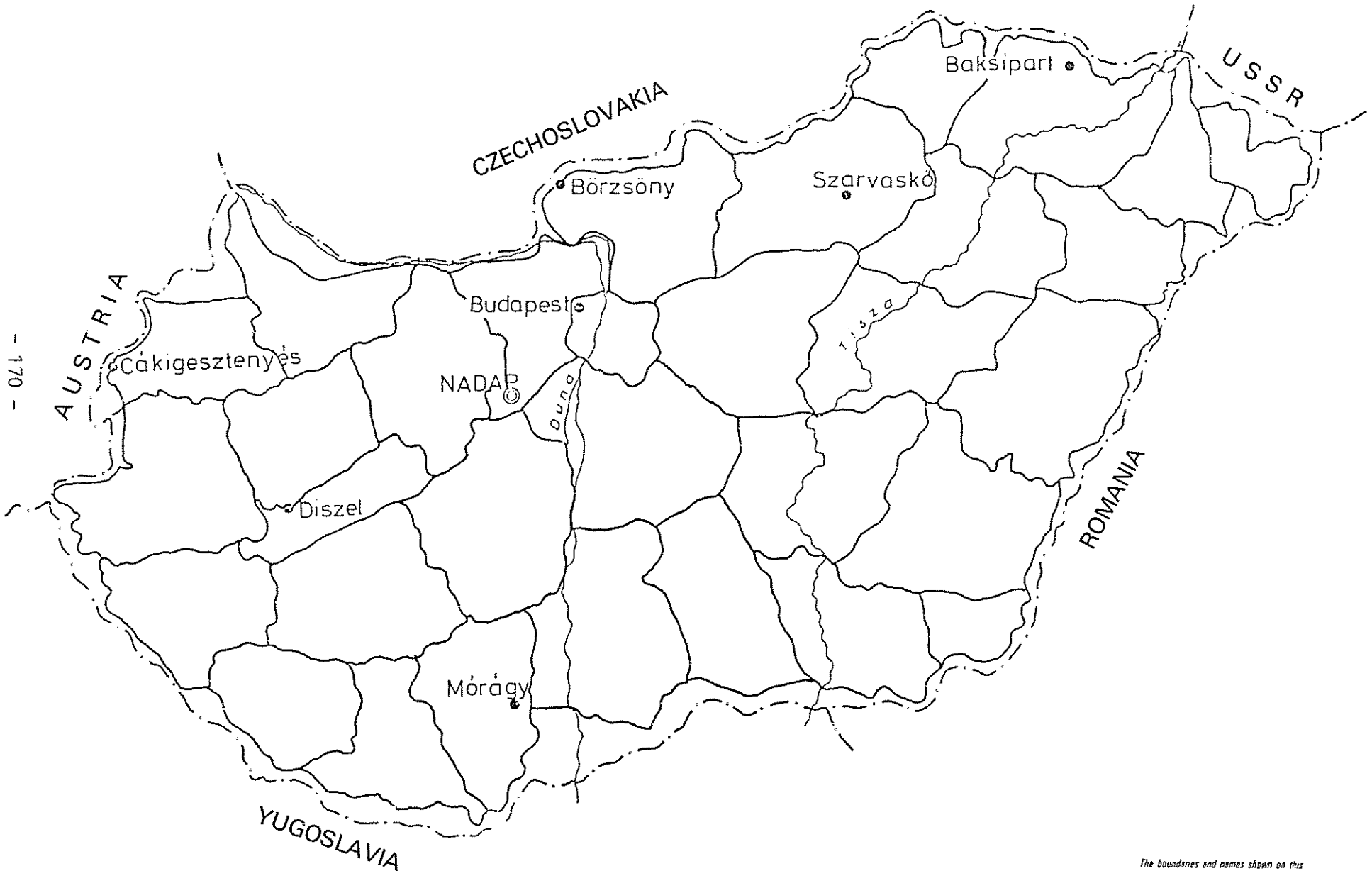
Figure 21. Hungary: first-order levelling network, 1948-1964



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This effort is facilitated first of all by the following characteristics (figure 22):

(a) Geological (tectonic) conditions had been considered during the planning of the net;

(b) Forty principal bench-marks were established in the first-order network; 15 of them are embedded in rock, while the other 25 are deep bench-marks, with depths of 15-20 m (see left side of figure 23);

(c) Average length of levelling sections is 1.0 km, but further special monumentation was applied on the levelling lines with 5-km spacings (see right side of figure 23);

(d) Permissible difference during to and from levellings is no more than $\pm 1.2 \sqrt{L}$ mm, where L is the length of the section in kilometres;

(e) Maximum permissible error of closure for the loops is $\pm 0.9 \sqrt{F}$ mm, where F is the circumference of the loop in kilometres.

Of this newest levelling network, the first-order net has already been completed (figure 22); the total length of the lines is 3,800 km, while the average circumference of the 11 loops is 480 km.

Having finished the measuring of the new first-order levelling net (1979), work has begun on the establishment and measurement of the new second- and third-order networks. Their total length will be about 20,000 km. Some 20 per cent of the work on the new second- and third-order nets is completed, and the entire network will be finished by 1990.

CONCLUSIONS

On the basis of this short paper, one may state that Hungary takes great care of its geodetic control networks. As a result, both the horizontal and the vertical control nets permit the co-ordinated execution of technical and cartographic projects of national scale.

The activities now in progress bring about these geodetic bases, which will constitute the foundation of scientific and other programmes of special accuracy, guaranteeing their successful execution. Hungarian practice introduced for the monumentation of geodetic control points (reinforced concrete towers, deep bench-marks) fosters the survival of points through several decades.

The Hungarian instrumental base and acquired professional experience with satellite geodetic techniques--as concerns both measurements and advanced processing of measurement data--form a realistic basis for effective participation of Hungarian experts in the establishment and improvement of geodetic control networks in other countries in the coming years.

Figure 22. Hungary: precise levelling network, 1973-1979

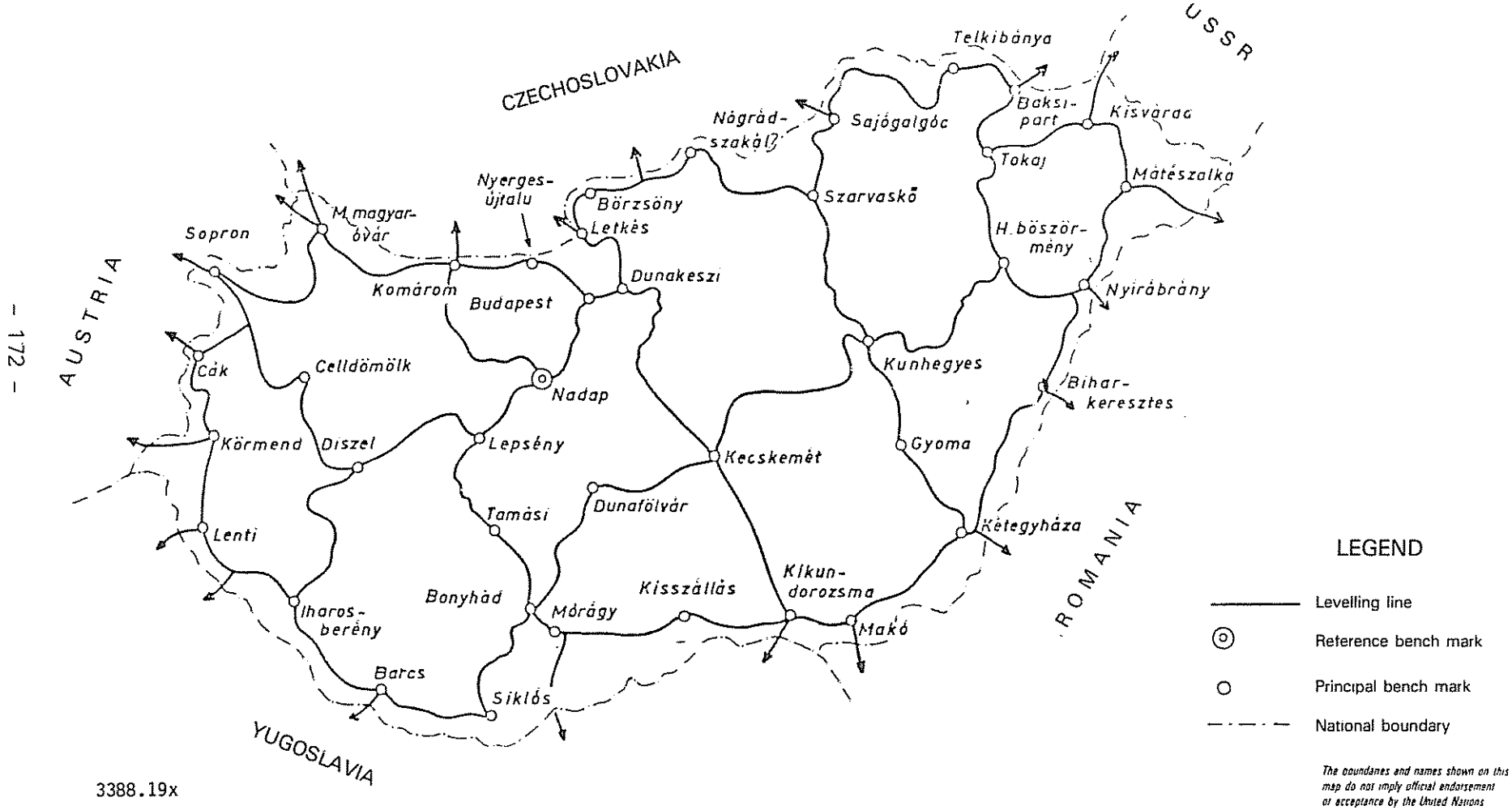
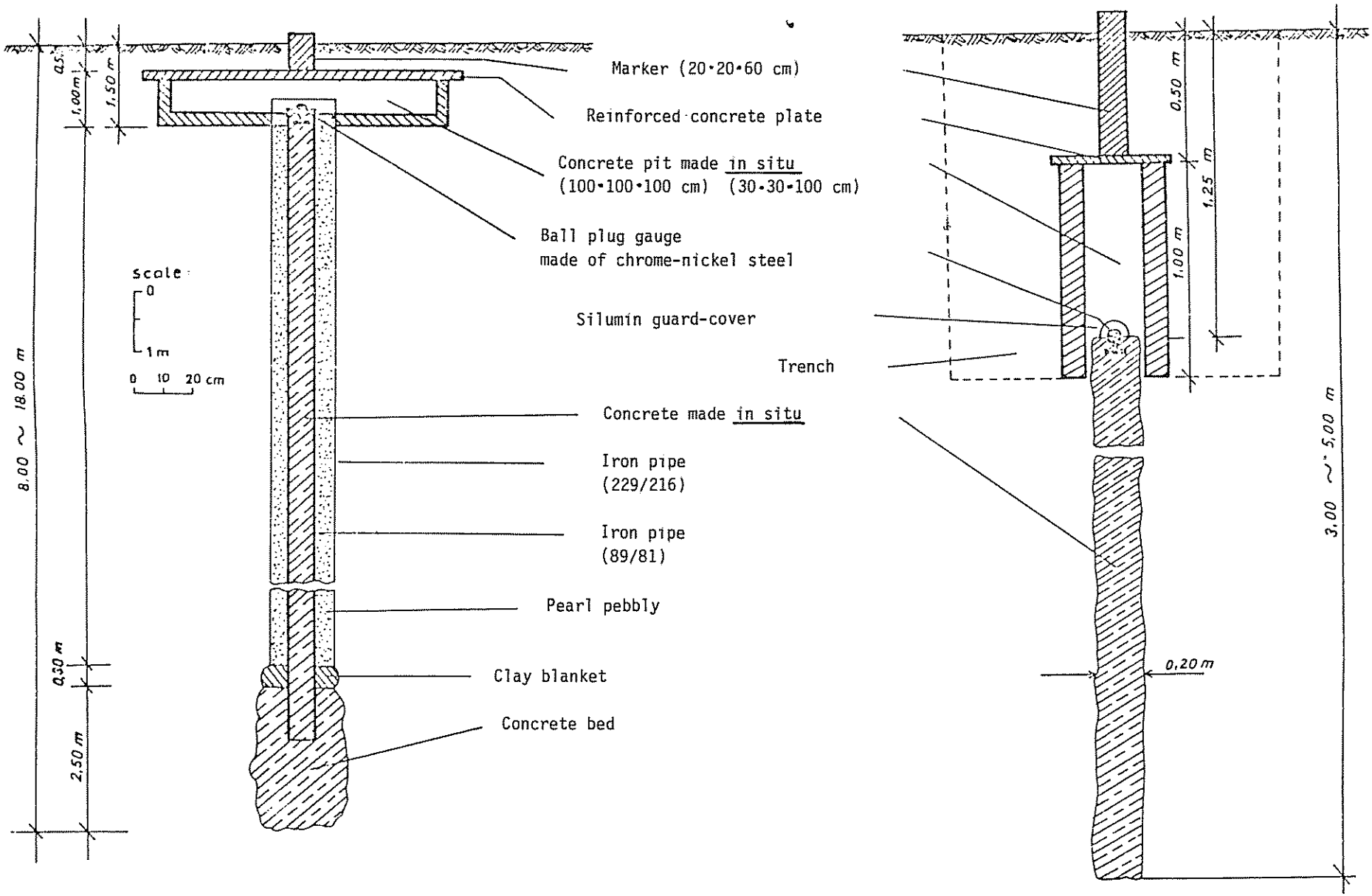


Figure 23. Hungary: bench-marks in precise levelling network



Principal bench=mark
with deep foundation

Bench=mark
with deep foundation

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JOINT DEMARCATION AND SURVEY OF THE INTERNATIONAL LAND BOUNDARY BETWEEN INDONESIA AND MALAYSIA*

Paper submitted jointly by Indonesia and Malaysia

RESUME

La Malaisie et l'Indonésie ont une frontière commune de 1 746 km, séparant le Sabah et Sarawak (Malaisie) du Kalimantan (Indonésie).

Des progrès ont été réalisés depuis que le memorandum d'accord a été signé en 1973, à Jakarta, entre les deux pays, sur la délimitation et le forage, et que le projet commun a été lancé en 1975. Le rapport contient une description des dispositions administratives de la structure institutionnelle et des méthodes et procédures suivies pour les levés, ainsi que les résultats obtenus à la fin de 1982.

Indonesia and Malaysia share a commun land boundary of 1,746 km between Kalimantan (Indonesia) and Sabah and Sarawak (Malaysia). It extends 333 km between Sabah and Kalimantan Timur (see figure 24, marked "Annex A", in pocket[1/]) and 1,413 km between Sarawak and Kalimantan Barat (see figure 25, marked "Annex B", in pocket[1/]). The international land boundary was agreed upon by the United Kingdom of Great Britain and Northern Ireland and the Netherlands, in accordance with the following Conventions and Agreements:

(a) The Boundary Convention signed in London dated 20 June 1891;

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* The original text of this paper appeared as document E/CONF.75/L.90.

(b) The Boundary Agreement signed in London, dated 28 September 1915;

(c) The Boundary Convention signed at The Hague dated 26 March 1928;

Due to the accelerated rate of development and the fact that the above-listed Conventions and Agreement did not precisely define the boundary along certain regions, it was agreed upon by the two countries to demarcate and survey precisely the international boundary.

BACKGROUND

On 26 November 1973, Malaysia and Indonesia signed at Jakarta a Memorandum of Understanding on the joint demarcation and survey of the land boundary between the two countries based on the above-mentioned Conventions and Agreement.

It was also agreed that the cost of the entire project would be shared equally between the two countries. An equal number of technical and supporting personnel will also be made available to carry out the project.

On 9 September 1975, the joint project for demarcation and survey of the international boundary between the two countries was officially launched.

IMPLEMENTATION

Organizational structure

To carry out the joint demarcation and survey project, three levels of committee were formed to guide and supervise the implementation:

(a) Joint National Boundary Committee. This is the main co-ordinating committee where government policies and guidelines concerning the project are discussed and agreed upon. This committee reports back to respective Governments;

(b) Joint Technical Committee. This committee ensures that the project shall be carried out along technically sound principles. The committee reports back to the Joint National Boundary Committee;

(c) Co-Project Directors Committee. There are two committees, one for the Sabah and Kalimantan Timur sector and one for the Sarawak and Kalimantan Barat sector. These committees are responsible for carrying out the actual demarcation and survey of the international boundary.

Survey projects

Project A: control survey

Project A consists of reconnaissance survey and the establishement of major control points along the entire length of the boundary and establishment of major boundary markers at salient points of the watershed.

Project B: demarcation and survey

Project B consists of demarcation and straight-line survey of the boundary. It also involves the emplacement of the international boundary markers.

DETAILED PLAN OF EXECUTION

The detailed plan of execution includes the areas outlined below:

(a) Administrative arrangement:

(i) Security forces support: arrangement; air clearance; security arrangement in border region; strength of security forces; and military uniforms including arms used by the Indonesian survey teams;

(ii) Logistics;

(iii) Communication;

(iv) Transportation;

(v) Liaison;

(vi) Helicopter support;

(vii) Helicopter crossing;

(viii) Standing rules for search and rescue;

(ix) Immigration clearance: arrangement; identification card; shoulder badge; and reservation of right to refuse entry;

(x) Customs clearance;

(xi) Medical assistance;

(xii) Finance;

(xiii) Working hours;

(xiv) Working period in the field;

(b) Plan of operation:

(i) Priority area;

(ii) Joint survey operation;

(iii) Joint survey team;

(iv) Composition of survey team;

(v) Survey Team Leader: responsibilities; duties;

(vi) Chief of Field Parties: responsibilities; duties;

(vii) Co-Project Director: responsibilities; duties; and meetings;

(viii) Meeting of Directors;

(c) Principle and guidance:

(i) Basis for demarcation and survey;

(ii) Watershed boundary;

(iii) Straight-line boundary;

(d) Method and procedure in the field:

(i) Boundary pillars and boundary markers: terminology; types of boundary markers; interval for emplacement of boundary markers; accuracy of Type-A boundary marker; numbering of boundary marker; numbering of type-C boundary marker; sharing of costs; boundary pillar not on watershed; displacement of boundary pillars and boundary markers due to earth movement; missing boundary pillars; new boundary markers replacing old boundary pillars; maintenance of boundary pillars and boundary markers;

(ii) Standards of accuracy;

(iii) Instruments: angular observation; station angle; adopted station angle; linear measurement;

(iv) Azimuth control;

(v) Adopted azimuth;

(vi) Common height datum;

(vii) Aerial photographs, maps and other data;

(viii) Reconnaissance survey;

(ix) Traverse;

(x) Cross-sectioning;

(xi) Final survey;

(xii) Field-book;

(xiii) Booking procedure;

(xiv) Computation;

(xv) Plans: types; preparation; officers responsible for survey and drafting; Chiefs of Field Parties and Survey Team Leaders; specification; starting co-ordinates; amendment to field plan; field plan for project A; symbols of boundary markers as shown on plans and maps; types of boundary pillars and boundary markers to be shown on maps attached to Memorandum of Understanding; exchange of transparencies of field plans;

(xvi) Modification of procedure;

(e) Progress report:

(i) Joint monthly progress report;

(ii) Composite progress report;

(iii) Comments by Co-Project Director;

(f) Border certificate;

(g) Documentary film;

(h) Memorandum of Understanding:

(i) Incorporation of Memorandum of Understanding into an Agreement;

(ii) Naming of Memorandum of Understanding;

(iii) Specifications for map to be attached to Memorandum of Understanding.

DOPPLER SATELLITE SURVEY

Due to the difficulties imposed by thick primary jungle and the lack of triangulation points for most of the Sarawak and Kalimantan Barat sector, it was decided that both countries would use the Doppler satellite position-fixing technique to establish the positions of 40 salient points along the border. The survey was done with Canadian Marconi Doppler satellite position-fixing equipment, using the broadcast ephemeris in the multi-stations and translocation modes. It was agreed upon by both countries that the results so obtained should be reduced to the WGS-72 and the NWL-10D reference frames for position and heights. Each country will then transform the results so obtained into its respective reference datum.

Forty sections were successfully fixed by Doppler satellite position-fixing techniques by the end of 1981. For further details of the modus operandi, results and analysis thereof, please see the annex to this report.

PROGRESS

The progress achieved from 1975 to the end of 1982 is described below:

(a) Kalimantan Timur and Sabah sector. The total length covered was 333 km. Project A covered 333 km (100 per cent) and project B, 178.8 km (53.7 per cent);

(b) Kalimantan Barat and Sarawak sector. The total length covered was 1,413 km. Project A covered 402.1 km (28.5 per cent) and project B, 309.6 km (21.9 per cent).

PROBLEMS

Much of the border region under the joint demarcation and survey is hilly and covered with primary jungle, without any modern communication systems. Therefore, the most efficient mode of transport for personnel, equipment, supplies etc. is by helicopters. The survey season is normally from five to eight months at one strech, due to weather conditions.

CONCLUSIONS

The progress of the project is considered satisfactory in view of numerous problems encountered. The project is carried out in the traditional spirit of good will, friendship and co-operation. Differences of opinion are amicably settled by reference to documentary evidences and consultations.

Note

1/ Certain unnumbered maps have been placed in the pocket at the end of this volume. Reference in the text indicates the numerical listing of such an illustration in the contents. Thus, figures 24 et 25 referred to above are unnumbered maps in the pocket.

Annex

Demarcation by Doppler techniques

In 1978, Indonesia and Malaysia decided to use Doppler positioning techniques for demarcation of salient points along the watershed boundary between Kalimantan (Indonesia) and Sabah/Sarawak (Malaysia). Forty stations have been positioned since the first observations were made in 1979. These stations were observed by the multi-station mode of operation with Kuching on the Malaysian side and Balikpapan on the Indonesian side as Doppler base stations, and three CMA-751 Doppler receivers roving along the watershed boundary.

The Doppler data were processed using PREDOP/GEODOP programs and transformed into the Timbalai Datum (the East Malaysian Geodetic System) as the datum agreed upon by both countries.

For the purpose of datum transformation, program BURSA was run, using three stations that had already been defined on the Timbalai Datum, namely Timbalai, Goram and Sijingkat.

The co-ordinates for these stations are given below:

Station	Latitude (N)	Longitude (E)	Height above sea-level (metres)
Timbalai	5°17'03".55	115°10'56".41	68.28
Goram	1°54'41".52	112°51'49".45	934.97
Sijingkat	1°35'24".48	110°26'14".92	89.86

Note: a = 6,377,298.52 m; 1/f = 300.8017 (Everest speroid).

For conversion of these geodetic co-ordinates to XYZ co-ordinates, it was necessary to assume a zero geoidal height for the three stations because no information was available with regard to the geoid in the area.

The BURSA program was used to solve for three translations and scale which would relate the co-ordinates in broadcast ephemeris co-ordinate frame to the co-ordinates on the Timbalai Datum. The rotations were not solved. The following mean transformation parameters were found:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{\text{NWL-10D}} \text{minus} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{\text{Timbalai Datum}} = \begin{bmatrix} -658.36\ \text{m} \\ 686.39\ \text{m} \\ -51.29\ \text{m} \end{bmatrix}$$

The plane co-ordinate system used to express the co-ordinates of the border markers on the common map is the one on the rectified skew orthomorphic projection system, with the Everest spheroid as the reference spheroid.

The range of accuracy of the Doppler survey results in the multi-station adjustment is summarized below:

Standard deviation in latitude:	0.094"(2.82 m)	_____	0.096"(2.88 m)
Standard deviation in longitude:	0.093"(2.79 m)	_____	0.096"(2.88 m)
Standard deviation in height:	5.7 m	_____	5.8 m

The accuracy obtained in the Doppler positioning seems much better than that of the first-order astronomical positioning as specified for the border

markers agreed upon by both contries in 1972 when Doppler techniques were not yet available for survey and demarcation of the international boundary, i.e., a probable error of 0.5" in latitude and longitude, respectively.

In the meantime, when the Land and Survey Department of Sarawak made connection between seven Doppler stations, from DS-001 to DS-007, with the existing trig network by tellurometer traverses, discrepancies were found in the results: in most cases, the values derived from the ground survey method do not agree with the Doppler survey method within the limit of the standard deviation of the Doppler survey.

This finding leads to the first suspicion that a network distortion exists and that the shortcomings may be in the computation of the geodetic network in the Timbalai Datum. It is suggested that an investigation be made: (a) in the datum definition; and (b) in the method of data reduction and adjustment of the geodetic network, in order to know the source of this network distortion.

Another suggestion is to solve for the rotation of the network with respect to the satellite datum.

Remarks

In the Memorandum of Understanding between Indonesia and Malaysia with regard to survey and demarcation of the international boundary between those countries, signed at Jakarta, in 1973, Indonesia agreed to adopt the Malaysian system of control for the purpose of survey computations (including height) to determine co-ordinates of the border markers for the interim period which would ultimately be converted in terms of the common datum. The definition of a common datum will be the next step, while for the interim period the misnomer "WGS-72 system" is used. In fact, it is the NWL-10D station co-ordinate frame using the WGS-72 ellipsoid. These co-ordinates will be listed in the common border map next to the rectified skew orthomorphic co-ordinates.

NEW SATELLITE LASER-RANGING SYSTEM OF THE HYDROGRAPHIC DEPARTMENT*

Paper submitted by Japan

RESUME

Le Département d'hydrographie japonais a entrepris, en 1980, d'établir un canevas géodésique marin des eaux côtières japonaises.

L'un des principaux éléments du projet est détermination du rapport entre le niveau de référence japonais et le niveau de référence géodésique mondial. On utilise pour cela les observations du télémètre laser du satellite LAGEOS.

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* The original text of this paper, prepared by A. Yamazaki, Director, Astronomical Division; and Y. Ganeko, Astronomical Division, appeared as document E/CONF.75/E.63.

En mars 1982 l'observatoire hydrographique de Simosato a acheté et installé un système de télémétrie spatiale au laser et les observations du LAGEOS se poursuivent depuis avril 1982. Elles sont réalisées en collaboration avec des stations laser du monde entier.

Ce système de télémétrie peut assurer l'observation du LAGEOS pendant toute la journée avec une précision de 10 cm. Le rapport décrit les spécifications du système et les résultats obtenus.

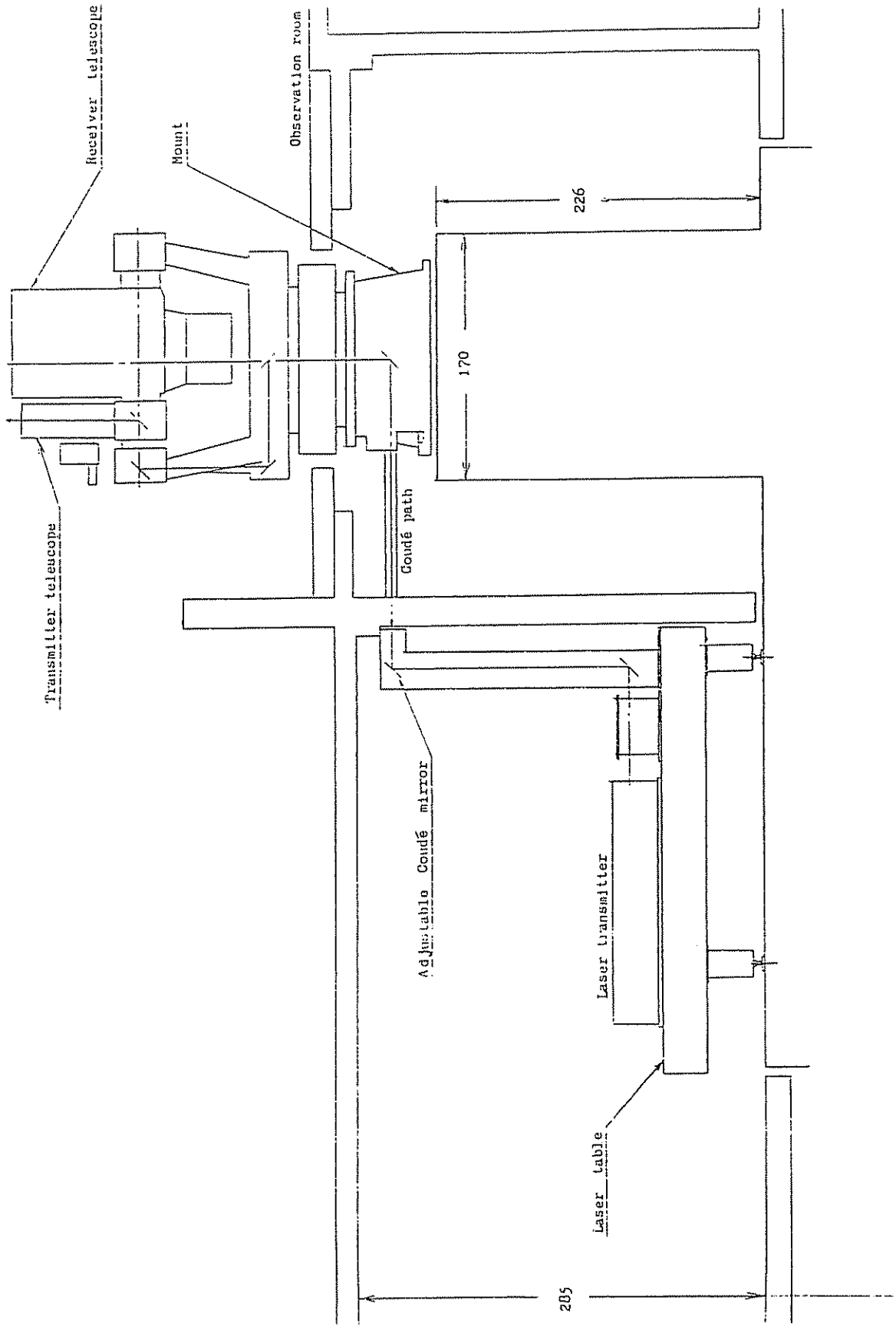
As announced at the Ninth Conference held in 1980, the Hydrographic Department began a project of constructing the Marine Geodetic Control Network around Japan as of fiscal year 1980. The project consists of two subprojects: (a) connection of off-lying islands to the local geodetic datum, the Tokyo Datum; and (b) determination of the relation between the Tokyo Datum and the World Geodetic Datum. For the former subproject, 13 off-lying islands have been connected to the Tokyo Datum until the end of 1982 by use of the Doppler translocation technique based on Navy Navigation Satellite System (NNSS) satellites. Since this method is effective for up to a distance of several hundred kilometres, more accurate connections of distant islands will be performed after the launch of the Japanese geodetic satellite (GS-1) which has capability of laser ranging and photographing and is scheduled to be launched at the beginning of 1986.

For the latter, a satellite laser-ranging system (SLRS) was purchased and installed at Simosato Hydrographic Observatory located at Kii Peninsula in March 1982. The ordinary observations of laser satellites, LAGEOS, Starlette and Beacon-C, have been continued since April 1982. The ranging observations are made in co-operation with laser stations throughout the world. All the stations are connected with each other through determination of orbits of laser satellites. Consequently, the position of Simosato will be given in a world geodetic co-ordinate system, and the well-established Japanese local datum will thus be related to the world geodetic co-ordinate system. In this paper, the status of the lsser-ranging system is described.

CONFIGURATION OF THE SYSTEM

The satellite laser-ranging system is composed of a mount, transmitting and receiving optics, a laser subsystem, receiving electronics and a control subsystem. The mount is the type of elevation-over-azimuth with a transmitting telescope of 17-cm diameter and a receiving telescope of 60-cm diameter. The resolution of encoders for both azimuth and elevation axes is 1.2 arc seconds. The mount is installed on a large concrete pier on which the laser subsystem in the next room is also fixed. Output pulses of laser light are transferred to the transmitting telescope by seven adjustable mirrors through a Coudé path (figure 26). The laser subsystem has a CW oscillator and four amplifiers of neodymium-YAG. An original-mode locked pulse of 6 nanojoules grows to 0.5 joule through amplifiers at 1,064 nanometres of wavelength, and final output energy after a second harmonic generator is 0.15 joule in normal operation. The half-height width of the output pulse is 0.2 nanosecond and the repetition rate is 4 pulses per second.

Figure 26. Japan: configuration of the satellite laser-ranging system
(*Unit = centimetre*)



All the receiving electronics attached behind the receiving telescope consist of a sun shutter, a computer-controlled spectral filter and a photomultiplier tube (PMT) with 29 per cent of quantum efficiency and 0.14 nanosecond of rise-time. The optical block diagram of SLRS is shown in figure 27. As for the control subsystem, a range counter has 20-picosecond resolution; and manual operations in addition to computer control are acceptable for tracking with joystick, transmitting divergence control, start-and-stop threshold-level control, range-gate position and width control, and mount position offset in relation to the predicted position. The clock, integrating rubidium frequency standard, is monitored by receiving four Loran-C waves of the North-west Pacific Chain within the precision of 1 microsecond. The delay time in the receiver is also monitored by a Loran-C wave simulator.

A minicomputer, which is PDP 11/60 with kilobyte memory, two 5-megabyte disc drives, a magnetic-tape drive, a paper-tape reader/puncher and a cathode-ray tube console, is used for the total system control.

OBSERVATION

The setting-up of SLRS began on 2 February 1982 at Simosato Hydrographic Observatory, which is located around 400 km south-westward of Tokyo. Ranging to a satellite, Starlette, succeeded on 8 March for the first time by using orbital elements supplied by SAO. At that time, four certain returns were obtained. The next evening, 324 returns from Beacon-C were recorded, and 132 returns from LAGEOS were obtained on 11 March 1982. These observations were successfully conducted by means of manual search of time offset change to orbital prediction and joystick operation. In April four daytime observations of the LAGEOS passes were attained. The ratio of number of returns to transmitted laser pulses is from 0 to 0.5, according to conditions of sky and reliability of orbital prediction. In the case of good transparency, all three satellites were sufficiently ranged even if the fourth amplifier of the laser subsystem was stopped and output energy was decreased to 50 microjoules.

Three ground targets were installed near the observatory some 1.4-2.4 km apart. Whenever the system ranges to the ground targets, an optical attenuator with variable rate from 2.5×10^{-5} to 1.0×10^{-10} is used for the safety of eyes.

PRELIMINARY DATA PROCESSING

An example of range data, 1,809 returns from LAGEOS, are shown in figure 28. It shows the residuals after smoothing by fitting seventh-order polynomials to range residuals, raw range values minus range prediction values. The root mean square of these residuals is 9.8 cm. Normal points for every 50 returns make the rms value to one seventh, namely, 1.4 cm. In order to obtain the internal delay of SLRS, range observations are made for the ground targets. Some 1.3-nanosecond range offset of SLRS is obtained.

According to the preliminary data-processing by the Aerospace Engineering and Mechanics Department of the University of Texas at Austin, 14 cm of root mean square range residuals to the determined orbit is obtained for 87 returns arbitrarily selected in about a 20-second interval from raw data of four LAGEOS passes.

Figure 27. Japan: block diagram of transmitting, receiving and laser alignment optics

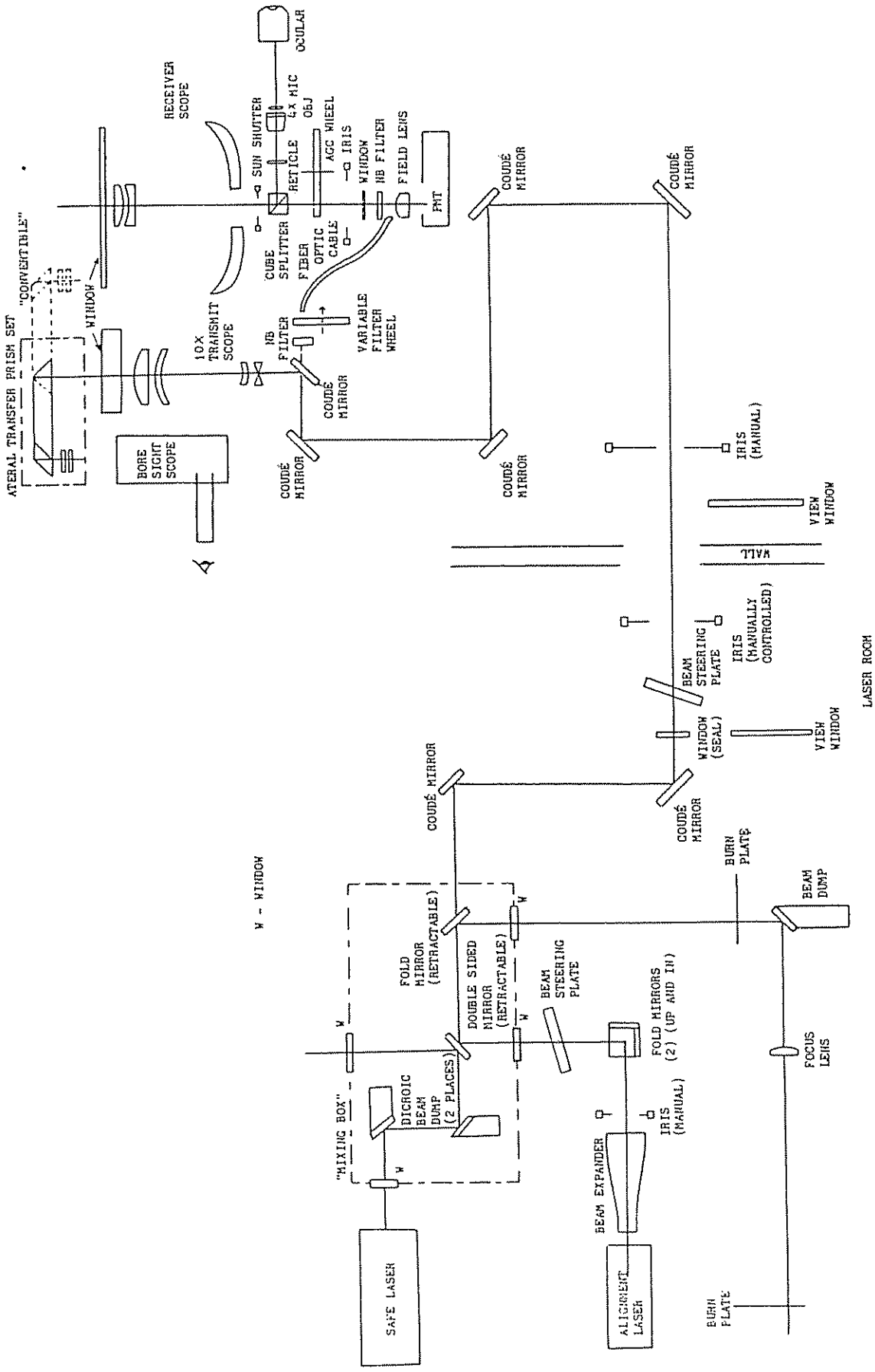
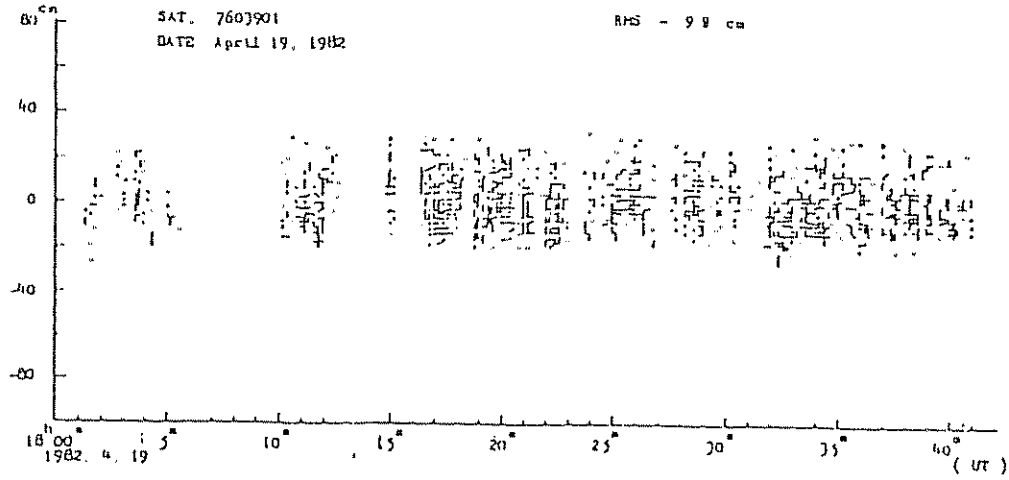


Figure 28. Japan: range residuals to seventh-order polynomial smoothing of a LAGEOS pass



All the range data will be processed by the orbital processor in Japan in order to utilize the data for the aforementioned project.

CONCLUDING REMARKS

The operation of the satellite laser-ranging system at Simosato Hydrographic Observatory has just begun. The tracking to day/night passes of LAGEOS and some night passes of Starlette and Beacon-C will be continued as far as the weather and the system condition permit. The relation between the Tokyo Datum and the world geocentric co-ordinate system will be obtained by incorporating data of other sites in the world. The international data exchange is essential for such a purpose. SLRS will be used to construct a precise local geodetic network in Japan with transportable laser-ranging systems after the launch of GS-1. It also will contribute to determination of the gravity field and some geophysical earth parameters and to measurements of the earth rotation rate and pole position, e.g., the MERIT project. It is expected, moreover, that laser-ranging systems will in future be able to detect plate motions by measuring baselines between sites located on different plates.

ON THE GEODETIC CONTROL SURVEY IN THE NORTHERN PART OF THE PHILIPPINES UNDER THE TECHNICAL CO-OPERATION OF JAPAN*

Paper submitted by Japan

In December 1976, the Government of the Philippines made a request to the Government of Japan for technical co-operation in the preparation of a topographic map required for the development of the Cagayan Valley River basin in northern Luzon. In response, the Government of Japan dispatched a preliminary survey team in January 1978 for consultation with the Bureau of Coast and Geodetic Survey (BCGS), the survey department of the Government of the Philippines, as well as for the inspection of the proposed project site. Based on the findings of the preliminary survey team, the Government of Japan decided to undertake this project beginning from fiscal year 1978.

The scope of work as decided for implementation is as follows:

(a) Project area: approximately 15,000 km^2 of the Cagayan Valley region in northern Luzon;

(b) Project period: five years from January 1979;

(c) Work description: aerial photography at 1:30,000 scale covering approximately 15,000 km^2; 1:25,000 topographic map covering approximately 11,000 km^2; 1:10,000 orthophotomap covering 300 km^2 (see figure 29).

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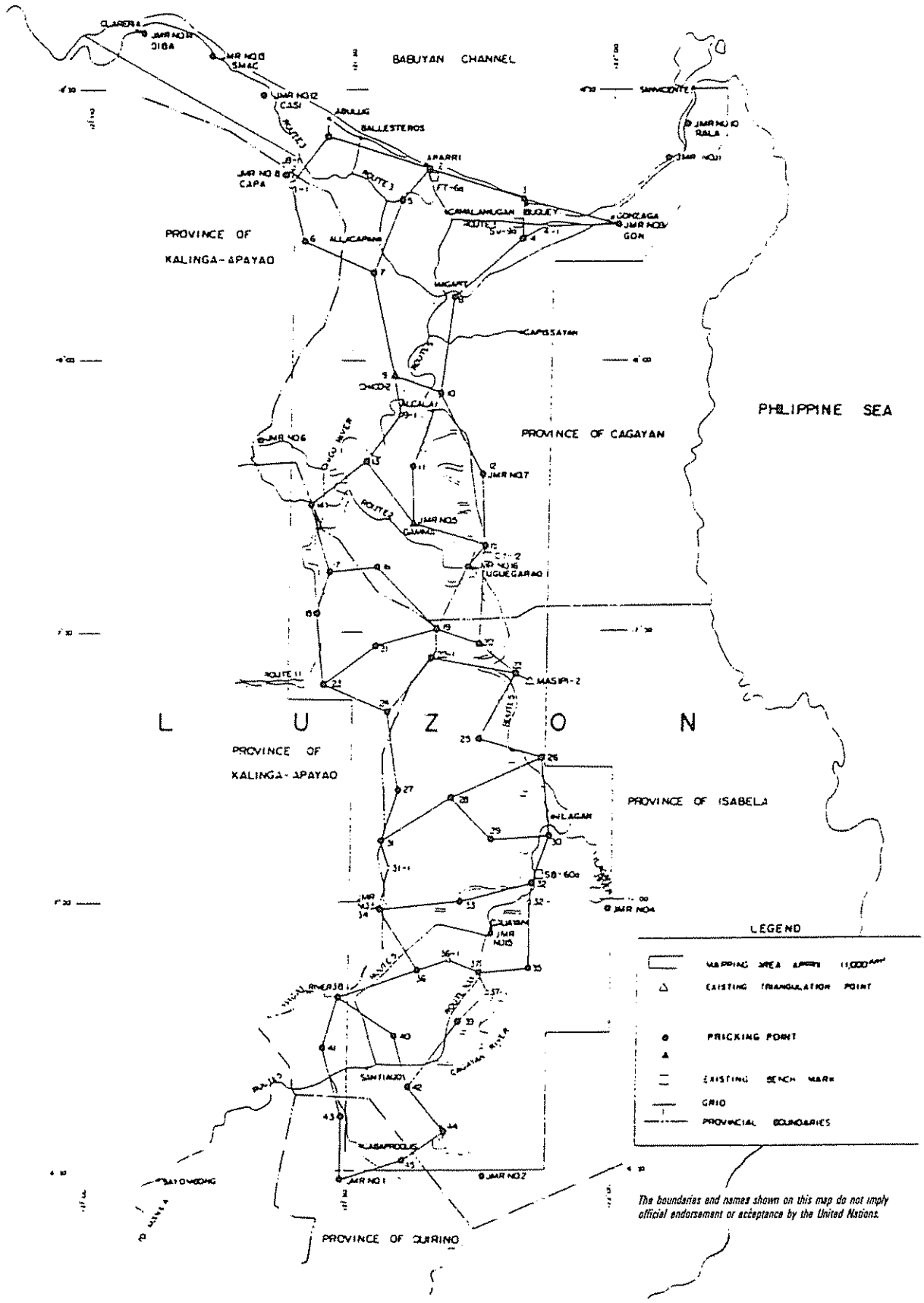
* The original text of this paper, prepared by Shigehiko Shino, Technical Adviser, International Engineering Consultant Associaiton Team Leader, Japan International Co-operation Agency, Cagayan Valley Mapping Project, appeared as document E/CONF.75/L.99.

Figure 29. Japan: pricked geodetic controls in second-stage survey of Cagayan Valley, Philippines



3388.20x

PROJECT AREA

The project area, mostly plains, is in the Cagayan Valley between 16°30' and 18°30' north latitudes and between 121° and 122° east longitudes, encompassing approximately 11,000 km^2 (see figure 30). This area faces the Babuyan Channel to the north and is demarcated by the Cordillera Central Mountains in the west and the Sierra Madre Mountains in the east.

The plains covered with fertile alluvial topsoil are especially suited for rice production but are affected by frequent flooding. The central part and southern mountainous areas of up to 400-m altitude are mostly overgrown with weeds and trees are scarce. On the other hand, the northern mountainous area is woody with trees that are over 20 m high. Also, the plains, except for paddy-lands, are mostly covered with coconut palm-trees, which obstruct visibility in the area.

FIELD SURVEY

BCGS re-established the first-order levelling and established JMR controls in 1979 and 1980. In 1980, the survey team of the Japan International Co-operation Agency (JICA) established 45 auxiliary ground controls by means of precise traversing and photo-pricking of ground controls.

Planning of control point distribution

While giving due consideration to the proposed distribution of JMR points to be affected by BCGS, control points that can be readily used as given points were selected along the principal roads within the survey area. Also, since control points had already been established within the survey area by triangulation, three control points, excluding lost points confirmed by preliminary inspection, were added to the traverse network to correlate the network with the geodetic co-ordinate systems.

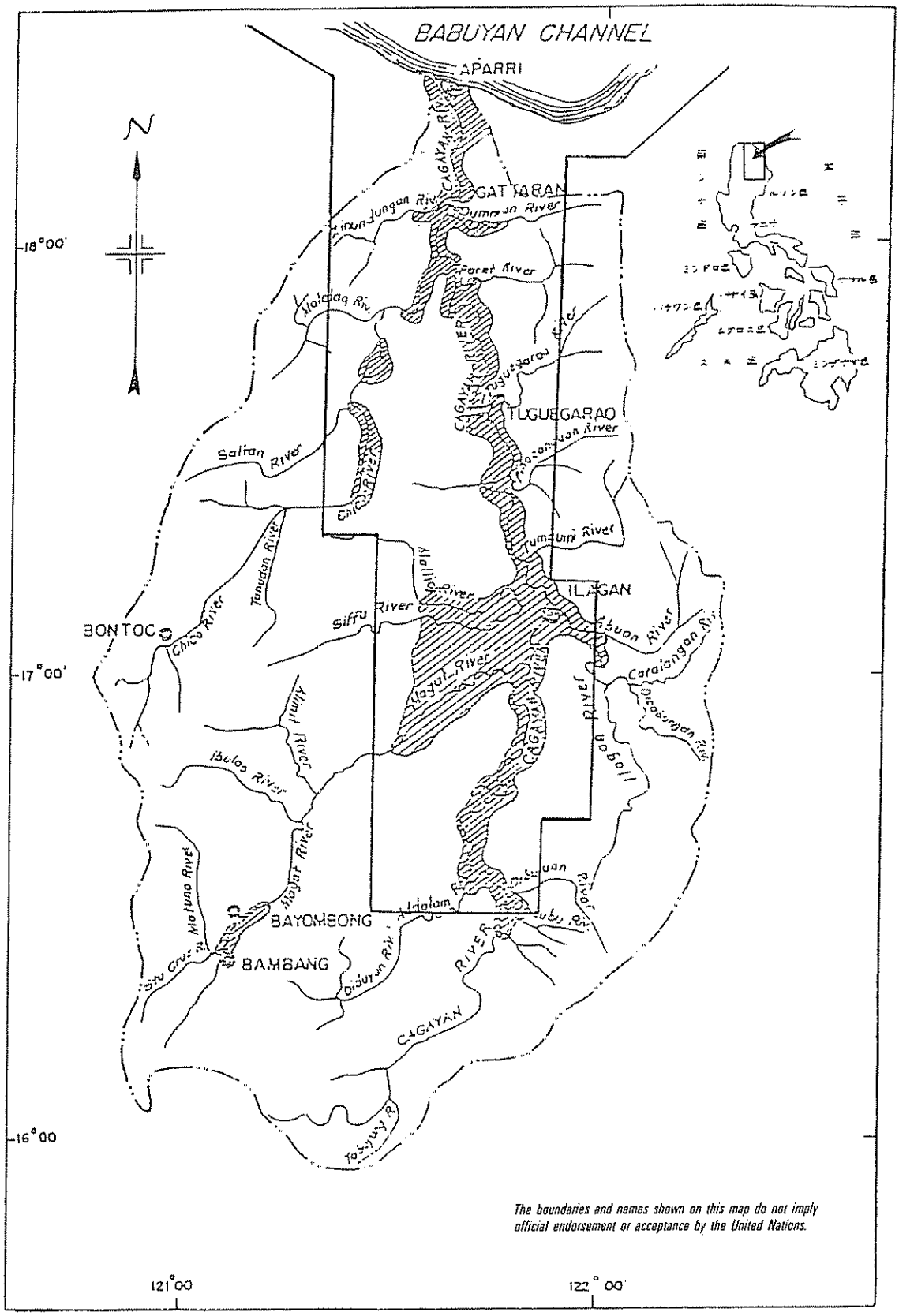
Distance measurement

The AGA geodimeter was used for distance measurement. In this instance, the length of each side was measured in two sets. A discrepancy of no more than 1:75,000 was allowed for two measured sets. When the discrepancy exceeded the tolerance, that distance was remeasured. For large discrepancies not exceeding the tolerance, the lengths were also measured again. To ensure high accuracy, distance measurement was conducted with intervals of over 30 minutes between sets. For long-distance measurement, close attention was paid to the atmospheric conditions to ensure measurement accuracy. Specifically, to prevent heat radiation from the ground, a thermometer was placed at a height of 3 m above ground level.

Horizontal-angle observation

Wild T3s were used for observing horizontal angles. Three sets of observations were made, with each set observed at 0°, 60° and 120°. The maximum allowable double angle difference was 12 seconds, and the maximum allowable

Figure 30. Japan: Cagayan River basin, Philippines; area subject to flooding



3388.21x

observed difference was 7 seconds. For any observation exceeding these limits, reobservation was conducted. Because a long-distance measurement was involved, a heliotrope and signal lamps were used for observing signal targets.

Vertical-angle observation

Four sets of simultaneous observations (two pairs make up one set) were conducted. Intervals of over 10 minutes were provided for each set of observation. The allowable variation in instrumental constants was limited to 10 seconds. Observations were made between 9 a.m. and 4 p.m.

Astronomical observation

For the purpose of azimuth correction, the astronomical survey by polaris observation was conducted at three points located within the survey area with reference to the polar star. Using Wild T3s, four pairs of observations were made at 0°, 45°, 90° and 135°. The observation points were NoS.2 (azimuth marker No. 5), 15 (azimuth marker JMR No. 16) and 36 (azimuth marker JMR No. 36-1) (see figure 31).

Levelling

In order to determine altitudes of newly established control points, the levelling was conducted from the existing first-order bench-mark on the principal roads at four points (Nos. 2, 3, 15 and 32). The duplication discrepancy was limited to 10 mm s km.

COMPUTATION

Approximate computation at site

Co-ordinates and elevations were computed by using observed data, such as horizontal angles, vertical angles; and distances corrected for weather conditions, grade and projection. This computation was conducted to certify accuracy of the traverse loop. All the results of this trial computation, given in table 19, were acceptable.

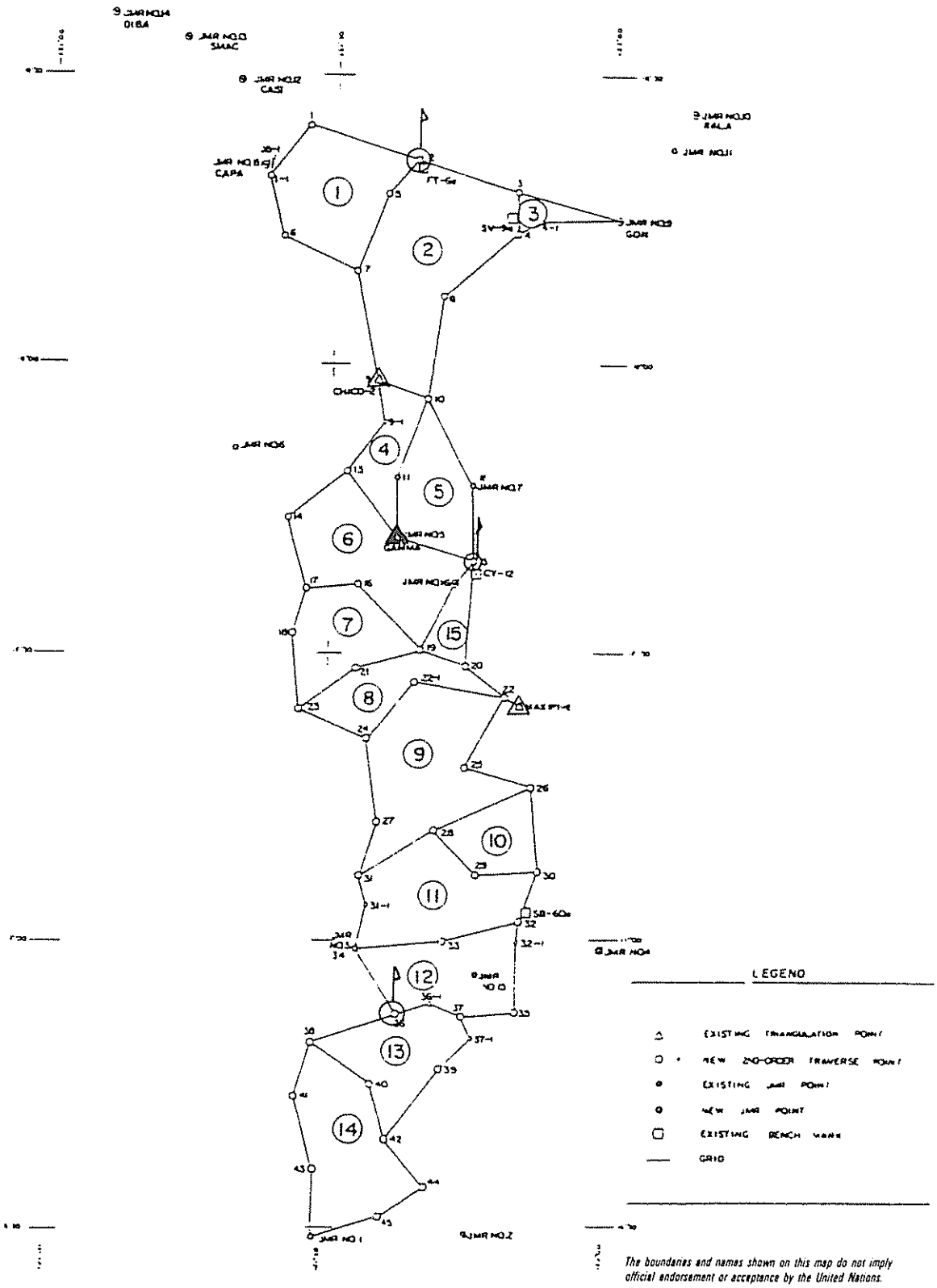
Precise computation

The adjustment of the net and the co-ordinate were computed as follows:

(a) JMR No. 5 (GAMMA) was assumed to be fixed and the azimuth was determined by azimuth observations at stations 2, 15 and 36;

(b) The net was connected to triangulation stations 9 ($CHICO_2$), $MASIPI_2$ and JMR No. 5 (GAMMA), and adjusted by the least-squares method;

Figure 31. Japan: second-stage survey of Cagayan Valley, Philippines



3388.22x

Table 19. Traversing accuracy of geodetic control survey of Cagayan Valley, Philippines

Point	ΣS (kilometres)	Allowable error $d\alpha$ (seconds)	Closure error	dxl (metres)	dyl (metres)	dhl (ratio)	Allowable error dH (metres)	Closure error
1	8.52	±6.12	-3.26	-0.064	+0.242	1:340 000	±1.08	-0.78
2	120.2	±7.07	-5.86	+0.505	+0.268	1:210 000	±1.34	+0.96
3	49.1	±5.00	+3.30	+0.371	+0.126	1:125 000	±0.79	-0.26
4	76.7	±6.12	+4.37	-0.007	-0.329	1:233 000	±0.96	-0.20
5	75.8	±5.59	-1.27	+0.233	+0.211	1:241 000	±1.02	+0.18
6	105.3	±7.07	+0.24	+0.248	-0.314	1:263 000	±1.15	-0.07
7	76.1	±6.12	-1.17	+0.136	-0.344	1:313 000	±0.95	-0.36
8	90.9	±6.61	+3.63	+0.479	+0.439	1:139 000	±1.05	-0.14
9	125.0	±7.07	+1.68	+0.010	+0.147	1:850 000	±1.34	+0.65
10	59.9	±5.00	+3.59	+0.206	+0.257	1:182 000	±0.92	+0.17
11	96.3	±7.07	-0.08	+0.185	-0.269	1:295 000	±1.06	-0.43
12	87.6	±7.07	+0.93	-0.285	+0.072	1:297 000	±1.00	+0.66
13	86.0	±7.07	-2.11	-0.339	-0.376	1:169 000	±0.98	+0.19
14	98.2	±7.07	-1.54	+0.402	+0.311	1:193 000	±1.04	-0.26
15	48.5	±5.00	+3.50	+0.369	+0.026	1:131 000	±0.79	+0.35

(c) The net was connected to JMR stations 8, 9 (GON) and 16 (CAG), and then adjusted by the least-squares method.

First, theree types of solutions mentioned above were computed by means of homogeneous net adjustment of co-ordinates in accordance with the items specified in the Minutes. The values obtained by item (b) were adapted as the final results. The following parameters were used for these computations:

(a) Reference ellipsoid: Clarks spheroid of 1866;

(b) Projection: transverse Mercator;

(c) Point of origin: northing, 0 m; easting, 500,000 m;

(d) Scale factor: 0.9995;

(e) Zone number: III.

The determination of elevation was conducted based on homogeneous net adjustment computation using the elevations of directly levelled control points 2, 3, 15 and 32 as the given data.

CONCLUSION

Adjustment of the geodetic co-ordinates for the precise traversing net, without deforming their rigid internal accuracy, on to the existing conventional triangulation points, which are in use for several decades of year, by the least-squares method applied in this project, is considered the most adequate solution.

The discrepancy between the geodetic co-ordinate obtained in this solution and the Navy Navigation Satellite System (NNSS) co-ordinate in common points are generally shifted -3.5 m in X and +2.7 m in Y direction. No good reason was found to adopt the NNSS data in adjustment of the traversing net. The NNSS JMR points, however, which are independent of this traversing net, can well be used as control points for aerial triangulation.

To establish dense national geodetic control points by the precise traversing method in an area with no existing triangulation points, NNSS primary control for geodetic adjustment can be used effectively; however, at least four NNSS controls are needed for safety.

Cost comparisons between triangulation, trilatration, precise traversing and the NNSS method were not made.

GEODYNAMIC SURVEYS*

Paper submitted by the Union of Soviet Socialist Republics

RESUME

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* The original text of this paper appeared as document E/CONF.75/L.95.

L'étude donne un aperçu des principes fondamentaux et des méthodes de travail sur des sites spécialement choisis en vue de déceler et d'étudier les signes cinématiques avant-coureurs des séismes, ainsi que des activités de détection des déformations du sol causées par la pression de l'eau contenue dans les grands réservoirs des centrales hydro-électriques ou d'origine technique. Elle relève les résultats les plus intéressants enregistrés jusqu'à présent et souligne les perspectives ouvertes par ces activités.

This paper briefly describes the basic principles and ways of handling geodetic works on sites selected for the purpose of finding and studying kinematic forerunners of earthquakes and detecting ground-surface deformations caused by the heavy water load at reservoirs of hydropower plants, as well as those of "technical origin", that is, deriving from industrial processes. The most interesting results obtained to date are noted and the development perspectives of these works are highlighted.

Geodetic works on geodynamic sites have greatly advanced in the Union of Soviet Socialist Republics. These works are undertaken to study, on the basis of precise geodetic measurements, the character of crustal deformations before earthquakes and also to determine the amounts of displacements accompanying earthquakes. In subsequent surveys, the scope of problems is extended. From the beginning, the Geodetic Service and the Academy of Science of the USSR established basic principles for setting up these works. As a result, there was unity of technical decisions and standard demands, which was important at the first stage, for the geodynamic sites had to be set up in various regions of the country, and the observations there had to be undertaken mainly by geodetic agencies that were inexperienced in conducting such surveys.

Naturally, the first several years were the formative period, when it was necessary to adapt psychologically to new tasks, to check out in practice the possibility of attaining the needed accuracy and to situate correctly, from the geological point of view, the future geodynamic sites. It was important to become accustomed to the idea that this was not an occasional experiment but the beginning of systematically conducted, highly precise geodetic works, oriented to solution of geodynamic problems. One area of study concerns the laws of crustal deformation in seismically active regions. The first, well-constituted observations were organized in the Alma-Ata and Tashkent regions in middle Asia. Later, geodynamic sites were established at hydropower plants where deformations could be caused by the water load of large reservoirs. It is well known in the study of seismic activity stimulation in regions of high dams that deformation observations are of particular scientific and practical importance.

The middle of the 1980s is marked by the growth of geodynamic sites, which now number more than 50. Geodetic works are currently conducted in every seismically active region of the USSR, including Kamchatka, where they are intended to scrutinize the deformation processes that result from volcanic activity. These works include sites of "technical origin", where large deposits of mineral resources are exploited and where expected ground-surface deformations are caused by industrial processes.

The ground-surface deformations under study by geodetic methods are fixed on the basis of repeating cycles of high-precision measurements inside geodetic control networks set up on geodynamic sites. These networks consist of angle and line networks containing, as a rule, about 10-30 points and/or a network of high-precision levelling lines. They are designed to take into consideration the basic tectonic deformation in the regions under study. In places with definitely readable deep breaks, local networks are created in the shape of separate or dual geodetic quadrangles with sides of about 2-3 km. Their purpose is to check the situation of weakened zones in the Earth's crust, where indictions of tectonic strain accumulations are prominently displayed.

The past five years were the period when the beginning "epochs" for following observations were founded at most geodynamic sites. At a number of them, some cycles of repeat observations have already been done. Thus, the period of works formation has finished and the stage of planned accumulation of observations has been reached. The needed experience in establishing them, as well as in the scientific analysis of results, has been gained. Now that the means and methods of work conduct are evident, the size of deformations, the measurements to which geodetic networks must be oriented, are experimentally evaluated. Those difficulties which have to be overcome to obtain credible results are also clearly seen.

The very nature of works discussed here makes it impossible to expect any final results from them in a short time--that is, to consider them a description of the deformation process in the region under study in a mathematical model with dimensions determined on the basis of observations.

Practice has shown that interesting deformations, particularly those caused by deep tectonic processes, are often just beyond the limit of existing means of observation. Therefore, only a painstaking analysis of consecutive cycles of measurements may permit determination of the "laws" sought.

None the less, the materials received as the result of every cycle of measurements are elaborated regularly and are analysed to the limits of existing feasibilities. Part of the results obtained to date have been published or presented at the annual conferences on geodynamic topics.

Some of the most advanced works are discussed below. The first relates to geodynamic sites in the north Tian-Shian region. In that vast territory, the levelling net was developed. Regular cycles of measurements fixed a line of events closely correlated with observed vertical displacements and manifestations of seismic activity.

Five cycles of measurements in the line and angle network near Alma-Ata, in the Zaily Alatau Mountains, have been completed. They indicate a hesitating character of horizontal displacements; analysis of these measurements has made it possible to determine potential places with concentrations of anomalous strains. The high-precision levelling conducted here twice a year on two short, meridionally oriented lines has provided the opportunity to create a geodetic clinometer, and its role in the future development of works will grow steadily.

The geodynamic sites in Fergana and Tashkent are actively observed. Special attention is given to frequently repeated levellings on previously disclosed anomalous lots; some of them are observed monthly.

The work results at the Gasli geodynamic site are quite definitive on the basis of measurements taken before and after the earthquakes in 1976. Allocations of both vertical and horizontal ground-surface deformations appearing to be a consequence of those earthquakes were determined. Data obtained on deformations about 1 m from the epicentre of the earthquakes have already been used for a study of the mechanism of earthquakes.

The results of horizontal surface deformations at the Kamchatka geodynamic site, near the Plosky Tolbachek volcano, are also known. They were obtained on the basis of specially organized geodetic measurements taken immediately after an eruption.

Furthermore, there is a sound file of data from the geodynamic sites located on the limits of the Baikal rift zone and the Baikal-Amur Railway.

Practically important results are obtained at the hydropower-plant geodynamic sites, where repeated measurements are taken once or twice a year. For example, on the basis of five cycles of observations at the Chirkey site, it was clearly shown that there was a reservoir-bed reaction to activity of the supplementary water burden. Observed deformations reflected not only variations of this load, caused by seasonal changes of the water-level in the reservoir, but slower processes of the Earth's crust to accommodate to modified hydrological situations. Local variations of a gravitation field, caused by instability of the water mass in the reservoir, were taken into consideration in analysing the development of observed continuous deformations.

Similar processes have been disclosed at the hydropower-plant geodynamic site in middle Asia, in particular at Nurek, where a more intensive lowering of the ground surface was found near the deep-water part of the reservoir (up to 10 mm per annum).

It should be noted that the above-mentioned deformations were fixed only on the basis of high-precision levelling data; range finder measurements have not yet permitted determination of any deviations consciously relating to horizontal displacements of the reservoir coasts.

Deformations at some industrial technical sites have been clearly fixed. The site at north Stavropol is an example. There, after detailed levelling, the ground-surface lowering, well correlated to the falling pressure of natural gas caused by deposit exploitation, was precisely measured. A detailed scheme of vertical-movement speed was eleborated for this region.

A similar picture of horizontal and vertical deformations was obtained for the Kiselevsk-Prokopievsk industrial/technical site.

The proved fact of contrasting vertical ground-surface movements seismically active regions is an important generalizing result. The existence of short-period components with large amplitude masks the slowly accumulating displacements. Study of the expanse and time spectrum of observed fluctuations is very interesting because it permits one to have some ideas on the reasons and mechanism of these movements. It is also necessary for working out well-proved methods of providing maps showing the speed of vertical movements of the Earth's crust in such regions.

On the basis of accumulated experience and of constantly supplied geophysical data, it is proposed to improve the scheme of checking geodetic networks at these geodynamic sites, to increase the frequency of repeat measurement cycles, to create at selected places permanent networks of the deformation station type; and to increase the composition of conducted observations, including on an equal basis, gravimetric measurements and also clinometer measurements at various distances from the centre.

The most essential task is a general improvement of measurement accuracy through the use of improved devices as well as through better managed works.

According to modern understanding of territorial dimensions, where deformations of the Earth's crust have preceded strong earthquakes, the geodetic checking networks must be spread over large regions. In this case, however, traditional geodetic methods prove to be too slow and expensive. First of all, they relate to the horizontal network. Thus, in view of the rapid progress of space-measuring technology, such methods as Doppler satellite systems and radio-interferometers will be basic in the near future.

Simultaneously with efforts to improve observations there will be continued research in the field of observed deformation connected with analysis of preceding earthquakes. They will be established on a regular basis and their contents will be clearly defined. It is necessary to study carefully and to set forth systematically and describe in detail, including all basic materials, observed deformations in regions where earthquakes have occured. Systematically arranged, these materials would undoubtedly be of great interest to specialists concerned with the study of earthquakes.

A TEST OF THE SWEDISH MOTORIZED LEVELLING SYSTEM*

Paper submitted by the United States of America

RESUME

En mars 1981, le Service géodésique national du Département hydrographique de la NOAA et le Service national suédois des levés de terrain ont mis à l'essai le système suédois de motonivellement sur une grille expérimentale près de Fredericksburg, en Virginie. Le matériel d'essai comprenait un instrument de nivellement autoréglable NI 002, deux mires Wild à bandes de un centimètre Invar, un système programmable d'enregistrement micronique 445C avec

* The original text of this paper, prepared by Charles T. Whalen, Chief, Vertical Network Division, National Geodetic Survey, National Ocean Survey of the National Oceanic and Atmospheric Administration, appeared as document E/CONF.75/L.47. Mention of a commercial company or product does not constitute an endorsement by the United States National Oceanic and Atmospheric Administration. Use for publicity or advertising purposes of information in the present document concerning proprietary products or the tests of such products is not authorized.

imprimante, deux petites Daf pour les portes mires et une camionnette Simca pour l'observateur et l'enregistreur. Les voitures étaient équipées de supports verticaux attachés à la mire qui permettaient de tenir la mire verticale pour les observations et de la maintenir en place quand la voiture était en mouvement sans descendre. Les mires étaient maintenues par des embases triangulaires pivotantes solides. Un trou protégé par une barrière percé dans le fond de la camionnette d'observation, qui était également équipée d'un appareil de levage pour l'instrument. Un pied du trépied porte-instrument passait par le trou dans le plancher les deux autres étaient positionnés sur le côté de la camionnette. L'appareil de levage servait à lever l'instrument pour le transport entre les stations et à le baisser à chaque station. Les résultats de l'essai montrent que la productivité par personne est supérieure de 70 pour cent par rapport aux methodes classiques utilisées par les unités de nivellement du Service géodésique. Le système suédois a fonctionné à une vitesse de nivellement moyenne de 1,85 km/heure. La distance de visée moyenne était de 35 mètres.

Systems using separate vehicles to transport a levelling instrument and rods between set-ups[1/] range from velocipedes used along railways by the United States Coast and Geodetic Survey (subsequently the National Ocean Survey) at the turn of the century, 2/ similar systems used by the Finnish Geodetic Institute for modern levelling surveys, 3/ to a system using three small cars developed by Peschel in collaboration with the Jena Company. 4/ Good results were reported using a system constructed in Sweden based on the Peschel system. 5/ Development of the Peschel system was unique in that it also included the design and development of the NI 002 reversible-compensator levelling instrument for motorized levelling. The NI 002 instrument is now used for bicycle and rail-handcar levelling in Finland, and for motorized levelling in Denmark, France, the German Democratic Republic, the Federal Republic of Germany, the Netherlands, Norway, Sweden, the United States of America and Zambia.

In 1980, the Director of the National Geodetic Survey (NGS), a component of the National Ocean Survey (NOS) of the National Oceanic and Atmospheric Administration (NOAA), asked the Director of the National Land Survey of Sweden to participate in a test of the Swedish motorized levelling system in the United States. Sten Wickbom, Director, National Land Survey of Sweden, accepted the invitation for the National Land Survey. The Swedish survey team and equipment arrived in the United States in early March 1981 to conduct the test.

EQUIPMENT

The equipment for the motorized levelling team is shown in figures 32-39. The Simca observing vehicle is shown in figure 32 with a Jenoptic NI 002 levelling instrument mounted on a 2-m slip-leg tripod. A standard tripod is secured behind the observer for connections to bench-marks where the levelling rod cannot be observed from the pick-up. The observer is equipped with earphones with an attached microphone for communication with the recorder/driver. A fabric sun-wind-rain shade, which can be mounted over the observer, is shown stored behind the observer.

Figure 32. United States of America: observing vehicle for use in Swedish motorized levelling system



Figure 33. United States of America: floor port for tripod leg used in Swedish motorized levelling system

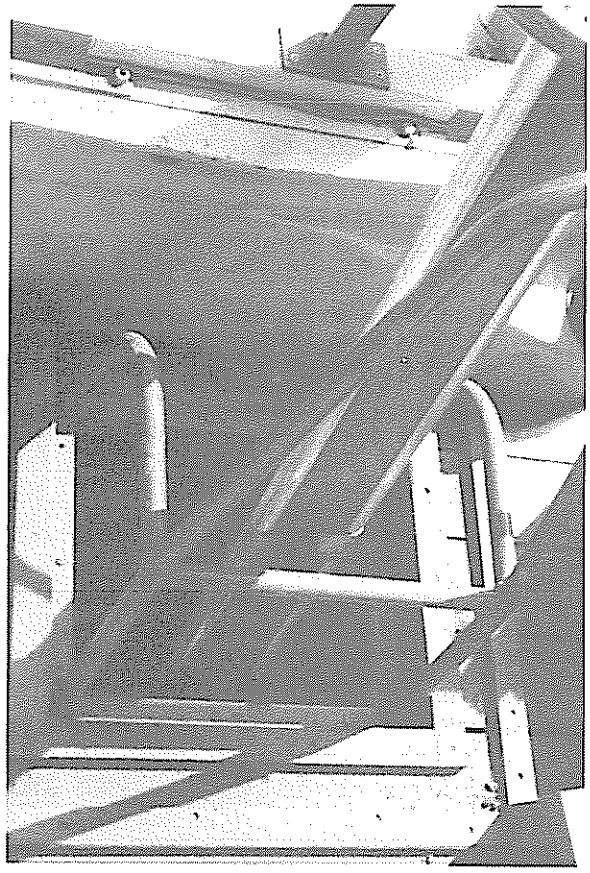
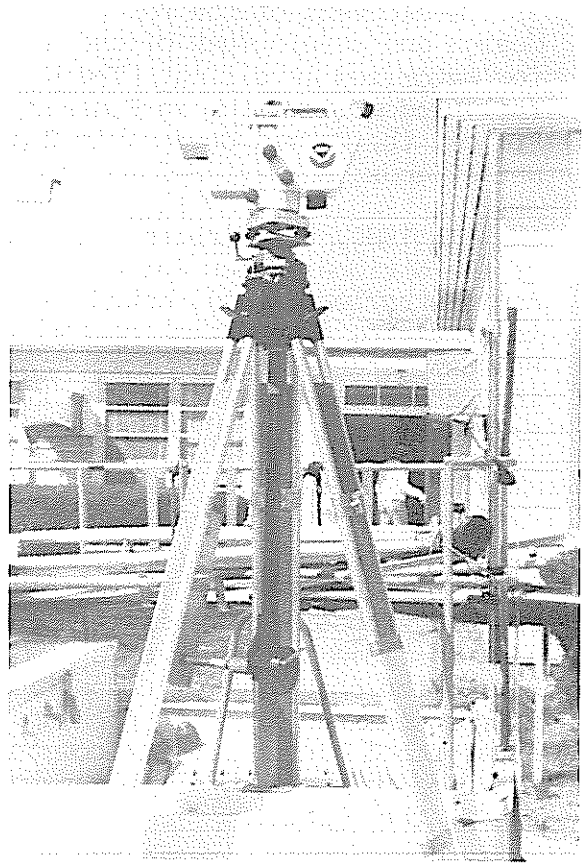


Figure 34. United States of America: Jenoptic NI 002 levelling instrument used in Swedish motorized system



The tripod is equipped with special footplates designed for set-ups on road shoulders or pavement. One leg of the tripod passes through the floor of the truck. Details of the floor port and guard-rail are shown in figure 33. The NI 002, with quick-level tripod head, is shown in figure 34 with the lifting device supporting the instrument for travel between stations. An adjustable device passes through the top of the tripod legs to keep them spread while the instrument is raised for movement between stations. The NI 002 control knobs pass through the instrument so they can be reached from either side. A right-angle prism is located at the top left of the instrument. An identical prism is located at the opposite side of the instrument. The prisms are used to point the instrument at a levelling rod. The reversible-compensator control knob can be seen underneath the back of the instrument. The swivel eyepiece, which permits observations from either the side or back of the NI 002, can be seen at the top of the instrument.

Figure 35 shows one of the two DAF cars with a rod-support device, and a Wild 1-cm Invar-band double-scale levelling rod resting on a turning-plate. The lever for adjusting levelling-rod vertically is shown above the rodman's left shoulder; and a temper, used to settle the turning-plate before placing the rod on it, is shown mounted on a door bracket to the left of the levelling rod.

Details of the rod-support device, safety retainer and quick-release plate are shown in figure 36. The rod can be removed from the vehicle by unsnapping the safety retainer, loosening the wing-nuts on the quick-release plate and lowering the plate to free the ball on the rod-support device.

Figure 37 shows a rotatable mirror mounted over the circular level on the back of the levelling rod. The mirror allows the rodman to align the rod vertically, with it facing forward or backward, while remaining in the vehicle. The handle on the rod-alignment lever is shown at the left side of the rod.

Figure 38 shows the triangular base-plate used to support the levelling rod. The two vertical pins are used to guide the tamping device and thereby protect the turning-point during the tamping operation. The rodman raises the levelling rod and passes the hook on the back of the rod (above the base plate in figure 38) through a ring on the door in order to secure the rod in an upright position and raises the base plate by the handle and hangs it on the door bracket before travelling between rod stations.

In figure 39, the three survey vehicles are shown in front of the NGS Instrumentation and Equipment Branch building at Corbin, Virginia.

SURVEY

The setting and recovery of bench-marks were accomplished by personnel of the NGS Vertical Network Division and the Instrumentation and Equipment Branch. The levelling team consisted of the following personnel from the National Land Survey of Sweden: Jean-Marie L. Becker, Team Chief, observer/recorder; Karl A. M. Stattin, observer/recorder; Peter H. Aahman, rodman; and Hans A. Aastrœm, rodman. Audy Murray, from NGS, assisted by observing and recording for the second half of the survey. Figure 40 shows the motorized-levelling test area,

Figure 35. United States of America: levelling rod and vehicle used in Swedish motorized system



Figure 36. United States of America: levelling rod-support device used in Swedish motorized system

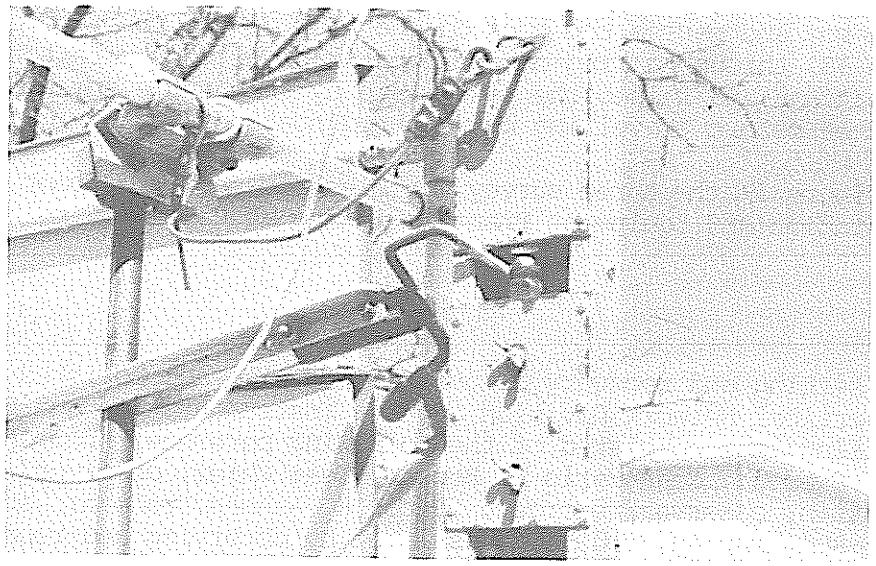


Figure 37. United States of America: rotatable mirror and circular level vial used in Swedish motorized system

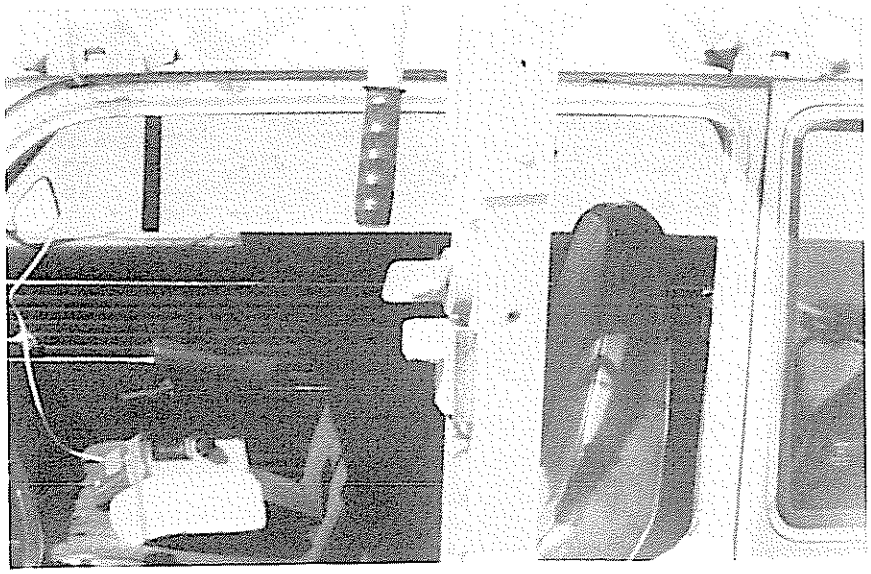


Figure 38. United States of America: levelling-rod base-plate used in Swedish motorized system

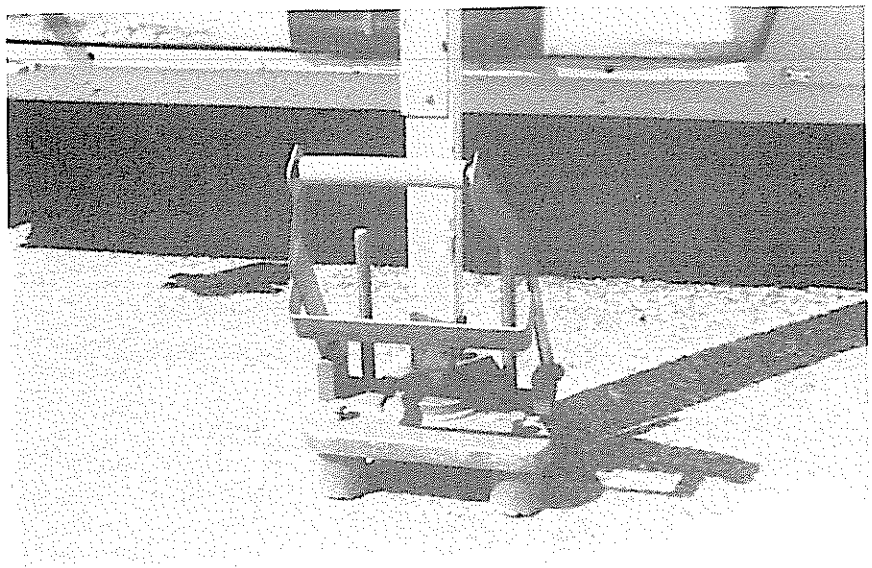


Figure 39. United States of America: motorized levelling vehicles used in Swedish system

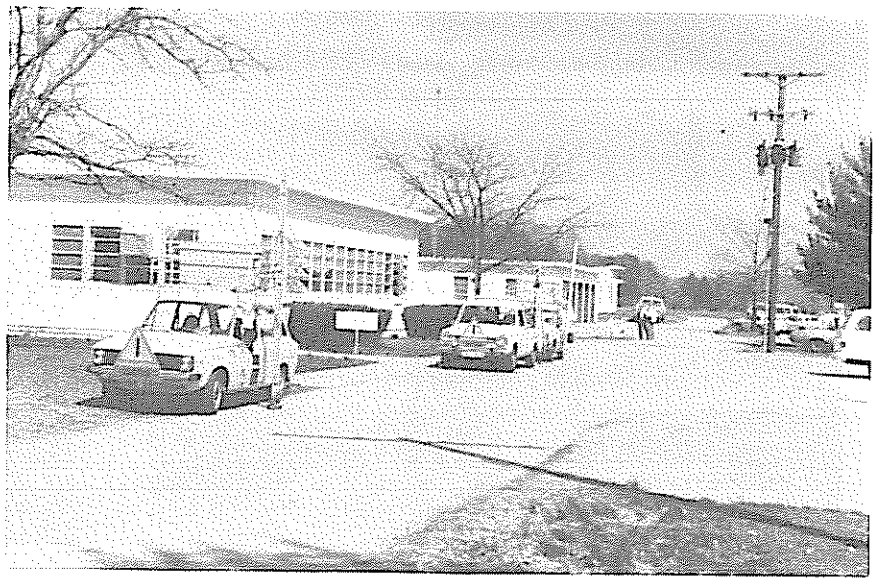
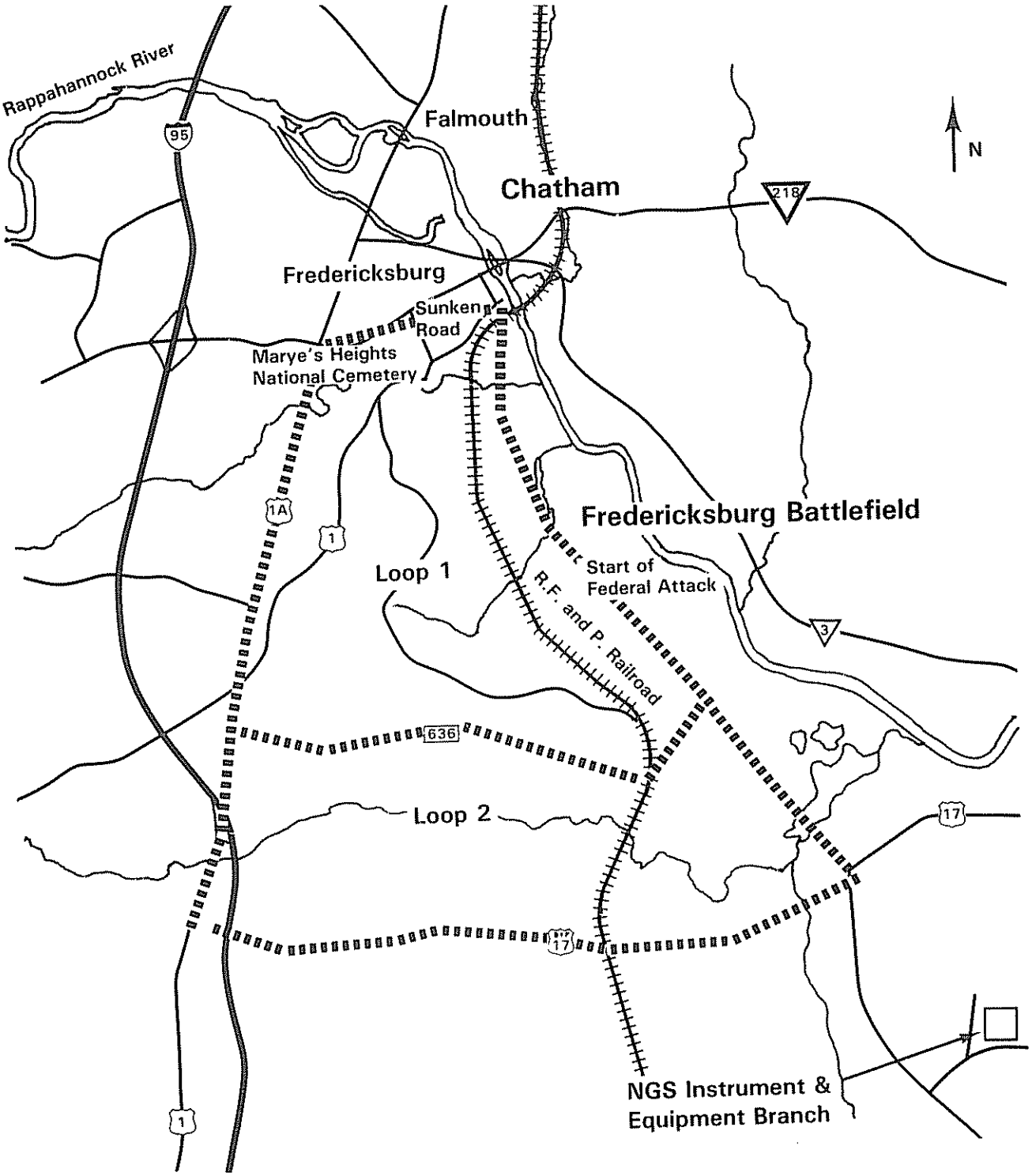


Figure 40. United States of America: motorized levelling test area



which is located about 90 miles south of Washington, D.C. The test course consists of two levelling loops over mostly two-lane paved roads bounded by Virginia highways 3 on the north (through Fredericksburg), 1 A on the west, 17 bypass on the south and 2 on the east. The NGS Instrumentation and Equipment Branch is shown south-east of loop 2. Interstate 95 is shown west of the test area. The total distance around the loops is 37 km. The two loops were surveyed twice for the test, using double-run procedures each time, for a total single-run survey distance of 160 km, including reruns.

The survey team was able to operate in snow, rain and winds gusting to 40 km per hour without loss of time due to weather. The temperature range was from -6 to +29 degrees Celsius. The survey was accomplished in 15 working days, between 16 March and 1 April 1981. The average time for each set-up, including travel between stations, was 2.3 minutes. Other survey averages were: 26.3 set-ups per hour; 1.85 km per hour (single-run); 10.7 km per workday; and 35.2-m sight distances.

DATA COMPUTATIONS

Levelling observations were recorded and printed on the Swedish Micronic 445C recording system during the survey. The observations were re-encoded in the office from the printer tapes and entered into a computer file. The descriptions were all keyed in the office from the field-sheets and entered into a computer file. The observations and descriptions were then converted to prescribed NGS formats 6/ with computer programs. The following corrections were applied to the computed elevation differences between bench-marks: levelling-rod calibration; levelling-rod Invar-band temperature; astronomical (earth tide); refraction; and (normal) orthometric. 7/ The levelling-rod calibration constants and coefficient of thermal expansion for the Invar bands were provided by the National Land Survey of Sweden.

TEST RESULTS

Test results are summarized below in table 20. Actual loop misclosures were well within the tolerance limit for first-order, class I surveys. 8/ The two surveys were adjusted and analysed by Johan J. Kok, visiting scientist to NGS from the Delft University of Technology, the Netherlands, using his SCAN-II program and techniques. 9/ The standard errors of the mean of a forward and backward run of a 1-km section, determined from least-squares adjustments of the section means from each survey, were 0.5 mm for the first and 0.7 mm for the second survey.

COMPARISON WITH NATIONAL GEODETIC SURVEY LEVELLING SYSTEMS

An NGS conventional levelling team consists of one observer, one recorder/driver, two rodmen and one pacer who marks the locations of the instrument stations and drives turning-pins for the rodmen. When travelling between set-ups, the observer normally rides on a step on the side of the vehicle and the rear roadman on a step at the rear of the vehicle. The rodman then walks from the

Table 20. Results of United States test of Swedish motorized levelling system

(Millimetres)

Survey	Survey results	First-order, class I tolerance
First survey		
Loop 1, misclosure per kilometre	+0.5	4.0
Loop 2, misclosure per kilometre	-0.6	4.0
Survey, standard error per kilometre of double-run levelling	0.5	1.0
Second survey		
Loop 1, misclosure per kilometre	-1.4	4.0
Loop 2, misclosure per kilometre	+1.2	4.0
Survey, standard error per kilometre of double-run levelling	0.7	1.0

instrument station to the next turning-point. Since 1980, some of the NGS levelling teams have been provided with two 110-cc motor-cycles to transport the rodmen between turning-points. 10/ The motor-cycles and the survey vehicle are equipped with precise odometers to measure equal distances between turning-points and the instrument station. A pacer is not needed when the motor-cycle system is used.

A comparison of levelling production from NGS conventional and motor-cycle teams with test results from the Swedish motorized levelling system is given in table 21. Using NGS conventional levelling production per person as a base, the NGS motor-cycle system increased production by 37 per cent and the Swedish motorized system increased production by 70 per cent. Production figures given in table 21 are based on kilometres of levelling observed. The fact that fewer days are lost due to weather with the Swedish levelling system is not reflected in the figures.

The significance of the increased rate of production can be put into perspective by projecting levelling-observation costs for the 75,000 km which remain to be surveyed for the National Geodetic Vertical Datum readjustment programme. The projected costs are given below in 1981 dollars: (a) Conventional NGS levelling system, 10.5 million; (b) NGS motor-cycle levelling system, 7.7 million; (c) Swedish motorized levelling system, 6.6 million. The projected cost reductions in relation to the conventional

Table 21. Comparison of levelling production of United States National Geodetic Survey systems and Swedish motorized system

Items	National Geodetic Survey		Swedish motorized system
	Conventional system	Motor-cycle system	
Persons per team	5	4	4
Levelling (kilometres)	460	1 039	158
Minutes per set-up	3.5	3.1	2.3
Average kilometres per hour	1.34	1.47	1.85
Average sight distance (metres)	39	38	35
Production per person (kilometres per hour)	0.27	0.37	0.46
Increase per person (percentage)	-	37	70

NGS levelling system and taking into account the cost of the new equipment, are $2.8 million and $3.9 million, respectively, for the NGS motor-cycle and Swedish motorized levelling systems.

CONCLUSION

The test of the Swedish motorized levelling system demonstrated that it could produced levelling of highest quality while increasing production in relation to the NGS conventional and motor-cycle levelling systems. Cost projections indicate that use of the Swedish motorized levelling system could reduce survey costs for the remaining 75,000 km of the National Geodetic Vertical Datum Readjustment Program by $3.9 million compared with the NGS conventional levelling system, or by $1.1 million compared with the NGS motor-cycle levelling system.

Notes

1/ For an overview of these systems, see H. Poetzschke, Motorized Leveling at the National Geodetic Survey, NOAA Technical Memorandum NOS NGS 26 (Rockville, Md., National Oceanic and Atmospheric Administration, 1980).

2/ See National Oceanic and Atmospheric Administration, National Ocean Survey (formerly United States Coast and Geodetic Survey), Annual Report of the Superintendent, 1916 (41 pages, out of print).

3/ See M. Takalo, "Measuring method for the third levelling of Finland", Report of the Finnish Geodetic Institute, No. 78:3 (1978); and "Bicycle levelling and handcar levelling and their uses in the third precise levelling of Finland", in Proceedings of the Second International Symposium on Problems Related to the Redefinition of the North American Vertical Geodetic Networks (Ottawa, Canadian Institute of Surveying, 1980), pp. 835-846.

4/ See H. Peschel, "Das Motorisierte Prazisionsnivellement leistungsfahigstes Verfahren genauer Hohenmessungen", Vermessungstechnik (Berlin, 1974), pp. 57-64.

5/ See J. M. Becker, "Experiences using motorized levelling techniques in Sweden", paper presented to the Congress of the Fédération internationale des géomètres, Stockholm, Sweden, 1977; and "Le nivellement motorisé en Suède: techniques et résultats à ce jour", in Proceedings of the Second International Symposium..., pp. 847-866.

6/ L. Pfeifer and N. Morrison, Input Formats and Specifications of the National Geodetic Survey Data Base, vol. II, Vertical Control Data (Rockville, Md., National Oceanic and Atmospheric Administration, Federal Geodetic Control Committee, 1980).

7/ For full details on the corrections, see E. I. Blazs and G. M. Young, Corrections Applied by the National Geodetic Survey to Precise Leveling Observations, NOAA Technical Memorandum NOS NGS 34 (Rockville, Md., National Oceanic and Atmospheric Administration, 1982).

8/ See Federal Geodetic Control Committee, Classification, Standards of Accuracy and General Specifications of Geodetic Control Surveys (Rockville, Md., National Oceanic and Atmospheric Administration, National Ocean Survey, 1974); reprinted 1980.

9/ For a description, see J. J. Kok, W. Ehrnsperger and H. Rietveld, "The 1979 adjustment of the United European Levelling Network (UELN) and its analysis of precision and reliability", Proceedings of the Second International Symposium..., pp. 455-483.

10/ See E. I. Balazs, "Geodetic leveling techniques in use and under development for the United States releveling program", Proceedings of the Second International Symposium..., pp. 815-834.

(b) Aerial photography, photogrammetry and orthophotomapping

CAMERA CALIBRATION IN THE DIVISION OF NATIONAL MAPPING*

Paper submitted by Australia

RESUME

La Division de cartographie a récemment entrepris d'étalonner les caméras utilisées pour la photogrammétrie aérienne, activité qui relevait précédemment du Laboratoire national de mesure. Elle utilise un goniomètre Hilger et Watts, de même qu'un autocollimateur et des plaques d'étalonnage. Elle comprend un service d'étalonnage expérimental pour le calcul des résultats et l'établissement d'un rapport complet. La Division étudie actuellement la possibilité de développer le service, en mettant notamment au point des méthodes d'étalonnage en vol.

Aerial survey cameras need to be calibrated at regular intervals in order to check the metrical properties of the camera. The specifications of the National Mapping Council of Australia 1/ state that each camera shall be calibrated annually and after it has been subjected to a physical disturbance which might affect its metrical properties.

Camera calibration services in Australia were formerly provided by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), which used the Hilger and Watts goniometer owned by the Division of National Mapping (Natmap) but installed in the CSIRO National Measurement Laboratory (NML) at Sydney. In 1982, Natmap moved the equipment to its Dandenong office and took over the responsibilities of NML for laboratory camera calibration. The service is available to all organizations that own aerial cameras. Once the camera is delivered to the Natmap laboratory, the calibration procedure takes about two days. The camera is released after the results have been computed.

EQUIPMENT

The equipment consists of a goniometer, an autocollimator and a series of calibration plates. The goniometer is similar to a large theodolite--a telescope supported by two trunnions, permitting rotation about a horizontal trunnion axis. Vertical circle readings to the nearest arc second can be made. No circle readings are available for rotation about the vertical axis.

Two calibration plates are currently used. The plate for cameras with flat focal planes is glass, 260 x 273 x 12 mm, polished flat to within two

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, appeared as document E/CONF.75/L.1.

microns. Grid-lines are ruled at nominal intervals of 10 mm along the two diagonals. An aspheric profiled calibration plate with a similar grid pattern, made by Wild, is used for calibrating Wild RC9 cameras.

METHODS

Natmap uses NML calibration procedures. These procedures--and a more detailed description of the equipment-- are given elsewhere. 2/

The calibration reports contain the following information:

(a) The co-ordinates of the principal point of autocollimation with respect to the fiducial centre, and their uncertainty;

(b) The co-ordinates of the fiducial marks with respect to the fiducial centre, and their uncertainty;

(c) The calibrated focal length, and its uncertainty. The calibrated focal length is determined by least-squares: the sum of the squares of the distortions is minimized;

(d) The co-ordinates of the principal point of symmetry for the calibrated focal length;

(e) In tabular form, the radial distortion for the calibrated focal length referred to the principal point of symmetry for each diagonal observed, and the mean;

(f) A plot of the co-ordinates of the points of autocollimation and symmetry with respect to the fiducial centre and the orientation of the fiducial marks;

(g) A plot of the symmetrical radial distortions for each diagonal and the mean.

FUTURE DEVELOPMENT

Natmap is investigating the provision of other laboratory calibration:

(a) Photographic calibration using existing equipment;

(b) Calibration of resolving power of the lens over the film format;

(c) Calibration of image illumination characteristics.

Also under investigation are various forms of in-flight calibration, at first at a photography scale of 1:80,000, using a test area near the Dandenong office. This would make it possible to provide both types of calibration at the same time.

Notes

1/ National Mapping Council of Australia, Standard Specifications for Vertical Aerial Photography, rev. ed. (Canberra, 1968).

2/ J. B. Patterson, "Calibration of photogrammetric cameras", Photogrammetria, vol. 34 (1978), pp. 69-78.

LAKE HUME PHOTOGRAMMETRIC TEST RANGE*

Paper submitted by Australia

RESUME

Le Royal Australian Survey Corps a aménagé une zone d'expérimentation de photogrammétrie dans le sud-est de l'Australie pour faciliter ses recherches sur les méthodes d'aérotriangulation et sur la localisation et la densité optimales des points de la restitution. Il s'agit d'une zone de 1° 30' de longitude et de 1° de latitude, qui comporte des points de repère horizontal sur un réseau approximatif de 16 km d'espacement et un réseau de quelque 680 points de repère vertical. Ces points de repère ont été identifiés par une méthode photographique spéciale et on a acquis plusieurs séries de photographies SWA à des échelles allant de 1:65 000 au 1:140 000. La zone sera aussi utilisée pour la mise au point de nouvelles techniques cartographiques.

A photogrammetric test range has been established in south-eastern Australia by the Royal Australian Survey Corps in order to support investigations into methods of aerotriangulation and optimization of ground-control positioning and density. It covers an area of longitude 1° 30' by latitude 1° and contains horizontal control on an approximate grid with 16-km spacing and vertical control networks with approximately 680 points. This control has been uniquely photo-identified and several sets of super-wide-angle (SWA) photography at scales ranging from 1:65,000 to 1:140,000 have been acquired. The range will also be used as a test-bed for the development of new mapping techniques.

BACKGROUND

The Lake Hume test range has been designed as a 1:250,000 map area in the Albury-Wodonga area. It is located between latitudes 35° 30' and 36° 30' South and longitudes 146° 30' and 147° 30' East. It includes portions of the following regular 1:250,000 map-sheet areas: (a) SI 55-14 Jerilderie; (b) SI 55-15 Wagga

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* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.10.

Wagga; (c) SJ 55-2 Wangaratta; (d) SJ 55-3 Tallangatta.

The criteria for the initial choice of area for the test range were:

(a) Vertical range: variation up to 2,500 ft over 25 per cent of area;

(b) Flat ground: 13 miles square as a minimum;

(c) Vegetation: 50 per cent to be open country and not more than 20 per cent heavily timbered;

(d) Water surfaces: preferably one large water surface;

(e) Communications: a reasonably distributed road pattern.

Briefly, the terrain varies from well-developed farm land along the Murray River basin, through undulating country to densely forested hills. The test range includes the Albury-Wodonga urban areas and a number of large water bodies, including Lake Hume.

PURPOSE AND AIMS

The original aim, that is, investigations into methods of aerotriangulation and photogrammetric adjustment, is under continuous review to reflect advances in techniques and availability of data.

DATA ACQUIRED

Since the early development of the test range, additional information has been acquired progressively. From time to time, it has been found that various items needed to be reobserved or replaced. The current status is outlined below.

Photography

The photographic coverage available is given in detail in table 22. Efforts are under way to fly additional RC10 88-mm super-wide-angle block coverage at altitudes of 40,000 ft and 45,000 feet, in order to provide nominal photo scales of 1:140,000 and 1:155,000, respectively.

The image quality of the photography varies from fair to poor but is representative of that frequently used for military mapping in Australia.

Diapositives

Uncorrected glass diapositives have been produced, for selected 60 per cent forward-overlap sets, from all of the photography listed in table 22.

Table 22. Super-wide-angle RC10 photographic coverage, Lake Hume test range, Australia

Serial	Nominal scale	Runs	Forward overlap (percentage)	Sidelap (percentage)	Remarks
1	1:60 000	6 x E-W continuous 4 x E-W part No tie runs	80	20-30	Block cover incomplete
2	1:90 000	17 x E-W continuous	80	60	Block complete
3	1:140 000	4 x E-W continuous E and W tie runs	80	20-30	Top (north) run missing Part block

Horizontal control

A grid of horizontal control points (7 rows x 10 columns) was specifically selected for the test range. Although other points exist in the area, this set has been selected on the basis of clearly panelled rigorously tested points.

Vertical control

Reduced levels based on the Australian Height Datum are available for approximately 680 ground points. These are mostly distributed along roads and railways in the area. They have been incorporated in the data and may be described by:

(a) Source. The reduced levels are derived from ground elevation metre and level traverses and include various geodetic survey control stations;

(b) Identification. Identification for the vertical control consists of a combination of diagrams and/or marked photo enlargements acquired in the field.

Airborne profile recorder control

Recently, a complete network of laser airborne profile recorder profiles--12 east-west and 7 north-south--has been flown. These profiles are being processed for inclusion in the test range data.

AERIAL TRIANGULATION

Preparation and measurement of the photography listed in table 22 have been progressed as follows:

(a) Serial 1 at 1:60,000. All point transfer (control, joins and pass-points) has been applied to the available runs. No measurement of image co-ordinates has been done;

(b) Serial 2 at 1:90,000. All point transfer, image co-ordinate measurement and strip formation is complete. Some model formation and model joins are below normal standards but were not improved by reobservation;

(c) Serial 3 at 1:140,000. All point transfer has been applied to the part block. Some measurement has been done.

Measurement has been confined to marked image points and principal points. Selected diapositives have had fiducial measurement made but only for the purpose of monitoring film strech.

EXPERIMENTAL WORK

The main experimental work carried out so far is in the area of block adjustment. Following preliminary adjustment of the odd numbered runs (20-30 per cent side lap) of 1:90,000 photography, the data was used in a project designed to compare the behaviour of polynomial, model and bundle methods of adjustment under similar conditions. Each method was given the same set of different horizontal control patterns and the results were compared. Then a large error was introduced into the ground values of points and the effect on horizontal positions in the block was analysed.

The results of the project can be summarized as follows:

(a) Accuracy. The accuracy was limited by some anomalies in the horizontal control identification or its transfer;

(b) Comparison. As this aspect of the project was purely comparative--identical data and equivalent conditions were applied in each method--a valid comparison was possible despite the control anomalies. All three methods produced comparable results except that the model adjustment method appeared to need more ground control in order to achieve the same horizontal positional reliability in adjusted values;

(c) Error detection. Most adjustment techniques include pre-processing which allows editing of the photogrammetric data. Detection of errors in ground control, its photogrammetric observation or transfer, relies upon the block adjustment. The results of the project demonstrate the following:

(i) Strip method. Polynomial adjustment, used according to particular constraints, effectively isolates errors in ground control. Editing of the photogrammetric points relies on pre-processing;

(ii) Bundle method. This method provides highly refined editing of photogrammetric points. It is also effective in isolating ground control errors;

(iii) Model method. At lower horizontal control densities, the model adjustment appears to absord errors in horizontal ground control much more readily than do the other models. It provides satisfactory editing of photogrammetric errors.

Further development

Polynomial adjustment continues to be used in routine production. Shut's bundle adjustment has been mounted on a PDP 1170/FORTRAN 77 installation (128,000 16-bit words) and is extended to handle approximately 300 models. When proved, this bundle adjustment will be applied to test range experimentation and production adjustments.

The next use of the text range data will involve the part block of ultra-high-altitude photography (see table 22, serial 3) and also an adjustment of the 60 per cent side-lap set (see table 22, serial 1).

OTHER APPLICATIONS

The adjustment of the even-numbered run set (20-30 per cent side lap) of 1:90,000 photography has been finalized to production level. Two 1:50,0000 mapsheets are currently being mapped on existing computer-assisted equipment in order to acquire bench-mark data which will be used in the acceptance trials on future semi-automated mapping systems. Bench-mark information will be used also in the validation of new procedures and techniques as they are developed.

As the availability of proved data in the test range increases, so does the range of potential applications to experimental work and to validation of procedures.

AIRBORNE PROFILE RECORDING*

Paper submitted by Australia

RESUME

Le profilographe aéroporté (APR) est un dispositif monté sur un aéronef en vue de déterminer le profil vertical du terrain survolé par rapport à une surface de référence isobarique donnée. Le système WREMAPS II d'établissement de cartes et de profils est utilisé

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* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.11.

par le Royal Australian Survey Corps depuis 1974. Les procédures et le matériel sont perfectionnés constamment. Avant sa mise en service, l'utilisation du radar profilographe aéroporté canadien Mk5 en Papouasie-Nouvelle-Guinée a permis d'acquérir une certaine expérience. Le système WREMAPS II fait suite au système WREMAPS I qui était utilisé par la Division de cartographie et le Département du développement national et de l'énergie. Il est utilisé depuis 1974 en Papouasie-Nouvelle-Guinée, en Indonésie et en Australie et il donne d'excellents résultats.

The airborne profile recorder (APR) is a system mounted in an aircraft for the purpose of measuring a vertical profile of the terrain beneath the aircraft with respect to a particular isobaric reference surface. The weapons research establishment mapping and profiling system (WREMAPS II) has been used by the Royal Australian Survey Corps since 1974. The procedures and equipment have gone through a continuous process of development since that time. Prior to its introduction into service, some experience had been gained in operating the Mk 5 Radar APR, which is Canadian owned and developed, in Papua New Guinea. WREMAPS II is a development of WREMAPS I, which was used by the Division of National Mapping of the Department of National Development and Energy. Since 1974, the system has been used in Australia, Indonesia and Papua New Guinea with great success.

SYSTEM DESCRIPTION

The APR system (see figure 41) is described below:

(a) Aircraft. A Beechcraft Queenair has generally be used but it is possible to use a Pilatus Porter or a suitably modified Australian Army Nomad;

(b) APR equipment. This consists of the following main components:

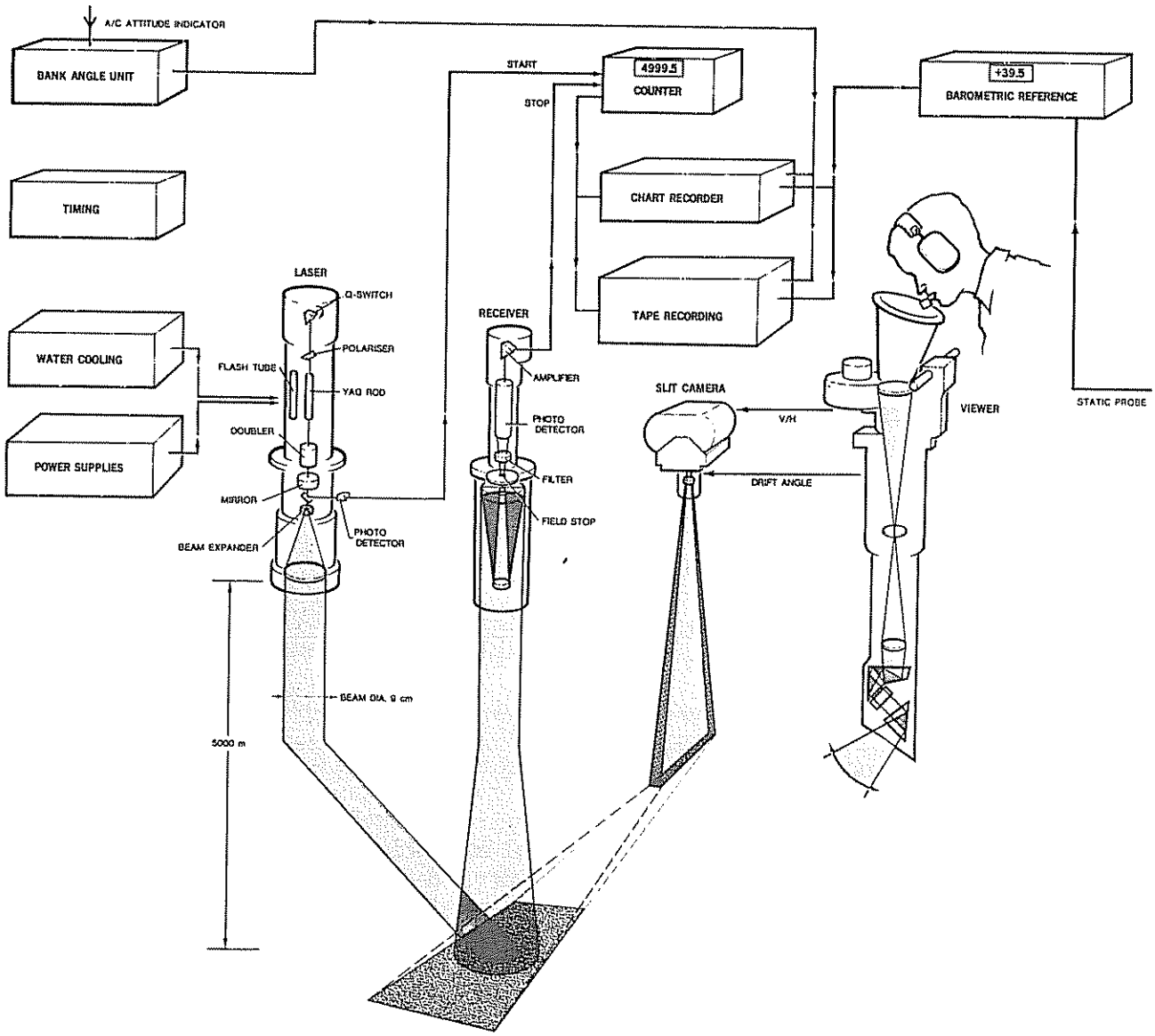
(i) Distance measuring equipment to determine the aircraft-to-ground separation. This is a combination of a laser, which generates short-duration pulses of green laser light vertically downward from the aircraft in a narrow beam; and an optical receiver, which detects the return reflected from the terrain. The aircraft-to-ground distance is determined from the elapsed time, which is recorded by means of a counter;

(ii) A barometric reference unit (BRU), which determines the deviation of the aircraft above or below the isobaric surface. It also actuates a pilot's altitude error display;

(iii) A timing unit, which provides the synchronization for the strip film, chart recorder and magnetic tape;

(iv) A profile recovery system consisting of a strip camera, which continuously photographs the laser spot ground path. This, coupled with the output of the timing device, provides the means of relating the terrain to the rest of the system;

Figure 41. Australia: schematic diagram of the airborne profile recorder system



(v) A data-recording system, which records the output from all other components in both digital form on data cassette and in analogue form on an ultraviolet chart;

(vi) An aircraft roll unit to monitor the attitude of the aircraft;

(c) Cartographic aerial camera. This camera provides the standard overlapping survey photography used for profile adjustment and identification.

PRINCIPLE OF OPERATION

Profiles are flown between terminal points of known height. The terminals normally take the form of the sea surface, another profile or a point heighted as a result of a ground survey. A typical terminal is a near-level 400-m linear or area future across the flight line. A profile is normally 30-40 km in length. The height is selected within the limitations of the equipment but is sufficient to give the best chance of linear isobaric surface conditions and stable aircraft behaviour. From practice, this has been found to be about 2,500 m above the height of the terrain.

The height of the reference isobaric surface over any terrain point is interpolated from each end with respect to time. Knowing the aircraft-to-ground distance and the height of the reference isobaric surface, the height for a particular terrain point may be calculated. Points that have been identified on the strip film, and for which a known height has been determined, are then transferred to the mapping photography.

A single APR profile is seldom required. It is normal for profiling to be carried out and adjusted in blocks. To meet the normal photogrammetric requirement for a single 1:250,000 block of 1:80,000 scale super-wide-angle photography, with vertical control at a density of every five models for 1:25,000 mapping and every seven models for 1:50,000 or 1:100,000 mapping, profiles would be flown as follows:

(a) Three east-west runs at intervals of 30 minutes in latitude;

(b) Five north-south runs at intervals of 22.5 minutes in longitude.

Under ideal conditions, a block such as this would require 15 hours of flying. Such a network is suited for most areas of Australia. Mountainous areas, however, such as in Indonesia and Papua New Guinea, may require a special configuration to suit the terrain and available control points.

DATA

Data are recorded in two forms: (a) digital record on a four-track 1.5-hour data cartridge (six hours of recording); (b) analogue record on an ultraviolet chart.

The digital magnetic-tape record constitutes the primary recording system. A Tektronix 4052 terminal has been provided to permit field verification and

reduction of the digital data. Terrain heights may also be readily obtained from the ultraviolet chart, which provides redundancy. It also provides an immediate diagnostic tool in the event of a system failure.

ACCURACY

The APR system provides aircraft-to-ground distances, with an error of less than 1 m for aircraft-to-ground separations of up to 5,000 m.

Many parameters must be considered when determining the accuracy of the total system. Loop misclosures for a profile network would normally be on the order of 5 m. Sources of errors in heights, determined from APR profiles, are:

(a) Errors in the distance-measuring equipment, misalignments between the laser and the strip camera, and errors associated with the barometric reference unit. Regular adjustment, checking and calibration keep these to a minimum;

(b) Height errors and poor identification at the terminal points;

(c) Curvature and noise of the isobaric surface.

After adjustment, final height values are determined to an accuracy of approximately ± 2 m.

LIMITATIONS TO PERFORMANCE

There are some limitations to the performance of the WREMAPS II APR equipment:

(a) Maximum aircraft to ground separation of 5,000 m. In some circumstances, the return pulse may not be received. This commonly occurs over water. To avoid interference with the next pulse, the height counter automatically stops at 6,000 m;

(b) Minimum aircraft-to-ground separation of 1,000 m. This limitation is imposed by the strip camera;

(c) The aircraft must operate at the nominated profiling altitude for at least 30 minutes before profiling commences. This allows the rate for the barometric reference unit to become linear;

(d) The maximum design altitude for the equipment is 8,000 m;

(e) Clear air is necessary between the aircraft and the ground. Cloud, fog and smoke haze may diffuse the laser beam and inhibit photography.

SAFETY ASPECTS

The expanded 6-mm laser beam is marginally unsafe at zero range and should not be viewed with the human eye at close range. In airborne operation, the system is unconditionally safe.

SIMULATED COLOUR FOR ORTHOPHOTOMAP PRODUCTION*

Paper submitted by Australia

RESUME

Le Royal Australian Survey Corps a mis au point des méthodes d'établissement d'orthophotocartes à partir de photographies monochromes permettant d'obtenir des résultats prévisibles et reproductibles.

Le document donne des précisions sur les progrès accomplis dans ce domaine au cours des deux dernières années.

The production of coloured orthophotomaps by tonally separating monochrome photography has been attempted by a number of map-production organizations with varying degrees of success. The main problems encountered have been the requirement for a large amount of manual intervention in order to avoid misleading the map user by depicting features in incorrect colours, a rather "flat" appearance to the map; and when process printing is attempted, a lack of repeatability of the colours achieved.

The Royal Australian Survey Corps uses two techniques for producing reproduction material suited for simulated colour orthophotomaps.

HALF-TONE IMAGERY

Traditionally, continuous-tone photographic imagery has been made suited for printing by the use of half-tone screens that break the image down into a series of variously sized but equally spaced dots. This method is widely used throughout the printing industry and in general produces satisfactory results. There is, however, some loss of resolution due to the dot pattern; and where retention of fine detail is required, the result produced is not always adequate.

Mapping photography is not normally flown or planned specifically for the production of orthophotomaps. Rather, it is flown and planned to suit ground control limitations, aerial triangulation requirements and general photogrammetric plotting needs.

As such, for most orthophotomaps produced by the Royal Australian Survey Corps, there is a requirement to place photographs together in a mosaic to cover the desired map format. Further, there is generally a need to produce a block of maps to cover a project area. Although photographic techniques are used to "tone-match" adjoining photographs, the results are not always the best that can be achieved.

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* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.12.

Half-tone techniques have an advantage in that screen densities can be controlled and, more importantly, repeated. Therefore, even though some resolution is lost, half-tone techniques are used, especially in moderately developed areas where tonal changes are more evident.

RANDOM-DOT IMAGERY

The random-dot technique is a screenless lothographic-printing method in which the continuous-tone image is transformed into a large number of small, approximately equally sized dots or grains; tonal variation is achieved by varying the concentration of these dots rather than by changing their size, as in the half-tone process. The retention of fine detail is excellent; and it has the advantage that the random-dot image is produced photographically, permitting the use of standard lithographic plates. Plate-making and printing procedures are no more critical than for half-tone or line-printing.

This is not a new technique and it has been recognized for a number of years as a method that could improve the resolution possible when printing orthophotomaps. The reason that it has not been widely used is that until recently nobody had perfected a production process that would produce repeatable and predictable results. The Royal Australian Survey Corps has developed procedures that will give these results and has adopted the random-dot technique as a standard method for the production of orthophotomaps from monochrome photography.

The Royal Australian Survey Corps has developed procedures controlling exposure by light integrator rather than time, development by automatic film processor and sensitometry applied to predict results. There are operations where human judgement is required; and although experience is being gained, repeatable results (particularly in urban fringe and moderately developed areas) are not always attained.

SELECTION OF TECHNIQUE

The selection of the technique to be used to produce orthophotomaps is generally done on a map project basis and is based on the quality of photography available. Because of the superior resolution characteristics of the random-dot technique, this procedure is preferred. If tonal changes between adjoining photographs are marked, then half-tone techniques may be used.

DUOTONE/FALSE-COLOUR ORTHOPHOTOMAPS

During 1980, the Royal Australian Survey Corps developed its own simulated-colour technique with the specific aim of providing a series of orthophotomaps that depict the relatively unpopulated outback areas of Australia in as near their true colour as possible. Because of the lack of major topographic features, the random-dot method was used to retain as much fine detail as possible.

Low-level or ground-colour photography is used to select the tonal separation points between shadow and vegetation, and open ground.

Two positives are produced, one to cover the contrast range required for the shadows only (the black printer positive) and one to cover the contrast range for both the shadows and the vegetation (green printer positive). A third positive is then produced with the exposure required to produce the full contrast range. However, the green printer positive is used as a hold-out mask so that only the open ground areas are reproduced. This is the brown printer positive.

The printing colours are selected in conjunction with the coloured photography to provide as accurate a depiction of the area as possible. The map has a combination green (vegetation) and brown (open ground) base with a black duotone darkening the extreme shadows and providing depth to the photographic imagery. While it cannot be claimed that a simulated-colour orthophotomap is completely accurate, it is considered that the user is provided with a good idea of ground colour and a product that is easier to interpret than a monochrome orthophotomap.

CONCLUSION

The false-colour duotone technique is particularly suited to the production of orthophotomaps of outback areas where an excellent approximation of true colour can often be obtained.

During fiscal year 1981/82, twenty-four simulated-colour maps were produced of outback areas of South Australia. Experience gained from the early maps permitted production of a further map of Derby, Western Australia, four of the North-west Cap area of Western Australia and eight of the central Queensland coast. In addition, four of the Townsville hinterland of North Queensland are at the printing stage, as are five of the area just west of Sydney and nine of central Victoria. A further 72 maps of outback areas of South Australia are at varying stages of compilation and cartography.

CARTOGRAPHIC ENHANCEMENT OF ORTHOPHOTOMAPS*

Paper submitted by Australia

RESUME

L'année dernière, le Royal Australian Survey Corps a établi un grand nombre d'orthophotocartes à des fins diverses. Les techniques d'accentuation cartographiques de chaque base d'images sont aussi variées que les orthophotocartes elles-mêmes.

Le présent document met en lumière la représentation cartographique des orthophotocartes et contient des renseignements sur les spécifications provisoires et les techniques de production.

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* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.13.

Since mid-1981, there has been a significant increase in the production of orthophotomaps in the Royal Australian Survey Corps. Many of these maps portray terrain in remote areas of central Australia. Others have been produced for moderately populated areas and training areas along the eastern coast of Australia. Some have been produced of urban fringe and urban areas.

BACKGROUND

Standard topographic mapping in remote areas of Australia has proved to be extremely difficult. The inland areas are characterized by typical arid and semi-arid features, including sand ridges, salt-pans, dry lakes, patchy low scrub and little or no surface drainage. Parts of the north-western coast are characterized by large areas of coastal flat (tidal ranges of up to 11 m occur), shallow offshore areas and hinterlands with few distinctive features.

During the period 1980-1981, the Royal Australian Survey Corps developed a simulated-colour technique for orthophotomaps--a technique that permitted the depiction of relatively unpopulated outback areas of Australia in as near their true colour as possible.

The technique proved to be so successful that its application was extended to include areas of high relief, moderately populated areas, urban fringe areas and selected urban areas.

The present paper contains a discussion of cartographic aspects (production methods, with particular emphasis on enhancement) of the orthophotomaps produced by the Royal Australian Survey Corps.

DISCUSSION OF CARTOGRAPHIC ENHANCEMENT

An orthophotomap possesses the pictorial qualities of aerial photography and the planimetric accuracy of a line map. The production of a cartographically enhanced orthophotomap has an economic advantage over a conventional topographic map in terms of man-hours and materials; and an advantage to the user in that relief, hydrographic and vegetation features that are difficult to symbolize, particularly in remote areas, are shown by photographic image.

Remote areas: produced at 1:50,000 scale

Features that are enhanced on orthophotomaps of remote areas include:

(a) Railways and associated features;

(b) All roads, including vehicle tracks;

(c) All buildings and sheds;

(d) Power-transmission lines;

(e) Telephone lines;

(f) Fences;

(g) Gates and grids;

(h) Windpumps;

(i) Airfields and associated features;

(j) Other cultural detail considered to have a landmark value;

(k) Pipelines, channels and drains;

(l) Dams and tanks;

(m) Contours.

Nomenclature includes:

(a) Towns and localities;

(b) Homesteads and outstations;

(c) Named railways;

(d) Named roads and tracks;

(e) Other named cultural features including yards;

(f) Paddock names (extremely remote areas);

(g) Named hydrographic features;

(h) Named relief features;

(i) Spot elevations;

(j) Contour values;

(k) Descriptive type for cultural, hydrographic, relief and vegetation features.

Moderately populated areas: produced at 1:25,000 scale

The amount of detail enhanced on the orthophotomaps of moderately populated areas varies according to the amount of cultural detail and the quality of the base image. Features normally enhanced include:

(a) Railways and associated features;

(b) Airfields and associated features;

(c) Roads, sealed and unsealed;

(d) Vehicle tracks (depending upon the density of detail);

(e) Prominent buildings not visually prominent on the imagery;

(f) Bridges, cuttings and embankments;

(g) Power lines;

(h) Other cultural detail considered to have a landmark value;

(i) Pipelines, channels and drains;

(j) Reservoirs, dams and tanks;

(k) Contours.

Nomenclature includes:

(a) Towns and localities;

(b) Prominent homesteads;

(c) Named railways;

(d) Named highways and roads;

(e) Important cultural features;

(f) Named hydrographic features;

(g) Named relief features;

(h) Spot elevations;

(i) Contour values;

(j) Descriptive type for cultural, hydrographic, relief and vegetation features.

Urban fringe areas: produced at 1:25,000 scale

Minimal cartographic enhancement is performed on the maps of urban fringe areas. Only railways, main through-roads, major cultural features, reservoirs, major channels and contours are cartographically produced.

Type is produced under similar guidelines as for conventional topographic maps in similar areas.

Urban orthophotomaps: produced at 1:10,000 scale

The amount of cartographic enhancement of urban orthophotomaps is assessed for each individual map.

In addition to any features required to be enhanced, such as railways and power lines, key features, including service facilities and major buildings, and communication features are enhanced by identification (and symbolization, if necessary) with the identification code, description and grid reference placed in the margin on the map.

Legend and margin data: all scales

Legend panels and margin layouts vary according to the type of detail enhanced; but in general, within the categories discussed above, standardization of format can be maintained.

In addition to the normal components in the margin (map identification code, scale, spheroid and grid reference, grid referencing guide, locations diagrams, symbology and directional relationships), the Royal Australian Survey

Corps orthophotomaps have area drainage classification, rainfall and temperature guides.

CARTOGRAPHIC PRODUCTION PROCEDURES

The actual enhancement to the orthophotomap is accomplished by using standard cartographic procedures. These include scribing, type stick-up, masking, retouching, legend set-up etc.

Major deviations from standard cartographic procedures are: (a) use of continuous-tone scribe material; (b) use of haloed type.

Contone scribe

Contone scribe, with its continuous-tone impression, its translucent, light-yellow colour and its excellent dimensional stability, is well-suited to this type of cartography. The superimposition of the actual map base imagery on to a scribe material allows accurate positional-scribing of detail to the image base.

Haloed-type

All-feature type, descriptive type and grid type are haloed against the darker (green and black) simulated-colour base imagery in order to ensure readability.

CARTOGRAPHIC SYMBOLOLOGY

Specifications have been established by modifying the symbolization all series (SYMBAS) used by the Royal Australian Survey Corps for standard topographic maps.

Type sizes and styles are in accordance with SYMBAS except that all internal type is increased in size a minimum of two points in order to improve legibility (especially on the dark image background of the printed map).

Scribed linear features, such as roads and railway lines, are generally produced 0.1 mm thicker than line-map symbolology.

Most point-feature symbols are enlarged 150 per cent.

Contour line-weights vary according to the region being mapped. As central Australia is relatively flat and red-brown in colour, contours need to be produced at 250 per cent standard line-weight, whereas eastern areas with dark-green vegetation permit line-weights that are only marginally increased or standard.

Fluorescent inks are used effectively on a simulated-colour image base to portray roads and contours. The colours have been tested under several lighting conditions.

Some urban orthophotomaps at 1:10,000 scale are produced with a monochrome image base with white contours.

CONCLUSION

The orthophotomap is a special topographic map product particularly suited to rapid-response mapping requirements and mapping areas of limited cultural development. The Royal Australian Survey Corps has published some 30 medium-scale maps of this type and has used the expertise gained to commence production of city fringe areas and urban areas.

ORTHOPHOTOMAPPING FOR THE MARKET-PLACE: THE QUEENSLAND EXPERIENCE*

Paper submitted by Australia

RESUME

Les orthophotocartes représentent une proportion de plus en plus importante de la production totale d'articles cartographiques du Département de cartographie et de topographie du Queensland. Après une certaine résistance au début, les utilisateurs s'intéressent de plus en plus au produit orthophotographique et, à certaines échelles, lui manifestent même une préférence marquée. Mais il convient d'analyser soigneusement ce phénomène avant de l'accepter tel qu'il se présente.

Convaincus que l'expérience du Queensland peut être utile à d'autres délégations, les auteurs du présent texte ont entrepris de décrire, documents à l'appui, la façon dont les utilisateurs ont accepté de plus en plus les cartes orthophotographiques et le rôle que celles-ci jouent dans la cartographie du Queensland. On y trouvera une description de la gamme actuelle de produits orthophotographiques et de la mesure dans laquelle les utilisateurs l'acceptent, en particulier en ce qui concerne la carte orthophotographique au 1:2 500 qui est celle que préfèrent les autorités gouvernementales locales. L'expérience particulière d'une importante autorité locale en ce qui concerne l'utilisation de ce produit et les avantages accrus qui en ont résulté est documentée ci-après. On trouvera également une brève description du matériel employé dans ces opérations ainsi qu'une étude de la façon dont l'orthophotographie est utilisée comme base de levés cadastraux. Enfin, on examine les aspects économiques de l'établissement de cartes orthophotographiques en soulignant combien il est trompeur d'accepter de simples comparaisons de coût pour établir les études coût/avantage.

On conclut dans le document que la carte orthophotographique à grande échelle avec un minimum d'accentuation d'image porte le coût/avantage du produit à son maximum.

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* The original text of this paper, prepared by the Department of Mapping and Surveying, Queensland, Australia, appeared as document E/CONF.75/L.46 and E/CONF.75/L.46/Add.1.

Sont également jointes au document des annexes où l'on trouvera des échantillons des produits orthophotographiques du Département, de brèves spécifications et une description plus détaillée ainsi qu'un organigramme de traitement pour l'établissement de l'orthophotocarte au 1:25 000 accentuée.

The orthophotomap was introduced in Queensland in 1974 by the Department of Mapping and Surveying. Early orthophotomaps were produced as monochrome publications on the scale 1:10,000, not on standard map format. At first, the product was viewed with interest by potential users, both government and non-government, but there was considerable reluctance to see the orthophoto in any way replace the conventional line map.

CUURENT RANGE OF ORTHOPHOTO PRODUCTS

The Department of Mapping and Surveying currently produces three orthophoto products:

(a) Black-and-white monochrome at 1:2,500 scale showing contours at 2-m intervals, selected spot heights and limited nomenclature (see figure 42);

(b) Black-and-white monochrome at 1:10,000 scale showing contours at 5-m intervals and limited nomemclature (see figure 43);

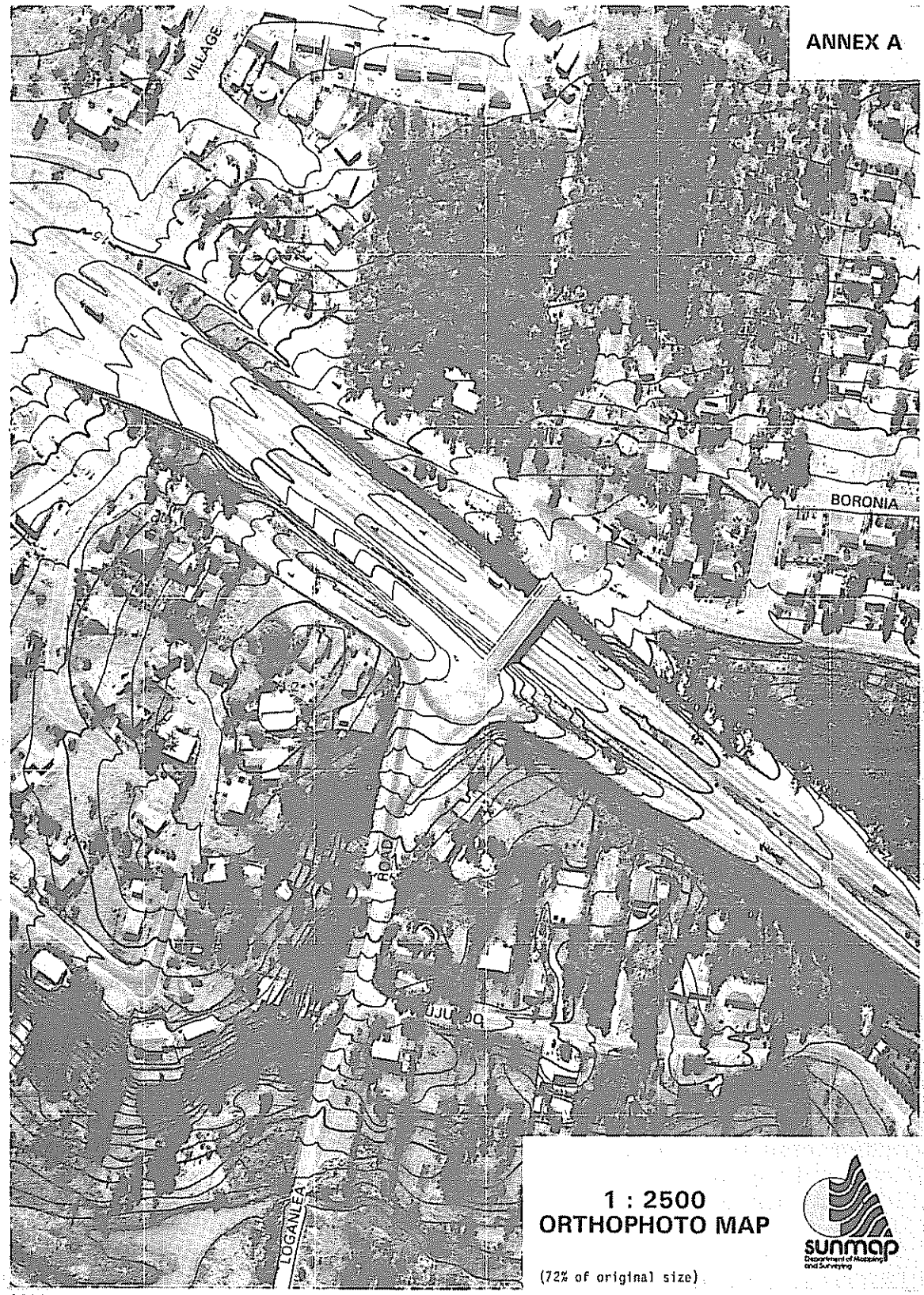
(c) Image-enhanced "duotone" in green and brown tonings at 1:25,000 scale, with 10-m contour intervals, blue line drainage and red road pattern. Further enhancement may be used to overcome interpretive ambiguities (see figure 44 in pocket 1/).

All products are on standard map format with the photogrammetric double model "triplet" providing continuous imagery for the full map-sheet. Thus, flying height is determined by the formatting requirements of the particular scale map and considerable accuracy is required in flight-line planning and subsequent aircraft navigation in order to meet this quite stringent specification. It is of interest to note that firms contracting for aerial photography have managed to achieve the flying accuracy without undue difficulty once the requirement is fully understood. An outline of the aerial photography specification is presented in annex I.

ORTHOPHOTOMAP AT 1:2,500 scale

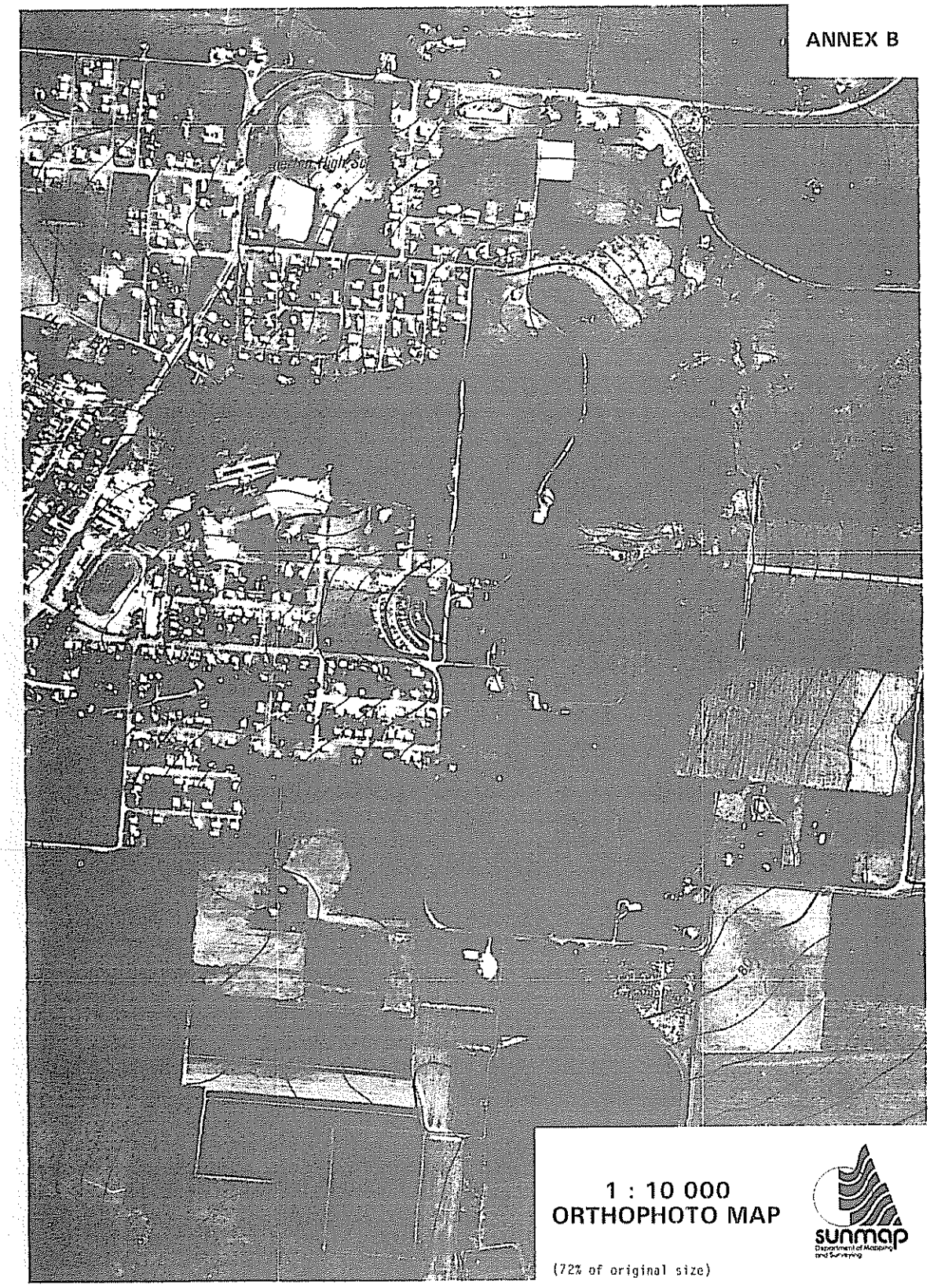
Perhaps the particular orthophoto product that has created greatest user interest, with a resulting demand for coverage, is the simplest of the three maps offered--the 1:2,500 orthophotomap. The interest of local government authorities in orthophotomap coverage at this large scale prompted the Queensland state government to introduce a cost-sharing mapping scheme whereby the local authority contributes 60 per cent of the estimated total cost of producing the required mapping. This 60 per cent contribution allows field survey for horizontal and vertical control, aerial photography and contour plotting to be carried out by private mapping firms. The 40 per cent share provided by the

Figure 42. Australia: orthophotomap at 1:2,500 scale



3388.23x

Figure 43. Australia: orthophotomap at 1:10,000 scale



state government comprises aerotriangulation, orthophoto profiling and projection, cartography and management. Thus, the overall production capacity of the Department of Mapping and Surveying is greatly expanded and a valuable impetus is given to the private mapping sector in developing their capacity for mapping work. The finished product comprises a composite film positive from which dye-line or ozalid copies can be pulled. Where demand justifies lithographic printing, it can be carried out from a single plate.

Well over 1,000 maps have been completed under the cost-sharing mapping scheme, and to date 19 local authority councils have entered the scheme.

Orthophotomap at 1:10,000 scale

The orthophotomap scale at 1:10,000 is a standard product of the Department of Mapping and Surveying. Its presentation is very similar to that of the 1:2,500 map but with 5-m contours. The contours for the 1:10,000 orthophotomap are currently plotted at a compilation scale of 1:16,667 and then enlarged to 1:10,000. The same contour plot is used for the 1:25,000 standard map series when these are produced from the same aerial photography in conjunction with the 1:10,000 orthophotomap series. Like the 1:2,500 series, the finished product is in the form of a composite film positive from which dye-line copies are produced, unless user demand has indicated the need for lithographic printing.

Orthophotomap at 1:25,000 scale

The very simple techniques and presentation applied to the 1:2,500 and 1:10,000 orthophoto products were found to be less effective on the scale 1:25,000, owing to the fact that the finer photo imagery inherent in the smaller scale product loses definition in the screening process necessary for reproduction.

To vercome this problem, an image-enhancement technique was adopted whereby four half-tone positives were produced photographically, each at different screen angles, from the continuous-tone orthophoto negative combined with combinations of two density masks. Then, after a process of compositing with various levels of highlighted line detail, printed down in the four process colours of magenta, yellow, cyan and black. Early results using this enhancement technique were very promising; but it was subsequently found difficult to achieve a consistent result from sheet to sheet, and in fact, effectively to standardize the entire process.

The four-color process has now been replaced by a more controllable duotone process for imagery enhancement whereby negative and positive density separation masks are produced and, after combination with half-tone positive screens of controlled dot size range, printed down in brown and green in order to give a visually pleasing and consistent imagery depiction that is well representative of the ground tonings of the aera being mapped. Three line enhancements of red (roads), blue (drainage) and black (grid, graticule, contours, boundaries and nomenclature) produce a five-colour final product which is lithographically printed. Details of the full procedure in current use are given in annex II.

At the time of preparation of the present report, six maps had been published using this technique and a further 44 sheets were close to publication.

USER ACCEPTANCE OF THE ORTHOPHOTO PRODUCT

It is difficult to persuade the public ratepayer, and indeed many members of the local authority councils, that expenditure on mapping af any type deserves some priority as opposed to the other essential services that are the traditional concern of this third tier of government, such as sewage, water-supply, kerbing and channelling, and the improvement of library and recreational facilities. Thus, it becomes a marketing exercise to persuade councillors and their ratepayers that the provision of suitable mapping will greatly facilitate the planning and development of all the services for which the council is responsible and will, in the medium term, provide substantial savings by the reduction of frequent repetitious and overlapping field exploratory and investigative surveys as well as a sound basis for council decision-making. The pictorial nature of the orthophoto product, whereby ground detail is presented with all of its subtleties in a way that never can be achieved by conventional line-mapping, makes it a more convincing document to the lay public and in many ways a more useful document to the professional user than the conventional map.

The level of acceptance accorded the orthophoto product has been emphasized by the client authorities that have entered the cost-sharing mapping scheme. A large local authority council abutting the city of Brisbane and therefore controlling a developing dormitory area where rural land is rapidly being converted to residential, commercial and light industrial use, and which had obtained 106 orthophotomaps on the scale 1:2,500 through the scheme, recently presented to a photogrammetry seminar a paper outlining the benefits that had accrued to the council as a result of the map coverage:

(a) Drainage purposes: catchment and run-off calculations and drainage scheme design;

(b) Water-supply purposes: demarcation between low-level and high-level supply systems; allocation of head-works charges to land developers; reservoir side locations; routing of water mains;

(c) Sewerage purposes: areas of sewage catchments; sewage pipe design to suit actual gradients; sewerage scheme design;

(d) Recreational areas: detail planning and design;

(e) Refuse land-fill: refuse-tip control and design;

(f) Flood area identification for planning purposes;

(g) Road works: route planning and preliminary trial cut-and-fill calculations;

(h) Slope analysis: rural and residential design;

(i) Quarry operations: environmental considerations;

(j) Land-suitability analysis: choosing of land for various uses--parks, schools, refuse-tip sites, commercial areas;

(k) Evaluation of rezoning, town-planning and subdivision applications: Initial assessment, including position of adjoining residences, extent of cleared land, relationship of physical features, vegetation and overall site appreciation;

(l) Preliminary subdivision design layouts: especially useful to private consultants and developers;

(m) Golf-course design;

(n) Public relations: displaying to the public aspects of the council's work.

EQUIPMENT

In 1973, the Department of Mapping and Surveying acquired the Geiger-Zeiss GZI orthophoto projector and two Zeiss planimats for profiling. The GZ1 has served well and the majority of orthophotomaps produced by the Department have been projected on that machine. In early 1983, the Zeiss Z2 orthophoto projector with associated Hewlitt Packard computer and HI FI software packages will replace the now aging GZ1. The Z2 will provide a full facility for creating digital elevation models from which both contours and profiles may be produced. Alternately, profiles may be produced from digitized contours.

In the private sector, a consortium of firms has recently acquired a Zeiss (Jena) topocart C with an orthophoto D projector which produces double-model orthophotos in the off-line mode with cross-slope correction. Use is made of this facilility by the Department in the cost-sharing scheme. Other private firms have orthophoto equipment of the on-line single-model variety.

BASE FOR CADASTRAL MAPPING

The orthophotomap has proved a useful base for the compilation of a companion cadastral map. The Queensland standard cadastral map is compiled on the Australian map grid to normal accuracy requirements and depicts the full cadastral network, with land parcels and tenure detail. Topographic detail (e.g., drainage pattern, limited hachured relief and major roads and railways) is shown in outline only. The resulting map is lithographically printed as a monochrome.

Because the cadastral network is still largely uncontrolled in terms of field survey and is therefore not relatable on the ground to the Australian Geodetic Datum, graphical accuracy at any given map scale can be achieved only by accepting as evidence of cadastral boundaries the fence pattern plotted on the standard topographic map or occuring in the imagery of an orthophoto. In effect, the visible fence pattern becomes the control on which the remaining full cadastral network can be constructed.

The publication scale of a cadastral map is largely determined by the density of the cadastral network to be depicted and hence it is not always economical to provide a companion cadastral sheet for each orthophotomap produced on the same scale. Nevertheless, the orthophotomap provides the ready

means by which a cadastral map can be compiled; and, in some cases, this factor alone may justify the production of an orthophoto base.

ECONOMICS OF ORTHOPHOTOMAPPING

It is usual to compare the production costs of the orthophotomap with the equivalent line map at the same scale and from this comparison draw the conclusion that the orthophotomap is a substantially cheaper product than the equivalent standard topographic line map. Other than on the scale 1:25,000, direct comparisons are difficult to find, since in the Queensland experience, standard line-mapping at larger scales has occured only infrequently. Differences in terrain characteristics from sheet to sheet also preclude reliable comparison. Nevertheless, a broad-based cost comparison was carried out recently for the purpose of establishing the relative value of mapping produced in Queensland as opposed to the other Australian states. In adopting the 1:25,000 topographic map as a value base of 1.00, other map products attracted the following values: (a) 1:25,000 orthophotomap (enhanced), 0.42; (b) 1:10,000 topographic map, 0.70; (c) 1:10,000 orthophotomap, 0.24; (d) 1:2,500 orthophotomap, 0.20.

In broad terms, the orthophotomap can be said to cost less than half that of the equivalent standard line map, and from this it may be construed that the orthophotomap is more cost-effective and has greater cost benefit. This latter statement is arguable since, for some users, the benefit of the line map may transcend its cost structure. The comparison is influenced greatly by the amount of plotted detail incorporated in the line map and by the amount of enhancement applied to the orthophotomap. In the latter instance, it is clear that this should be limited to the minimum amount necessary to retain legibility and user utility.

A further factor that must influence any cost comparison is the scale of photography. In order to achieve single-photo format on the 1:25,000 orthophotomap, super-wide-angle photography at a scale of 1:75,000 is used. Standard 1:25,000 topographic maps are compiled from wide-angle photography at 1:37,500 scale and hence the field control requirement of the former is approximately half that of the latter, with a resulting substantial cost reduction.

In drawing comparisons between conventional line-mapping and orthophotomapping, due consideration must be given to capital equipment costs, which may be as high as 750,000 Australian dollars for a complete system of orthophoto projection, profiling and associated computer equipment. This is an additive cost since the formal range of other photogrammetric equipment will still be required for aerotriangulation and, perhaps, plotting. (Cheaper orthophoto equipment is available, of course, especially of the on-line single-model variety.)

From the foregoing discussion, it may be seen that any simple production cost comparison between the orthophotomap and the conventional line map must be carefully analysed. For some users at least, the lesser benefit accrued from the orthophoto product may completely negate the apparent cost-saving. For other users, the infinite detail inherent in the imagery of the orthophotomap may provide an increased benefit as well as a cost-saving. Hence, the actual needs of the user must be known in order to appreciate the benefits that may be gained or lost.

CONCLUSION

In the final analysis, the decision whether to introduce orthophoto products must be made in the light of several factors, only one of which is production cost. Consideration must be given to the nature of the products, their scale and intended use, the availability of supporting photographic technology and the specific advantages and disavantages of offering to the map user photo-imagery with its full range of subtle ground detail as opposed to an interpretation of a pre-selected and essentially limited range of the same detail. Much might depend upon the map user himself, his level of training and sophistication as a user. The question may be asked whether the task of interpreting aerial photo-imagery should be passed to the user or retained by the photogrammetrist.

In the experience of the Department of Mapping and Surveying, the advantage of orthophotomapping is maximized in the larger scale product (1:10,000 or larger) with minimal enhancement.

Note

1/ Certain unnumbered maps have been placed in the pocket at the end of this volume. Reference in the text indicates the numerical listing of such an illustration in the contents. Thus, figure 44 referred to above is an unnumbered map in the pocket.

Annex I

DETAILS OF ORTHOPHOTOMAPS

Maps at 1:2,500 scale

Format size: 56 1/4" x 56 1/4"
Sheet dimensions: (15° S. lat.), 672 mm (26.5") East x 691 mm (27.2") North
Area covered: 1,680 x 1,728 m (2.90 km^2)
Flying height above datum: 1,430 m
Camera lens: 152.4 mm (6")
Scale of photos: 1:9,400
Contour interval: 1 m
Printed in black and white

Maps at 1:10,000 scale

Format size: 3 3/4' x 3 3/4'
Sheet dimensions: (15° S. lat.), 672 mm (26.5") East x 691 mm (27.2") North
Area covered: 6,720 x 6,910 m (46.46 km^2)
Flying height above datum: 5,720 m
Camera lens: 152.4 mm (6")
Scale of photos: 1:37,500
Contour interval: 5 m
Printed in black and white

Maps at 1:25,000 scale

Format size: 7 1/2' x 7 1/2'
Sheet dimensions: 15° S. lat.), 538 mm (21.2") East x 553 mm (21.8") North
Area covered: 13,443 x 13,826 m (185.9 km^2)
Flying height above datum: 6,660 m
Camera lens: 88 mm (3.46")
Scale of photos: 1:75,000
Contour interval: 10 m
Printed in five colours: duotone base brown and green; type, black; drainage, blue; road classifications, red
Sheet dimensions are calculated using the Australian map grid.

Annex II

ENHANCED ORTHOPHOTOMAPS AT 1:25,000 SCALE: DETAILED DESCRIPTION

Orthophotomapping has become a useful means of providing quick topographic coverage. By allowing the orthophoto to convey detail, such as buildings, fence lines, vegetation, creeks and roads, fewer line and feature overlays are necessary. On scales of 1:2,500 and 1:10,000, the final map consists of the half-tone orthophoto, a contour overlay and a type overlay.

Because of the scale and the necessary half-toning for reproduction, detail is not as readily visible on a 1:25,000 orthophotomap as on the 1:2,500 or 1:10,000 orthophotomaps. The imagery definition therefore has to be improved. This is done by enhancing the orthophoto in two ways. The first is by photographic means, producing a green-and-brown orthophoto from the black-and-white aerial photography; the second by producing line overlays for creeks and roads to be printed in blue and red, so aiding interpretation of detail on the final map.

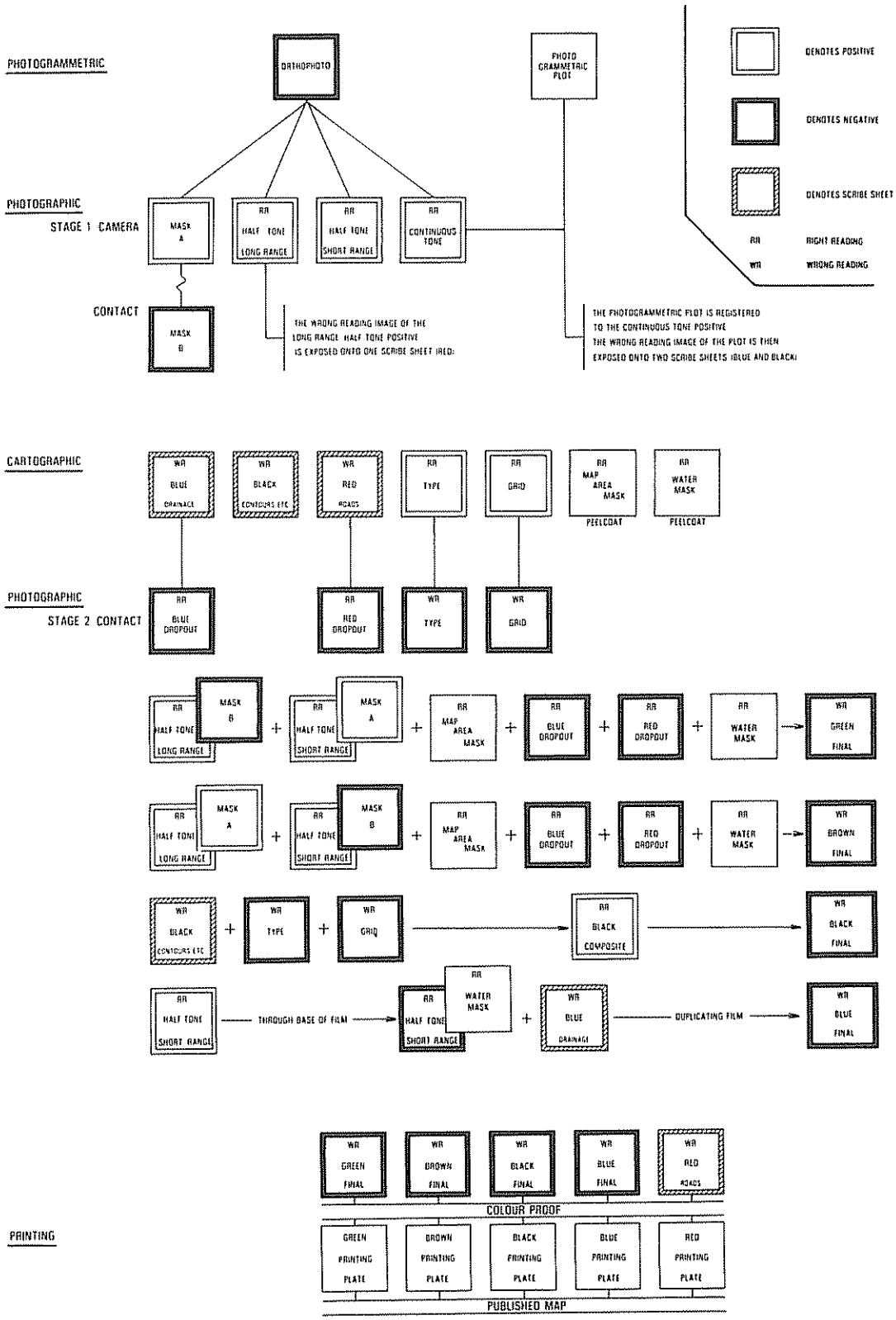
Production of the enhanced orthophotomap at 1:25,000 scale consists of three steps: stage 1 photography; cartography; and stage 2 photography.

STAGE 1 PHOTOGRAPHY

Stage 1 photography takes palce after production of the orthophoto negative and involves the preparation of a continuous-tone orthophoto positive, mask A and mask B, a long-range half-tone positive and a short-range half-tone positive (see figure 45).

From visual examination of the continuous-tone orthophoto positive, a cut-off point in the density range of the orthophoto is determined. The cut-off point is chosen to separate the darker "shadow" areas from the lighter "highlight" areas of the orthophoto, and it is used to produce mask A. The orthophoto negative is used to expose mask A; this is a positive of the shadow areas only and is clear in the highlight areas. Mask B is a direct negative of mask A and is therefore a positive of the highlight areas and clear in the shadow areas.

Figure 45. Australia: flow chart of enhanced orthophotomapping at 1:25,000 scale; coastal and water mass



Shadow areas will include areas of dense vegetation as well as wet areas and the southern slopes of ridges. Highlight areas will include flat cultivated or grassy fields and the northern slopes of ridges clear of vegetation. Correct execution of the density separation is vital to the appearance of the final green-and-brown orthophoto and is ultimately dependent upon the quality of the aerial photography.

The orthophoto is then used with a glass screen to expose the long-range and short-range half-tone positives. The long-range positive is produced so that the screened dot size ranges from 90 per cent in the darker shadow areas to 5 per cent in the highlight areas. The short range is produced so that the screened dot size ranges from 50 per cent in the shadow areas and 5 per cent in the highlight areas. Sun-flare areas on the aerial photography are disregarded.

CARTOGRAPHY

The cartographic content of the 1:25,000 enhanced orthophotomap comprises the compilation of a drainage overlap to be printed in blue, a road overlay to be printed in red, and a contour road and railway overlay and a type overlay, both to be printed in black. The three line overlays are produced as three separate scribe sheets. A map area mask is prepared for use in stage 2 photography as well as a water area mask for coastal sheets.

STAGE 2 PHOTOGRAPHY

The purpose of stage 2 photography is to produce the final negatives for printing. The brown and green final negatives are produced by an involved system using masks A and B and the long- and short-range half-tone positives (see figure 45).

To produce the green final negative, the long-range image is exposed in the shadow areas using mask B and the short-range image is then exposed in the highlight areas using mask A. This procedure is reversed to produce the brown final negative where the long-range image is exposed in the highlight areas using mask A and the short-range image is exposed in the shadow areas using mask B.

So that there will be no green or brown under the blue creeks and red roads, it is necessary to produce drop-out negatives from the red and blue scribe sheets. The drop-out negatives are then individually exposed in the production of the green and brown final negatives. The map area mask is also exposed at this stage so that the orthophoto image outside the map neatline is burnt out.

On coastal or large water area sheets, the orthophoto imagery in the water area is dropped out in the production of the green and brown final negatives by using the prepared water area mask. A final blue negative is then prepared by using the short-range half-tone positive, the water area mask and the blue scribe. Therefore, on the final map, the orthophoto is printed in green and brown on the land area and blue only on the water area.

Except on coastal and large water area sheets, the blue scribe is used as the final negative for printing of the blue. Similarly, the red scribe is used as the final negative for printing the red. A composite black final negative is produced of the black scribe (contours etc.), type overlay and grid.

A colour proof of the five negatives (green, brown, blue, red and black) is then prepared and checked before the map is ready for printing.

PLANNING AND CADASTRAL PROJECTS FOR URBAN AND RURAL REGIONS WITH THE AID OF ORTHOPHOTOMAPPING*

Paper submitted by the Federal Republic of Germany

RESUME

Un exemple simple illustre la façon dont les orthophotocartes peuvent être facilement utilisées pour la planification dans divers domaines, de même qu'à différentes étapes. En même temps, les orthophotocartes peuvent servir de base pour la production de cartes cadastrales et pour l'enregistrement de données cadastrales. Il a été démontré qu'avec l'assistance technique de pays industrialisés, il s'agit, pour les pays en développement, d'une méthode très économique et satisfaisante du point de vue pratique. On utilise des méthodes graphiques très simples sans recourir à des ordinateurs. La production d'orthophotocartes, avec l'assistance de sociétés allemandes spécialisées dans la photogrammétrie aérienne a accéléré les travaux.

It is well known that in many developing countries there is a lack of suitable maps for urban and rural projects. The question is how to obtain suitable maps for planning and cadastre as rapidly as possible.

In projects assisted by the Federal Republic of Germany in Central America, the Caribbean, Brazil and the Philippines, it was found that by using orthophoto projectors or rectifiers (for flat areas), it was possible to produce photomaps within a short period of time for:

(a) Planning of metropolitan areas for streets, water-supply, sewers, erosion zones, zoning plans, housing areas, regional planning measures, slum-clearing etc.;

(b) Planning in rural regions for agricultural projects for land improvements, drainage and irrigation, and grazing lands for cattle-breeding as well as land reform measures;

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* The original text of this paper, prepared by J. Nittinger, Secretary-General, Advisory Group for Technical Co-operation in Surveying and Mapping (BEV), Münster, appeared as document E/CONF.75/L.30.

(c) Establishing a graphical cadastre and land register by delimitation of property boundaries and field verification of ownership.

Described first below is the way in which orthophotomaps on scales from 1:10,000 to 1:2,000 (see figures 46-48) were used in projects.

The Federal Republic pf Germany, with the assistance of air survey firms located there, has produced and delivered orthophotomaps at suitable scales and sheet layouts. Whenever possible, the services of each partner have been the determination of the necessary ground control points and their location on the respective aerial photographs. In addition, the description and co-ordinates of existing triangulation points in the respective areas are supplied.

PLANNING WITH ORTHOPHOTOMAPS

Orthophotomaps contain comprehensive information on all topographic objects and other features visible from the air. They represent an excellent tool for many planning activities.

Photo-interpretation for special subjects requires the preparation of interpretation keys. In this case, it is necessary for the photo-interpreter to visit the locality and to select particular small areas from which, with the aid of an aerial photograph, such interpretation keys are prepared. After the preparation of interpretation keys, specialists can carry out a photo-interpretation of the entire area in the office without having to resort to the field.

The Federal Republic of Germany carried out a pilot study for Nicaragua with the aim of showing how thematic maps can be produced by this method. The bases used for the production of the thematic maps were orthophotomaps at the scales mentioned above.

As a basis for a cadastre project in the city of Port-au-Prince, Haiti, orthophotomaps at 1:1,000 scale were produced. With tese maps, property location, property boundaries and ownership were obtained.

The great advantage of orthophotomaps is their geometric quality and the high information content of an aerial photograph.

ORTHOPHOTOS IN RURAL REGIONS

With the aid of suitable aerial photographs, orthophotomaps for planning in rural areas and an interpretation key, the following information can be obtained:

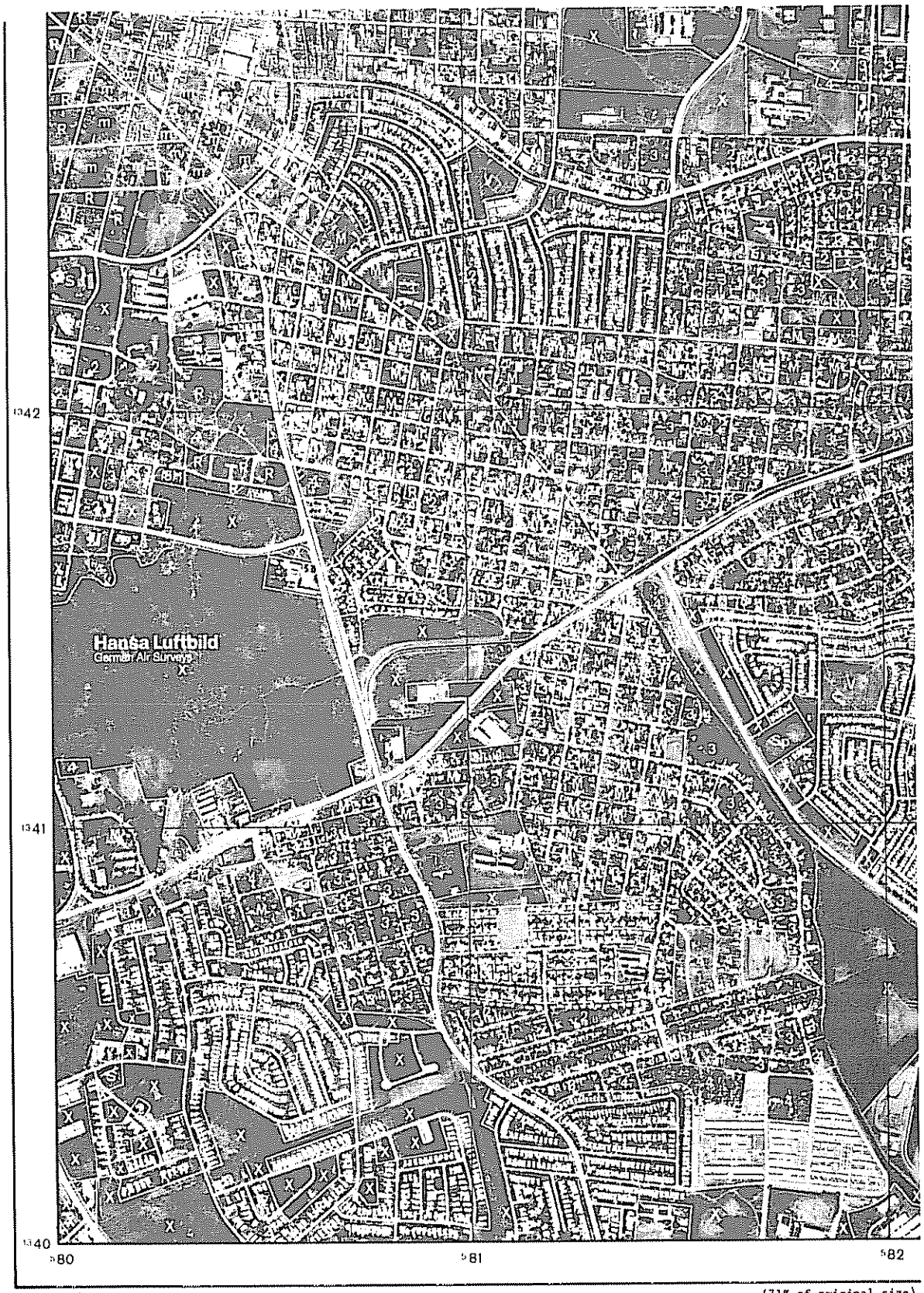
(a) Infrastructure of the area;

(b) Utilization of agricultural areas (land use);

(c) State and structure of land (size of parcels etc.);

(d) Hydrological conditions;

Figure 46. Federal Republic of Germany: orthophotomap at 1:10,000 scale as a base for production of thematic maps



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(71% of original size)

Figure 47. Federal Republic of Germany: orthophotomap at 1:2,000 scale of a rural region combined with the cadastral map

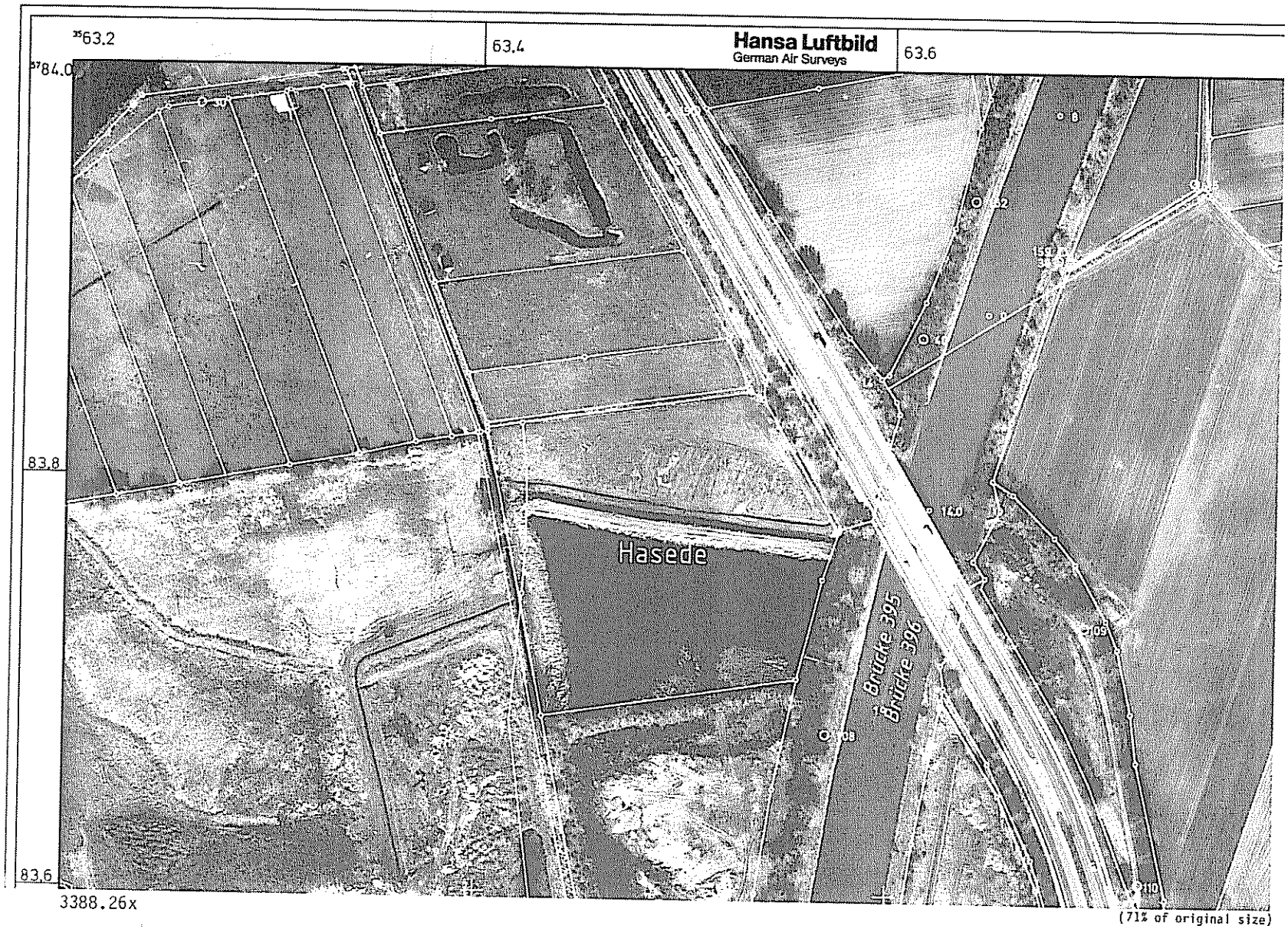
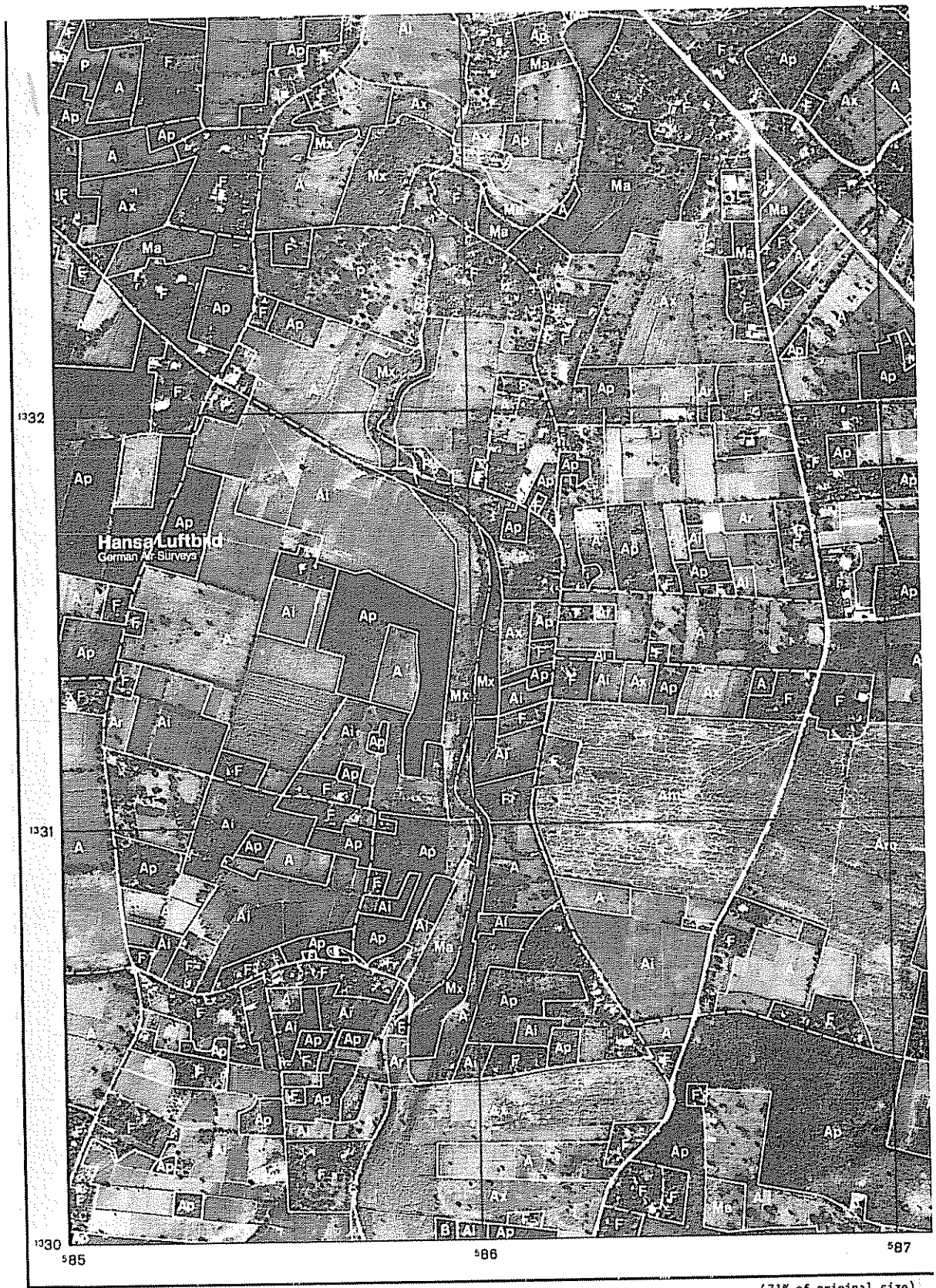


Figure 48. Federal Republic of Germany: orthophotomap at 1:10,000 scale of an urban region for production of a graphical cadastre



(e) Moisture content of the soil;

(f) Condition of the soil, including indications of the moisture content.

The use of orthophotomaps, in combination with photo-interpretation and the necessary local investigations, allows determination of the quality of the soil in selected areas and of wind and water erosion, and can thus be the basis for agricultural planning and land reform measures in developing countries. For agricultural projects, suitable maps aerial photographs or orthophotomaps are a necessity.

An effective method for the improvement of the entire agrarian structure is land reform combined with a reallotment of properties to practical-sized lots. In some cases, the local population does not yet understand and appreciate the advantage of such methods. The rearrangement and reallotment of property for the purpose of improving the agriculture in certain areas allows efficient cultivation; furthermore, no old land titles have to be defended or contested. With such reform measures, an increase in agricultural yields can be accomplished. These aims, however, are long term.

ORTHOPHOTOS IN URBAN REGIONS

With the production of orthophotomaps for planning purposes in urban and rural regions, it is also possible to use them for the establishment of a cadastre and land register. This establishment is not as difficult in rural zones as in urban regions. Boundary lines are often more clearly visible due to cultivation. Corner points of boundary lines can therefore generally be pricked on an overlay, which is then used as the basis for drawing the boundary lines.

In cases where property corners are not visible from the air, they can be resurveyed on the ground by measuring and computing co-ordinates from visible and identified topographic points on orthophotomaps. It is evident that ground surveying of lines and determination of co-ordinates of property corners takes place more frequently in urban than in rural regions.

The question is whether this graphical method for the establishment of cadastral boundaries meets the requirements of accuracy. In the opinion of the author, this method for the establishment of property boundaries in connetion with the establishment of a land register is sufficient. In general, the accuracy of the cadastral boundaries is satisfactorily ensured by proper selection of the scale of the map. It is important taht the cadastral work is established in a relatively short period of time for a complete region and with sufficient accuracy.

With orthophotos, it is possible to record the property parcels of a region, to establish a numbering system for the property parcels and to compute the area for each parcel in order to obtain other information (type and size of buildings, use of property etc.). Based on these data, it is possible to establish a land register, which could contain such legal information as ownership, mortgages and easements. Then, with this information it is possible to levy taxes and to provide certificates of landownership to the owner.

All of this information on properties is of great importance in planning projects in rural and urban areas. Especially in rural areas, it is extremely important to know the number of owners before carrying out a rearrangement and reallotment of property projects. Before carrying out agricultural improvements in particular areas, it is necessary to have control of property ownership in order to prevent real estate speculation. It is the duty of a Government to protect the little owner against such speculations. A cadastre is the best inventory ownership, landholder and land use. Figure 46-48 contain sample cadastral maps for rural and urban areas which have been derived from orthophotomaps. An orthophotomap also gives a good idea about the entire topographic situation.

Surveying, mapping and compilation of land information are of great importance for political, administrative, economic, social and technical co-operation between developing countries and industrialized countries for several reasons, including:

(a) All political, adminsitrative, economic, social and technical activities of a country should be based on the thorough knowledge that a country has been able to acquire. Knowledge in this context means exact knowledge of how to establish surveys of the country's natural resources, to determine type and size of land coverage and its utilization, to undertake value assessments of land property and to demarcate inviolable national borders;

(b) All reform measures undertaken by the parliament and Government of a country should be based on an effective and well-functioning administration with data from surveying, mapping and land information recorded by surveying institutions and presented for various applications, such as property or land register, property taxation, statistics, agrarian reforms, land reclamation; and drainage, irrigation or infrastructural improvements.

In the beginning, it is not necessary that surveying and mapping projects be carried out by existing local government surveying organizations of the developing country. At that time, it is often convenient and economical if surveying and mapping, which require a great number of expensive photogrammetric and other instruments, are carried out by consulting firms of industrialized countries. The advantage in these cases is that the work can be carried out quickly; and on-the-job training of local engineers and technicians is possible, which will lead to a gradual set-up of staff, instruments and organization. Therefore, the Federal Republic of Germany has, in some developing countries, established a surveying and mapping organization, with technicians and engineers from the Federal Republic as technical advisors and instructors in partnership with staff from the respective developing country, with the intention of establishing a local institute for sruveying and mapping in due time. It should be considered that the acquisitiion and setting-up of instruments in the absence of an efficient survey organization, trained staff and suitable facilities (i.e., without air-conditioning and stable voltage etc.) can hold up the progress of projects:

(a) The proper economic and technical strategy has to be planned for the establishment of a survey and mapping organization;

(b) In some cases, people are of the opinion that remote-sensing procedures and satellite imagery can replace conventional surveying and photogrammetric methods. While remote-sensing and satellite photographs would be a useful tool for some special type of projects, especially in small-scale work, large-scale mapping for cadastre, land reform and land register, and mapping for engineering and agricultural projects are still predominant;

(c) In the opinion of the author, it is necessary to warn of requiring too great a perfection for surveying and mapping projects in developing countries in the beginning. Many developing countries do not yet have sufficient funds, organization and staff members to carry out projects to accepted standards.

For these reasons, the fastest and most economic method of producing orthophotomaps is preferable. These maps are useful for:

(a) Topographic and thematic maps for planning in various fields;

(b) Establishment of cadastre and land information systems;

(c) Recording of public utilities;

(d) Updating of existing line maps;

(e) Combining orthophotomaps and cadastral maps, and many other purposes.

It is hoped by the author that this presentation to the Conference demonstrates what a useful product orthophotomaps can be for many applications and at various stages in planning the future.

PRODUCTION OF ORTHOPHOTOMAPS, ILLUSTRATED BY AN EXAMPLE*

Paper submitted by the Federal Republic of Germany

RESUME

La production rapide et économique des documents de planification est une tâche importante dans le monde entier. L'expérience de la République fédérale d'Allemagne prouve qu'il est nécessaire d'établir une série de cartes adaptées à la planification. Les planificateurs dans le domaine de l'administration et de l'économie notamment ont besoin de ces documents cartographiques. Cette série de cartes devrait être à l'échelle de 1:5 000 ou 1:10 000.

Compte tenu de l'état actuel des techniques, la production de photocartes revêt une importance exceptionnelle. Pour produire ce type de cartes, il faut redresser la photographie. S'il existe des dénivelés de plus de 25 mètres sur une feuille, la photo doit être redressée à l'aide d'un orthoprojecteur. Pour contrôler le

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* The original text of this paper, prepared by K.-H. Bastian, Landesvermessungsamt Rheinland-Pfalz, Koblenz, appeared as document E/CONF.75/L.44.

projecteur, il est nécessaire de disposer de renseignements sur le relief. Dans les systèmes d'orthophotographie analytique modernes, ces renseignements sont obtenus par des modèles d'altitude numériques. Ces modèles, établis au cours de la production initiale, peuvent être réutilisés pour la révision des cartes. C'est le grand avantage des orthophotocartes. L'ancienne planimétrie est simplement remplacée par une nouvelle orthophotographie.

La production d'orthophotocartes est décrite ci-après à l'aide d'un exemple représentant une région de la République fédérale d'Allemagne. Les modèles d'altitude numériques peuvent être produits de différentes manières, en fonction des documents existants. Suivant leur origine, ils ne sont utilisés que pour le contrôle du système orthophotographique Z2 ou, en plus, pour la dérivation des courbes de niveau. Après l'exposition du film par la méthode orthophotographique, on décrit l'étape suivante. Le présent document contient une description des normes d'un système orthophotographique analytique, compte tenu du matériel existant au Service cartographique de Rhénanie-Palatinat.

HISTORICAL DEVELOPMENT OF ORTHOPHOTOMAPPING

The history of orthophotography dates from the beginning of the twentieth century. Theoretical ideas date from around 1915 but they were not put into practice before 1931. Because of the technological possibilities existing up to the 1960s, the constructional solutions of orthophotography were confined to analogous instruments.

It was precisely the orthoprojectors produced on an analogous basis in the early 1960s that brougth about the breakthrough in practice. From the very beginning, the orthophoto technique became an accepted method for the quick and economic production of complete map series.

In the meantime, great progress was made in the field of electronics (e.g., in data processing, the storage media as well as in digital and servo techniques), so that it was only a question of time before the analogous equipment of the orthophoto method was substituted by analytical orthoprojectors. Since 1982, the State Survey Office of Rhineland-Palatinate has used the analytical orthoprojection system Z2 for the production of basic maps of the Federal Republic of Germany.

PRODUCTION OF PLANNING DOCUMENTS ON SCALES OF 1:5,000 OR 1:10,000

Preliminary remarks

The new production of planning maps on scales 1:5,000 and 1:10,000 is one of the most important assignments of national surveying. Considering their purpose and their scale, these maps are the link between the plans of property cadastre and the topographic maps at 1:25,000 scale. The State Survey Office began the production of the national basic map at 1:5,000 scale in 1949.

If an attempt were made to cover the Federal Republic of Germany with these important planning maps at 1:5,000 scale and to produce them by the conventional method (i.e., by photogrammetric plotting of planimetry and contour lines, followed by a topographic field-check), some decades would be needed.

Moreover, the revision of such a map series is so time-consuming that it can hardly be accomplished in the fixed five-year cycle. Without adequate revision, a map series soon loses topicality and is, in the end, only of historical value.

Production of the orthophotomap

General background

For the solution of these two problems, the production of the orthophotomap seems of special importance. Therefore, the State Survey Office began the production of orthophotomaps at 1:5,000 scale early in 1982. With elevation differences of more than 25 m in a map-sheet, it is necessary to rectify the aerial photograph by differential methods. To guarantee a uniform scale, additional corrections must be applied because of the natural differences of elevations. Under these conditions, the photomap can only be produced on the basis of orthophotos.

Principle of the orthophoto technique

Rectification is carried out by the successive exposure of small photo strips, with image position, enlargement and image rotation controlled in relation to the ground position, ground height and terrain slope. For the control, a digital elevation model is necessary.

Advantages of the orthophotomap

The production of photomaps will at first be concentrated mainly on the areas that are not yet covered by common topographic maps in order to ensure a speedy provision of large-scale maps for technical and regional planning for these areas as well. With the production of photomaps, the greatest bottlenecks that have so far prevented increasing the production rate in topographic mapping will be avoided.

The photogrammetric plotting of the planimetry is replaced by the orthophoto. Data acquisition is reduced to the digital storage of the contour lines on magnetic tapes. The local topographic field-check and the fair-drawing of the planimetry are no longer necessary.

Above all, however, the problem of revision can be solved very elegantly. The control data of the digitally controlled orthoprojectors are terrain data. Tehey are measured and stored during the initial production of the photomap. This data record, which contains the elevation data of the terrain, can be used as often as desired for the repetition of the rectification with more recent aerial photographs. In this case, it is only necessary to relate the new aerial photographs to the available data record by control points.

Contrary to the method used for the revision of the conventional maps, the photomaps are not revised by deleting the old planimetry and adding the new one but are substituted by a completely newly rectified aerial photograph.

Photo flight

The photo flight necessary for the production and revision of the photomap should be performed in spring, before the trees come into leaf. The flying altitude above ground is approximately 1,900 m. The aerial survey camera has normally a calibrated focal length of 153 mm, resulting in a photo scale of 1:12,500. The exposure interval is such as to guarantee an end lap of 90 per cent and a side lap of 30 per cent. With the photo format of 230 x 230 mm, a map-sheet of the basic map at 1:5,000 scale is covered by two models.

Control points

Pre-marked points, as well as points pricked on adjoining aerial photographs with a point transfer device, are used as control points (see figure 49). They are arranged in such a way that there are two control points in each corner of the model. The pre-marked control points serve as full control points. Their elevations are determined terrestrially. The planimetric co-ordinates are obtained by aerotriangulation.

The control points pricked on the aerial photographs with the point transfer device serve only as planimetric control points. Their co-ordinates are also obtained by aerotriangulation. As vertical control points (e.g., road crossings) are used which can precisely be set in the model with the floating mark whose height is unambiguously defined on the ground.

Analytical orthophoto system Z2

The aerial photographs are transformed with the analytical orthoprojector Z2 into orthophotos. The components of the orthophoto system Z2 are: the projector as basic equipment; the control unit; the computer with display terminal; and the software package with the programs for the computer.

The largest photo format of the standard model is 250 x 250 mm. The exposure controlled by the exposure program SCAN is performed meandering between the margins defined by the sheet corner co-ordinates.

The program produces a differential rectification with a model approximation by secants. With a slit width of 0.2 mm and a scanning speed of 50 mm per second the luminous intensity is sufficient for the exposure of orthochromatic films.

Hardware system of the State Survey Office of Rhineland-Palatinate

The components of the analytical orthophoto system are shown in figure 50. The orthoprojector (Orthocomp Z2) is connected to the computer (HP 1000) via the control unit. Besides this, the stereoplotters Autograph A8 and the Planicart E3 or the Stereoplanigraph C8 are connected to the computer via the data transfer stations Direc 12.

Figure 49. Federal Republic of Germany: control point system in orthophotomap production

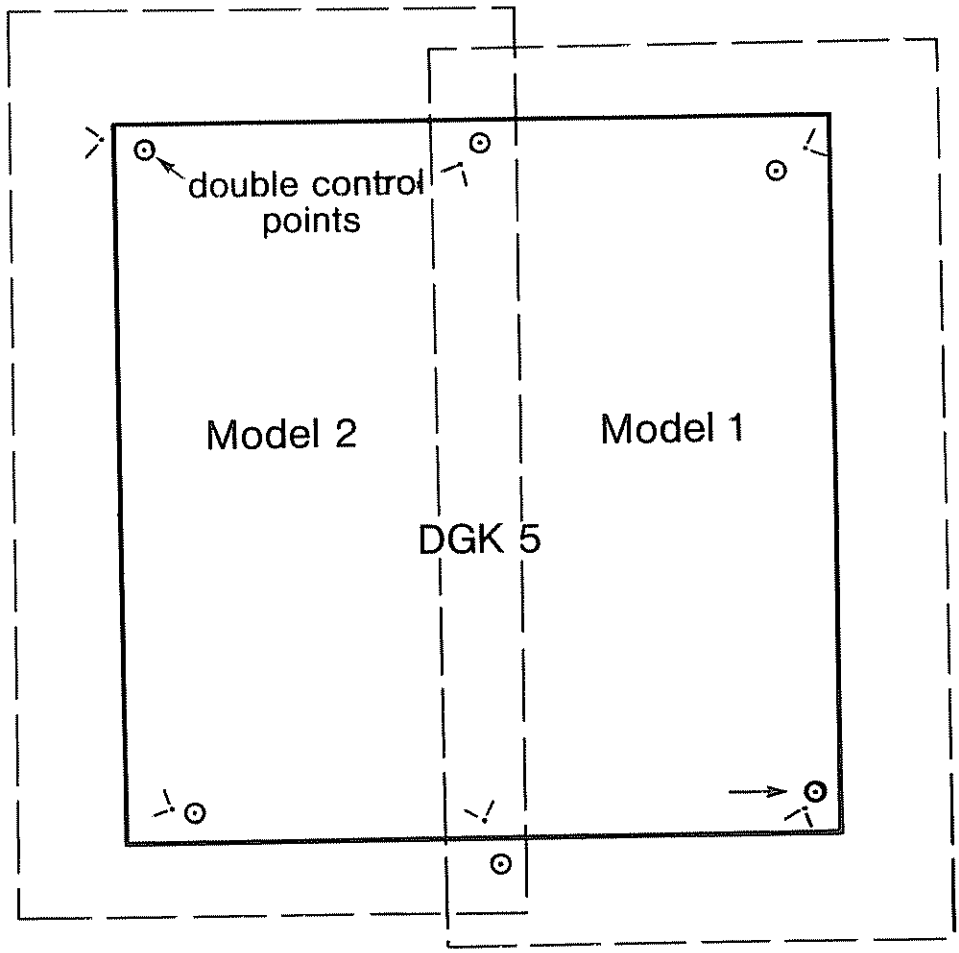
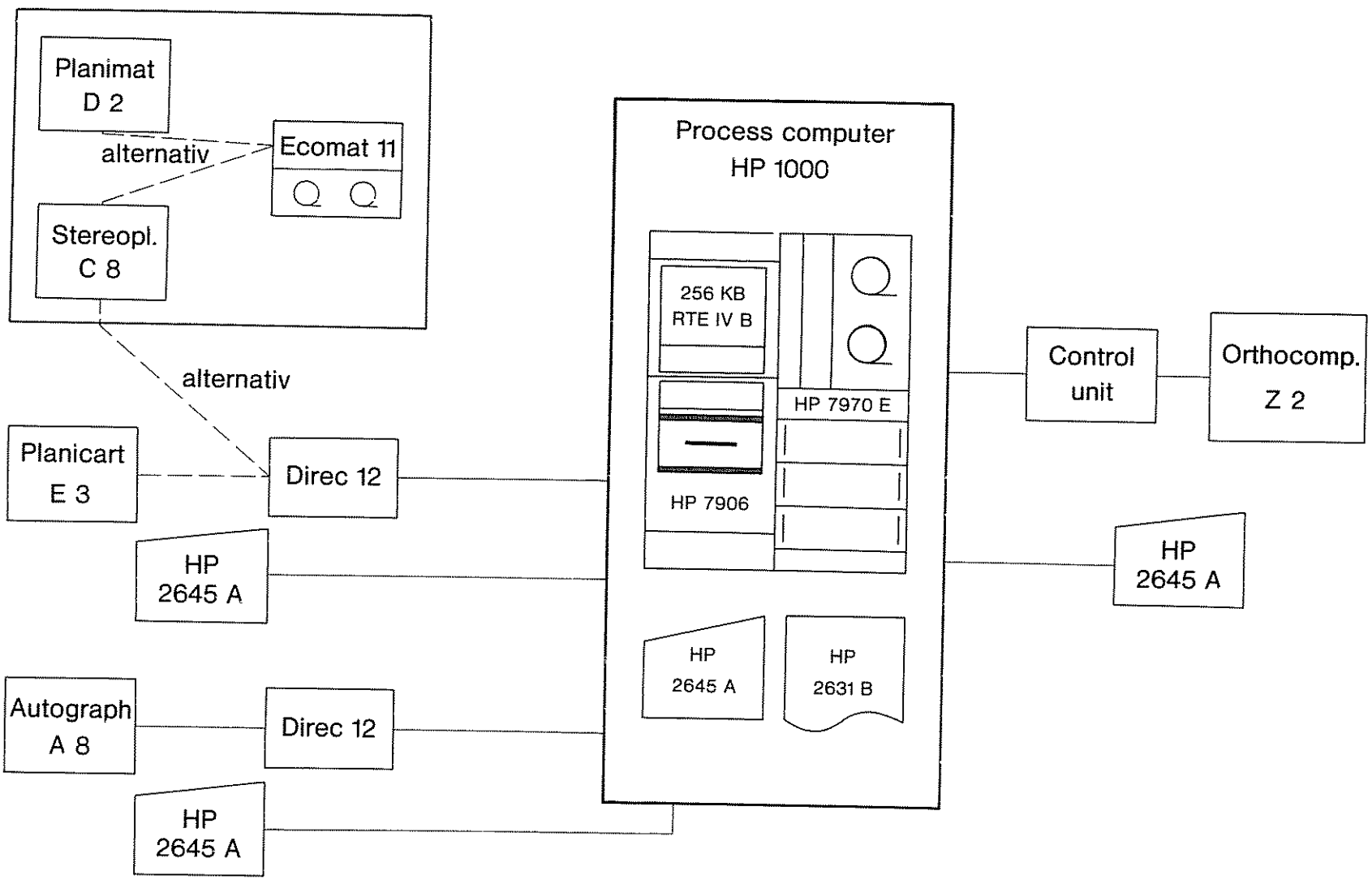


Figure 50. Federal Republic of Germany: hardware components of the orthophoto system of the State Survey Office of Rhineland-Palatinate



Direct peripherals of the computer HP 1000 are a magnetic-disc unit HP 7906, a tape recorder HP 7970, a line-printer HP 2631 B and a main or computer terminal HP 2645 A.

Since the minicomputer HP 1000 is used both for the control of the orthoprojector and for data recording, the core memory capacity had to be extended to 256 kilobytes, which allows the simultaneous running of different programs.

Digital elevation models

In order to utilize fully the capacity of the analytical orthoprojector, a great number of digital elevation models are needed which are related to the relevant basic map-sheet. For the production of digital elevation models, three methods are applied:

(a) The digital recording of contour lines in an absolutely oriented stereo model, using photos at 1:12,500 scale. The recording, released by time increments, is equivalent to a distance of 2-3 mm between two points. The contour lines thus recorded are smoothed by a fifth-order interpolation function and reproduced nearly free of errors at an automatic drawing-table. Within one year, the contour lines of 340 map-sheets at the most can be recorded. This is not enough to fully utilize the capacity of the orthoprojector Z2;

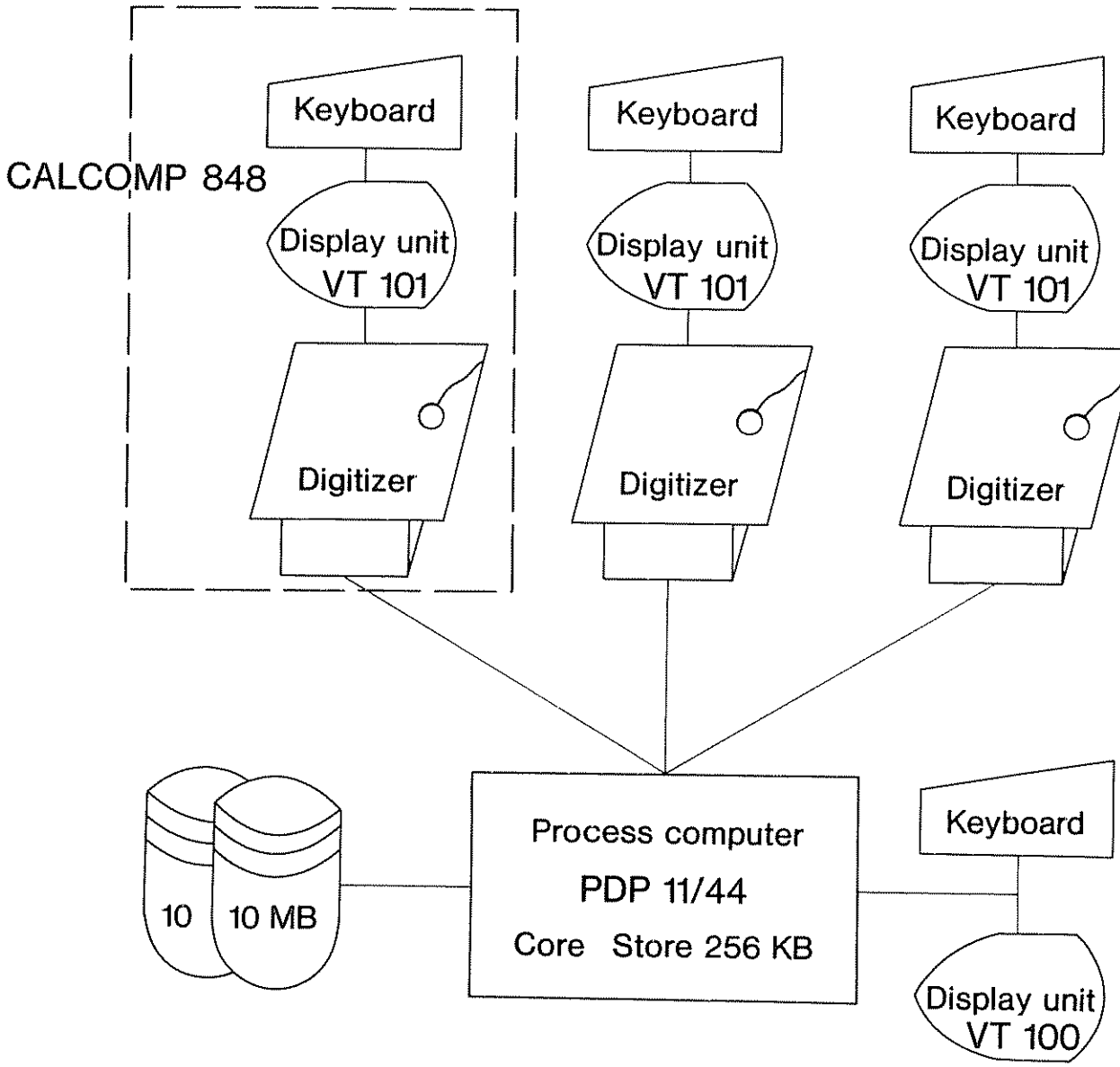
(b) For this reason, additional digital elevation models are produced in simplified form by measuring vertical profiles in relatively oriented stereo models based on aerial photographs at 1:34,000 scale. These photographs are normally used for the revision of the topographic map at 1:25,000 scale. The profiles are arranged parallel to each other, at a distance of 50 m. Within the profiles, all changes of slope are recorded. The fault lines, structure lines and landmarks with extreme heights and depths, which are very important for a digital elevation model, are recorded separately. All data are stored by model. On an average, one model has about 7,000 points. Together with the control points which are also recorded by model, a three-dimensional similarity transformation is carried out to the national co-ordinate system by computatiom. As planimetric control points, trigonometrical points are used. As vertical control points, spot heights taken from topographic maps or the elevations of road crossings are used. The vertical accuracy of the profile points as well as their density are adequate for orthoprojection but it is not possible to derive from these points exact contour lines for the basic map at 1:5,000 scale. These digital elevation models are used first for the production of orthophotomaps without contour lines;

(c) In areas with exact contours, measured either terrestrially or photogrammetrically, a new measurement of profiles or contour lines is not necessary. The available contour lines are digitized by efficient digitizers. At present, the existing digitizing equipment consists of three CALCOMP 848 digitizers and a control computer PDP 11/44 (see figure 51). It is intended to extend it to a graphically interactive system in the future.

Cartographic compilation

For the cartographic and technical processing of the orthophotomaps produced by means of digital elevation models, different methods can be applied.

Figure 51. Federal Republic of Germany: digitizing system in orthophotomap production



A practicable way may be briefly described:

(a) Drawing of the contour lines. Since the contour lines (figure 52) are recorded with little distance between the points, it is possible to produce the contour line foil by automatic scribing with proper signature placement. For this, the precise plotter Contraves Cora 2 is used;

(b) Manual cartographic compilation. In view of the process described above, the manual cartographic work is reduced to the mounting of the lettering and of the elevation and contour line figures, to the design of map frame and margin and to the matching of the contour lines at the edges of the adjoining sheets. Once the foils "marginal data and map frame", "orthophoto" and "map margin mask with lettering of the inside" are available, further processing depends upon the desired kind of reproduction.

Reproduction and printing

If the print or diazo processes are applied for the reproduction, all of the single foils have to be exposed together in two steps by using an autotypic contact screen.

For a photographic reproduction, the autotypic contact screen is no needed. Apart from that, the procedure corresponds to the one mentioned above. The two procedures are illustrated in figure 53 and 54, respectively.

Performance of the Orthocomp Z2

Using all the photogrammetric equipment available at the State Survey Office, about 300 orthophotomaps with contour lines can be produced each year.

Rhineland-Palatinate is covered by 5,012 sheets of the Federal Republic basic map at 1:5,000 scale. Taking eight working hours each day and five days each week as a basis, the Orthocomp Z2 can produce about 1,600 orthophotos (400 x 400 mm) annually. This capacity is completely sufficient for the revision of the map series at 1:5,000 scale (see figures 55 and 56).

Using all possibilities of contour-line digitizing, the large gaps existing in the series of the basic map at 1:5,000 scale will be closed in fewer than 10 years.

CONCLUDING REMARKS

The large-scale maps (1:5,000 or 1:10,000 scales) are needed as the basis for the planning projects of the administration and economy in developed and developing countries. The quick and economic provision of such maps is an important task of surveying and mapping throughout the world. The production of the orthophotomap meets these requirements. However, this procedure can only be applied in regions with ground visibility, that is, in open treeless areas and in urban areas. In wooded areas, the visibility of the ground strongly depends upon the growing season. This means that in all those areas where vegetation does not obstruct the view, the production of orthophotomaps is the appropriate means for rapid provision of entire map series.

Figure 52. Federal Republic of Germany: contour lines, orthophotomap production

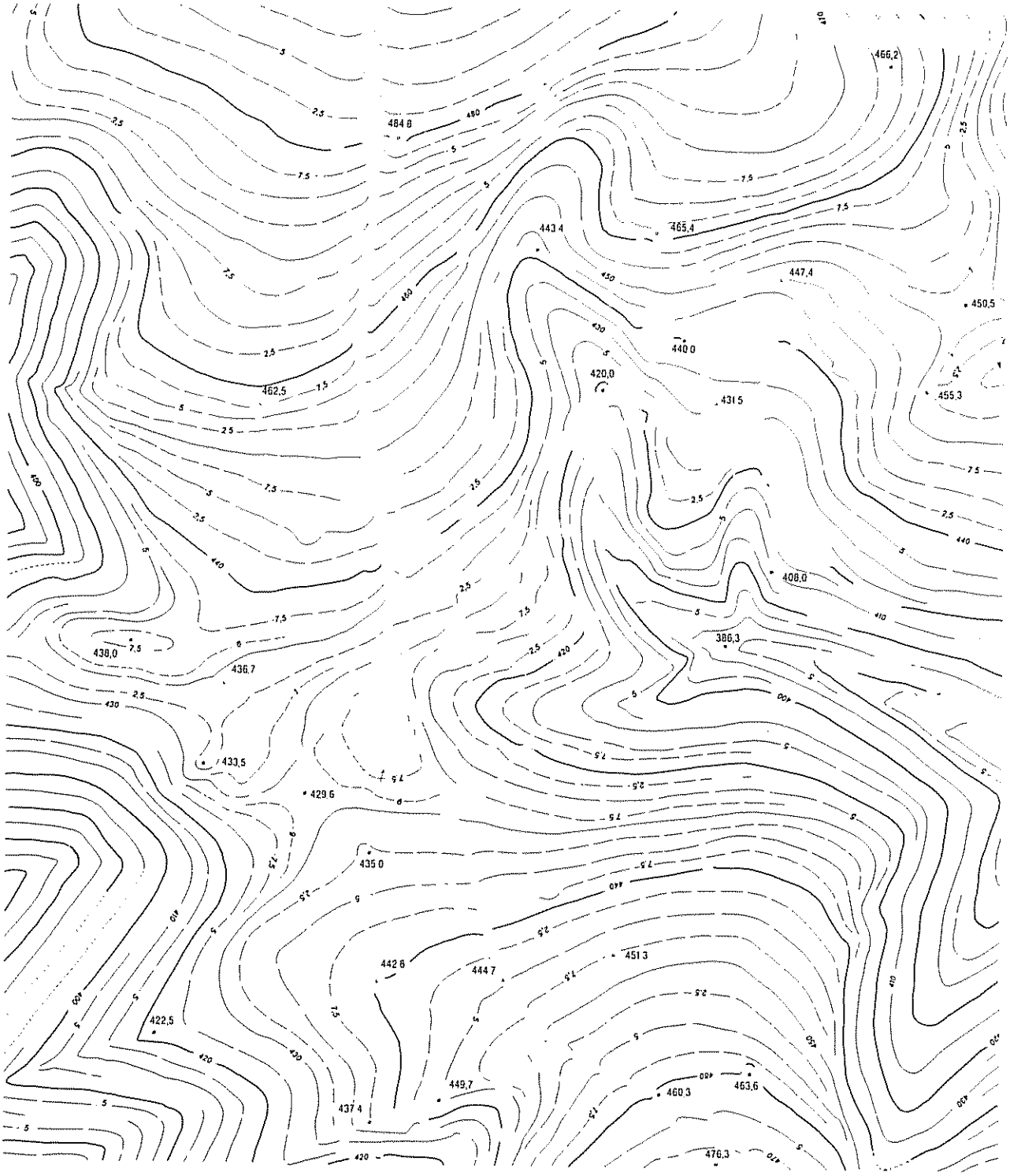


Figure 53. Federal Republic of Germany: sequence of operations in orthophotomap production with diazo print or print map reproduction

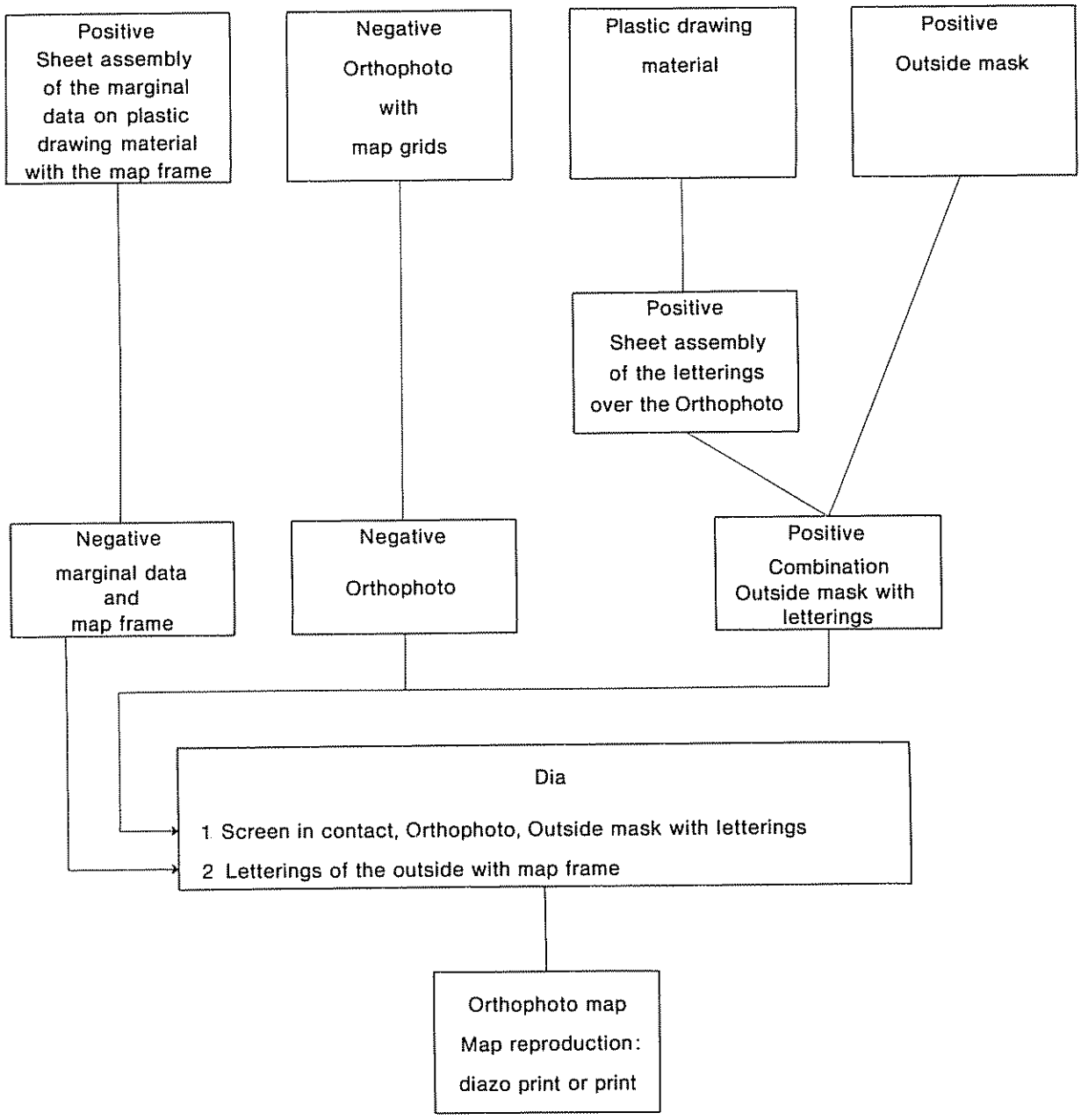


Figure 54. Federal Republic of Germany: sequence of operations in orthophotomap production with photographic map reproduction

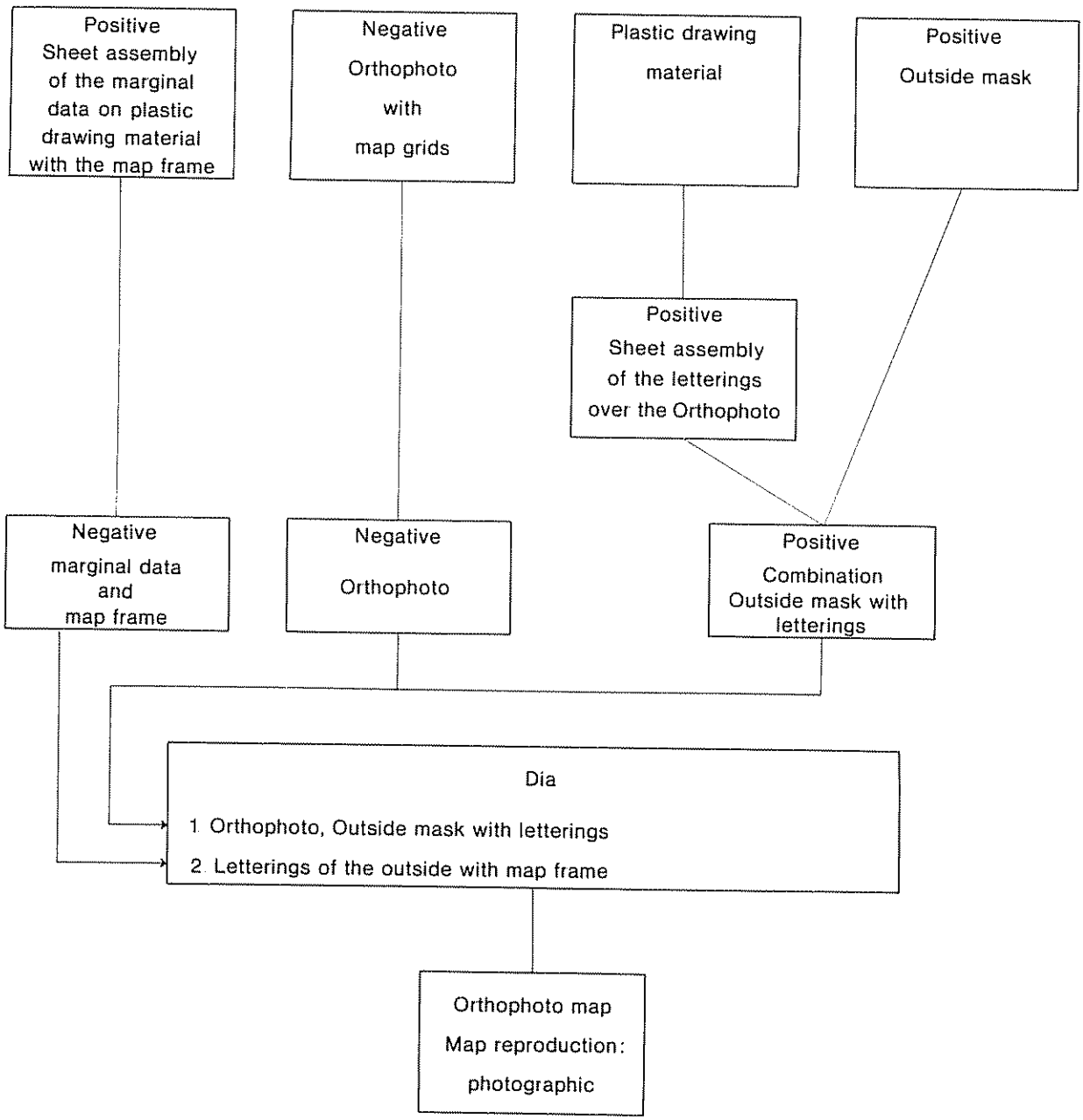


Figure 55. Federal Republic of Germany: orthophotomap at 1:5,000 scale



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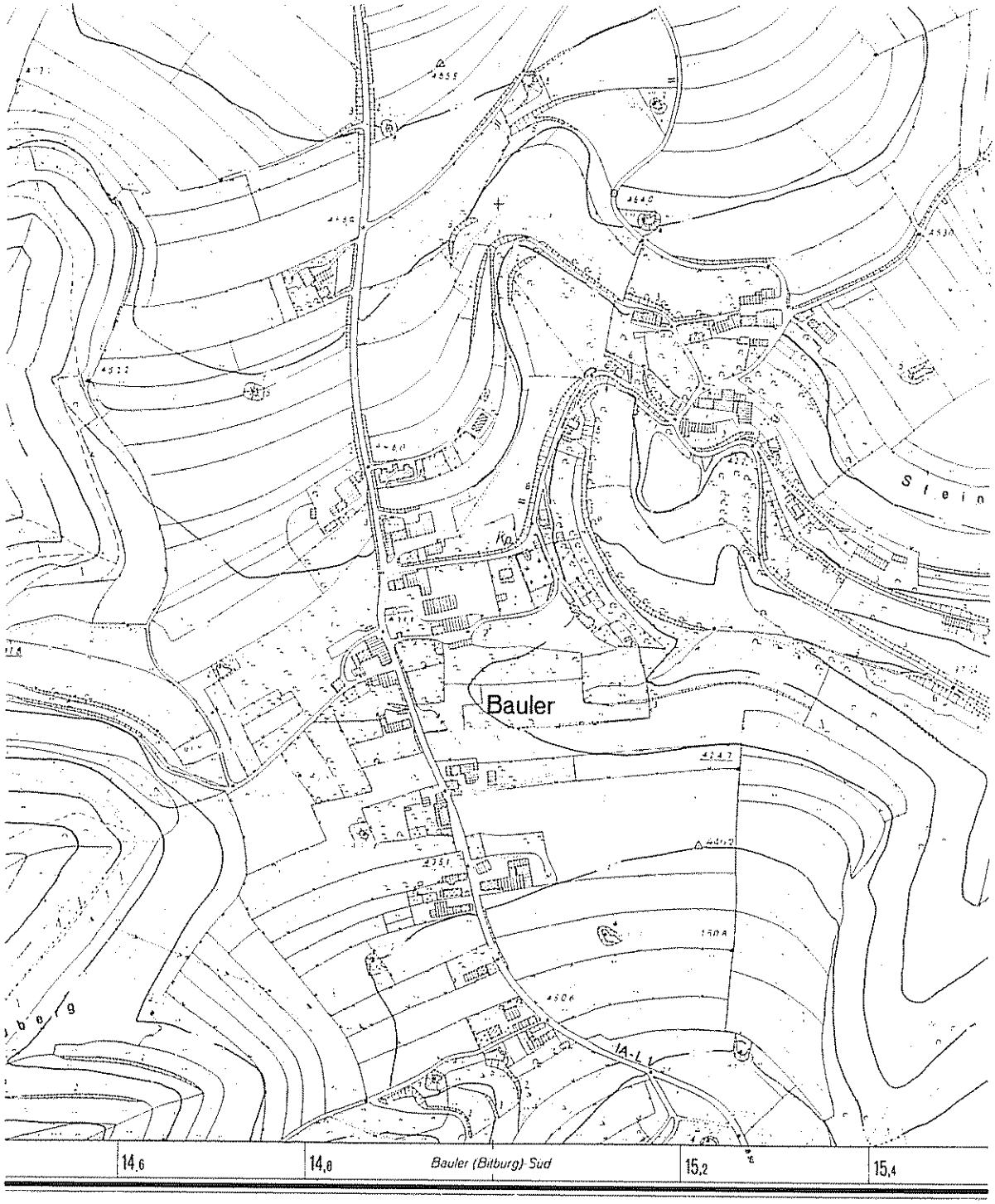
(75% of original size)

Figure 56. Federal Republic of Germany: basic map at 1:5,000 scale



Landesvermessungsamt Rheinland-Pfalz

Herausgegeben 1982

3388.29x

Ausgabe 1981

(75% of original size)

ESTIMATION OF VOLUME OF GALUNGGUNG VOLCANIC MATERIALS AND PREDICTION OF POTENTIAL MUD FLOES USING AERIAL PHOTO-INTERPRETATION TECHNIQUES*

Paper submitted by Indonesia

RESUME

L'exposé décrit l'éruption du volcan Galunggung dans la partie occidentale de Java (Indonésie). Pour estimer le volume de matériaux volcaniques et de boue déplacés du sommet du volcan jusqu'à sa base, on a pris des photographies aériennes verticales à des fins d'interprétation, aussi bien en infrarouge noir et blanc qu'en fausses couleurs au 1:11 000 et au 1:15 000. Le résultat de cette estimation est donné.

After resting for 64 years, the Galunggung volcano exploded on 4 April 1982; that eruption was followed by repetitive eruptions at irregualr intervals. There have been 22 explosions up to 22 August 1982, and it is still continuing.

Eruptions of efflata (bombs, alpilli, sand and ash), hot clouds and poisonous gases caused direct destruction in the area immediately surrounding the crater. Deposition of volcanic materials either by river transport or from the air on the slope of the Galunggung forms potential mud flows (lahar) treatening towns and villages, fertile agricultural lands, roads and bridges located on the lower ground.

Repetitive eruptions and the west monsoon beginning in October/November require timely estimation of the lahar volume and its potential paths. This information is critically needed to prevent loss of lives and other destruction.

Application of remote sensing in general and aerial photo-interpretation for such purposes will provide more accurate and up-to-date information. This probably is the first time that aerial photo-interpretation has been used for lahar prediction in Indonesia.

THE GALUNGGUNG EXPLOSIONS

Several thousand years ago, an explosion created a large crater (±1,000 m in diameter) and blew down the east-south-east crater wall. The explosion gave Galunggung its current breached cone appearance.

Stone and sand were thrown in an easterly direction to the Tasikmalaya plain. The lahar that followed was later deposited in the neighbourhood of the Tasikmalaya-Manonjaya road; some of the flow reached the slope of the

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* The oriignal text of this paper, prepared by Perum Survai Udara (PENAS), Jakarta, appeared as document E/CONF.75/100.

Sawal volcano on the other side of Citandui. From the western and southern slopes of the Galunggung, another mud flow moved over Singaparna and joined the flow coming down from the eastern slope. After a long process of erosion and weathering, these deposits became what is known now as "Ten Thousand Hills Complex" to the east of Singaparna and north-west of Tasikmalaya.

On 8 October 1892, another explosion caused the loss of many lives because of hot clouds, which are actually hot and glowing lava. At that time, they were blowing across Citandui as far as 16 km. Two years later, from 7 to 19 October 1894, an explosion threw away a lava plug and again a part of the crater wall collapsed.

Another plug was formed during a "peaceful" explosion on 16 July 1918. Within one month after the first eruption, the lava plug was protruding to form a hill measuring 560 x 440 m and 85 m high. This plug was known as Gunung Jadi.

During the recent explosions, Gunung Jadi was blown away; hot clouds swept in an east-south-easterly direction along the Cibanjaran-Cikunir valleys and through the crater wall, opening to a distance of $\pm$4 km and covering an area of 1,200 ha. In early July 1982, mud flows deposited on the slope of Galunggung covered an area of 22,881,250 m^2. Danger zone I, covering an area of 4,000 ha; and danger zone II, covering an area of 5,700 ha, which should be entirely abandoned, were included with an area of 15,750 ha in an alert zone. Over 30,000 people were moved from the dangerous zones and placed in several camps.

It is worth while to note the following facts from previous explosions. During the explosion of 1822, approximately 56 million m^3 (specific gravity = 2.3) of volcanic materials were dispersed.

A part of those materials was transformed into lahar on 12 October 1822, and the materials deposited from the explosion of 1894 were flowing down the slope as lahar on 27 and 30 October 1894. It seems that October brought enough rain intensity to move down the mud flows in both eruptions. There had been a slight change as far as the main direction of the mud flow was concerned in 1822; the main direction was east-south-east which was slightly changed in a south-easterly direction in 1894.

APPLCIATION OF PHOTO-INTERPRETATION TECHNIQUE

Vertical aerial photographic surveys using metric cameras with 6-inch focal length were conducted in April and August 1982 by the Indonesian Air Force. For obvious reasons, civilian aircrafts were prohibited from flying near the Galunggung volcano.

The following aerial photographs were obtained:

(a) Black-and-white infra-red and false colour infra-red photographs, at approximately 1:11,000 scale, covering a limited area from the crater and down along the Cikunir-Cibanjaran valley, were taken on 4 April, 1982;

(b) Black-and-white infra-red photographs taken from 14 to 17 August 1982, covering a larger area and on approximate scale 1:15,000.

False colour infra-red photographs give more information concerning the effects of the eruption on the environment. Volcanic ash coverage on vegetation, damaged crops and availability of surface water are features more readily discernible in false colour than in black-and-white infra-red photographs. Much of the interpretation, however, was done using the black-and-white photographs of August 1982 (see figure 57), mainly due to the coverage and dates of the survey. On the other hand, availability of aerial photos taken in different months is very useful for comparison.

Estimation of the volume of volcanic materials is based on the area covered by volcanic debris and its depth. Measurement of the area gives more precise results using recent photographs, while the depth of the volcanic materials can only be measured in the field.

For area measurement, a Zeiss stereocord equipped with a Direc-1 was used for transferrig and computing photo point co-ordinates into a HP 9815-A desk computer, using for this task Orientation Pilot and Planarea program tapes. Input data required focal length of the camera, flight altitude above mean ground level and vertical and horizontal control points. Due to time constraints, vertical and horizontal control points are derived from topographic sheets at 1:50,000 scale. The result of these measurements can be read on a print-out.

Stratification of the studied area, based on watershed boundaries, was completed before the area measurement. Three watersheds were delineated and measured:

(a) Stratum A: western and southern slopes of Galunggung, covering a part of the Ciwulan watershed with a total area of ±11,000 ha;

(b) Stratum B: southern slope of Galunggung, mainly along the Cikunir and Cibanjara valleys (tributaries of Ciwulan). Main lahar is deposited in this stratum, total area of ±600 ha;

(c) Stratum C: a portion of the Citandui watershed located on the east-south-east slope of the Galunggung with its main tributaries Ciloseh and Cimampang, covering an area of ±11,000 ha.

The total area studied was approximately 22,000 ha and total surveyed area, ±30,000 ha.

Field survey for profile measurement was conducted by a team consisting of members from the Directorate of Vulcanology, the Directorate of Environmental Geology and Perum Survai Udara (PENAS). Only a limited time, from 15 to 22 August 1982, was available for the team to accomplish its task. These profile measurements were undertaken at points from 2 to 3 km apart along each survey line. Six survey lines were designed for this purpose (see table 23). The survey lines have a south-west/north-east direction, perpendicular to the main lahar flow in the Cikunir-Cibanjaran valleys and located at 2,500-m intervals.

Distinction can be made between the material transported and deposited by river on the slope, which is called "lahar"; and that settled down from the air, known as "non-lahar".

Figure 57. Indonesia: volcanic materials based on aerial photography, Galunggung, August 1982

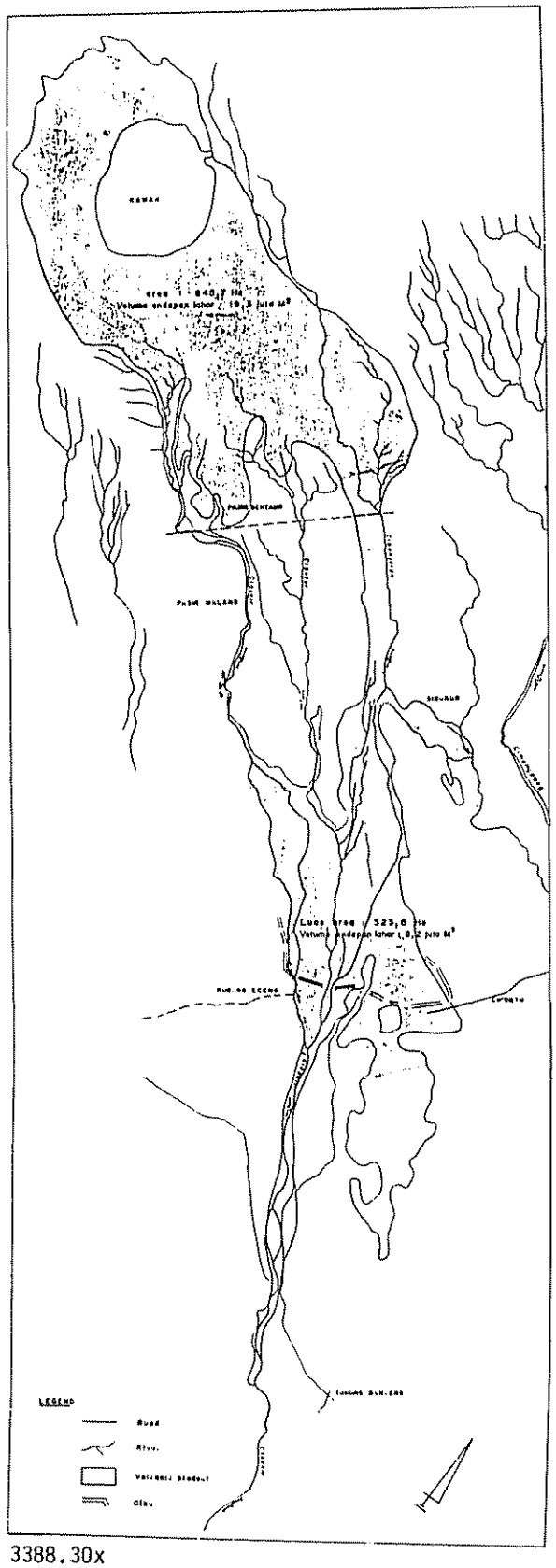

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Table 23. Field measurements of Galunggung volcanic materials, 15-22 August 1982

Profile and location (sample)	Depth	Average depth (centimetres)	Description
A-A1			
1	6		Ash and sand
2	36		Ash and sand
3	14		Ash and sand gravel
4	14		Ash and sand gravel
5	15		Ash, coarse sand
6	15	12.17	Ash, coarse sand
7	15		Ash, coarse sand
7 a	22		Ash, coarse sand
7 b (add)	160		Lahar
8	15		Ash, coarse sand
9	12		Ash, coarse sand
10	10		Ash, coarse sand
11	2		Ash, coarse sand
B-B1			
1	5		Ash and sand
2	5		Ash and sand
3	6		Ash and sand
4	6		Ash and sand
5	7		Ash and sand
6	8		Ash and sand
7	20	9.6	Ash and sand
8	230		Lahar
9	83		Lahar
10	8		Sand ash
11	6		Ash sand
12	10		Ash sand
13	8		Ash sand
14	7		Ash sand
C-C1			
1	3		Ash, fine sand
2	3.5		Ash, fine sand
3	4		Ash, fine sand
4	5		Ash, coarse sand
5	8		Ash, coarse sand
6	7	6.3	Ash, coarse sand
7	8		Ash, fine medium coarse
7 a	65		Lahar
8	5.5		Ash, fine medium coarse
9	4.5		Ash, fine medium coarse
10	10		Ash, fine medium coarse
11	10		Ash, fine medium coarse

Table 23 (continued)

Profile and location (sample)	Depth (centimetres)	Average depth (centimetres)	Description
D-D1			
1	2.5		Ash, fine sand
2	3		Ash, fine sand
3	3		Ash, fine sand
4	3		Ash, fine sand
5	2		Ash, fine sand
6	5	6	Ash, fine sand
7	5		Fine and medium sand
8	6		Ash, fine sand
9	5		Medium sand
10	8		Medium sand
11	8		Medium sand
12	10		Medium sand
E-E1			
1	2		Fine sand
2	2		Fine sand
3	3		Ash, coarse sand
4	3		Ash, coarse sand
5	3		Ash, coarse sand
6	5	4.6	Ash, coarse sand
7	4		Medium sand (ash)
8	4		Ash, fine medium sand
9	10		Ash, fine medium sand
10	5		Ash, fine medium sand
11	10		Ash, fine medium sand
F-F1			
1	1.5		Ash, fine sand
2	2		Ash, fine sand
3	2		Ash, coarse fine sand
4	2		Ash, coarse sand
5	2	3	Ash, coarse sand
6	3		Ash, coarse sand
7	5		Ash, coarse sand
8	5		Ash, coarse sand
9	6		Ash, coarse sand
10	1.5		Ash, fine sand

The lahar deposits were of various depths and were located in the crater and in the Cikunir-Cibanjaran valleys. Near the crater, in the vicinity of Kihiang, the depth was 10 m, while in the upper part of the Cikunir-Cibanjaran valleys, 3-4-m layers of volcanic material could be found, just as in Sinagar (3-4 m) and Cihanjuang (3 m). It became lighter in the lower part of the valleys, as in Tawangbanteng ($\pm$2 m) and Sukasari (0.85 m).

As for the non-lahar deposits, the average depth in each profile is given below (see also figure 58):

Profile	Depth (centimetres)
A - A1 (near the crater)	12.17
B - B1	9.6
C - C1	6.3
D - D1	6.0
E - E1	4.6
F - F1 (lava plain)	3.0

For the location of each profile, see figure 59. Rock sample were collected during the field survey for chemical and petrographic analysis.

ESTIMATION OF VOLCANIC MATERIAL

Estimations of volcanic materials were grouped into lahar and non-lahar volumes. Average depths and standard deviations for each stratum are given below (see also table 24):

(a) Stratum A: non-lahar material; average depth is $\underline{X}$ = 7.17 cm, with standard deviation $\underline{S_X}$ = 7.1 and number of observations $\underline{n}$ = 32;

(b) Stratum B: mostly lahar materials, covered by non-lahar. Average total depth of both materials is $\underline{X}$ = 158.0 cm, with standard deviation $\underline{S_X}$ = 84.64 and number of observations $\underline{n}$ = 7. Assuming the non-lahar layer has a depth similar to stratum A, then one finds an average depth of lahar deposit of 150.83 cm and non-lahar of 7.17 cm;

(c) Stratum C: non-lahar materials with $\underline{X}$ = 6.58 cm, $\underline{S_X}$ = 3.30 and $\underline{N}$ = 32.

Volume estimations for strata A, B and C were computed as shown in table 25. Out of the total volume, the three strata had a volume of 24,605,000 m^3. The amount of dry accumulates (non-lahar) deposited in strata A and C was 15,125,000 m^3, plus those found on top of the lahar on stratum B, which was estimated at 430,200 m^3 (7.17 cm x 600 ha) = 15,555,200 m^3. The amount of lahar deposits found in stratum B and the crater was (8,277,158 m^3 - 430,200 m^3) +19,372,500 = 27,219,458 m^3.

As far as coverage of the volcanic products is concerned, a large increase could be discerned. Aerial photographs taken in April 1982 show a coverage of 2.9 million m^2 and those of August 1982 show a coverage of 5.6 million m^2 (stratum B).

Figure 58. Indonesia: profile of strata of non-lahar deposits, Galunggung area

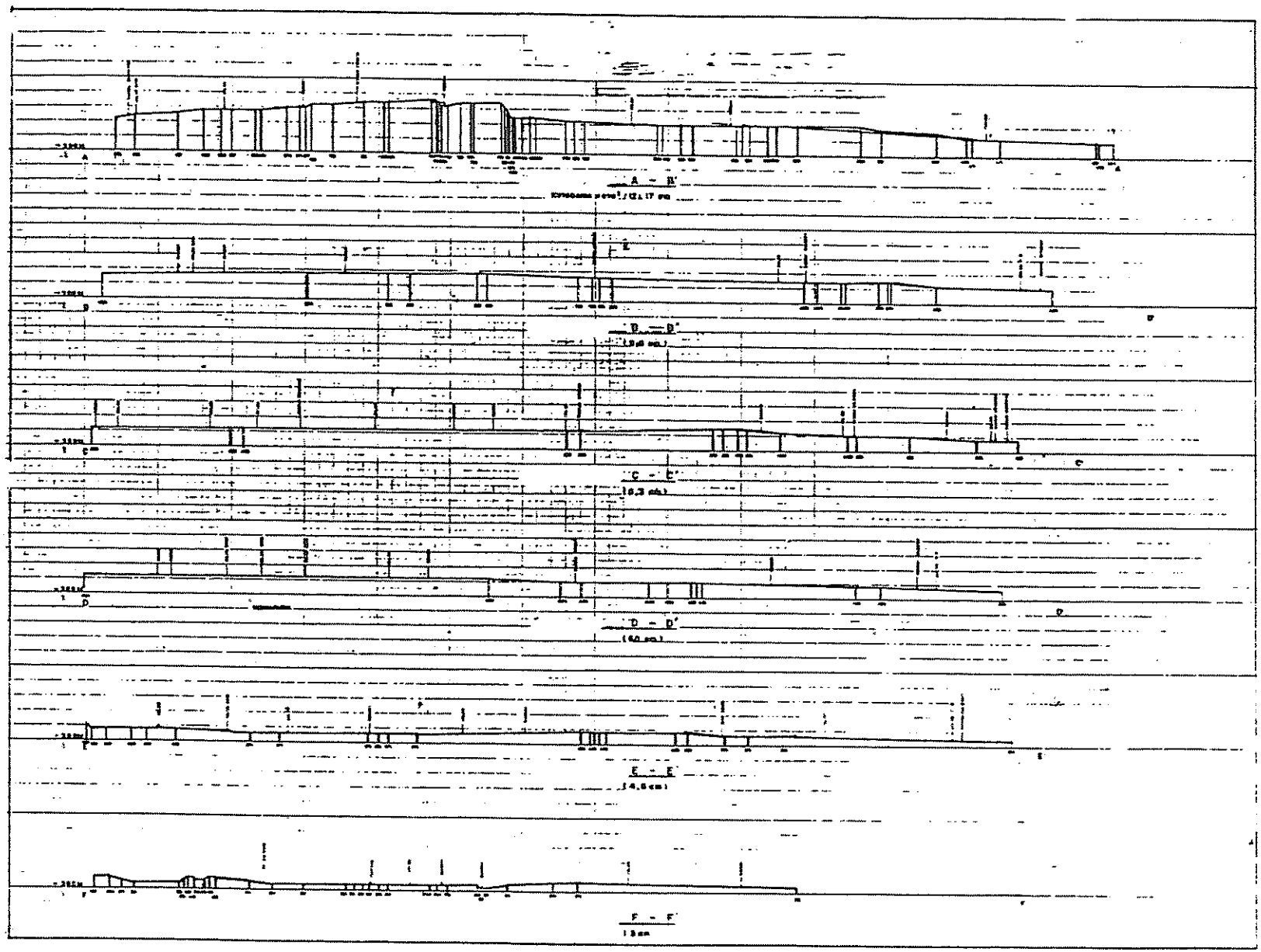

Figure 59. Indonesia: location of profiles of non-lahar deposits from Galunggung volcano

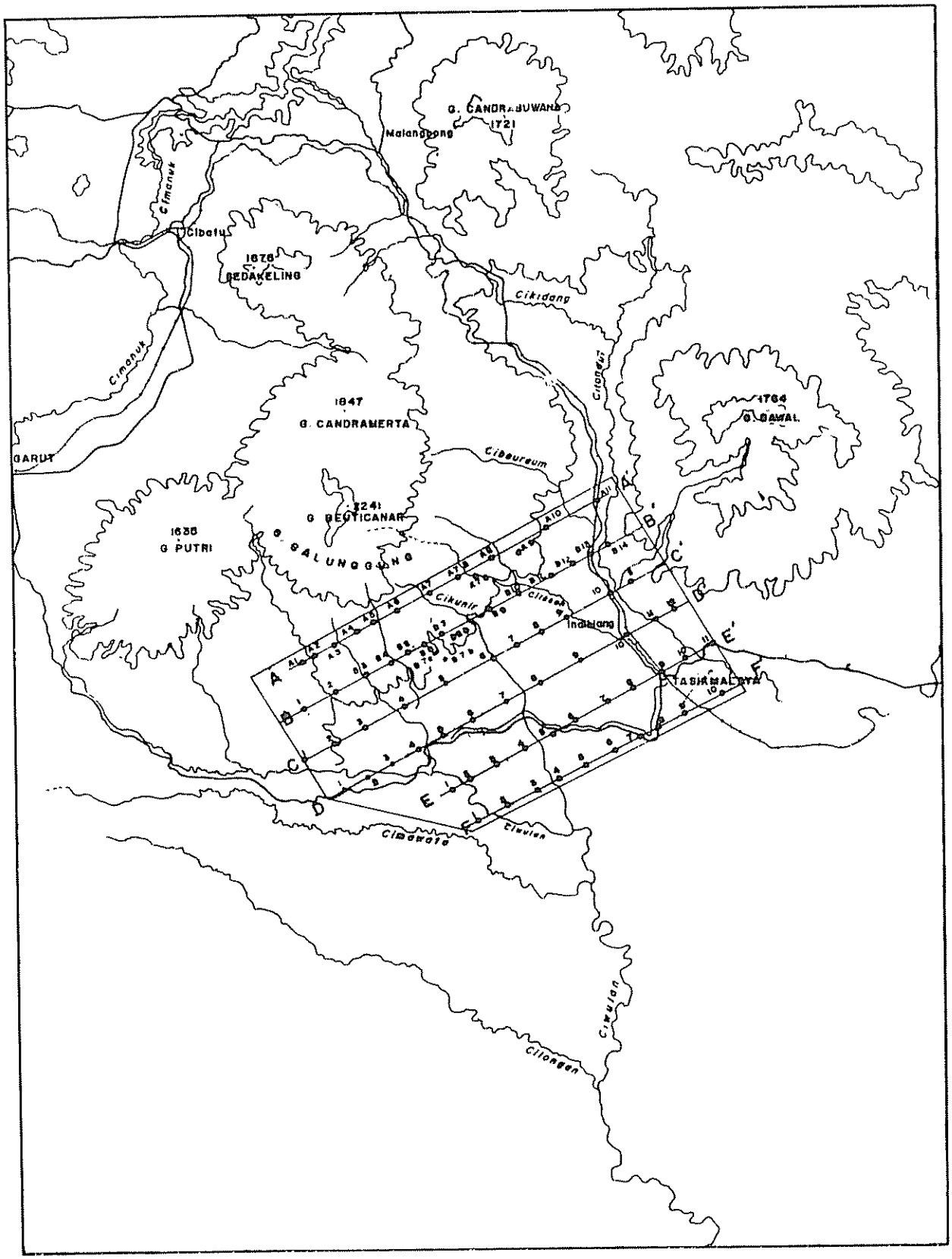

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Table 24. Average depths and standard deviations of Galunggung volcanic materials

Sample	Stratum A: west and south slopes, ±11,000 hectares		Stratum B: south slope, ±600 hectares		Stratum C: Citandui watershed	
	X = t (centimetres)	X^2	X = t (centimetres)	X^2	X = t (centimetres)	X^2
1	6	36	160	25 600	15	225
2	36	1 296	230	52 900	12	144
3	14	196	83	6 899	10	100
4	14	196	65	4 225	8	64
5	15	225	83	6 899	2	4
6	15	225	285	81 225	6	36
7	15	225	200	40 000	10	100
8	5	25	-	-	8	64
9	5	25	-	-	7	49
10	6	36	-	-	5.5	30.25
11	6	36	-	-	4.5	20.25
12	7	49	-	-	10	100
13	8	64	-	-	10	100
14	20	400	-	-	5	25
15	3	9	-	-	5	25
16	3.5	12.25	-	-	8	64
17	4	16	-	-	8	64
18	5	25	-	-	10	100
19	8	64	-	-	3	9
20	2.5	6.25	-	-	5	25

Table 24 (continued)

Sample	Stratum A: west and south slopes, ±11,000 hectares		Stratum B: south slope, + 600 hectares		Stratum C: Citandui watershed	
	$X = t$ (centimetres)	X^2	$X = t$ (centimetres)	X^2	$X = t$ (centimetres)	X^2
21	3	9	-	-	4	16
22	3	9	-	-	4	16
23	3	9	-	-	10	100
24	2	4	-	-	5	25
25	5	25	-	-	10	100
26	2	4	-	-	2	4
27	2	4	-	-	2	4
28	3	9	-	-	3	9
29	3	9	-	-	5	25
30	1.5	2.25	-	-	5	25
31	2	4	-	-	6	36
32	2	4	-	-	1.5	2.25
Total	229.5	3 258.75	1 106	217 728	219.5	1 721.75
$\bar{X}$ (=$\bar{t}$)	7.17		158		6.58	
$S^2 = \frac{x_i^2 - \frac{(\sum x_i)^2}{n}}{(n-1)}$	51.03	7 163.33		10.87		
$S_{\bar{x}} = \sqrt{S^2}$	7.10	84.64		3.30		

Table 25. Estimation of lahar and non-lahar volumes, by stratum or location, Galunggung area

Stratum or location	Average depth, $\bar{X}$ (centimetres)	Standard deviation, $S_{\bar{X}}$	Approximate area (hectares)	Approximate volume (cubic metres)
A	7.17	7.10	11 000	7 887 000[a/]
B	158.00	84.64	600	8 277 158[b/]
C	6.58	3.30	11 000	7 238 000[a/]
Crater	300	-	645.75	91 372 500[b/]
Warirang-Pasir Bentant	(Estimated)			
Total	-	-	23 245.75	42 774 658

a/ Non-lahar.

b/ Mainly lahar.

PREDICTION OF MUD FLOWS

Morphologically speaking the Galunggung volcano can be divided into three main sections:

(a) Upper section: the crater and the cone. Volcanic products, including lahar, were deposited in this section. Such deposit poses a potential danger, because it can be transformed into rain mud flows threatening the lower section of the lava dome;

(b) Middle section: lahars of previous eruptions and dry accumulates were partially deposited in this section. Intense erosion has taken place here, creating gullies or valleys;

(c) Lower section: the lava plain covered by river flood deposits and in some cases by lahars. A fertile plain extends from Singaparna through Tasikmalaya to Indihiang.

Along the northern rim of the lava plain a chain of hillocks, the Ten Thousand Hills Complex, extends from east of Singaparna towards north-west of Tasikmalaya. Cikunten and its tributaries flow from the western slope of the

Galunggung into Singaparna plain. The terrain in the lower part of the middle section slopes slightly towards Singaparna, and the overflow of the Cikunir is very likely to affect the town and its surrounding area. Tasikmalaya and its surrounding plain always had been affected by cold mud flows from previous eruptions, although the town is somewhat protected by the small hills in the direction of the Singaparna plain and the Ciwulan. The northern section of Tasikmalaya and the Indihiang plain, however, are exposed to mud flows coming down along the Ciloseh and the Cimampang.

Based on the terrain configuration, threee main lahar flows are expected: (a) Cikunten-Singaparna flows; (b) Cikunir-Cibanjaran flows with its main branch threatening Singaparna and the area east of the town; (c) Ciloseh-Cimampang flows, which will hit the northern section of Tasikmalaya and Indihiang.

Dams and check-dams will minimize the impact of the mud flows and therefore reduce the damage to settlements and infrastructures. There will, however, be continuous and repetitive lahars during rainy seasons for several years to come, which will cause protracted difficulties and damage to the area. Apart from rice-fields, fish-ponds and other crop lands which are already covered by permanent lahar, it is expected that the following agricultural lands will be damaged by the coming rain mud flows:

(a) Rice-fields and uplant dry lands, 10,100 ha;

(b) Non-irrigated lands, 2,900 ha;

(c) Forest lands, 3,250 ha.

(For land-use in the area, see figure 60.)

Mud flows are in fact not entirely a volcanic phenomenon; rainfall intensity also plays an important role. Average rainfall intensities recorded in the area surrounding Galunggung are given in table 26. From these figures, it is clear that rainfall intensity begins to increase in October. Based on the rainfall data and on previous lahar, the mud flows should occur in October or November. Judging from the prolonged dry season in this year, it is more likely that the lahar will begin to flow in November.

REMARKS AND CONCLUSIONS

Because of the repetitive character of the eruptions, a timely study concerning volume estimations of volcanic products and prediction of rain mud flows should be made. This in itself creates a time constraint. Conventional aerial photographic survey requires a near-ideal atmospheric condition if good results are to be obtained; in the case of the Galunggung survey, such a condition is almost non-existent.

Haze, normal cloud and suspended ash reduced in one way or another the quality of aerial photographs. Repetitive photography in the case of Galunggung can be very useful in making comparisons, but such an effort is costly. From the photographs, it can be seen that between April and August 1982 the area covered by volcanic debris increased from 290 to 560 ha.

Figure 60. Indonesia: land-use map of Galunggung area

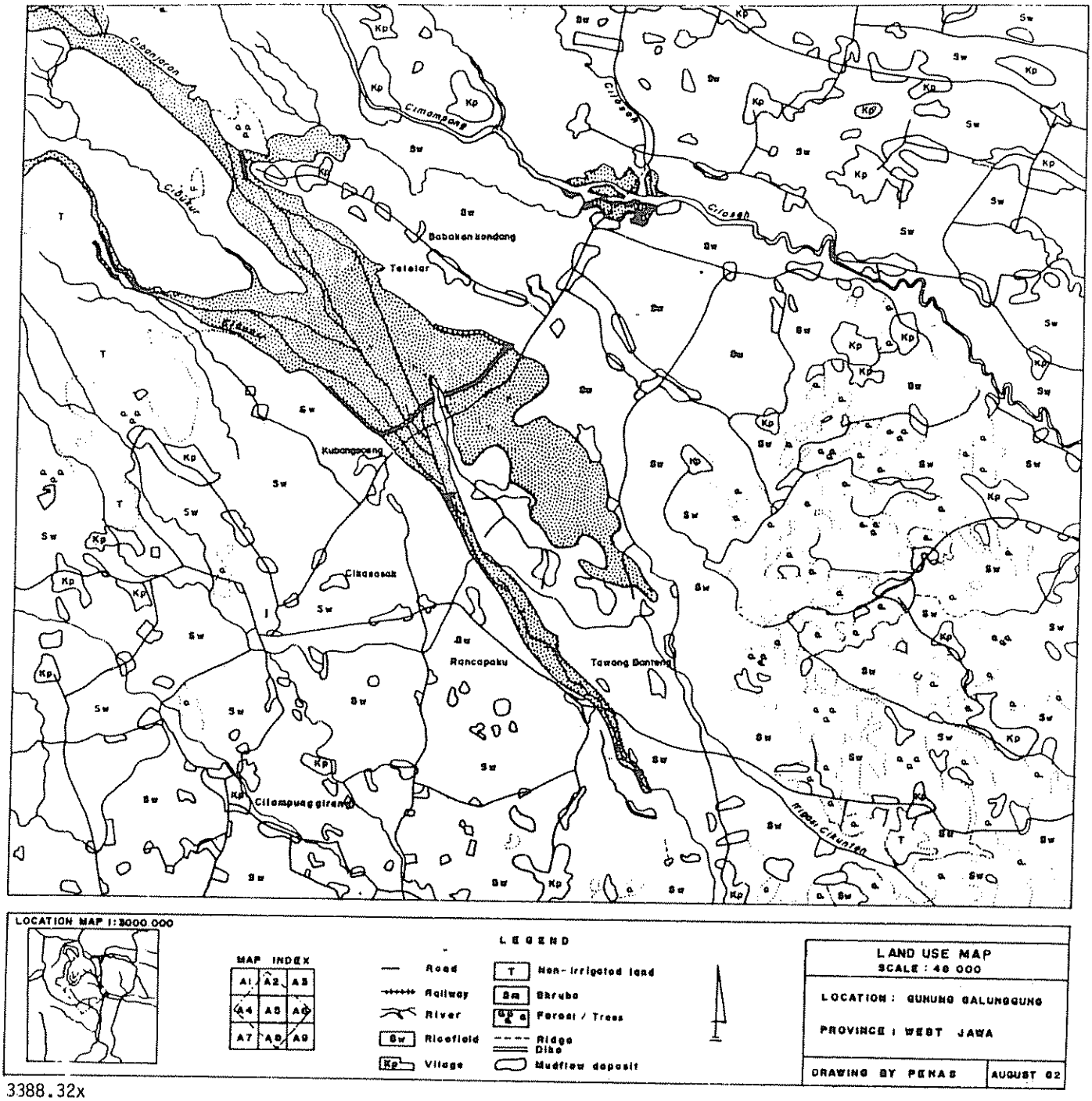

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Table 26. Average maximum rainfall in areas surrounding Galunggung volcano, September-December, various periods

(Millimetres)

Station	Average maximum rainfall within 24 hours				
	September	October	November	December	Period
223:Rajapolah	3	18	74	70	1961-1970
230:Tasikmalaya	31	77	72	75	1961-1970
231:Manonjaya	18	35	64	50	1961-1970
218:Singaparna	62	135	86	96	1931-1960
219:Jayatani	74	144	78	72	1931-1960
223:Rajapolah	30	36	47	59	1931-1960
230:Tasikmalaya	39	72	68	69	1931-1960
231:Manonjaya	39	67	60	74	1931-1960

A rough estimation of volcanic materials shows that 15.6 million m^3 of dry accumulates or non-lahar are covering an area of $\pm$1,200 ha on the western and south-western slope as well as the east-south-eastern slope. The lahar deposit poses a potential and real danger, because more of the materials will be transformed into mud flows, as compared with the non-lahar deposits. The limited number of samples measured in the field and application of watershed as based for stratification instead of lahar and non-lahar distribution gave a relatively high value of the standard deviation ($\underline{S}_{\bar{x}}$).

Mud flows are predicted to hit Singaparna from two directions: those coming down the Citunken; and overflows of the Cikunir-Cibanjaran rivers. The northern section of Tasikmalaya and Indihiang are exposed to lahars from the Ciloseh-Cimampang watersheds. Dams and check-dams will reduce the impact, but continuous and recurrent lahars will affect the area for several years to come. The extent of the damage to agricultural land is predicted to affect 10,100 ha of rice-fields and upland dry land, 2,900 ha of non-irrigated crop land and 3,200 ha of forested area.

In conclusion, it can be said that all these efforts were made possible because the eruptions occurred during the dry season. Therefore, aerial photographic interpretation could be put to optimal use.

To increase alertness towards volcanic explosions and the secondary dangers, it is important to take the following measures:

(a) To prepare large-scale topographic maps (1:5,000) of parts of the volcanic dome;

(b) To maintain well-equipped observation posts to watch active volcanoes;

(c) To use remote-sensing techniques to monitor volcanic activities. LANDSAT-4 with digital processing systems owned by several government agencies should be utilized as much as possible. Application of a thermal infra-red scanner to detect changes of volcanic phenomena would contribute to the acquisition of important information.

Co-ordination of available resources is needed not only for relief but, more important, for prediction of coming disasters.

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THE GROWTH OF DOMESTIC SURVEY FIRMS IN SUPPORT OF MAPPING THE COUNTRY*

Paper submitted by Indonesia

RESUME

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* The original text of this paper, prepared by the Association of Indonesian Survey and Mapping Enterprises, Jakarta, appeared as document E/CONF.75/L.101.

Un marché en pleine expansion, du fait d'une forte demande en cartes et photographies aériennes, et une politique gouvernementale favorable au développement des sociétés nationales sont deux des facteurs ayant entraîné une croissance considérable des cabinets de topographie et de cartographie. Le présent rapport décrit le plan de développement national et le rôle des cabinets de topographie en Indonésie.

The demand for various types of maps has been increasing since the beginning of the five-year national development plans (PELITA) in 1969. In addition to a nation-wide systematic mapping programme to produce topographic maps, there are also growing needs for large-scale engineering maps, thematic and cadastral maps.

A rapidly growing market, due to the pressing demand for maps and aerial photographs and favourable government policies towards the growth of domestic firms, is conducive to the significant development of the survey and mapping enterprises. It is encouraging to witness an increasing role of these firms in a field that formerly was a government concern.

This report is directed to providing an outline of the development and the role of survey firms in Indonesia.

DEVELOPMENT OF SURVEY AND MAPPING ENTERPRISES

The development of the survey and mapping enterprises can be best illustrated by the membership of the Association of Indonesian Survey and Mapping Enterprises (AISME), because it includes 85 per cent of the domestic firms having significant capacity. Table 27 shows the increasing number and capabilities of the domestic firms prior to and during the successive five-year plans.

Of the 51 member companies, 49 are private firms and the remaining two are Government-owned. The majority of the firms offer services in terrestrial surveys and several for their development. On the other hand, the development of hydrographic survey firms has been very slow. This situation is a direct result of a distinct lack of knowledgeable and experienced hydrographic surveyors, as hydrographic surveying was for navigational charting only, as well as because of the much greater capital costs involved for equipment and logistics. A lucrative market of offshore surveying in conjunction with oil exploration has been served mainly by foreign firms.

Almost all of the firms are based either at Jakarta or at Bandung, while those in provincial cities, if they exist at all, have very limited capabilities. This is a disadvantageous situation, since most of the development projects are located in the provinces outside Jawa. This is even more the situation if the job requires purely terrestrial survey for which mobilization of surveyors and equipment can be very costly. In case of aerial surveying, the situation can still be economically and technically tolerated.

During the first and second PELITA, the scarcity of qualiifed personnel was a major handicap, especially for those falling into technologist (Diploma 3 university course) and technician (Diploma 1 university course or its equivalent) categories. Although this situation still prevails in the provinces, there has

Tableau 27. Growth of the Association of Indonesian Survey and Mapping Enterprises

Period	Accumulated number of memberships	Survey and mapping capabilities					
		Terrestrial	Aerial survey and mapping				Hydrographic
			APY	PGY	PI	AGS	
Before five-year plan	5	4	1	--	1	--	--
First five-year plan	21	20	5	6	5	1	2
Second five-year plan	40	37	6	8	7	1	4
Third five-year plan	51	47	10	12	10	1	5

Note: APY = aerial photography; PGY = photogrammetry; PI = photo-interpretation; AGS = airborne geophysical survey.

been improvement, thanks to the initiative of government institutions and universities in organizing courses in surveying, photogrammetry and cartography.

On the other hand, vocational training and education in the field of hydrographic and related ocean sciences are currently almost non-existent. However, some steps have already been taken to rectify this situation, although only in a small scale.

Table 28 shows the categories and distribution of survey personnel in 1981.

According to the 1981 record, the following units survey equipment were in use:

Theodolites	1,080
Levelling instruments	1,006
Electronic distance measuring instruments	148
Doppler receiver	5
Anaeroid barometer	8
Stereoplotter	44
Orthophoto instruments	7
Aerotriangulation instruments	7
Rectifier-enlarger	8
Reproduction cameras	6

Table 28. Categories and distribution of personnel among members of the Association of Indonesian Survey and Mapping Enterprises, 1981

Category	Terrestrial surveys	Aerial surveys	Hydrographic surveys	Total
Professionals	327	27	20	368
Technologists	395	48	51	494
Technicians	2 094	408	126	2 628
Total	2 816	477	197	3 490

Fourteen aircraft are modified for aerial photographic missions. One firm owns five of these aircraft, including two Beechcraft Super King Air 200s equipped with LTN-72 inertial navigation systems integrated with a photogrammetric integrated control system capable of high-altitude (33,000 feet above sea-level operations. The other aircraft are hired from air-charter companies; all of them have piston engines. For execution of large government projects, more aircraft can be made available for small-scale (down to 1:100,000) photography. The AISME members own 19 aerial cameras, mostly from Wild and Carl Zeiss (Oberkochen) and some from Carl Zeiss (Jena).

The main hydrographic survey instruments owned by AISME members are:

(a) Sextant;

(b) Electronic distance measuring instrument;

(c) Theodolites;

(d) Levelling instrument;

(e) JMR-1A, Doppler positioning instrument;

(f) Magnavox 1502, Doppler positioning instrument;

(g) Tide-gauges;

(h) Wave recorder;

(i) Echo-sounders;

(j) Current meters;

(k) Meteorological instrument;

(l) Sub-bottom profiling equipment, such as Sparker arrays, Uniboom and Pinger;

(m) Piston gravity corers;

(n) Temperature salinity bridge;

(o) Radio-communication equipment;

(p) Computerized interface systems;

(q) Magnetometers;

(r) Sidescan-sonar;

(s) Sub-bottom profiling system;

(t) Grab samplers.

ROLE OF MAPPING FIRMS

Large-scale map production for engineering purposes is the mainstay of the domestic firms. Other jobs include detailed ground surveys for various civil works, opening of new rice-fields, reclamation of swampy lands; planning for resettlement sites, oil pipelines and electrical transmission lines; urban engineering; and geodetic surveying, e.g., Doppler positioning for horizontal control and national vertical control networks. Typical jobs normally assigned to local companies in hydrographic charting are harbour construction and navigation, including horizontal and vertical controls, submarine pipeline feasibility studies, well-head site surveys and rig-positioning to support offshore oil and gas exploration.

The following information will help to provide a picture on the scope and magnitute of the role of domestic firms.

Transmigration programme

Extensive infra-red aerial photopgraphy at 1:20,000 scale is being carried out for the transmigration programme, including the programme for the coming fourth PELITA (1984-1989), with a view to overcoming bottle-necks at the planning stage. Prospective areas should be flat with a maximum slope of 8 per cent to prevent soil erosion and thereby make dry-land and food-cropping feasible. Uncontrolled mosaics on the original phot scale of 1:20,000 are used for preliminary study of drainage pattern, slope classification, land utilization and soil condition. For actual planning for site development, topographic maps at large scales (1:10,000 and for specific area 1:5,000) are prepared.

Unfavourable weather conditions, limited time and widely scattered location of sites to be surveyed are constraints that can only be overcome by a unified management of available resources.

The success of operations led to increased volume of the work entrusted to the consortium (see table 29).

Table 29. Aerial photography by domestic firms for transmigration programme, Indonesia, 1980/81-1982/83

Fiscal year	Number of sites	Total area (hectares)
1980/81	124	2 497 370
1981/82	69	1 870 560
1982/83	427	10 166 450

Urban mapping project

To improve the conditions of the cities, the Government has decided to map 100 cities at 1:1,000 scale in the form of either line or orthophotomaps. The maps will be used for urban planning, which includes betterment of low-income residential areas, improvement of drainage systems, provision of clean water and general city planning. Land registration, fiscal cadastre and city inventory will benefit from the availability of the new maps. The project is financed jointly by the World Bank and the Government and is tendered to domestic firms.

Agricultural projects

Orthophotomaps at 1:5,000 or 1:1,000 scale, with contour lines and spot heights (derived from ground survey) are widely used in planning of main and secondary irrigation channels as well as dams for agricultural projects. Terrestrial survey is applied for more detailed measurement, for example, in construction planning for tertiary irrigation ditches. The so-called "tertiary programme" plays a major role in boosting production, e.g., by increasing the annual harvest to twice a year. The goal of the tertiary programme is to provide irrigation networks for 800,000 ha in the third PELITA. Another important programme is land development, covering 300,000 ha, in conjunction with transmigration to be completed the end of the third PELITA (1984).

Replanting and extension of industrial crops in connection with growign agro-industries contribute significantly to the demand for survey and mapping services, especially aerial photography and terrestrial surveying. National soil systematic mapping is being executed by Department of Agriculture while acquisition of aerial photographs for the purpose is normally done by domestic firms.

Geology and mining

A large portion of the archipelago is covered by side-looking airborne radar (SLAR) and synthetic-aperture radar (SAR). These radar images are used for preliminary exploration for oil, coal and ores. For medium-scale (1:50,000) topographic mapping in support of planning and site development, the aerial photogrammetric method is used. The large mining companies have their own capability for assessment of mining potentials using aerial surveys. Detailed terrestrial survey provides data and terrain information to support engineering activities.

For regional systematic geological mapping (Java at 1:100,000 and other islands at 1:250,000), which is being carried out by the Government, the need for aerial photographs is supplied by the domestic survey firms.

Forestry

With the establishment of wood-based industries, growing demand on new agricultural lands and increasing shifting cultivation, forest maps, as one of the sound bases for forest and land management, are sorely needed.

Reconnaissance forest-type mapping, which is conducted by the Government, as well as preparation of forest and topographic maps at 1:20,000 scale, which is obligatory for forest concession holders, are using aerial photographs supplied by the domestic companies.

Cadastral surveys

Although by law the cadastral survey is under full control of the Government, a portion of the job is assigned to domestic firms. As previously mentioned, urban maps prepared by those firms will be utilized to support cadastral mapping. Another work normally done by the domestic companies is large-scale aerial photography (1:5,000-1:10,000).

Other engineering projects

Large-scale maps prepared by using aerial photogrammetric methods are increasing in demand for planning of road construction, improvement and extension of runways, development of industrial sites, planning for electrical transmission lines and microwave networks, oil and water pipeline construction and other purposes.

Hydrographic and related marine surveys

In conjunction with the "oil boom" in the early 1970s, advanced technology for offshore exploraiton and exploitation was introduced to Indonesia. Unlike the previous main acitvity of navigaitonal charting, current hydrographic surveys have included positioning surveys for marine seismic exploration and drilling rigs, drill-site hazards surveys, crude-oil pipeline routes, control survey

for pipelaying operations and for offshore structure maintenance programmes, as well as surveys for miscellaneous offshore construction, such as flow stations and gathering platforms; and feasibility studies for establishing large and small new ports to meet increasing interinsular shipping. It is expected that a significant amount of cable-laying will take place, linking the smaller islands to large centres.

Other activities

There are other activities that do not deal directly with actual survey and mapping, but have a crucial bearing on them, in which the firms are deeply involved through AISME.

These activities are in the form of active participation with the Government and other groups in the formation and drafting of the Qualification Standards for Survey and Mapping Companies as well as the Survey and Mapping Act. Both drafts, after going through formal procedures, will become important documents in guiding the comapnies toward higher professional standards and creating a sound basis for national management of survey and mapping activities.

In the field of education, most facilities owned by the companies are open for pratical exercises for students from various universities and training institutions.

AISME is also actively engaged in promoting the role of survey and mapping in the national development through participation in seminars and market development and by free distribution of a monthly bulletin.

PROSPECTIVE TRENDS OF DOMESTIC FIRMS

The national policy to develop natural resources potential as one of the foundations for economic development has brougth its rewards. Amid the uncertainties of the world economy, the Government has decided to do whatever is appropriate to maintain the hard-won momentum. This means that strategic sectors, such as agriculture, transmigration and road construction, have a high scale of priority. Large engineering maps and detail surveyings will be used increasingly for preparation of line maps or orthophotomaps on scales of 1:1,000 or smaller, while for large-scale mapping terrestrial surveys will be more appropriate.

It seems very likely that the domestic firms will be involved in stereocompilation and cartographic work related to national systematic mapping, because of limited capacity of the agencies. This is a logical way to avoid further delay in the production of national topographic sheets on smaller scale 1:50,000 or 1:100,000. These maps or their derivatives on smaller scales (1:250,000 and smaller) are urgently needed for preliminary studies in conjunction with regional development and for resources inventories.

Although systematic geological mapping is being done by the Geological Research and Development Centre, project-oriented surveys are a potential market for the firms. Airborne, seaborne and ground geophysical surveys are expected

to increase due to oil and gas explorations and geothermal and coal deposit surveys. The same applies for geotechnical and hydrological surveys.

In the field of oil survey, more jobs on land capability and suitability studies will be awarded to the survey companies, primarily due to overburdened government facilities.

National forest planning requires immediate attention in order to bring about sound management of this important resource. Such management is urgently needed to cope with rapidly growing wood-based industries, greater demand for agricultural lands, pressing needs for soil and water conservation in densely populated islands and the expanding practice of shifting cultivation. Detailed surveys for watersheds and forest concessions management will be increased in the near future.

Foreign survey firms will continue to dominate the hydrographic survey for two to three years to come, although there are some indications that more of these firms still presently be in closer co-operation with the domestic companies.

In the near future, more terrestrial survey companies will be established and some of them will be based in large provincial cities. The older terrestrial survey firms will grow and develop photogrammetric capabilities. Several of the domestic companies will expand their capabilities into natural resources assessment using remote-sensing techniques and geophysical surveys, and some of them will invest their capital in soil chemistry and soil mechanics laboratories.

CONCLUSIONS

When the first five-year-plan or PELITA was being formulated, the Government faced a major problem of not having sufficient data and information on almost every sector. Data on natural resources were scanty, outdated and unreliable. Less than 40 per cent of the land area had been mapped on standard topographic sheets at 1:25,000; 1:50,000 and 1:100,000 scales; these maps were 40 years old and therefore outdated.

Although the Government embarked immediately on an ambitious plan to map the whole land area systematically, the development programme could not afford to wait and should proceed as planned using existing and newly acquired information specially collected for this purpose. Not all of the badly needed information could be provided by the hard-pressed government agencies. This opportunity attracted the private sector to establish survey and mapping companies.

These firms have frown in number and capability with extraordinary speed. They have been actively involved in the process of development. Their role is becoming increasingly important and their capabilities widened; they are not limited only to land surveying but include natural resources assessment. They have applied modern survey and mapping technology commonly used in the developed countries. The domestic firms form an important element in the national mapping capability and are indispensable in the development of the country.

(c) Remote sensing from space for cartography

USE OF LANDSAT IMAGERY TO SUPPLEMENT CONVENTIONAL IMAGERY IN MEDIUM-SCALE AND SMALL-SCALE MAPPING AND CHARTING*

Paper submitted by Australia

RESUME

On a utilisé avec un certain succès les images LANDSAT pour l'établissement de cartes à moyenne échelle et à petite échelle. On a recouru aux techniques photomécaniques pour placer les images dans la projection nécessaire. Les images n'ont pas été manipulées à l'aide des techniques de visualisation graphique.

LANDSAT imagery has been used with success in mapping at medium scales and charting at small scales. Photomechanical techniques have been used to manipulate the imagery projection. No attempt has been made at image manipulation using computer-graphics techniques.

The Royal Australian Survey Corps uses conventional imagery for mapping at medium and small scales. On a number of occasions, LANDSAT imagery has been successfully used as supplementary imagery for medium-scale mapping and also as an aide in the porduction of small-scale derivative maps and charts. Graphical techniques have generally been used to provide image fit; however, some success has been achieved in digitizing the outlines of offshore detail and manipulating the digital data to fit existing control.

The Royal Australian Survey Corps has been engaged in topographic mapping of the mainland of Australia, its offshore islands and territories, and other countries, including Papua New Guinea. In addition, the Corps undertakes the production of aeronautical charts. The scales of these products range from 1:25,000 to 1:1,000,000. The policy for topographic mapping at medium to large scales is to use conventional metric photography as source material, controlled and aerotriangulated to ensure conformity with specifications. Small-scale products are produced by derivation from larger scale source material.

APPLICATIONS OF LANDSAT IMAGERY

The mapping policy outlined above assumes that metric-quality imagery is available and that control or aerotriangulation, or both, exist or can be economically obtained within the time constraints that are placed on military mapping. This is not always the case, and in such instances, compromises are necesary to ensure that the time constraints shall be satisfied.

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* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.14

LANDSAT imagery has been used on several occasions to position photography where aerotriangulation is not possible and field survey is not feasible. The predominant application of this technique has been in mapping of offshore islands and reefs--particularly in the northern Barrier Reef area of Australia and the island chains to the south-east of Papua New Guinea. A graphical method is used in which the LANDSAT imagery is projected in a rectifier and manipulated to give a best fit to the conventionally positioned detail in the mainland. The rectified image is then used to position, scale and orient conventional imagery or plotted detail of the offshore feature. The map accuracy statement has been amended appropriately to reflect the technique used.

LANDSAT imagery has been used to plot detail where conventional imagery does not exist, has been flown at other than the optimum time of day or is out of date. Several reef areas have been depicted from band-4 imagery where there is no conventional photography, or where photography has been flown at or near high tide and reefs have been obscured. Where photography is old, imagery has been used to plot limited detail, such as vegetation boundaries, in small-scale aeronautical charts. The LANDSAT imagery is again projected in a rectifier and manipulated photomechanically to give a best fit to the cultural detail that has been derived from existing mapping by photomechanical procedures. In each of these techniques, the accuracy statement is amended to reflect the procedures that have been used.

LANDSAT: ITS APPLICATION TO MARINE PARK MANAGEMENT OF THE GREAT BARRIER REEF*

Paper submitted by Australia

RESUME

Les récifs de la grande Barrière sont l'une des principales caractéristiques marines du monde. Maintenir un bon équilibre entre, d'une part, leur protection et leur préservation et, d'autre part, l'exploitation raisonnable de leurs ressources est une opération qui défie toute planification. Les décisions à prendre exigent une excellente compréhension des récifs et de leur milieu. Cela constitue, en soi, une vaste entreprise en raison de l'étendue géographique de la région des récifs de la grande Barrière et de la complexité de sa structure et de ses écosystèmes.

Le présent document décrit la manière dont on a élargi les capacités de LANDSAT afin d'obtenir une vue d'ensemble des récifs, met en lumière certaines de leurs caractéristiques intrinsèques et les présente sur une base de coordonnées géographiques.

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* The original text of this paper, prepared by the Australian Survey Office, Department of Administrative Services, appeared as document E/CONF.75/L.15.

Situated along the north-eastern part of Australia contiguous to the coastline of Queensland (see figure 61), the Great Barrier Reef extends some 2,000 km just south of Papua to 24°30' south. The Great Barrier Reef region, which includes all of the Great Barrier Reef south of 10°41' south covers an area of approximately 348,700 km^2 on the continental shelf. Within the region, sections of the Great Barrier Reef Marine Park may be proclaimed. The reef was described in the nomination by the Government of Australia for its inclusion in the World Heritage List as follows:

"The Great Barrier Reef is not a continuous barrier but a broken maze of coral reefs, some with coral islands called cays. The Reef comprises some 2500 individual reefs which range in size from less than one hectare to more than 100 square kilometres, and in shape from flat platform reefs to elongate ribbon reefs. In some places the reefs are separated by channels of no more than 200 metres width, while elsewhere they may be as much as 20 kilometres apart. Most reefs are submerged, with some being exposed at low tide."

"The individual reefs of the Great Barrier Reef are composed of the accumulated remains of plant and aninal calcium carbonate skeletal material, supporting a veneer of living plants and animals. There are 71 cays on the Reef.

"The Great Barrier Reef is the world's largest and most complex expanse of living coral reefs, encompassing many unique forms of marine life. There are over 1500 species of fish and about 400 species of coral. Other well represented animal groups include sponges, anemones, marine worms, crustaceans, molluscs and echinoderms. This great diversity of life forms, especially in the endemic species, makes it an area of enormous scientific importance." 1/

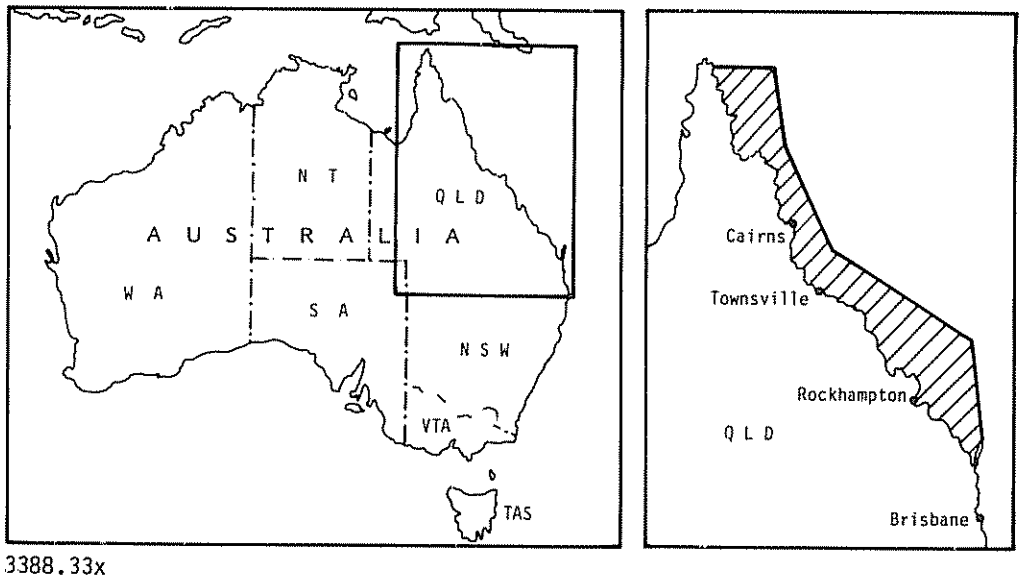
Establishing suitable bases on which to record the physical attributes of the Great Barrier Reef and monitor the many influences on its environment is a formidable undertaking. All the Australian Government's mapping and surveying agencies together with the Queensland agencies are sharing in the task. The present paper addresses but one of the initiatives taken to provide some of the information being sought.

GREAT BARRIER REEF MARINE PARK AUTHORITY

The Government of Australia and the State Government of Queensland co-ordinate the management and conservation of the Great Barrier Reef. This is achieved through a Ministerial Council representing both governments, a formal enactment known as the Great Barrier Reef Marine Park Act 1975 and the operations of the Great Barrier Reef Marine Park Authority (GBRMPA).

The Great Barrier Reef Marine Park Authority has a full-time chairman, two part-time members and a small staff of specialists in resource management and marine science. They are responsible for, among other things, co-ordinating, arranging for and carrying out research and investigations, preparing zoning and management plans for Marine Park areas and making recommendations concerning regulations in the Marine Park.

Figure 61. Australia: Great Barrier Reef region



3388.33x

THE BRIAN PROJECT

The Great Barrier Reef Marine Park Authority was aware from its formation of the potential of LANDSAT in possibly providing some of the many classes of information they seek for effective execution of their role. Consequently, GBRMPA approached the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to ask its Division of Water and Land Resources to investigate how LANDSAT satellite images might be used to identify characteristics of the reef and show up any long-term changes in its appearance.

A research team headed by David Jupp (CSIRO) developed the Barrier Reef Image Analysis (BRIAN) package. 2,3/ This was a joint project between CSIRO, James Cook University and GBRMPA, with financial support from the Australian Marine Sciences and Technologies Advisory Council (AMSTAC). The BRIAN package is a minicomputer-based interactive system which was developed as a means of interpreting large amounts of geographical information quickly and economically. Detailed information of specific sites can be used to produce a computer classification over much larger areas. This extended interpretation can then be used as a low-cost inventory or as the basis for further investigation.

After some extensive ground truth studies on Heron Island Reef, in the southern region of the Great Barrier Reef, the differentiation possible between adjoining reef zones was improved and confidence in the system increased to claim that labelling was at least 93 per cent accurate for major categories and 76 per cent accurate for finer categories. During this phase of the project, it became very apparent that considerable attention would have to be given to the number and distribution of ground control points required for satisfactory registration and interpretation of a LANDSAT image to a geographical base. Therefore, a set of image rectification procedures, using a model of the satellite orbit and mechanical distortions, was developed and applied during the extension of this work into the Cairns section in the northern region of the Great Barrier Reef. The results of this research are in the process of being reported to supporting agencies and published as scientific articles.

LANDSAT RECTIFICATION OF REEF AREAS

At the invitation of GBRMPA and CSIRO, the Australian Survey Office of the Department of Administrative Services, together with the Navy Hydrographer and the Queensland Department of Mapping and Surveying, joined the research on the use of LANDSAT on the reef. The specific input required from the Australian Survey Office was to assist in improving the geographical reliability of the rectified LANDSAT scenes through the identification and provision of suitable control.

For several years, the Australian Survey Office had been working on a programme of producing 1:5,000 rectified photomaps of specific reefs from aerial photography. 4/ In addition to providing large-scale images of reefs, these photomaps provided geographical co-ordinates over the reefs, which were a subset of the previously established first-order control for 1:100,000 and 1:250,000 mapping.

Small-scale mapping and hydrographic charting of the reef has of course been proceeding since the early days of the Australian coastline discovery in the latter half of the eighteenth century. It is only in more recent times, however, that 1:250,000 maps of the entire reef area have become available. The adjacent Queensland coast is covered by 1:100,000 mapping but this does not extend over all of the reef.

Before proceeding to explain briefly the rectification process, it might be useful to recap some of the features of LANDSAT imagery as compared with conventional aerial photography. LANDSAT records in a continuous swath 185 km wide across the Earth's surface using an oscillating mirror to sample, at approximately 60-m intervals across the path, the intensity of electromagnetic radiations within selected wavelength bands. The variation of about 1:1.5 in the scale of satellite track to scan direction, mirror velocity, spacecraft attitude and the skew effect of Earth's rotation under the spacecraft orbit all affect the accuracy of the image obtained. Furthermore, the LANDSAT flight paths, being fixed in their orientation, cannot be aligned as with aerial photography to optimize the best locations for ground control points.

The process of rectification that has been developed can be summarized in the following steps:

(a) Uisng the interactive graphics which are the basis for BRIAN, the line and pixel number of a point is obtained by identifying the point on the graphics screen using a movable cursor;

(b) The Australian map grid (AMG) co-ordinates of the same point are determined from an existing 1:250,000, 1:100,000, 1:5,000 or other suitable map;

(c) The AMG co-ordinates are converted to a local co-ordinate system with the centre of the scene becoming the origin. Using the satellite model, corrections are made for the systematic geometric distortions;

(d) Assuming an affine relationship between the two co-ordinate systems, the ground control points that have been misidentified or incorrectly scaled can be removed;

(e) An image-to-map transformation based on the satellite model which, because of significant attitude variations in the satellite orbit, may be a higher transformation than affine, is then completed and the original image resampled to fit the map projection.

Analysis of the accuracy of transformation of reef images using this method show root mean square differences of 50-60 m at the ground control points. Also, a model for the predictive error away from the control can be generated. This model can be used to identify the most suitable locations for attempting to establish further control if that is required. Provided as an overlay, it can also help a user of a transformed image to know the probable accuracy of the image position at any point.

Although not substitutes for but supplements to conventional mapping, an interesting revelation from rectified images prepared to date is that a few reefs have been found apparently not plotted in their true relative position on existing charts and maps of the area. Differences of up to half a kilometre have been detected. 5/ This is not a surprising result when the early reef navigation techniques are compared with the advantages of the macro-consolidated view of reefs provided by the LANDSAT satellite.

Water-depth delineation

A further significant development from the LANDSAT/reef research at CSIRO is the ability to determine zones of water depth, particularly those in the range of 0.5-15 m, which are the depths of most interest to GBRMPA. This technique has neither the accuracy nor the resolution to replace the need for hydrographic charting, and it is only effective in clear-water areas. Nevertheless, it will considerably accelerate the perception of which areas of the reef have predominantly shallow water cover and it will allow very rapid and accurate entry of bathymetric data into computers for hydrodynamic studies.

Output of results

At this point in time, the most effective method of presenting the many output results of the rectifications and thematic overlays is to use an Applicon ink jet plotter. This device allows a low-cost colour plot of results. An magnetic tape is generated from the computer rectification/interactive graphic manipulation of each scene which drives the Applicon, itself computer-controlled.

Other considerations

The potential for mapping the various attributes of the reef, sourced from LANDSAT images, is obviously large. Water turbidity, effluent plumes, oil spillages etc. can all be readily integrated into the presentation of output.

Tempering the effectiveness of all the techniques is the pragmatic consideration of obtaining such suitable LANDSAT imagery. The reef by its own disposition is frequently cloud-covered and/or there is a strong, mostly south-east, wing prevailing. The coincidence of suitable conditions for many of the mapping applications of LANDSAT imagery on the reef (that is, calm clear water, clear sky and suitable sun angle) with a satellite overpass has been shown by David Jupp to occur with an expectation of about 7 or 8 times out of a possible 20 a year. Moreover, some of the reef top features of interest are only discernible in LANDSAT data when they are out of water. If the low-tide conditions that this implies are added as a further constraint on LANDSAT imagery, then the expected number of suitable overpasses drops to two or three a year. 6/

CONCLUSIONS

Research on the application of LANDSAT to the Great Barrier Reef has proven it to be a viable method for provision of an effective catalogue of reef features hitherto assembled on a comparatively diminutive scale. The Australian Survey Office has followed through the research to develop it further into a suitable production environment to extend LANDSAT analysis across the entire reef area.

The methods developed to fulfil the basic requirements of GBRMPA are not exclusive in their application to the Great Barrier Reef. They will have many further applications as a general means of regional mapping/analysis for the the purposes of planning. 7/

Notes

1/ "Nomination of the Great Barrier Reef for inclusion in the World Heritage List", prepared by the Great Barrier Reef Marine Park Authority, January 1981.

2/ "LANDSAT looks at the Great Barrier Reef", Ecos, No. 31 (1982), a publication of the Commonwealth Scientific and Industrial Research Organisation, Bureau of Scientific Services, Science Communication Unit.

3/ D. L. B. Jupp and others, "The BRIAN method for large-area inventory and monitoring", Proceedings of the Second Remote Sensing Conference, Canberra, September 1981.

4/ W. Lamond, "The process and problem of producing large scale photomaps of the Great Barrier Reef", Workshop on Remote Sensing on the Great Barrier Reef, Townsville, May 1982.

5/ D. L. B. Jupp, "Rectification of LANDSAT data to cartographic bases with application to the Great Barrier Reef Region", Workshop on Remote Sensing...

6/ D. L. B. Jupp and K. K. Mayo, "The physical basis for remote sensing on the Great Barrier Reef by LANDSAT", Workshop on Remote Sensing...

7/ D. L. B. Jupp and others, "Rectification of LANDSAT data to cartographic bases for the purposes of planning in the Great Barrier Reef Region", paper submitted to the URPIS 10 Conference, Sydney, December 1982.

COMPILATION OF SATELLITE IMAGE MAPS FOR LAND USE*

Paper submitted by China

RESUME

* The original text of this paper appeared as document E/CONF.75/L.61.

L'exposé décrit comment le Département de l'information du Centre national de télédétection chinois établit ses cartes d'occupation des sols à partir d'images satellite en prenant comme référence des cartes topographiques à grande échelle. Ce procédé permet de gagner du temps dans l'établissement des cartes et répond aux besoins de recensement des ressources terrestres.

LANDSAT multispectral images have been imported by China since 1975. Research on the basic theory and technology of remote sensing mapping was begun in 1978. In 1981, the National Remote Sensing Centre (NRSC) was established with three centre-affiliated departments: Department for Technical Training; Department of Research and Development; and Information Department. The Information Department is located in the Research Institute of Surveying and Mapping, National Bureau of Surveying and Mapping. This Department is responsible for collecting and editing nation-wide catalogues of satellite images, importing them from abroad and supplying the information to domestic agencies. Services in micro-storage and automatic retrieval for remotely sensed data, preparation of photomaps in colour, and research and experiment for part of thematic maps are also undertaken by the Department. To date, 63 satellite image maps of nation-wide land use on the scales 1:1,000,000 and 1:2,000,000 have been compiled and published. Satellite image maps for land use at 1:500,000 scale are being prepared. Research and experiment on automatic classification of land use and digital image-processing have been initiated. A system for image micro-storage, automatic retrieval and rapid reproduction was also set up in the Department. Some 30,000 satellite images in various formats have been duplicated and provided to the domestic departments and agencies concerned.

In this paper, only the compilation of satellite image maps for land use is briefly described.

Urgent needs in development of the national economy and current technical conditions have laid the foundation for compiling land use maps from satellite remotely sensed data.

China is a country with a vast territory, diversified natural environment and rich natural resources. For national economic development and construction of modern facilities, it is extremely important to determine the current status of nation-wide land resources.

Nation-wide topographic maps at 1:50,000 and 1:100,000 scales and aerial photographs are available.

According to the practical requirements of the country, with the comprehensive use of satellite remotely sensed images and the existing information of surveying and mapping, research and experiment on the basic theory and technology for satellite remote-sensing mapping are carried out and various types of satellite image maps for land use are produced.

A brief account of the basic method for compiling satellite image maps for land use on the scales 1:500,000 and 1:2,000,000 is given below:

(a) The mapping scale, format size and map projection of satellite image maps for land use are fixed in accordance with the requirements of qualitative analysis and quantitative measurement for land resource inventory. National satellite image maps for land use at 1:2,000,000 scale, with a normal polyconic equal-area projection, are available to national and provincial departments of agricultural planning as a reference for making a comprehensive survey of current situation in the use and distribution of land resource when working out long-term projects in agriculture. Satellite image maps for land use on the scale 1:500,000 are provided to planning agencies at national and provincial levels for the general investigation of current status of land resources. The maps are formatted for individual provinces, each of them independently using a normal polyconic equal-area projection;

(b) The control point co-ordinates for satellite images are measured on 1:50,000 and 1:100,000 large-scale topographic maps, and both the transformation between Gauss projection and normal polyconic equal-area projection and the computation of co-ordinates of graticule intersections in latitude and longitude and marginal points for mapping are made by computers. Then, all these points are plotted onto the same polyester emulsion film as a control base for correction and mosaic of satellite images. After that, the systematic and accidental errors of satellite images are corrected by the optical method and the photo compilations are obtained by mosaicking rectified satellite images. Before the mosaicking of satellite images is completed, the adjustment of contrast in satellite remotely sensed images is made by the masking film method;

(c) The mapping content and representation method are fixed according to the main use of satellite image maps for land use.

On the 1:2,000,000 scale satellite image maps for land use, in addition to the representation of outlined distribution features of 10 ground class elements, the names of main counties, cities and rivers are shown. Ground class elements of these maps are interpreted from satellite images at 1:250,000 scale.

The interpretation of ground class elements for satellite image maps for land use on the scale 1:500,000 and the area measurement are carried out on satellite images at 1:250,000 scale by using visual interpretation and a mathematical satistical method. The other mapping elements are basically selected in accordance with the editorial principles for The Provincial Atlas of the People's Republic of China. The practical interpretation process for ground class elements of the image maps is: first, according to nation-wide different morphological features and land-use units, the site interpretation is made in the field and a typical sampling area is established; secondly, referring to the phenological information for most parts of the country for different times, the office interpretation is made by individual provinces, with eight categories involving colour, shape, structure, slope position, correlation, horizontal distribution, vertical distribution and seasonal variation; lastly, the interpretation classification is checked in the field or with aerial photographic maps.

Practice proves that when the satellite image is highlighted in its most current situation, it provides a great volume of information and abundant content. Multi-date satellite images are advantageous to interpretation classification. In the mapping process, with the comprehensive use of large-scale topographic maps and aerial photographs, not only can the weakness of satellite images be remedied, but the time and expense for obtaining the control points to rectify satellite images can be reduced. Furthermore, a large amount of field-work can be done in office instead. Hence, the production period for compiling satellite image maps for land use may be shortened. Although this effort is only a preliminary attempt to prepare satellite image maps for land use, it is welcomed and appreciated by the departments of resource exploitation and utilization and planning administrations in China.

UTILISATION DU TRASTER POUR LA RESTITUTION DES IMAGES A GEOMETRIE NON CLASSIQUE*

Document présenté par la France

The superiority of analytical equipment over the usual equipment arises from the following characteristics:

(a) A considerable simplification of the mechanics makes it possible, at a reasonable cost, to obtain a major increase in accuracy, with, as a corollary, a gain in productivity, e.g., diminution of the image acquisition scale to that of the plotting scale;

(b) The presence of a fairly powerful calculator and adequate software makes the apparatus more flexible and facilitates its initial adjustment. 1/ In particular, for mapping, it is possible to plot images with non-conic geometry, such as: push-broom satellite imagery (Système probatoire d'observation de la Terre, SPOT); underwater imagery; and panoramic photography.

The modifications made to the MATRA TRASTER software in order to plot the above mentioned types of imagery will be described in the near future.

PROGRAM FOR CREATING AND TILTING MODELS

Each type of geometry requires a specific computer program, written in FORTRAN, which establishes and solves the equations for model formation.

These programs, developed on another computer, can be easily transferred to the SOLAR computer on the TRASTER machine.

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* Le texte original de ce rapport, préparé par M. D. Kirsner, Institut géographique national, a paru sous la cote E/CONF.75/L.72.

For SPOT, the mathematical modelling was carried out and tested 2/ at the Institut géographique national (IGN), using data supplied by the Centre national d'études spatiales (CNES).

For accuracy reasons, the program will be used for forming models based on images that have been subjected to a minimum of geographical deformation since their acquisition, e.g., level-1A images. (Likewise, one prefers plotting original documents rather than duplicates.)

PROGRAMS FOR PILOTING NEGATIVES

Programs for steering negatives were also adapted to unconventional types of geometry.

It should be remembered that a program is responsible for calculating 100 times per second the co-ordinates of a negative as a function of the field co-ordinates modified by the operator using the sphere and cylinder. This makes it possible to have a continuous displacement of the negative holder.

The calculation of the three-variable functions is carried out in real-time for simple functions. For more complex functions, the programs are based on tabulation techniques; they linearly interpolate the co-ordinates of negatives in three-dimensional grids (each of the four co-ordinates is a function of the X, Y and Z field co-ordinates). In order to ensure the linearity of the functions, only the non-conic parts are interpolated, which enables one to reduce the size of the tables to be used.

This method makes the program independent of the geometry and so one can plot all types of images regardless of the complexity of calculating the co-ordinates of the negatives. It will thus be possible to adapt the TRASTER to a new geometry simply by adding a module for forming and tilting the photogrammetric model.

Consequently, at the moment the model is formed, the program calculates the co-ordinates on the negative of points spaced regularly in the field and retains the grid so calculated for later plotting. During the plotting, the program is only required for interpolation, thus leaving the calculator free for other applications.

For SPOT, at 45° latitude the grid has the following intervals in field co-ordinates: 2 km in X; 5 km in Y; 3 km in Z; i.e., 1,200 points for an average scene or a grid of 9,600 bytes.

For more complex applications, the maximum grid size is 2,048 points for a configuration of 128 kilobytes and 6,134 points for 256 kilobytes.

La supériorité des restituteurs analytiques sur les appareils classiques tient à deux caractéristiques de ceux-ci:

a) La simplification très importante de la mécanique permet, pour un prix de revient restant raisonnable, une augmentation substantielle de la précision, avec pour corrolaire un gain de productivité (diminution de l'échelle de prises de vues à échelle de restitution égale, par exemple);

b) D'autre part, la présence d'un calculateur relativement puissant et d'un logiciel adéquat rend l'appareil plus souple et facilite sa mise en oeuvre. 1/ En particulier, pour la cartographie il est possible de restituer des images à géométrie non conique telles que: images de satellite à défilement (type SPOT - Système probatoire d'observation de la Terre); images sous-marines; photographies panoramiques.

Nous allons décrire les modifications qui ont été apportées aux logiciels du TRASTER (de la société MATRA) pour la restitution de ces imageries.

PROGRAMMES DE FORMATION ET BASCULEMENT DU MODELE

Chaque type de géométrie nécessite un programme spécifique, écrit en FORTRAN, qui pose et résoud les équations de formation du modèle.

Des programmes mis au point sur un autre ordinateur sont ainsi facilement transportables sur le SOLAR du TRASTER.

Pour le cas de SPOT la modélisation mathématique a été réalisée et testée 2/ à l'Institut géographique national (IGN) à partir de données fournies par le Centre national d'études spatiales (CNES).

Pour des raisons de précision, les programmes sont prévus pour former le modèle sur des images ayant subi le moins de déformation géométrique après la prise de vue, c'est-à-dire les images de niveau 1A. (De la même façon, on préférera restituer des originaux plutôt que des contretypes.)

PROGRAMMES DE PILOTAGE DES CLICHES

Le programme de pilotage des clichés a été également adapté aux géométries non conventionnelles.

Rappelons qu'il est chargé de calculer 100 fois par seconde les coordonnées cliché en fonction des coordonnées terrain modifiées par l'opérateur à l'aide de la boule et du cylindre, et permet ainsi un déplacement continu des porte-clichés.

Le calcul de ces fonctions de trois variables est réalisable dans les temps pour des fonctions simples. Pour les fonctions plus complexes le programme fait appel à des techniques de tabulation: il interpole linéairement les coordonnées cliché dans une grille tridimensionnelle (chacune des quatre coordonnées est une fonction de X, Y et Z terrain). Pour s'assurer de la linéarité de la fonction, seule la partie non conique est interpolée, ce qui permet d'utiliser des tables de dimension réduite.

Cette méthode rend le programme indépendant de la géométrie et permet de restituter tout type d'image quelle que soit la complexité du calcul des coordonnées cliché. Il sera ainsi possible d'adapter le TRASTER à une nouvelle géométrie en n'ajoutant qu'un module de formation et de basculement du modèle photogrammétrique.

Ainsi au moment de la formation du modèle, le programme calcule les coordonnées cliché de points régulièrement espacés sur le terrain, et sauvegarde la grille ainsi calculée pour les restitutions ultérieures. Pendant la restitution le programme n'a besoin que d'interpoler, laissant ainsi le calculateur libre pour d'autres applications.

Dans le cas de SPOT, à 45 degrés de latitude, la grille a un pas de: 2 km en X terrain, 5 km en Y terrain, 3 km en Z terrain, soient 1 200 points pour une scène moyenne, c'est-à-dire une grille de 9 600 octets.

Pour des applications plus complexes, la taille maximale de la grille est de 2 048 points pour uen configuration de 128 K octets et de 6 134 pour 256 K octets.

Références

1/ Y. Egels et D. Kirsner, "Le logiciel TRASTER de l'Institut géographique national", Bulletin de la Société française de photogrammétrie et de télédétection, vol. 4, bull. 84 (1981), p. 29 à 40.

2/ Voir ci-dessous, Hervé Guichard, "Exploitation cartographique d'un satellite à défilement: application à SPOT".

APPORT DE SPOT A L'ETUDE DU MILIEU URBAIN*

Document présenté par la France

SUMMARY

The Système probatoire d'observation de la Terre (SPOT), the French remote-sensing satellite due to be launched in 1984, will have characteristics that will be valuable for urban studies. Its square pixel, 20 x 20 m in the multispectral mode and 10 x 10 m in the panchromatic mode, will be much more compatible with the size of urban objects than the LANDSAT pixel.

Consequently, it appeared interesting to evaluate the contribution of SPOT imagery to urban studies. In order to be ready for the launching, it was necessary to commence the research immediately

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on imagery simulated above towns that were both characteristic and representative of the current problems facing urban developers.

As a part of the SPOT simulation project carried out in West Africa at the end of 1981, the Institut géographique national became a co-investigator for urban studies on two sites: (a) Dakar, along with the Direction de l'aménagement du territoire and the Faculté des lettres du Sénégal; (b) Niamey, in collaboration with the Direction de l'urbanisme du Niger. Over Dakar city, two 10-m panchromatic flight axes were covered; and over Niamey, two 10-m panchromatic axes and three 20-m multispectral axes were covered.

These sites were selected because of certain specific characteristics of those two cities:

(a) Dakar city has a very strict urban plan made up of quite distinct homogenous districts with well-defined boundaries. Naturally, one selected that city for investigating the SPOT capabilities in urban areas. Consequently, the resolution required was the largest possible, 10 m; and it was preferable to neglect the radiometric aspect in order to gain on the textural aspect;

(b) A master development and town-planning scheme for Niamey was being compiled at the time of the simulations. Consequently, it was very interesting to benefit from the availability of an aircraft to have simultaneous data recording and also to evaluate the contribution SPOT might make to the compilation of such master plans. Two flight axes covered the town itself with 10-m resolution for solving more specific urban problems; and three axes with 20-m resolution in the multispectral mode covered an area nine times that of the city, for analysing urban environment problems.

Le satellite français de télédétection SPOT (Système probatoire d'observation de la Terre), qui doit être lancé en 1984, aura des caractéristiques précieuses pour les études d'urbanisme. En effet, son pixel carré de 20 x 20 m en mode multispectral et de 10 x 10 m en mode panchromatique sera beaucoup plus compatible avec la taille des objets urbains que ne l'était celui de LANDSAT.

Il nous a paru alors très intéressant d'essayer d'évaluer l'apport des images SPOT pour des études d'urbanisme. Afin d'être prêt pour le lancement, il fut nécessaire de commencer l'étude immédiatement sur des images simulées au-dessus de villes, à la fois caractéristiques et représentatives de problèmes courants qui peuvent se poser à l'aménageur urbain.

Dans le cadre de la campagne de simulations SPOT qui a eu lieu en Afrique de l'Ouest à la fin de 1981, l'Institut géographique national (IGN) s'est porté co-investigateur en milieu urbain sur deux sites: Dakar avec la Direction de l'aménagement du territoire et la Faculté des lettres du Sénégal, et Niamey avec la Direction de l'urbanisme du Niger. Sur la ville de Dakar deux axes en panchromatique 10 m ont été réalisés, et sur Niamey deux en panchromatique 10 m et trois en multispectral 20 m.

Le choix de ces simulations s'explique par certaines spécificités de ces deux villes:

a) La ville de Dakar présente un plan urbain très rigoureux, fait de quartiers bien distincts, homogènes et aux limites nettes. Ceci nous a amené tout naturellement à choisir cette ville comme site d'une étude d'appréciation de la finesse de SPOT en milieu urbain. La résolution demandée a donc été la plus fine possible, soit 10 m, préférant négliger l'aspect radiométrique au profit de l'aspect textural;

b) Le schéma directeur d'aménagement et d'urbanisme (SDAU) de Niamey était en cours à l'époque de la simulation. Il a donc paru extrêmement intéressant de profiter de l'opportunité de l'avion dans ce secteur à la fois pour avoir des données simultanées à l'enregistrement et pour apprécier l'apport de SPOT à la réalisation d'un SDAU. Deux axes couvrent la ville elle-même avec une résolution de 10 m, pour résoudre des problèmes plus spécifiquement urbains, et trois avec une résolution de 20 m en multispectral, couvrant une superficie de neuf fois la ville, pour pouvoir faire face à des problèmes d'environnement urbain.

SPECIFICITES ET DIFFERENCES DE SPOT ET LANDSAT

Le milieu urbain a fait l'objet de peu d'études de télédétection par satellites, comparé aux innombrables travaux réalisés dans d'autres domaines, tels que occupation du sol, agronomie, géologie, hydrologie, etc. Les deux raisons principales en sont dans beaucoup de cas la confusion entre les villes et les sols nus, et dans tous les cas la mauvaise résolution des images LANDSAT, dont le pixel de 80 m est incompatible avec la taille standard des objets urbains.

En effet, toutes les tentatives d'utilisation de LANDSAT, ne serait-ce que pour obtenir une carte d'occupation du sol urbaine, ont souvent donné des résultats inférieurs à ceux que l'ont aurait pu obtenir par d'autres moyens. Ainsi les différentes classes d'occupation du sol urbaines n'ont jamais dépassé le nombre de quatre, et sont bien plus souvent au nombre de deux pour une ville moyenne.

Cependant, l'image LANDSAT devient plus intéressante lorsque l'on aborde le problème de l'environnement urbain. Ainsi la limite entre la ville et le non bâti sera, au prix d'un passage en console interactive, facilement appréhendable. De même, les variations de degré de minéralisation sont visibles sur l'image LANDSAT.

En revanche SPOT se révèle extrêmement précis dans le détail des objets urbains. Ainsi la voirie se révèle jusqu'aux voies de dessertes, alors que seules les artères principales sont visibles sur LANDSAT. Les différents quartiers s'individualisent nettement et précisément, et pas seulement en fonction du type de toiture, mais aussi de l'agencement spatial, parfaitement visible sur l'image. Les espaces verts apparaissent jusqu'au niveau du petit square, et il est à espérer que la stéréoscopie donnera des informations sur la hauteur des bâtiments.

CHAMPS D'ACTIONS POSSIBLES

L'image SPOT combinant les aspects positifs d'une photographie aérienne (bonne résolution, choix de "l'émulsion") et d'une image de satellite (moindre coût, possibilités de traitements numériques), le champ de ses applications sera très grand.

La première application à laquelle on peut songer est une simple cartographie de la ville, qui parfois n'existe que de manière très imprécise. Des études sont actuellement en cours à l'IGN pour la réalisation d'un plan urbain à l'aide d'images SPOT. Pour cela, les images en panchromatique 10 m sont les mieux adaptées.

De même une étude d'occupation du sol verra son nombre de classes croître pour atteindre la précision de l'îlot, voire même mieux dans certains cas. Ainsi à Dakar, la zone industrielle est nettement différentiable du reste de la ville. De plus, certains sous-quartiers de zones d'HLM (habitations à loyer modéré) sont individualisables. A Niamey, les quartiers nouveaux construits ont pu être séparés de ceux en construction. On peut aussi étudier et cartographier certains paramètres d'environnement comme la quantité de biomasse, paramètre indispensable tant pour l'analyse urbaine instantanée que pour des prévisions futures.

Les études d'évolution bénéficieront de l'aspect multi-temporel de l'imagerie spatiale, avec bien sûr un degré de précision plus grand. L'évolution du schéma urbain pourra être apprecié tant sur le plan du contenu des îlots ou quartiers, que sur celui de l'extension spatiale proprement dite.

L'un des domaines ou l'image SPOT sera la plus utile est celui des études projectives. En effet, la visualisation de la ville et de son environnement proche permettra à l'aménageur de voir l'impact de différentes réalisations sur certains paramètres écologiques ou économiques (comme justement le degré de verdurisation). Il sera possible de visualiser l'évolution urbaine future, donc d'assurer une meilleure planification à moyen et à long terme.

TRAITEMENTS

Les algorithmes de traitement actuellement existants, et utilisés pour les images LANDSAT, se révèlent malheureusement pour la plupart inefficaces pour le traitement des images SPOT. En effet, l'image LANDSAT, comme nous l'avons dit, permet une séparation en peu de classes; cependant, elle offre l'avantage d'effectuer dès la saisie des données une généralisation cartographique, ce qui est ce que l'on cherche dans la plupart des cas à obtenir. En revanche les images SPOT, qui sont beaucoup plus précises, perdent cette généralisation. C'est ainsi, par exemple, qu'une usine et sa cour peuvent apparaître comme quelques pixels ne se rattachant à aucun centre de classe fortement représenté, mais dont l'information demande quand même à être traitée. Nous pourrions multiplier de tels exemples à l'infini, il suffit de regarder une simulation SPOT pour s'en convaincre.

C'est ainsi que les critères d'identification et de classification devront être basés sur l'étude des textures de l'image autant que sur l'étude purement radiométrique. Ou, en d'autres termes, l'image devra être photo-

interprétée afin de dégager toute l'information qu'elle contient. Ceci se fera éventuellement sans l'aide d'un ordinateur, lorsque les algorithmes ne sont pas encore implantés, mais lorsqu'on désirera un traitement automatique il faudra reprogrammer une grande partie des mécanismes du photointerprété pour obtenir des résultats satisfaisants.

Cependant, il faut bien se garder de désirer un automatisme intégral. Ainsi certains traitements sont plus rapides visuellement qu'à la machine (bien que le progrès technologique en informatique risque de rendre cette affirmation vite périmée). Il faut alors concevoir le traitement dans le sens d'une plus grande interactivité entre l'interprète et la machine, qui sera là comme élément de calcul et d'aide à l'interprétation. Par exemple un découpage en quartiers homogènes, qui est actuellement rapide visuellement ne l'est pas encore automatiquement. On pourrait alors concevoir un traitement interactif, où le découpage initial serait rentré par l'interprète, chargé à la machine d'effectuer le calcul des paramètres à l'intérieur de la zone ainsi crée. On ferait alors de la "photo-interprétation assistée par ordinateur".

CONCLUSION

L'image SPOT est dans la logique du besoin de précision accru que réclame l'observation urbaine depuis l'espace. Actuellement, même si elle ne répond pas à toutes les exigences des urbanistes (on ne pourra pas utiliser les images pour travailler à l'échelle du 1:5 000), la richesse d'information satisfera beaucoup de décideurs. Il est déjà sûr que SPOT n'est pas LANDSAT en plus fin, SPOT est autre chose, et qui ouvre la porte de l'imagerie spatiale urbaine.

UTILISATION DE LA THERMOGRAPHIE AEROPORTEE EN MILIEU LITTORAL*

Document présenté par la France

SUMMARY

The acquisition of thermal data by airborne remote-sensing equipment, in conjunction with sample thermometer measurements on the ground, make it possible to obtain, after expert interpretation, valuable information on the surface temperatures of homogeneous zones, such as water. For this reason, thermal imagery is used for studying and monitoring littoral aquatic zones, which are quite sensitive and change as the result of numerous activities carried out there, e.g., development, tourism, industry and fishing.

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In a more general manner, remote sensing applied to water resource studies was considered one of the four main operational themes of the Interministerial Remote Sensing Operation (OPIT), which is proof of the importance of this problem, both at the national level and throughout the world. Linked to development in most of its aspects (food, industry, urban etc.), the water problem concerns many countries, developed or being developed, including those with vast arid zones.

After the first significant experiments, thermal remote sensing arrived a few years ago at the operational stage, as is demonstrated, among others, by the operations regularly carried out by the Institut géographique national at the request of major French public or industrial organizations, such as Electricité de France (EDF), certain technical services in large cities and even some other Governments.

After a summary of the basic principles of thermal imagery operations and their interpretation, two types of current applications, the search for fresh water springs in the sea near the coastline and the monitoring of discharges from EDF thermal generating stations, whether nuclear or not, are briefly described.

L'acquisition de données thermiques par télédétection aéroportée, conjointement à l'échantillonnage thermométrique au sol, permet d'obtenir, après interprétation par un spécialiste, des informations précieuses sur la température de surface de milieux homogènes, tels que l'eau. D'où l'application de la thermographie à l'étude et à la surveillance du milieu aquatique littoral, particulièrement sensible et évolutif du fait des activités nombreuses qui s'y exercent: aménagement, tourisme, industrie, pêche etc.

D'une manière plus générale, la télédétection appliquée à l'étude des ressources en eau a été considérée comme l'un des quatre thèmes principaux de travail de l'OPIT (Opération interministérielle de télédétection) - preuve de l'importance, à l'échelle nationale comme à l'échelle mondiale, de ce problème. Lié au développement sous la plupart de ses aspects (alimentaire, industriel, urbain), le problème de l'eau concerne de nombreux pays, parmi lesquels, bien entendu, ceux comportant de vastes zones arides, qu'ils soient développés ou en voie de l'être.

Passé les premières expérimentations significatives, la télédétection thermographique est parvenue depuis plusieurs années à un stade opérationnel, comme le démontrent, entre autres, les opérations régulièrement pratiquées par l'Institut géographique national (IGN) à la demande de certains grands organismes publics, administratifs ou industriels, tels que Electricité de France (EDF), certains services techniques de villes, voire certains ministères étrangers.

PRINCIPE DE LA THERMOGRAPHIE

Tout corps est émetteur d'énergie, sous forme d'onde électromagnétique. Pour un corps donné, cette émission dépend de nombreux paramètres, dont la température. D'où la possibilité, en effectuant une mesure d'énergie, d'obtenir à distance la température d'un corps. Il faut effectuer la mesure aux longueurs d'onde correspondantes à l'émission la plus forte, pour obtenir le meilleur pouvoir séparateur. Aux températures terrestres, ce maximum se situe entre 3 et 14μ, dans la bande dite infra-rouge thermique (qu'il ne faut pas confondre avec l'infra-rouge proche, entre 0,7 et 1,3μ, près du visible), mais il se rapproche du visible lorsque la température augmente (c'est ainsi qu'un métal devient rouge lorsqu'on le chauffe à une certaine température). Comme l'atmosphère absorbe les rayonnements compris entre 5 et 8μ, il y a deux gammes de longueurs d'onde utilisables: 3 à 5μ et 8 à 14μ; c'est la seconde qui donne le meilleur pouvoir séparateur, et qui est utilisée lorsque l'on veut faire du quantitatif aux températures normales.

Cependant ce n'est pas exactement la température qui est mesurée, mais une énergie. La relation entre les deux est assez complexe, et très mal modélisée. Elle dépend de facteurs aussi variés que le matériau émissif, la longueur d'onde considérée, la température, l'état de rugosité de la surface, la direction d'émission. Il existe donc un facteur, l'émissivité, rapport entre l'énergie réellement émise et celle émise par un corps théorique appelé corps noir, à la même température, qui prend en compte ces divers paramètres. Le corps noir étant par définition celui qui émet le maximum d'énergie, l'émissivité est donc un facteur compris entre 0 et 1.

LES MATERIELS UTILISES

A partir d'un détecteur thermique, la formation de l'image thermique se fait par balayage (technique consistant à découper ce que l'on thermographie en d'étroites bandes parallèles), qu'il soit double (caméra thermographique) ou simple (scanneur). Dans ce dernier cas, la progression de l'appareil perpendiculairement au balayage formera l'image. C'est pour deux aspects complémentaires de la thermographie que sont utilisés ces instruments. La caméra présente les avantages d'une grande maniabilité, et d'un faible coût, alors que le scanneur permet d'obtenir une image homogène d'une zone de vastes dimensions très rapidement.

Nous dirons peu de choses sur les caméras, n'en utilisant pas à l'IGN. Elles sont essentiellement utilisées pour résoudre un certain nombre de problèmes industriels, comme le contrôle de revêtement de four, la recherche de défauts dans les cheminées, les conduites, les vannes, des isolants électriques défectueux, ou aussi des problèmes d'habitat, recherche de défauts d'isolation, manque d'étanchéité, recherche d'anciennes structures etc.

En revanche, L'IGN possède un scanneur depuis une dizaine d'années. Celui actuellement utilisé est un scanneur de marque Daedalus. Il est constitué d'un détecteur sensible dans la gamme 8 à 14μ dont la sensibilité est de 0,2^{o} C, de deux corps noirs de référence qui sont réglés à deux températures, une haute et une basse, d'un miroir tournant qui balaye le terrain sur

88°, et qui se calibre à chaque tour sur les corps situés l'un en début l'autre en fin de balayage, d'une électronique interne et d'un écran vidéo sur lequel le signal s'inscrit, permettant quelques réglagles électroniques. Le signal est ensuite enregistré de manière analogique sur une bande magnétique. Cette bande est ensuite restituée sur un film photographique 70 mm dont sont tirées des épreuves papier. Conventionnellement à l'IGN, les températures croissantes sont représentées du blanc vers le noir. Ce matériel est embarqué à bord d'un aéronef qui est différent selon les opérations réalisées. A l'IGN jusqu'à présent l'hélicoptère Alouette III, l'Aérocommandeur et le Hurel-Dubois ont été utilisés comme vecteur aérien pour des opérations thermographiques.

Signalons aussi que certains satellites sont équipés de détecteurs thermiques. C'est le cas de SEASAT 1, de Nimbus 7, Tiros N et METEOSAT, avec des résolutions variant entre 800 m et 7 km. Leur utilisation est essentiellement liée à des problèmes météorologiques ou océaniques, tels que l'aide à la pêche au thon, dans le golfe de Guinée (repérage des fronts thermiques, localisations préférentielles des bancs de thons, - application développée par le Centre national d'études spatiales (CNES), l'Office de la recherche scientifique et technique outre-mer (ORSTOM) et la Météo nationale).

Nous allons maintenant passer en revue des deux types d'applications courantes: la recherche de sources d'eau douce sous-marines, et la surveillance des rejets thermiques industriels.

LA RECHERCHE DE SOURCES D'EAU DOUCE LITTORALES

Appliquée aux problèmes aquatiques, la thermographie s'affranchit en grande partie du problème de l'émissivité: en effet, l'eau a une émissivité pratiquement constante et voisine de un.

L'application liée aux résurgences d'eau douce en mer utilise le fait qu'un rejet est rarement à la même température que le milieu dans lequel il s'écoule. D'où des anomalies thermiques plus ou moins visibles sur les thermographies, et dont le sens peut d'ailleurs varier suivant les saisons.

Une préparation soigneuse, et surtout une mission très complète sur le terrain, sont indispensables pour mener à bien les opérations. La préparation consiste principalement à étudier sur le plan géologique la région concernée, à l'aide de tous les documents disponibles (cartes, photos aériennes, iamges-satellite), de façon à limiter l'enregistrement thermographique et l'investigation aux zones favorables.

L'enregistrement proprement dit nécessite de nombreuses précautions quant au choix de la période et des conditions opératoires: saison favorisant les contrastes thermiques, période de fort débit probable des résurgences, marée étale, absence de houle et de vent. La mission de terrain consiste essentiellement à mesurer in-situ la température de l'eau et son degré de salinité.

En même temps il est évidemment nécessaire de localiser toutes les anomalies et de les reporter sur un document cartographique. Des enquêtes beaucoup plus poussées sur les anomalies les plus fortes permettront ensuite de procéder à l'évaluation et à l'explotiation, le cas-échéant, de celles-ci.

Les réalisations de l'IGN dans ce domaine peuvent se résumer de la façon suivante:

a) En 1971, une campagne thermographique dans la région du Havre a été entreprise, après une étude géologique ayant montré que le système des accidents géologiques orientait le cheminement de type Karstique des eaux continentales vers une certaine zone littorale, assez éloignée, en laquelle la détection des sources n'était d'ailleurs pas aisée, beaucoup de résurgences étant constituées d'eau de mer. La thermographie de cette zone a permis de distinguer sur l'estran à marée basse une trentaine de sources d'eau douce dont le débit allait jusqu'à 120 000 m^3 par jour.

b) En 1975, des études de pollution faites sur le littoral méditerranéen (région Fos-Marseille) ont mis en évidence un certain nombre de résurgences d'eau douces parmi les très nombreux rejets ou apports d'eaux continentales (fleuves, canaux, étangs, usines). C'est le cas notamment pour les sources sulfureuses de l'anse d'Arnette, et surtout pour les résurgences froides observées dans les calanques des environs de Cassis.

c) En 1976-1977, une importante campagne thermographique a été menée au Maroc à la demande du Ministère des travaux publics (Direction de l'hydraulique), à la fois sur le littoral méditerranéen et sur le littoral atlantique. Deux séries de thermographies ont été menées, l'une à petite échelle (1:80 000) pour les deux niveaux de marée, l'autre à moyenne échelle (1:30 000) à marée basse, le choix des périmètres de cette seconde investigation ayant été orienté par le dépouillement de la première mission au 1:80 000. Précédée d'une étude des conditions thermiques locales et de l'interprétation complète des thermographies, les missions sur le terrain ont permis de détecter de nombreux indices de résurgences d'eau douce, situées en général soit en bordure de massifs cristallins très fracturés (par suite d'une activité volcanique) comme à Arkount, soit en bordure de massifs sédimentaires dotés de circuits Karstiques importants, comme à Tiznit. Au total une cinquantaine de points d'eau ont pu être mis en évidence, parfois regroupés en trois ou quatre secteurs particuliers. Il est à noter que les conditions météorologiques précédant l'investigation jouent un grand rôle dans les résultats de celle-ci. Ainsi, des inondations s'étant produites dans l'arrière-pays, de nombreuses présences d'eau douce ont été trouvées en bord de mer, toutes n'étant pas pour autant des résurgences à caractère permanent. D'où la nécessité déjà signalée d'explorer et d'évaluer soigneusement les phénomènes découverts (débit, permanence, localisation) préalablement à toute exploitation.

d) En 1978, un enregistrement thermographique a été réalisé sur le cours du Doubs afin d'y détecter des résurgences sous-fluviales ou affluentes. Accompagnée d'une solide étude géologique et d'une photo-interprétation morphologique, la thermographie (effectuée par hélicoptère, cette fois) a permis de relever de nombreux indices de sources affluentes (résurgences au niveau du Doubs), mais par contre aucun indice de résurgence sous-fluviale: il semble que le débit du fleuve à cette époque de l'année (mars) ait été trop important, masquant du même coup les eaux résurgentes et entraînées par le courant.

e) En 1981, une mission de télédétection par thermographie a été exécutée aux îles du Cap-Vert afin de chercher, au voisinage des côtes, d'eventuelles résurgences sous-marines: le problème des ressources en eau est fondamental

sur ces îles volcaniques où certaines terres pourraient être mises en culture grâce à une irrigation plus poussée. Réalisées sur 8 des 10 îles que compte l'archipel (les deux autres îles n'ayant pu traitées faute d'une météo favorable), les thermographies enregistrées après une longue préparation de la mission ont permis de repérer une soixantaine d'anomalies thermiques liées à des sources d'eau douce sous-marine, ainsi qu'une trentaine d'autres, identifiées avec moins de certitude. Des travaux d'interprétation sont en cours et une nouvelle mission sera peut-être conduite en 1982 pour préciser les résultats obtenus. L'enregistrement a eu lieu à une altitude de 2 700 m environ, tandis que les mesures au sol étaient faites quasi-simultanément, à l'aide d'un analyseur multi-paramètres (PH, température, oxygène, dissous, conductivité et turbidité) et d'un salinomètre. La principale difficulté a résidé dans les perturbations causées par les vents violents et fréquents dans cette région, qui rendent inopérantes toute tentative d'enregistrer le rayonnement thermique émis par la surface de la mer.

On voit d'après ces exemples l'apport original et efficace que peut assurer la thermographie pour la recherche de nouvelles ressources en eau. Ces caractéristiques d'efficacité et d'aptitude à traiter de vastes étendues se retrouvent dans les autres domaines d'application, celui de la détection des rejets thermiques (d'origine industrielle ou non) en mer.

DETECTION DES REJETS THERMIQUES EN MER

La principale application, couramment utilisée, est celle de la détection des rejets de centrales électriques, menée conjointement par Electricité de France et l'IGN. Il s'agit de localiser et de caractériser le panache thermique dans sa forme et ses dimensions, ainsi que dans son évolution: en mer ou dans les estuaires les conditions varient évidemment constamment, et l'évaluation doit être faite aux quatre états caractéristiques de marée: haute, basse, flot et jusant.

Cette évaluation doit également être faite à différentes époques correspondant aux étapes-clés de la mise en service et du fonctionnement des centrales: état initial avant le démarrage; état après le démarrage de chaque tranche; suivi régulier jusqu'à la stabilisation de la tache thermique, lorsque la centrale a atteint son taux de production nominal. Cette nécessité conduit à mener les opérations en été comme en hiver (dans ce dernier cas, on est parfois confronté à des difficultés liées aux conditions météorologiques.

Dans ce contexte, la complémentarité de la méthode thermographique aéroportée avec les mesures thermométriques au sol apparaît comme particulièrement fructueuse: la thermographie traduit la répartition des températures à la surface de la mer, d'une manière globale et simultanée sur l'ensemble de la zone; les mesures au sol, quant à elles, permettent d'avoir des valeurs de température ponctuelles, tant en surface (ce qui permet d'étalonner l'image thermographique) qu'en profondeur (ce qui peut permettre de mieux définir le volume du panache). Il est ainsi possible de comparer, lors de la mise en service des centrales, le panache observé et le panache théorique prévu par les spécialistes selon les modèles hydrauliques calculés. En six ans, quelque 25 opérations ont été ainsi réalisées par IGN et EDF, tant sur le littoral que sur des sites fluviaux. Ces opérations comprennent une partie terrain qui

comporte, autre la thermographie proprement dite, un certain nombre de mesures in-situ (température, courantologie, topométrie pour la localisation de ces mesures elles-mêmes). Il a été fréquemment fait usage de bouées chauffantes qui, destinées à être visibles sur les thermographies, sont localisées grâce à des mesures topométriques à partir de la côte, et sont également utilisés comme points de repère au voisinage desquels les relevés de température et de courants sont pratiqués. On utilise de préférence, depuis peu, une localisation par radar installé à bord du bateau qui exécute les mesures.

Les opérations comportent également une partie en atelier, qui consiste en un tracé d'isothermes (par voie plus ou moins automatisée suivant les cas de figure: en général réalisation automatique d'équidensités correspondant aux isothermes ou tracé à l'aide d'un densitomètre dans les cas simples où la thermographie est assez homogène). Ces isothermes (de 0,25 en 0,25° C - de 0,5 en 0,5° C ou de degré en degré C) sont reportées sur un fond de plan mis à jour pour la circonstance.

Ces résultats ont été vérifiés dans certains cas par comparaison aux enregistrements de thermographes qui n'avaient pas été pris en compte pour le calage en température de la thermographie (neuf thermographes sur le site de Gravelines).

Comme nous l'avons signalé précédemment, le succès d'une opération est fortement conditionné par la météorologie, les périodes de passage du vecteur devant avoir lieu à des périodes bien définies (fort coefficient de marée, passages successifs à quatre périodes de la marée, vent faible). Dans ces conditions, la souplesse de l'hélicoptère s'est avérée particulièrement fructueuse car elle permet au dernier moment des modifications du plan de vol pour profiter d'une éclaircie ou passer sous le plafond de nuages. Dans le cas présent, il s'agissait de l'hélicoptère Alouette III de l'IGN, spécialement équipée pour la photographie aérienne verticale, oblique et la thermographie.

On se doit de signaler pour terminer que l'utilisation de la thermographie n'est pas limitée à ces opérations périodiques et strictement localisées. D'autres inventaires de rejets, industriels et urbains, ont été réalisés en 1976-1978 sur les côtes de la Manche et de l'Atlantique, sur près de 2 000 km, à la demande du Ministère de l'environnement et du cadre de vie (Direction de la prévention des pollutions et nuisances - Service des problèmes de la mer). Dans un autre domaine, celui des pollutions accidentelles, la thermographie a été également utilisée, conjointement à la photographie aérienne classique, après le naufrage de l'Amoco Cadiz: si la photographie permet un suivi correct des nappes et une étude de la pollution du littoral, l'apport spécifique de la thermographie intervient dans l'évaluation de l'épaisseur des nappes dérivantes, point très important pour coordonner les opérations de lutte contre la pollution.

Concluons en soulignant le caractère récent de la thermographie et la probabilité pour que de nouvelles applications, liées à de nouvelles technologies, se développent en grand nombre à partir de ce paramètre invisible que nous commençons tout juste à découvrir: la température de notre sol.

L'INVENTAIRE DU LITTORAL - FRANCE*

Document présenté par la France

SUMMARY

The production of inventory mapping requires the collection of a considerable amount of data. Digitizing those data and using powerful computer procedures open new perspectives for using thematic cartography.

The Institut géographique national has developed a cartographic processing chain whose major assets are the constitution of files and the use of an automatic plotter. That chain was constructed, in particular, for producing an inventory of the littoral showing both land use and land legal status. Hand-drawn documents are produced in the normal manner either by interpreting aerial photographs (land use) or based on data collected from local authorities (legal status).

The outlines of zones and administrative boundaries are digitized by scanning equipment and coding is carried out in an interactive manner.

The area symbols and screens are generated by automatic plotting in order to produce the films required for offset printing. Thematic files are crossed with administrative files in order to produce statistical data banks.

New products can be produced from such digital data, for example: (a) synthesis-derived maps; (b) maps produced crossing several themes; (c) statistical calculations. As the programme will be repeated every five years, il will be possible to update the files and automatically compile evolution maps.

Au long de ses 5 000 kilomètres, le littoral français voit se dérouler une succession de paysages variés à vocation agricole, touristique ou industrielle: côte rocheuse sauvage, prairies, forêts, longues plages sableuses, deltas marécageux, ports. Il est donc l'objet d'enjeux économiques importants de la part d'intérêts et de groupes de pression multiples. La cartographie du littoral est destinée à mieux faire connaître cette zone sensible afin de guider la politique des pouvoirs publics et de faciliter la négociation entre partenaires.

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* Le texte original de ce rapport, préparé par J.-P. Grelot, Institut géographique national, a paru sous la cote E/CONF.75/L.75.

Pour que cet inventaire ne soit pas seulement une image historique mais devienne un réel outil d'aménagement, il lui a été donné un aspect dynamique par la prise en compte de l'évolution de l'occupation du sol et par la mise en évidence des relations entre l'utilisation théorique de l'espace, traduite par la législation, et son affectation réelle que l'on peut observer sur une couverture photographique. Le bénéfice que l'on est en droit d'attendre de techniques de cartographie automatique apparaît ici clairement: en faisant passer le processus de rédaction par la constitution de fichiers, on engrange les données sous une forme qui, tout en assurant leur parfaite conservation, permet leur utilisation dans les meilleures conditions. Encore faut-il que les techniques employées se révèlent suffisamment efficaces pour traiter ce type de cartographie, sur le plan graphique comme en termes de coûts et de délais.

LES DONNEES

Se limitant à une bande côtière d'une largeur d'enviorn 5 km, la cartographie d'inventaire du littoral porte sur deux aspects:

a) L'usage du sol (147 coupures grand format au 1:25 000), situation présente observable;

b) Le statut du sol (23 coupures au 1:100 000) qui doit orienter l'utilisation présente et future de l'espace.

L'usage du sol

L'usage du sol est obtenu, pour la partie terrestre, par une photo-interprétation à moyenne échelle réalisée par l'Institut géographique national (IGN). Les principales rubriques de la légende de cette carte différencient l'espace urbian, l'espace agricole et naturel, l'espace linéaire côtier. Les renseignements pour la partie maritime sont collectés auprès des administrations locales: ils portent sur les cultures marines et les richesses naturelles exploitées ou à protéger.

Le statut du sol

Le statut du sol est également établi à l'aide de données fournies par les administrations locales. Il a deux composantes:

a) La vocation juridique du sol résultant des documents d'urbanisme, des réglementations forestières, des parcs nationaux, réserves naturelles, sites naturels et monuments classés ou inscrits, et du statut de la mer;

b) La maîtrise foncière opérée par les propriétés publiques.

LE PROCESSUS DE REDACTION CARTOGRAPHIQUE

La numérisation

La numérisation des données se fait en deux étapes. La maquette de contours, reprise en tracé sur couche et orientée selon le système Lambert, est analysée automatiquement par un scanneur à balayage. Le fichier maillé ainsi obtenu est traité de manière à squelettiser les contours et corriger les imperfections puis à attribuer un code commun à tous les points d'une même unité. On obtient un fichier informatique que l'on peut qualifier de "géographique".

On procède alors à la codification des informations thématiques: il s'agit simplement d'établir une correspondance entre chaque unité et le code thématique fourni par la maquette, puis de transcrire ce résultat sur un support informatique, sorte de fichier "statistique". Cette codification est réalisée interactivement au moyen d'une table à numériser par pointé à l'intérieur de la parcelle; un double codage permet d'éliminer les erreurs. L'ensemble de ces informations constitue une base de données de l'espace littoral.

La légende

La mise au point de la légende, dans sa représentation graphique, a été faite en respectant deux contraintes: automatiser le plus grand nombre possible de phases de réalisation, de manière à réduire les interventions manuelles, donc les délais et les coûts; assurer une cartographie de très grande qualité tout en restant en quadrichromie, toujours pour des considérations économiques.

Les poncifs ont été dessinés au moyen d'une console interactive couleurs et constituent une bibliothèque; la typographie commune à toutes les cartes de la série (titres et sous-titres) a été numérisée à l'aide du scanneur, pour compléter un fichier comportant la légende.

La sortie des typons

La sortie des typons de la quadrichromie se fait en traitant simultanément le fichier "géographique" et le fichier "statistique", puis en mettant en place, par programme, les poncifs de la bibliothèque et en adjoignant enfin le fichier de légende. Les poncifs et les trames sont générés sur films par un appareil automatique de restitution à laser, de manière à fournir les planches de noir, cyan, magenta et jaune sur lesquels interviennent éventuellement des compléments de rédaction manuelle: ajout de symboles ponctuels, des éléments de légende propres à chaque carte, puis intégration du fond plani-oro-hydrographique. Une épreuve d'essai est réalisée par procédé Cromalin pour permettre un contrôle avant l'impression en quadrichromie.

LES PRODUITS DE BASE

Le résultat de ce processus est visualisé sous deux formes: des séries de cartes, accompagnées de tableaux de données statistiques.

Les cartes

L'outil de base est la carte d'usage du sol, dont la légende fait apparaître immédiatement les deux niveaux de lecture. Au premier regard, le lecteur différencie les espaces urbains (tous vifs et saturés, poncifs géométriques), les espaces agricoles (teintes fraîches, poncifs lâches), les espaces naturels (teintes terreuses), le linéaire côtier (poncifs noirs), l'espace aquatique (sur la teinte bleue de l'hydrographie, poncifs figuratifs en cyan pour les cultures et les exploitations et en magenta pour les richesses à protéger). A l'intérieur de chacun de ces ensembles, un examen plus détaillé (deuxième niveau de lecture) permet de retrouver chaque poste de la légende.

Sur le plan technique, les seuls éléments ajoutés manuellement sur cette carte sont les symboles ponctuels du magenta (rejets, mitage), l'endigage, le nom de la feuille, les noms et limites de communes sur la planche de noir; il est d'ailleurs envisagé de numériser ces éléments afin de les restituer automatiquement. Les contours de zones de la photo-interprétation, les écritures de la légende ainsi que les amorces kilométriques sont générés automatiquement sur la même planche aur les poncifs noirs.

Les cartes figurant le statut du sol sont à certains égards plus complexes, car de nombreux thèmes viennent se superposer. La base en est la carte de vocation juridique qui comporte les documents d'urbanisme traduits par des teintes rappelant l'usage du sol (espaces voués à l'urbanisation, à l'agriculture, zones naturelles), un thème forestier en poncifs magenta (interdiction de défrichement, forêt de protection, périmètre de défense de la forêt contre l'incendie), la protection des sites en poncifs noirs (parcs, réserves, sites classés ou inscrits), le statut de la mer en poncifs magenta ou cyan. Elle est complétée par une carte de maîtrise foncière monochrome utilisant des trames et des poncifs; des symboles ponctuels sont ajoutés manuellement pour les emprises linéaires et les propriétés de taille réduite.

Pour établir une première comparaison entre le statut et l'usage du sol, une carte résumée de l'usage est également produite. La réduction d'échelle du 1:25 000 au 1:100 000, le regroupement des thèmes de l'usage en sept classes (zones urbaines, zones agricoles, zones naturelles, terrains boisés, zones humides, cultures marines et richesses naturelles) et l'assemblage de 3 à 8 coupures au 1:25 000 pour chaque feuille au 1:100 000 s'opèrent automatiquement par un ensemble de programmes, de sorte que la planche thématique de poncifs monochromes est produite directement sans opération de photogravure.

Les statistiques

Le second type de documents fournis de manière systématique est une fiche de statistiques communales. Aux données de population et de logement issues des recensements généraux de 1968 et 1975, on ajoute les emprises totales des thèmes pour chaque commune en distingant trois degrés géographiques de sensibilité: le cordon littoral proprement dit, qui s'étend depuis la côte jusqu'à une profondeur de 2 kilomètres, une zone moins sensible de 2 à 5 kilomètres et l'arrière-pays au delà de 5 kilomètres. Ces résultats sont obtenus par croisement informatique des planches de contours numérisées et des fichiers de limites communales. Les surfaces sont éditées en hectares.

LES PRODUTIS DERIVES

La richesse du processus mis en oeuvre vient directement de la constitution de fichiers, et particulièrement de fichiers en mode maillé. Outre que les données recueillies sont conservées en parfait état, toute l'information portée sur la carte imprimée est immédiatement exploitable pour aboutir soit à une nouvelle carte thématique, soit à des résultats statistiques. De plus, les moyens techniques utilisés permettent, tout en restant en quadrichromie, une extrême variété de choix de teintes ou de symboles, en conservant une qualité graphique qui dépasse celle des meilleures réalisations traditionnelles. Enfin, l'échelle d'édition peut être choisie à volonté et des assemblages de cartes contiguës réalisés très rapidement.

Les sorties cartographiques

Un certain nombre d'essais d'exploitation des fichiers ont été menés à ce jour. Ainsi, on a pu opérer la sélection d'un thème ou d'un groupe de thèmes, en l'associant à l'assemblage de plusieurs coupures et à un changement d'échelle; ceci permet la mise en évidence d'un phénomène particulier ou la présentation d'une description synthétique de l'espace sur une vaste zone couvrant plusieurs feuilles du découpage initial. Par croisement de thèmes en provenance de cartes éditées à la même échelle ou à des échelles différentes, l'un des thèmes agissant comme un masque sélectif vis-à-vis de l'autre, on visualise les interactions entre différents phénomènes tels la législation et l'usage réel. On a pu étudier ainsi le degré de protection des espaces naturels face à une urbanisation diffuse liée au développement touristique.

Les exploitations statistiques

Une autre classe de produits est constituée par des sorties purement statistiques. Celles-ci peuvent être l'équivalent, dans le domaine statistique, des documents cartographiques décrits précédemment, mais on peut y ajouter:

a) Des calculs de ratio en vue de déterminer une typologie des communes ou de régions naturelles selon un ensemble de critères (vocation touristique, agricole ou industrielle);

b) L'intégration de données en provenance d'autres fichiers nationaux français comme les recensements généraux de la population ou de l'agriculture, l'inventaire des équipements et services communaux, le fichier de la construction, le fichier des entreprises et des établissements, etc.

On construit ainsi une base de données statistiques communales dont les différentes composantes s'enrichissent mutuellement pour concourir à une meilleure connaissance du littoral et un meilleur suivi de son évolution.

LA MISE A JOUR

La reconduction du programme est prévue selon un rythme quinquennal.

Cette option a conduit à intégrer l'aspect mis à jour dès la conception de la chaîne de production de l'état de référence, issu d'une couverture photographique aérienne réalisée en 1977.

Pour la seconde génération, le photo-interprète disposera de la carte de référence et de la mission photographique de l'été 1982. La maquette de photo-interprétation sera établie sur un fond comportant la topographie et les contours des zones initiales: seules seront dessinées les zones ayant subi des modifications entre les deux prises de vues, que ce soit dans leur définition géométrique ou dans leur contenu thématique. Le travail de rédaction sera donc considérablement allégé. Cette maquette sera numérisée de la même façon que dans le processus initial, et la mise à jour sera faite par un processus entièrement informatique. On disposera alors de deux fichiers de l'usage du sol, l'un à la date de référence, l'autre correspondant à l'état actuel. On pourra alors établir une carte à jour ainsi que des cartes d'évolution.

Le nombre de thèmes exclut de représenter toutes les évolutions sur une carte unique; certaines sont d'ailleurs par nature impossibles ou peu significatives. Mais l'avantage de la filière numérique associée à la cartographie en mode maillé est de pouvoir dresser automatiquement ces cartes d'évolution sans nécessiter une nouvelle interprétation par comparaison des deux états et une nouvelle rédaction pour chaque type de carte d'évolution: le gain de temps et de coût est appréciable. Par ailleurs, tous les calculs statistiques peuvent être effectués, soit en pourcentages globaux, soit plus finement en calculant la matrice des évolutions. Ces résultats, totalement impossibles à obtenir avec une cartographie classique manuelle, peuvent guider le choix des cartes d'évolution à établir.

CONCLUSION

Cette grande opération que constitue l'inventaire du littoral s'inscrit dans une étape décisive de la cartographie thématique. Les cartes éditées assurent deux fonctions essentielles: une fonction de synthèse, de rassemblement des connaissances à un moment donné, qui intéresse surtout les techniciens, et une fonction didactique de transmission de l'information par l'image auprès d'un public plus large comprenant les décideurs, les politiques, les aménageurs, les enseignants et toute personne préoccupée par le devenir de l'espace littoral.

Mais le cartographe n'apparaît plus exclusivement auteur et producteur d'une carte: cette carte est désormais utilisation particulière d'un fichier ou d'un ensemble de fichiers à travers un logiciel, et le cartographe doit devenir informaticien pour concevoir et développer ces fichiers et ces logiciels pour tirer le meilleur parti de la masse de données enregistrées. Et si le document de référence, celui qui contient toutes les données, n'est plus la carte mais un fichier numérique, la puissance de l'informatique et des automatismes est mise à la disposition du cartographe qui peut réaliser rapidement des sorties multiples et variées faisant appel à des modes de représentation aussi élaborés qu'il le souhaite.

TELEDETECTION PAR SATELLITE ET CARTOGRAPHIE AUTOMATIQUE*

Document présenté par la France

SUMMARY

The systematic acquisition in digital form of spatial imagery concerning large areas makes it possible to produce original cartographic documents efficiently having the following advantages: (a) rapiditiy (through automation); (b) homogeneity; (c) reduced costs; and (d) sometimes even aesthetic value.

In topography, using colour composites after geometrical rectification, radiometric processing (to obtain colours compatible with cartographic conventions) and assembly with computed compensation, it is possible to produce mosaics of images as topographic backgrounds for existing maps as well as for new ones. This makes the cartographic message more expressive, often more objective, or even more accurate when compared with certain old surveys.

In thematic mapping, the use of computers for semi-automatic interpretation of satellite image content, through supervised classification techniques, leads to general thematic maps of land use as a whole or of a particular theme such as agriculture or forestry. A comparison of results obtained by the Institut géographique national with other data collected by conventional methods, e.g., agricultural or cadastral statistics, has shown that spaceborne remote sensing is a powerful tool for quantitative analysis, of which cartography is only one of the ways of expression but obviously an irreplaceable one.

D'abord utilisés à des fins purement stratégiques, les satellites - et particulièrement ceux lancés au cours de la dernière décennie - ont grandement étendu leur champ d'applications civiles: la météorologie en premier lieu, puis plus récemment, les télécommunications et l'observation de la terre.

La cartographie a trouvé, au sein de cette dernière, un nouvel essor, que tente d'expliquer, dans les deux principaux domaines - topographique et thématique - qui la constituent la présente communication.

DOMAINE TOPOGRAPHIQUE

L'établissement d'une carte topographique par des moyens classiques conduit à une suite d'opérations longues et onéreuses, particulièrement dans les

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* Le texte original de ce rapport, préparé par H. Le Meu, F. C. Lummaux et J. Poulin, Institut géographique national, a paru sous la cote E/CONF.75/L.76.

régions où la cartographie est quasiment inexistante. Ces contraintes inévitables contredisent le besoin souvent pressant d'une meilleure connaissance de l'environnement nécessaire tant au développement qu'à sa protection. Or la cartographie, outil de base pour représenter la terre et s'y repérer, est encore loin d'être partout disponible: par exemple une grande partie de l'Afrique et de l'Amérique latine n'est pas couverte à une échelle supérieure au 1:200 000, d'après un rapport de l'Organisation des Nations Unies (1974).

Dans ce cadre, l'apparition puis le développement sur une base systématique de la télédétection spatiale grâce aux satellites d'observation de la Terre, tels que ceux dela série LANDSAT, peuvent être considérés comme une aubaine. Fournissant des données à distance et répétitives - donc permettant une vision à la fois globale et actuelle - ces satellites autorisent, par la définition de nouveaux types de cartes, une automatisation accrue des procédés de production, des coûts réduits, une diffusion plus rapide, une mise à jour plus fréquente, toutes qualités rendues plus que jamais nécessaires par la rapidité de l'évolution.

L'Institut géographique national (IGN), qui s'est intéressé aux images spatiales dès leur naissance, a ainsi mis au point une chaîne de production fondée sur une utilisation semi-automatique des données LANDSAT, que, à titre d'exemple, nous allons décrire maintenant.

Les "spatiocartes"

Une "spatiocarte" se distingue d'une carte topographique au sens usuel du terme par son fond: en lieu et place du dessin "restitué" conventionnel, on trouve en effet l'image elle-même, représentée soit en noir et blanc, soit en composition colorée, et combinée, ou non, à des informations complémentaires - routes, voies ferrées...-, le reste, habillage, toponymie, demeurant classique.

Une telle carte, si sa finalité ne change pas, bouleverse toutefois bien des habitudes quant à sa lecture: la description des objets ne fait plus appel à leur contour comme c'est le cas dans une carte au trait, mais à deux notions qui en définissent le contenu: l'arrangement spatial des différentes composantes de l'objet (ou texture) et l'apparence de cet objet dans l'image (ou radiométrie). Il est certain qu'une utilisation optimale du contenu d'une spatiocarte ne va pas sans quelques bribes d'informations relatives tant aux caractéristiques de l'image qui en constitue le fond qu'à son mode d'enregistrement ce qui, hélas, ne suffit pas à supprimer toutes les confusions. En particulier la constitution d'une légende, qui serait à la fois précise, efficace et concise, pose un problème qui, en l'état actuel, ne semble pas résolu de façon satisfaisante.

D'autre part, le pouvoir séparateur - ou résolution - limité des capteurs actuels restreint le choix des échelles, mais en revanche (en contrepartie) facilite la généralisation. Il semble que le domaine des applications purement topographiques de LANDSAT ne descende guère au-dessous du 1:250 000. Une spatiocarte est donc, par définition, une carte à petite échelle.

Les moyens et les méthodes

Les innombrales avantages des systèmes de traitement d'images semblent désormais trop connus qu'il soit nécessaire d'insister plus longtemps. Nous nous contenterons donc de la description du processus de production sans préciser plus avant le type de matériel utilisé. Les différentes étapes en sont les suivantes:

Choix des scènes LANDSAT couvrant la zone considérée

Prétraitements

Corrections géométriques

Corrections rediométriques

Découpage en feuilles et assemblage en mosaïques

Dessin de l'habillage, de la légende, de la toponymie

Ajout d'informations complémentaires

Génération des typons et épreuves d'essai

Impression et livraison

Cette liste exhaustive appelle quelques commentaires:

a) Le choix des scènes ne va pas, dans certains cas, sans quelques surprises: il n'est pas rare, en effet, qu'une région du globe particulièrement mal lotie climatiquement parlant ne soit visible du satellite que tous les cinq ans. Quand on ajoute à cela les contraintes spécifiques du mode d'enregistrement, certaines zones, ne peuvent être couvertes qu'avec un ensemble d'images dont la différence d'âge entre la plus jeune et la plus vieille atteint allégrement le premier des nombres parfaits;

b) Les prétraitemetns ont pour but de définir la représentation (noir et blanc, couleur) et d'augmenter le contraste de l'image afin d'en améliorer à la fois l'esthétique et la lisibilité;

c) Les corrections géométriques garantissent la précision de la carte et sont tributaires du nombre de points d'appui disponibles - il en faut au moins cinq par scène. Cette précision dépend en outre de la résolution et il est illusoire de vouloir se référer dans ce cas au fameux "1:10 mm à l'échelle" - cette référence n'a d'ailleurs pas plus de sens pour les cartes classiques, compte tenu des échelles considérées ici. Il est raisonnable dans les cas favorables, de chiffrer la précision de localisation moyenne à environ 100 mètres;

d) Les corrrections radiométriques sont destinées, si nécessaire, à homogénéiser et standardiser la radiométrie d'images enregistrées à des dates différentes;

e) Les autres opérations, à l'exception de la fabrication des typons d'impression qui recourt à un système d'insolation des films par caméra à laser pilotée par mini-ordinateur, sont du ressort des procédés cartographiques classiques. Une automatisation plus poussée de ces derniers constitue l'un des axes de recherche actuels.

CONCLUSION

Rapide, suffisamment précise pour des besoins immédiats, peu coûteuse, à la fois dans sa fabrication et son entretien, facile à réviser si l'on suppose un approvisionnement constant en données spatiales, cette cartographie d base constitue en même temps un outil efficace pour les pays qui en sont démunis, ainsi qu'un remarquable exemple d'application opérationnel de la télédétection spatiale, où les ordinateurs et les procédés les plus récents d'automatisation côtoient pour un temps encore la plume du dessinateur.

DOMAINE THEMATIQUE

Dépassant le domaine de la seule amélioration d'image et de son intégration dans la carte topographique régulière, le traitement d'image permet également de dresser une cartographie thématique du sol grâce à l'interprétation semi-automatique (assistée par ordinateur) de l'image, qui conduit à une liste de thèmes et à des couleurs conventionnelles de représentation.

De manière générale cette réduction de l'image en quelques niveaux interprétés (ou interprétables) s'appelle une classification.

De cette classification, carte thématique, présentée sous forme numérique, on peut bien entendu calculer des statistiques diverses, ce qui permet des comparaisons intéressantes avec d'autres statistiques existantes sur la même zone.

A titre d'exemple, nous allons présenter succinctement les principes et principaux résutlats d'une étude demandée par la Commission des communautés européennes sur la cartographie à moyenne échelle (1:100 000) de l'occupation du sol pour un département français: le département de la Loire.

Méthodes et résultats

La méthode employée pour faire la classification interne d'occupation du sol de la scène LANDSAT 212-28 du 18 septembre 1978 utilise des méthodes de classification par fonction de distance.

On cherche à distinguer 12 thèmes d'occupation du sol, dont la définition serait à peu près:

- feuilles
- résineux
- landes
- prairies permanentes
- cultures fourragères
- cultures non fourragères
- vignes
- sols nus - carrières
- eau
- centre ville
- banlieue
- zone industrielle

et à estimer le pourcentage d'erreur de la méthode.

Compte tenu de la diversité des paysages sur cette zone on a procédé à un découpage du département en 12 régions homogènes qui ont été classées indépendamment.

Le parfait raccord entre ces classifications, vérifié par des calculs statistiques, permet de rassurer l'utilisateur quant à la stabilité spatiale des algorithmes utilisés.

L'intérêt de ce découpage est double: d'une part il permet de pallier la dérive radiométrique à l'intérieur de l'image et d'autre part il diminue, vis-à-vis de la classification dans chaque zone, le nombre de thèmes à rechercher, par apport d'une information extérieure (par exemple on ne cherche pas de vignes dans la plaine du Forez puisqu'on sait parfaitement qu'il n'y en a pas) ce qui permet de diminuer le pourcentage d'affectation aléatoire de la classification.

Les villes ont aussi été extraites de l'image avant les classifications, par une méthode un peu plus compliquée et pour des raisons analogues.

La méthode de découpage a utilisé ici des fichiers numérisés de limites de communes, mais ce n'est pas nécessaire et on a fait, dans d'autres pays, des découpages d'images n'utilisant pas de fichiers exogènes (sans naturellement passer par un découpage manuel, qui donnerait de mauvais résultats ou serait beaucoup trop long à élaborer précisément).

On a ensuite calculé la validité du résultat obtenu à trois niveaux:

a) Au niveau du pixel avec une estimation stratifiée par enquête directe sur le terrain;

b) Au niveau communal par comparaison avec les statistiques du recensement général de l'agriculture (RGA);

c) Au niveau départemental par comparaison avec les statistiques cadastrales et agricoles.

On trouve alors une erreur moyennne pixel de l'ordre de 20 pour cent et une erreur moyenne départementale et communale de l'ordre de 12 pour cent.

L'examen détaillé de ces calculs d'erreurs et des sources d'erreurs permet de conclure que la majeure partie des erreurs pixel à pixel provient du défaut de résolution de LANDSAT (parcellaire de taille voisine du pixel). On peut prévoir que dans des conditions analogues, les données SPOT permettront, sur un parcellaire de cette taille, d'obtenir une erreur pixel à pixel de l'ordre de 8 à 12 pour cent et une erreur communale ou départementale très faible et résultant surtout de différences de nomenclature.

De la carte d'occupation du sol on dérive très aisément des cartes de statistiques communales montrant par exemple le pourcentage de surface agricole utile ou de forêts, qu'il est intéressant de comparer acec celles qu'on dérive des statistiques du RGA.

La carte des écarts entre le RGA et la classification pour la surface agricole utile met en évidence la quantité d'exploitations qui ne sont pas

recensées sur la commune où elles se trouvent physiquement (le RGA recense les explotiations agricoles sur la commune où elles ont leur siège social). En effet l'écart entre l'estimation de la surface agricole utile par le RGA et par la classification sur le département est nul, et l'étude statistique permet de montrer qu'alors il devrait être quasiment nul au niveau communal ce qui n'est pas le cas à cause de cette particularité du RGA.

CONCLUSION

Ainsi la télédétection complète les méthodes classiques de statistique d'occupation du sol en faisant le lien avec la position spatiale des objets recensés. En effet les statistiques classiques, si elles restent un plus précises que les statistiques issues de la télédétection (plus précises non pas en valeur numérique mais en précision thématique), ne s'intéressent qu'à des entités de taille assez grande (commune, département) et sont donc mal localisées alors que la télédétection permet de lcoaliser plus finement les données.

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EXPLOITATION CARTOGRAPHIQUE D'UN SATELLITE A DEFILEMENT: APPLICATION SPOT*

Document présenté par la France

SUMMARY

The recently launched LANDSAT-4 satellite (30 m resolution) and the future launching by France of the Système probatoire d'observation de la Terre (SPOT) satellite 10 m resolution, lateral observation option) will make it possible to undertake new cartographic operations.

Consequently, it was necessary to estimate the accuracies that one might expect with those applications; they are discussed in this paper.

A satellite orbit is not a random phenomenon, and the orbit plus the imaging device together form an optical system.

The transition form the instrumental system to the final projection system results from a series of transformation which lead to two equations linking the x_p, y_p rectified co-ordinates to the p, q line and column co-ordinates of the original image.

The coefficients of those equations are determined by a certain number of control points which make it possible either to build up an image if one has altimetric data available in the form of a digital terrain model or to carry out photogrammetric plotting if one has two images recorded from different viewing angles.

An analysis of those equations shows that the only critical accuracy parameter is the variation of attitude greater than the first order in time; and in the case of SPOT, approximate onboard measurements of that quantity will be available.

SPOT thus constitutes a new accurate tool particularly adapted to cartography.

ANALYSE MATHEMATIQUE ET EVALUATION DE LA PRECISION CARTOGRAPHIQUE DES IMAGES SPATIALES

L'orbite d'un satellite n'est pas aléatoire et l'ensemble orbite - instrument de prises de vues (à balayage) constitue un système optique.

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* Le texte original de ce rapport, préparé apr H. Guichard, Institut géographique national, a paru sous la cote E/CONF.75/L.77.

Le passage du système instrumental à un système de projection final se fait par une série de transformations qui aboutissent à deux équations liant les coordonnées rectifiées x_p, y_p aux coordonnées lignes et colonnes (p, q) de l'image brute (figure 62).

Les coefficients de ces équations sont déterminés par un certain nombre de points d'appui et permettent ainsi, soit de donner une image si on dispose d'une cartographie connue en altimétrie (modèle numérique de terrain), soit de faire une restitution photogrammétrique si on dispose de deux images enregistrées à des angles de prises de vues différents.

La discussion de ces équations montre que le seul facteur critique de précision est la variation d'attitude d'ordre supérieur au premier en temps, dont on connaîtra d'ailleurs dans le cas du Système probatoire d'observation de la Terre (SPOT) des valeurs approchées mesurées à bord.

SPOT constitue ainsi un outil nouveau, précis et particulièrement adapté à la cartographie.

ORBITE DU SATELLITE: ATTITUDE

Si on considère le déplacement du satellite SPOT correspondant à une seule scène la variation t du temps par rapport à la prise de vue centrale sera inférieure à 4,5 secondes.

On sait que la trajectoire d'un satellite peut de définir par une ellipse de foyer 0 centre de la Terre (ellipse osculatrice) mais dont les paramètres dits osculateurs varient sous l'influence de fonctions perturbatrices (figure 63). L'effet relatif de ces fonctions est indiqué ci-dessous pour une orbite type SPOT:

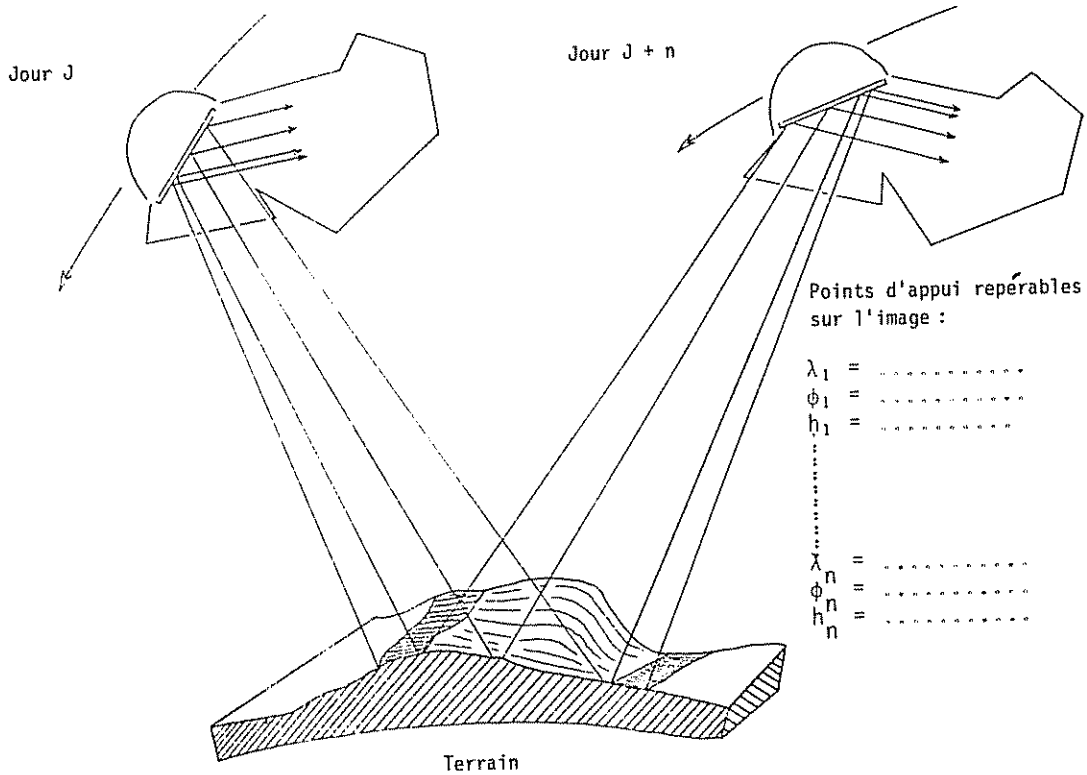
attraction centrale (orbite képlérienne)	1
aplatissement de la Terre (fonction perturbatrice R20)	10^{-3}
autres irrégularités de la Terre (termes $\neq R\ 20$)	10^{-6}
attraction luni-solaire	10^{-7}
autres (pression solaire, frottement)	10^{-8}

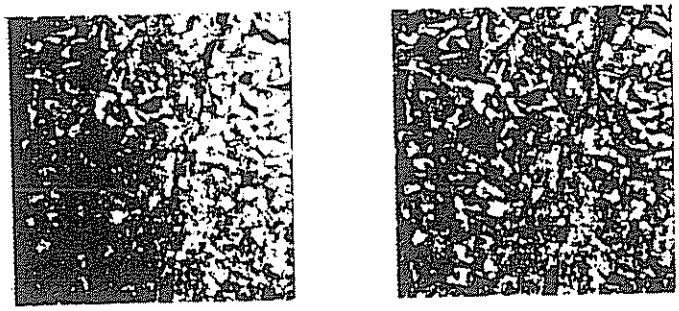
L'étude de ces perturbations montre que sur une scène la variation de ces paramètres osculateurs peut être considérée comme linéaire en temps si l'on néglige les effets inférieurs à 10 cm.

Nous verrons par la suite que ces variations se combinent avec d'autres inconnues (attitude, erreur de positionnement de la géodésie) ce qui fait que la connaissance de l'orbite ne réduit pas le nombre d'inconnues.

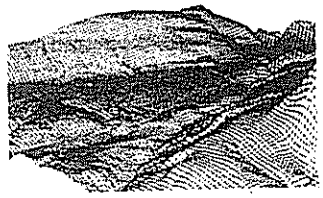
L'attitude du satellite à $t = 0$ (centre de scène) c'est-à-dire T, R, L (tangage, roulis, lacet), est inconnue mais s'intègre avec d'autres inconnues. Il en est de même des variations linéaires de ces valeurs. Les résidus restent dans les limites faibles qu'on peut traiter à l'aide des valeurs mesurées à bord comme nous verrons plus loin. L'ensemble satellite/HRV constitue alors un instrument de prises de vues.

Figure 62. France : passage du système instrumental à un système de projection final





Couple stéréoscopique



Modèle numérique de terrain



Image rectifiée



Carte topographique

EQUATIONS LIANT LES COORDONNEES IMAGE AUX COORDONNEES TERRAIN

Nous utiliserons comme coordonnées terrain la projection conforme centrée sur $\underline{M}_0$ centre de scène, d'axe $\underline{M}_0\underline{x}_p$ tangent au balayage central (à l'instant $\underline{t} = 0$) et d'échelle 1 en $\underline{M}_0$ (figure 64). Toutes les projections conformes, dans la dimension de la scène, ne diffèrent entre elles que de quantités négligeables. La projection géométrique sur le plan tangent en $\underline{M}_0$ des points d'altitude 0 se confond à peu de choses près avec ces projections. Pour les points d'altitude $\underline{h}$ il suffit d'appliquer à la projection de ces points une correction d'échelle égale à: $1 / (1 + \underline{h}/\underline{N}_0)$.

Cela fait que pour passer du repère instrumental au repère final $(\underline{x}_p, \underline{y}_p)$, il faudra appliquer un certain nombre de rotations et translations qui aboutissent à deux équations liant $\underline{p}$, $\underline{q}$ coordonnées image, où $\underline{p}$ est la coordonnée ligne, $\underline{q}$ le rang du pixel dans la ligne avec $\underline{t} = k.\underline{p}$ ($\underline{k}$ de valeur $\underline{k} = 1{,}504\ 10^{-3}$ sec, dans le cas SPOT panchromatique), à $\underline{x}_p$, $\underline{y}_p$, $\underline{h}$.

L'étude de l'ordre de grandeur de chacun des termes de différents degrés montre que les deux équations de visée dans le repère instrumental initial peuvent s'écrire dans le système final $(\underline{x}_p, \underline{y}_p)$ sous la forme:

$$\underline{F} = \underline{P}_1.\underline{p} + \underline{y}_p\ (1 + \delta\gamma\ .\underline{X}) - \tau\ .\underline{H} - \left[\underline{H}.\ \delta_1\underline{T}^*\right] = 0 \qquad \text{Equation en "y"}$$

$$\underline{G} = \underline{X} + \frac{\theta - \alpha\ .\underline{q}}{1 + \theta\ .\alpha\ .\underline{q}}\ \underline{H} + \frac{\ .\underline{q}}{1 + \theta\ .\alpha\ .\underline{q}}\ \underline{Q} - \left[\underline{Q}\ .\ \underline{R}\right] = 0 \qquad \text{Equation en "X"}$$

avec:

$$\underline{X} = (\underline{x}_p - \underline{a}.\underline{y}_p)\ \ (1 + \underline{h}/\underline{N}_0) + \underline{b}.\underline{y}_p^2 + c.\underline{x}_p.\underline{y}_p$$

$$\underline{H} = \underline{h} - \frac{x_p^2}{2\ \underline{N}_0\ \rho_0} \quad ;\ \underline{T}^* \text{ fonction linéaire de } \underline{T} \text{ et } \underline{L}.$$

Les termes entre crochets représentent les variations d'attitude dont nous parlerons plus loin.

Les différents coeffcients $\underline{P}_1$, $\delta\gamma$, θ, τ, $\underline{a}$, $\underline{b}$, $\underline{c}$, $\underline{Q}$, γ_0 (angle de l'axe $\underline{x}_p$ avec l'Est ou orientation de la projection) s'expriment en fonction des paramètres de l'orbite, de la prise de vues (angles β_0 du miroir, attitude) et des éléments terrestres (λ_0, ϕ_0 coordonnées du point central, $\underline{r}$ rayon terrestre en ce point).

Ces formules montrent que même dans le cas d'une orbite parfaitement connue, il reste quatre inconnues par équation. Si un certain nombre de points

Figure 63. France : attitude d'orbite du satellite

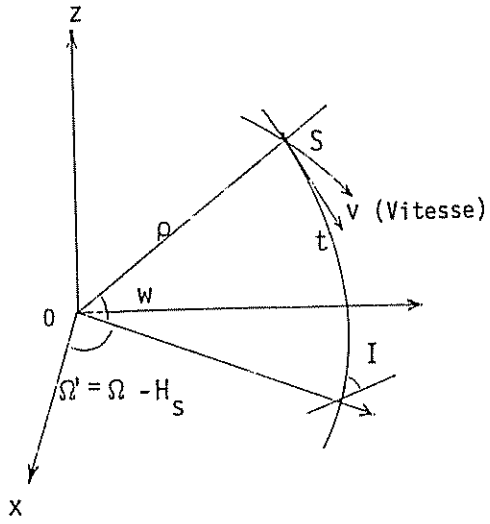
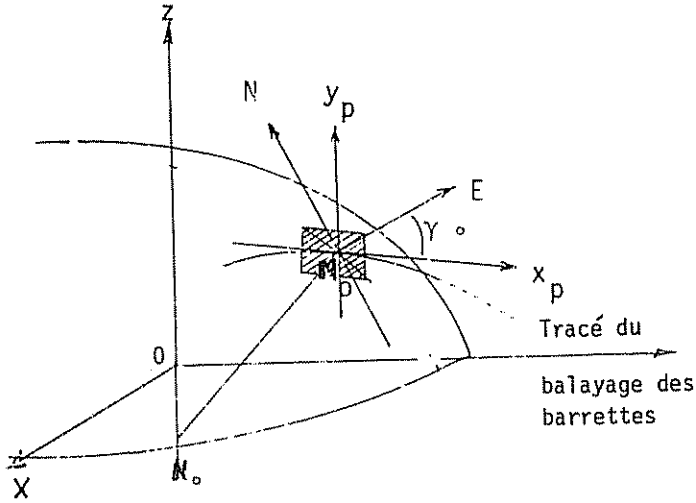


Figure 64. France : liant des coordonnées image aux coordonnées terrain



d'appui sont connus (quatre au minimum), les coefficients de ces équations peuvent être déterminés.

RESOLUTION DES EQUATIONS

Partie principale

Si un certain nombre de points d'appui sont connus, nous pouvons, ayant toute résolution, connaître une valeur approchée de $\underline{P}_1$, $\delta\gamma$, τ , ∂ , $\underline{a}$, $\underline{b}$, $\underline{c}$, $\underline{Q}$, λ_0, ϕ_0, γ_0 et suffisamment exacte pour certains d'entre eux.

La première équation $\underline{F} = 0$, qu'on peut écrire $\underline{F}_0 + \Delta F = 0$, $\underline{F}_0$ étant la valeur de $\underline{F}$ pour les éléments de départ, ΔF s'exprimant en fonction des variations des coefficients, permet de déterminer les valeurs de $\underline{P}_1$, τ , γ_0, $\underline{Y}_0$, $\delta\gamma$.

L'orientation étant ainsi connue, la pose de la seconde équation $\underline{G}_0 + \Delta \underline{G} = 0$ détermine de même les autres coefficients $\underline{Q}$, θ , $\underline{a}$, $\underline{b}$, $\underline{c}$, $\underline{x}_0$.

En réalité, comme un certain nombre de ces coefficients sont connus déjà avec suffisamment de précision, il, n'y a que quatre inconnues par équation (sans tenir compte jusqu'à présent des termes résiduels d'attitude dont nous parlerons plus loin). Dans la pratique pour un coefficient quelconque $\underline{C}$, on posera:

$\underline{Pds}.\Delta \underline{C} = 0$, $\underline{Pds}$ étant le poids qui dépend de la précision avec laquelle on connaît $\underline{C}$ au départ en fonction des formules qui le définissent.

A titre d'exemple, dans le cas de $\underline{P}$ nous aurions:

$$\frac{3,000}{46}\ \varepsilon_{\underline{p}}.\Delta \underline{p}_1 = 0 \text{ (orbite inconnue)}$$

$$\frac{3,000}{12}\ \underline{p}.\Delta \underline{p}_1 = 0 \text{ (orbite connue)}$$

si $\varepsilon_{\underline{p}}$ représente la précision de pointé des points d'appui.

Erreurs dues à une géodésie de point fondamental mal placé et de géoïde inconnu

La discussion des erreurs possibles montre que ces inconnues complémentaires s'intègrent dans les coefficients des équations en $\underline{y}$ et $\underline{x}$ à des résidus négligeables près.

Pour des raisons identiques, on peut directement passer d'une projection conforme à la projection de base par des formules simples (le second degré suffit) ce qui permet un traitement de l'image ultérieur particulièrement pratique.

Termes complémentaires d'attitude

Jusqu'à présent nous ne nous sommes pas occupés des termes complémentaires $[\underline{H}_0 \cdot \delta_1 \; T^*]$ et $[\underline{Q} \cdot \delta_1 \underline{R}]$, δT^* et $\delta \underline{R}$ représentent des variations d'attitude par rapport à leur valeur à $\underline{t} = 0$.

Suivant les spécifications de SPOT et à l'examen de simulations du Centre national d'études spatiales (CNES) on constate (sur une scène) les résultats suivants en prenant six points d'appui:

a) En ne prenant pas en compte les termes $\delta \underline{T}^*$ et $\delta \underline{R}$, l'erreur moyenne (sondée sur des points de maillage) est de l'ordre de 2 à 3 m en $\underline{x}$ et $\underline{y}$ (les variations d'attitude linéaire en temps s'intègrent dans les autres coefficients);

b) En prenant les valeurs réelles d'attitude (données dans la simulation) les écarts sont de 0,20 m (vérification des équations);

c) En tenant compte des mesures à bord issues de la simulation et en posant des équations complémentaires du type (exmeple pour $\underline{R}$):

$$\delta \underline{R}_{\underline{i}+1} - \delta \underline{R}_{\underline{i}} = \text{mesure à bord}, \quad \underline{R}_0 = 0$$

$$\underline{R} = \delta \underline{R}_{\underline{i}} \; \frac{\underline{p}_{\underline{i}+1} - \underline{p}}{\Delta \underline{p}} + \delta \underline{R}_{\underline{i}+1} \; \frac{\underline{p} - \underline{p}_1}{\Delta \underline{p}}$$

avec un poids déterminé et pour des valeurs régulièrement espacées de $\Delta \underline{p}$ ($\underline{p}_{\underline{i}+1} - \underline{p}_{\underline{i}} = \Delta \underline{p}$), les erreurs résiduelles sont inférieures au mètre.

Valeur géométrique d'une scène

En résumé, on peut dire que pour une scène, avec un minimum de quatre points d'appui (six parait être le nombre souhaitable), on connaît la loi de passage des coordonnées terrain λ , ϕ , $\underline{h}$ (ou $\underline{x}$, $\underline{y}$, $\underline{h}$) aux coordonnées image $\underline{p}$, $\underline{q}$ avec des écarts qui, avec de bons pointés, sont bien inférieurs au pixel.

RESTITUTION D'UNE SEULE IMAGE: MODELE NUMERIQUE DE TERRAIN

Avec des points d'appui connus en λ , ϕ , $\underline{h}$ (ou $\underline{x}$, $\underline{y}$, $\underline{h}$) on sait qu'on peut trouver par méthode classique de normalisation et résolution les coefficients des équations donnant pour $\underline{x}_p$, $\underline{y}_p$, $\underline{h}$ (ou $\underline{x}$, $\underline{y}$, $\underline{h}$) les valeurs $\underline{p}$ et $\underline{q}$ des coordonnées de l'image brute.

Pour que cette image puisse être rectifiée avec une valeur cartographique correspondant au 1:100 000 ou au 1:50 000, il est nécessaire de connaître en tout point l'altitude avec une précision cohérente et donc pour cela de disposer d'un modèle numérique de terrain (MNT) qui donne l'altitude de points régulièrement espacés (tous les 100 m par exemple) (figure 65). L'altitude d'un point quelconque sera calculé simplement par interpolation.

La précision avec laquelle l'altitude doit être connue dépend beaucoup du débatement du miroir puisque le terme principal en $\underline{h}$ dans l'équation en est $\theta.\underline{h}$, θ étant un terme de valeur proche de $\underline{tg}\ \beta_0$.

On voit sur la figure 65 l'erreur commise en position pour 1 000 m de dénivelée; les deux courbes correspondent aux deux bords de la scène.

Le graphique (figure 66) représente la précision en altitude requise pour ne pas faire d'erreurs supérieures au pixel (10 m dans le cas du panchromatique) en planimétrie. Dans le cas où les modèles numériques de terrain n'existent pás, ce graphique indique également l'échelle de la carte qu'il suffit de numériser en fonction de l'angle de prise de vues: pour 3° de débattement du miroir, une carte au 1:250 000 suffira largement.

Rectification: chaque point de terrain $\underline{x}$, $\underline{y}$ (et donc $\underline{x_p}$, $\underline{y_p}$) aura grâce à son MNT son altitude $\underline{h}$ connue et donc ses coordonnées image correspondante $\underline{p}$, $\underline{q}$. On peut donc ainsi trouver pour chacun des points $\underline{x}$, $\underline{y}$ régulièrement espacés de 10 m par exemple la valeur radiométrique correspondante dans l'image brute soit par interpolation dynamique, soit au plus proche voisin, ce qui donne image rectifiée.

RESTITUTION PHOTOGRAMMETRIQUE DE DEUX IMAGES SATELLITE

Tout d'abord, pour que la restitution (c'est-à-dire la connaissance des coordonnées de tout point non seulement en $\underline{xy}$, mais aussi en $\underline{h}$) puisse se faire, il est nécessaire que les deux prises de vues à partir de deux orbites Ω_1 et Ω_2 (figure 67) soient effectuées avec des angles $(\beta_0)_1$ et $(\beta_0)_2$ très différents (comme en photogrammétrie classique).

Il faudra aussi préalablement effectuer sur film la visualisation (par un appareil précis type Vizir par exemple) de chacune des scènes en utilisant soit la bande brute (corrigée radiométriquement) soit semi-corrigée (voir plus loin).

Ces films seront disposés comme des photographies aériennes habituelles sur un appareil restituteur analytique (où l'intersection des rayons perspectifs ne se fait pas optico-mécaniquement mais par le calcul numérique en temps réel du déplacement à effectuer). Les coordonnées $\underline{p}$, $\underline{q}$ se déduiront des coordonnées plaques par la lecture de ces coordonnées après pointage des repères de fond de chambre qui donneront les coefficients de la transformation linéaire à effectuer.

Il y a, là aussi, pointage des points d'appui connus en $\underline{x}$, $\underline{y}$, $\underline{h}$ et introduction de leurs coordonnées comme pour une restitution habituelle.

Figure 65. France : modèle numérique de terrain

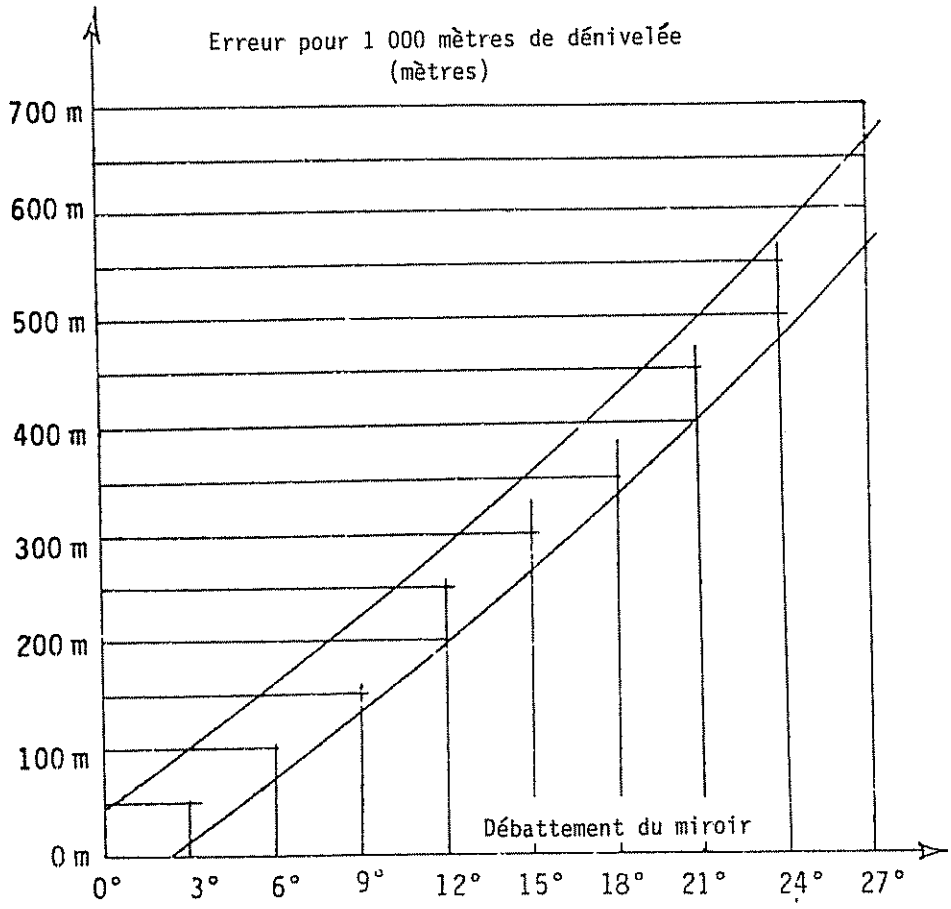


Figure 66. France : précision en altitude nécessaire pour n'avoir pas d'erreur supérieure à 10 mètres

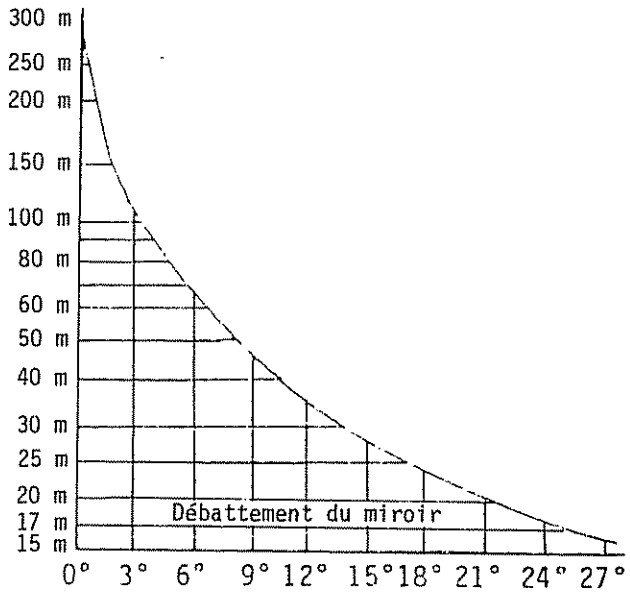
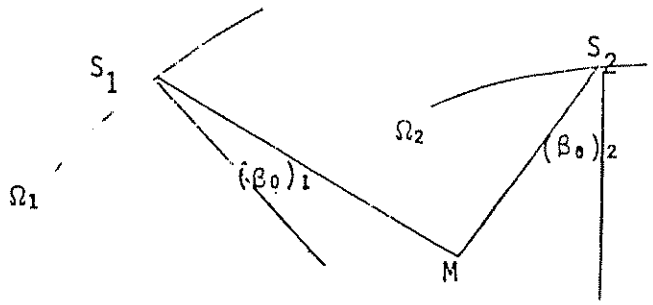


Figure 67. France : deux prises de vues à partir de deux orbites



Le calculateur associé à l'appareil effectue le calcul de compensation comme auparavant mais il y a à faire remarquer qu'en plus des équations habituelles d'observation "en $\underline{y}$ et en $\underline{x}$ sur des points d'appui connus, il y a intérêt à ajouter des pointés sur points homologues non connus en $\underline{x}$ $\underline{y}$ $\underline{h}$ comme dans une restitution classique.

Nous ajoutons donc à chaque fois quatre équations d'observation à cinq connues complémentaires $\underline{x}_{p1}$, $\underline{y}_{p1}$ (coordonnées scène 1), $\underline{x}_{p2}$, $\underline{y}_{p2}$ (coordonnées scène 2) et $\underline{h}$ (altitude commune) mais liées par deux relations:

$$\underline{x}_1 \quad (\underline{x}_{p1}) = \underline{x}_2 \quad (\underline{x}_{p2}, \underline{y}_{p2})$$

$$\underline{y}_1 \quad (\underline{x}_{p1}) = \underline{y}_2 \quad (\underline{x}_{p2}, \underline{y}_{p2})$$

Les fonctions $\underline{x}$ ( ) et $\underline{y}$ ( ) représentent les lois de passage d'un système de coordonnées d'une plaque à la projection commune et sont des fonctions linéaires de $(\underline{x}_0)_1$, $(\underline{y}_0)_1$, $\Delta\gamma_1$, et $(\underline{x}_0)_2$, $(\underline{y}_0)_2$, $\Delta\gamma_2$.

Cela permet d'avoir un "modèle" cohérent qui permet une restitution homogène.

Notons que dans ce cas, deux points connus en $\underline{x}$, $\underline{y}$, $\underline{h}$ suffisent.

La restitution se fait ensuite comme en photogrammétrie classique à la différence que le logiciel pilote utilise les équations en "$\underline{y}$" et "$\underline{x}$" pour connaître les $\underline{p}_1$, $\underline{q}_1$ et $\underline{p}_2$, $\underline{q}_2$ correspondants à un point d'altitude. La variation du $\underline{h}$ (par la pédale des $\underline{z}$) permet de mettre en coïncidence les deux points de l'image.

Le sous-produit (très important) de la restitution cartographique qu'on peut effectuer ainsi est la constitution d'un modèle numérique de terrain (soit déduit des courbes filées lors de la restitution, soit par pointés en maillage).

Pour certaines latitudes, l'anisotropisme des deux visualisations peut être trop grand et la fusion stéréoscopique difficile. Il est alors nécessaire de faire une correction rapide: les lignes en tant que telles ne sont pas modifiées; chaque pixel dans la ligne est déplacé d'une manière linéaire en fonction de $\underline{q}$ et $\underline{p}$. Les coefficients $\underline{a}$ et $\underline{Q}$ sont alors modifiés mais cela ne change pas la forme des équations.

RESTITUTION PAR SEGMENTS

Un segment est un groupe de scènes successives (avec même orientation du miroir) dont nous supposerons que la première scène comporte au moins un point connu, ainsi que la dernière.

Sans rentrer dans le détail, indiquons que la résolution de l'ensemble du segment est possible en utilisant également les équations en "$\underline{y}$" et "$\underline{x}$" de chaque scène avec un minimum de quatre points sur l'ensemble du segment:

a) Calcul de coefficients approchés (à partir du premier point);

b) Pose des équations d'évolution des coefficients d'une scène à l'autre (poids très fort);

c) Equation de bordure, liant des points de la dernière ligne d'une scène et de la première ligne de la scène suivante;

d) Evolution des $\underline{T}^*$ et $\underline{R}^*$ comme précédemment. En fin de calcul nous disposerons de l'ensemble des coefficients de chaque scène qui permettront donc de restituer celle-ci avec un MNT, soit de l'adjoindre à une scène prise d'une autre orbite pour la restituer photogrammétriquement (dans ce cas le poids des coefficients complémentaires à partir de valeurs approchées est évidemment beaucoup plus fort mais rien n'est changé dans le principe.

Il est à noter que sur les dernières simulations d'attitude reçues du CNES, à l'échelle de plusieurs scènes, l'attitude ($\underline{T}$, $\underline{L}$, $\underline{R}$) présente des variations de forme périodique et à un facteur linéaire près (qui s'intègre dans les autres inconnues), les mesures à bord ont la même forme, ce qui est très important pour ce type de restitution.

CONCLUSION

Il y a tout d'abord un certain nombre de remarques à faire. Il est évident que la connaissance d'une bonne orbite (paramètres $\underline{w}_0$, $\underline{n}$, $\underline{v}$, ρ) si elle n'est pas indispensable et si elle ne réduit pas le nombre des équations amène cependant des informations intéressantes et permet de donner un poids plus fort aux équations complémentaires citées plus haut (Résolution des équations, partie principale).

Par ailleurs, en ce qui concerne la pose et la résolution des équations d'observation, il est bien évident, vu le temps très réduit de calcul (de l'ordre de la seconde pour une scène) qu'on pourra faire des itérations permettant de donner rapidement un caractère rigoureusement linéaire aux équations et aboutir à la solution correcte si les données de départ sont mal connues. Cela ne changera le temps de calcul que d'une manière insignifiante vis-à-vis du temps total de traitement.

La méthode que nous avons utilisée pour arriver aux équations finales nous montre que la seule hypothèse, conforme aux spécifications du CNES, que nous ayons faite est que la régularité géométrique des capteurs dans une barette soit respectée. Encore n'est-ce pas là une nécessité impérieuse car il est simple de rajouter une loi de déformation en fonction du rang du capteur. Le reste: orientation des barettes, valeur de $\underline{K}$ et α n'a besoin d'être connu que d'une manière approchée et se ramènent à des tangages, roulis, lacet complémentaires ainsi qu'à des variations d'échelle en $\underline{x}$ et $\underline{y}$. Toutes ces quantités sont indécorrélables des inconnues principales et n'introduisent pas d'erreurs supplémentaires.

L'aspect "figé" des équations en $\underline{y}$ et en $\underline{x}$ fait qu'on peut utiliser de mauvais points d'appui pour faire une meilleure cartographie à l'aide de SPOT.

Expliquons-nous: sur une carte au 1:250 000 un point bien identifiable peut avoir en planimétrie jusqu'à 50 m d'erreur. Si une région qui n'est cartographiée qu'au 1:250 000 présente de nombreux points d'appui identifiables, le produit résultant aura une bien meilleure précision que le document initial.

Il faut enfin bien mettre en valeur les possibilités nouvelles de SPOT, qui est réellement le premier satellite cartographique:

a) Résolution de 10 m (et précision de restitution finale sans doute meilleure);

b) Orientation du miroir de -27° à 27° qui permet de multiplier considérablement les probabilités de prises de vues dans des régions de mauvaises conditions météorologiques;

c) Orientation du miroir de -27° à 27° qui permet la constitution de modèles stéréoscopiques et la restitution de zones non cartographiées;

d) Continuité et "rigidité" de l'orbite qui va permettre la restitution de segments et, de ce fait, une restitution cartographique qui n'exige qu'un nombre réduit de points d'appui;

e) Système de balayage statique (barettes) et non plus mobile qui conduira vraisemblablement à une meilleure tenue d'attitude (rappelons-nous qu'une variation linéaire est sans effet sur la précision) qui est finalement le facteur primordial de précision.

En dernière conclusion, cette étude permet de montrer qu'on peut, dans tous les cas, espérer une précision de restitution meilleure que 10 m (dans le cas du panchromatique) qui permet ainsi, soit de réaliser une cartographie régulière en planimétrie au 1:50 000, soit une révision au 1:25 000 et dans tous les cas fournir aux utilisateurs des documents avec une précision géométrique meilleure que le pixel ce qui permet, entre autres, des superpositions multitemporelles.

Ajoutons que les équations en x et en y sont applicables à d'autres satellites à défilement en remplaçant les coefficients de X et H dans l'équation en x par des fonctions de q liées au mode de balayage.

LE PROGRAMME D'OBSERVATION DE LA TERRE PAR SATELLITE SPOT*

Document présenté par la France

SUMMARY

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* Le texte original de ce rapport, préparé par Christian Veillas, Centre national d'études spatiales, a paru sous la cote E/CONF.75/L.78.

The Système probatoire d'observation de la Terre (SPOT), programme conceived and designed by the Centre national d'études spatiales (CNES), is being built by French industry working in association with European partners (Belgium and Sweden); it consists essentially of a series of Earth observation satellites and of an Earth station for data reception.

The first SPOT satellite will be launched in 1984 and will observe in three spectral bands (in the visible and near infra-red portions of the spectrum) with a good sampling step of the order of 20 m and in a broader spectral band (panchromatic black and white) with a ground sampling step of the order of 10 m.

The purpose of the programme is to make a significant contribution to world-wide efforts directed to meeting the information requirements of Earth resource detection and management activities in such fields as topographic cartography, oil and mining exploration, agriculture, hydrology, forestry, land use and coastal studies.

Le programme SPOT (Système probatoire d'observation de la Terre) conçu par le Centre national d'études spatiales est réalisé par l'industrie française en association avec des partenaires européens (Belgique et Suède). Il comprend une série de satellites d'observation de la Terre et des stations terriennes de réception de données.

Le premier satellite, lancé en 1984, permettra d'obtenir des observations à haute résolution dans trois bandes couleur du spectre visible et proche infrarouge avec un pas d'échantillonnage au sol de l'ordre de 20 mètres ainsi que des images panchromatiques en noir et blanc avec un pas d'échantillonnage au sol de l'ordre de 10 mètres.

L'objectif du programme est d'apporter une contribution significative à la satisfaction des besoins croissants en informations ressentis par les responsables de la gestion des ressources terrestres dans des domaines d'activités tels que la cartographie, l'agriculture, l'hydrologie, les forêts, l'aménagement du territoire, la prospection minière et pétrolière et les phénomènes côtiers.

SPOT permettra d'effectuer notamment:

a) Des études sur l'utilisation du sol et l'évolution de l'environnement;

b) Une évaluation des ressources naturelles renouvelables (agriculture, forêt, eau);

c) Une contribution à l'exploration des ressources minérales;

d) Des travaux cartographiques dans la gamme des moyennes échelles telles que le 1:100 000, l'établissement de cartes de types nouveaux et la révision fréquente des cartes aux échelles de l'ordre de 1:50 000.

La capacité particulière de visée latérale de SPOT lui permettra d'assurer l'observation d'une région quelconque de la Terre avec une périodicité variant de un à quelques jours, rendant ainsi possible le suivi de phénomènes localisés à évolution relativement rapide. Elle permettra aussi la vision stéréoscopique du relief des régions observées par association de vues prises sous des angles différents.

Les données seront soit transmises en temps réel vers des stations de réception directe (plusieurs stations sont en projet dans les pays d'Asie et du Pacifique, une station est actuellement en développement au Bangladesh), soit enregistrées à bord s'il n'existe pas de stations de réception dans la région observée. Dans ce dernier cas, elles seront transmises vers les stations centrales de réception de France ou de Suède et commercialisées par la Société SPOT IMAGE. L'Institut géographique national et le CNES sont parmi les principaux actionnaires de cette société, créée le 1er juillet 1982.

Le second satellite SPOT 2 sera prêt à être lancé dès 1985. Les satellites suivants assureront la continuité de fourniture des données sur une période de 10 ans et plus suivant le développement du marché des images.

MAPPING FROM SPACE: PREPARATIONS FOR THE PHOTOGRAMMETRIC CAMERA EQUIPMENT ON SAPCELAB, SEPTEMBER 1983*

Paper submitted by the Federal Republic of Germany

RESUME

Pour la première mission Spacelab, qui aura lieu à la fin de 1983, la charge utile de téléobservation de la Terre comportera une chambre métrique. Ce sera une chambre de prise de vues aériennes modifiée de très haute qualité.

La phase de mise au point du matériel est terminée et les instruments sont prêts à être montés sur Spacelab.

L'utilisation des chambres métriques dans l'espace, domaine qui n'a pas encore été exploré, peut contribuer sensiblement à améliorer la couverture cartographique de la Terre. L'expérience en question constitue un premier pas pour combler cette lacune en utilisant les capacités accrues qu'offre le système de transport spatial.

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* The original text of this paper, prepared by G. Konecny, Institut für Photogrammetrie und Ingenieurvermessung der Technischen Universität, Hannover, appeared as document E/CONF.75/L.89.

Le document contient un résumé des objectifs scientifiques de l'expérience, ainsi qu'une description détaillée du système de prises de vues et un exposé général du déroulement des opérations et du système de commande au cours de la mission.

The last photographic space mission that was of interest for photogrammetric applications was the Skylab mission in 1973. The next photogrammetric experiment from space will be the metric camera experiment, which will be carried on board the joint first Spacelab mission of the European Space Agency (ESA) and the United States National Aeronautics and Space Administration (NASA), at the end of 1983. This experiment, will be the first time taht a calibrated photogrammetric camera with the standard aerial film format of 23 x 23 cm is used in space to obtain high-quality photographs of Earth's surface.

The development of the camera system is completed and it is now subject to integration into the Spacelab payload. The camera is a modified aerial survey camera of the type Zeiss RMK A 30/23. The experiment hardware was developed jointly by the Deutsche Forschungs- und Versuchsanstadt für Luft- und Laumfahrt (DFVLR, Aerospace Research Establishment) and industry in the Federal Republic of Germany and was provided free of charge to ESA as part of the common European experiment facilities. ESA in turn ensures the experiment's flight and co-ordinates distribution of the experiment data.

OBJECTIVES

For reasonable resources planning and management, an earth atlas of all exploitable areas in the scale range of 1:50,000 to 1:100,000 is required. Even 1:250,000 mapping would be sufficient for many areas and needs. The demand is well illustrated in table 30. Taking into account the age of many existing maps and the too slow progress of map production using existing mapping techniques, one can assume that the figures given in table 30 have not changed very much since 1970. The lack of maps is particularly evident in the developing regions, such as Africa, South America and parts of Asia.

A possible remedy is the acquisition of high-resolution imagery from low orbiting space platforms using high-quality survey camera systems. The experiment therefore intends to test whether high-resolution mapping photography is suited for:

(a) Compiling topographic and thematic maps especially in unpopulated or less developed regions of the world;

(b) Updating and revising topographic and thematic maps in populated and developed areas of the world.

The selected camera is expected to provide imagery at a ground resolution of 20-30 m, and it is therefore considered suited for detecting details for mapping at small scales (1:100,000 - 1:250,000) and for certain aspects perhaps even medium scales (1:50,000 - 1:100,000).

Table 30. Status of world cartography, by region

(Percentage)

Region	Scales			
	1: 1,250-1:31,500	1:40,000-1:75,000	1:100,000-1:126,000	1:140,000-1:250,000
Africa	0.04	19.6	51.4	69.5
North America	16.8	41.0	10.2	98.4
South America	2.7	7.3	12.2	16.9
Europe	53.2	65.7	66.4	86.0
Asia	4.5	32.2	10.5	53.2
USSR	-	40.0	100.0	100.0
Oceania	0.3	4.9	0.8	96.0
Total	6.0	25.0	30.2	72.0

Source: World Cartography, vol. X (United Nations publication, Sales No. E.70.I.4).

The objective of the mission is therefore predominantly to test the mapping capabilities of high resolution space photography taken at the resolution limit of image motion on a large film format of 23 x 23 cm.

For stereoscopic evaluation, the photographs will be taken with 60 per cent and in part with 80 per cent overlapping. The 80 per cent overlapping is of special interest for analytical photogrammetric processing. In this case, the pairs of images to be evaluated would always be formed by the first and fifth image, whose overlap range amounts to 20 per cent. By so doing the elevation accuracy can theoretically be increased, but this remains to be demonstrated. With aerial triangulation, a planimetric poistion accuracy of $\pm$ 5 - 10 m and an elevation accuracy of $\pm$ 20 - 35 m can be expected.

The photographs can be evaluated with conventional photogrammetric equipment into line maps and orthophotomaps. In this way, it can be exactly demonstrated for the first time to what extent satellite imagery can contribute to the solution of the world-wide mapping problem.

It cannot be expected that the first Spacelab metric camera experiment will actually be able to collect photography for production purposes. The short duration of the mission limits the objectives to providing test capabilities for mapping from space photography. At the same time, the mission is to provide high-resolution test imagery potentially useful to other disciplines, including geology, land use, agriculture, oceanography and even meteorology.

SPACELAB SYSTEM

Spacelab is a manned and reusable space laboratory developed by ESA to be carried by the NASA Space Shuttle. Spacelab consists of two elements: a pressurized module with several segments and a non-pressurized instrument platform consisting of up to five pallets. During the entire mission, Spacelab remains within the cargo bay of the Space Shuttle.

A total of 37 scientific and technological experiments--13 sponsored by NASA and 24 by ESA--have been selected for the first mission. These experiments can be broken down into five major discipline groups: atmospheric physics and earth observation; plasma physics; material science; astronomy and solar physics; and life science.

One of the earth observation experiments is the metric camera, which is interfaced to an optical window in the pressurized module. During camera operations, the optical axis of the instrument will be oriented local vertical to Earth. This is accomplished by an appropriate attitude manoeuvre of the Shuttle.

The first Spacelab launch is currently planned for the last quarter of 1983, with a mission duration of seven days. The nominal flight altitude is 250 km and the orbit inclination is 57°.

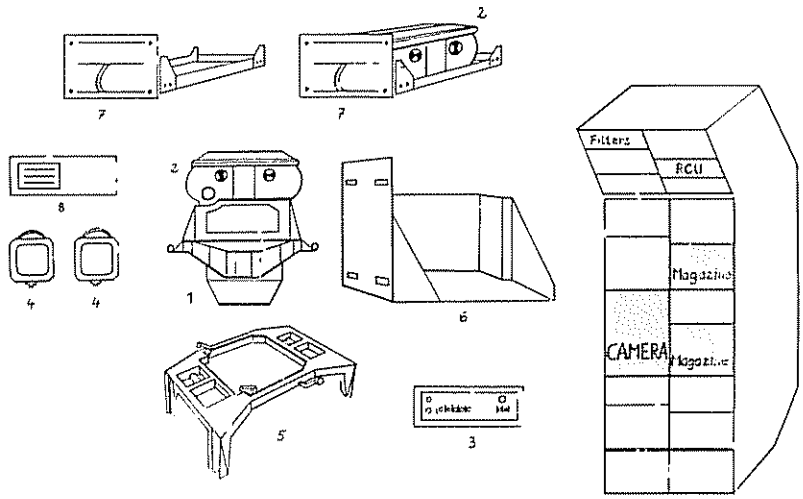
CAMERA SYSTEM

The camera system consists of the following equipment: (a) camera body with optics; (b) two film magazines containing aerial film of 24-cm width; (c) two filters; (d) a remote control unit (RCU); (e) camera suspension mount; (f) stowage containers (see figure 68).

Camera, film magazines and filters are stowed in special containers in experiment racks during launch and landing. The stowage containers for the camera and the magazines are designed as slide-in drawers for easy handling in orbit. The camera interfaces to the optically flat high-quality window via a suspension mount, which is permanently mounted to the window adapter plate. The remote control unit is installed in an experiment rack and remains there throughout the mission.

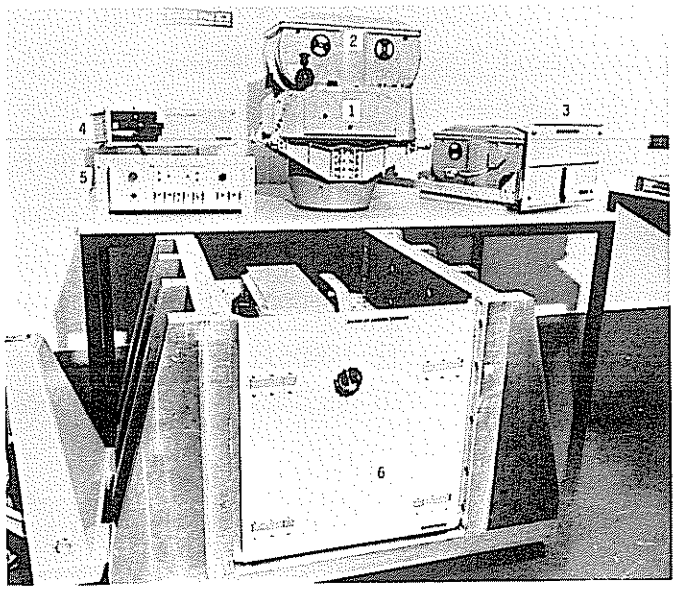
In orbit, the camera will be installed on the suspension mount, fitted with a magazine and electrically connected to the remote control unit (see figure 69). These tasks will be carried out by the payload specialists on

Figure 68. Federal Republic of Germany: metric camera system for the first Spacelab mission



Note: 1=camera; 2=magazine; 3=remote control unit; 4=filter; 5=camera suspension mount; 6=camera stowage; 7=magazine stowage container; 8=filter container. The rack for stowage of the camera system is shown on the right.

Figure 69. Federal Republic of Germany: metric camera flight hardware for Spacelab mission



Note: 1=camera; 2=film magazine; 3=film magazine in stowage container; 4=filter in stowage container; 5=remote control unit; 6=camera stowage container.

board. Before the end of the mission, they have to remove the camera and magazine from the window and stow it again in the rack for the landing phase.

The camera

The camera is a modified version of a commercial aerial survey camera of the type Zeiss RMK A 30/23.

Mechanical and electrical changes of the original RMK A 30/23 were necessary to meet the mission requirements concerning safety, strength, handling under zero gravity and remote control. For mass reduction, the inner lens cone and the focal plane frame were fabricated in aluminium instead of steel.

The flight camera (figure 70) is now equipped with special anti-vibration mounts, locking devices, handles and reinforcing brackery. The harness was fully replaced by a non-tonic and non-flammable one. New EMC-filters were added and the circuits for remote control were adapted to the Spacelab system requirements.

A new display module with light-emitting diodes (LEDs) was introduced to print auxiliary data, such as image number, time of release event, exposure time and f/stop for every image on the film (figure 71). The exact time of the shutter release is recorded with an accuracy of thousands of a second. This time signal is triggered by a photodiode which is placed behind the shutter.

Beside the auxiliary data, a six-step grey wedge is exposed on every image frame (figure 71). The densities of the different steps reach from 0,05 to 1,50. Further characteristics of the camera are listed below:

(a) Type: modified Zeiss RMK A 30/23

(b) Lens: Topar Al with seven lens elements;

(c) Calibrated focal length: 305,128 mm;

(d) Maximum distortion: 6 μm (measured);

(e) Resolution: 39 lp/mm Awar on Aviphot Pan 30 film;

(f) Film flattening: by blower motor incorporated in the camera body;

(g) Shutter: aerotop rotating disc shutter (between the lens shutter);

(h) Shutter speed: 1/250 - 1/1,000 second in 31 steps;

(i) f/stops: 5.6-11.0 in 31 steps;

(j) Exposure frequency: 4-6 seconds and 8-12 seconds;

(k) Image format: 23 x 23 cm;

(l) Film width: 24 cm;

(m) Film length: 150 m = 550 image frames;

(n) Dimensions: camera, 46 x 40 x 52 cm; magazine, 32 x 23 x 47 cm;

(o) Mass: camera, 54.0 kg; magazine, 24.5 kg (with film).

Figure 70. Federal Republic of Germany: metric camera for first Spacelab mission

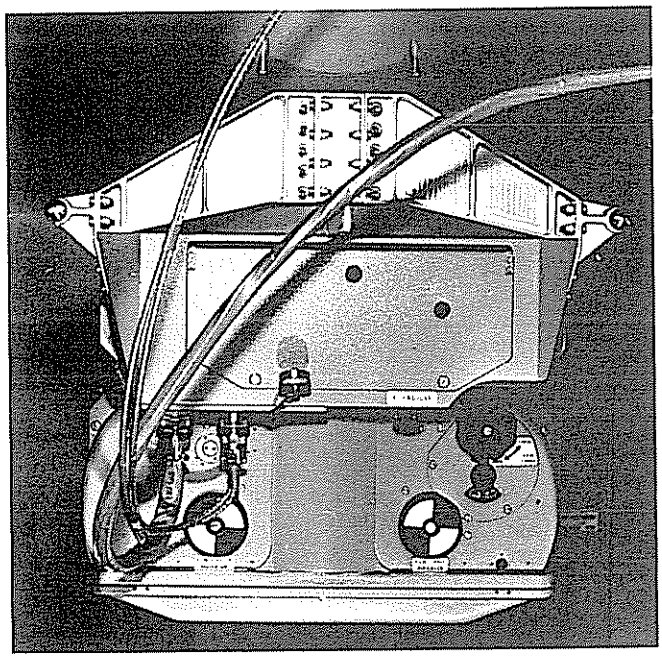
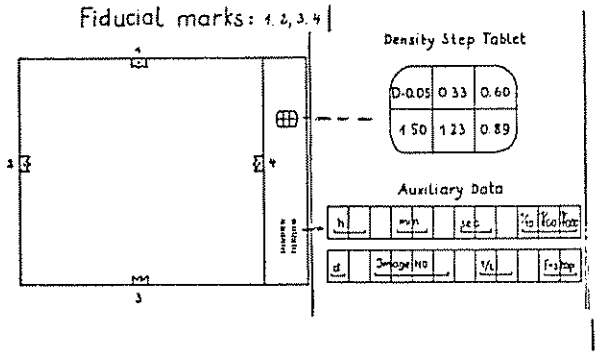


Figure 71. Federal Republic of Germany: metric camera image frame



Remote control unit

The newly developed remote control unit (figure 72) interfaces the Spacelab Command and Data Management System (CDMS) and the power distribution system with the camera. The remote control unit utilizes a 16-bit u-processor to control the camera operation. The control data will be loaded from the mass memory unit (MMU) od CDMS and transferred to the camera by way of the remote control unit.

The following functions can be software-commanded by the remote control unit or can be manually performed at its control swtiches: on/off; start/stop of serial or single exposure; adjustment of 60 or 80 per cent overlap.

When the camera is manually operated, exposure time and f/stop have to be set at the camera using adjustment control knobs. The remote control unit also performs: (a) tagging of shutter release time; (b) conditioning of housekeeping data; (c) conditioning and control of power supply; (d) control of auxiliary data recording.

High-quality window

The camera is interfaced to the optical high-quality window by means of a suspension mount. A mock-up of the suspension mount is shown in figure 73.

This mount is equipped with a tilt mechanism by which the camera can be brought and "parked" in an oblique position. This position allows for easy exchange of lens cover, filters and removal and closing of the inner safety cover of the optical window.

The window is the same as was designed for Skylab. It is a 59 x 44 x 4-cm rectangular plate of type BK 7 borosilicate crown glass of high optical quality. The optical performance of the window was carefully evaluated by optical tests, and its influence on the quality of the photographs was shown to be negligible.

An analysis showed that even a slight bending or deflection of the window caused by the inside pressure of Spacelab can be neglected with regard to image quality. The spectral transmission curve of the optical window is shown in figure 74.

The window is equipped with its own heating system that controls window temperature to minimize temperature gradients across the glass and prevent condensation.

OPERATION AND CONTROL

The loading of the film magazines and their unloading after landing will be made in darkrooms on the ground before launch and after completion of the mission, respectively. Two magazines, each containing 150 m of film, providing up to 1,100 images, will be used. Each magazine will contain a different film type.

Figure 72. Federal Republic of Germany: remote control unit for Spacelab

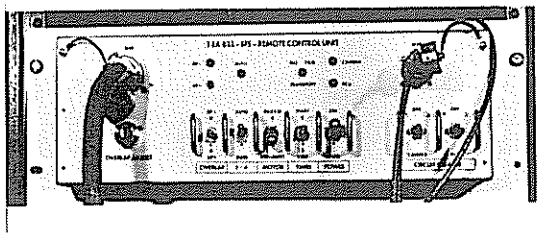


Figure 73. Federal Republic of Germany: mock-up of camera suspension mount

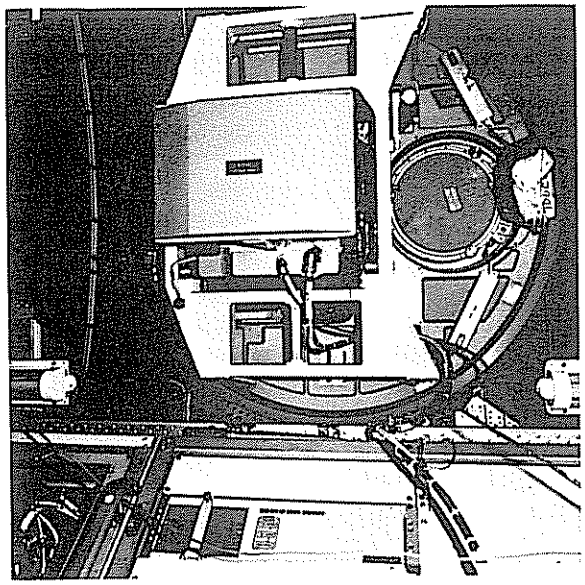
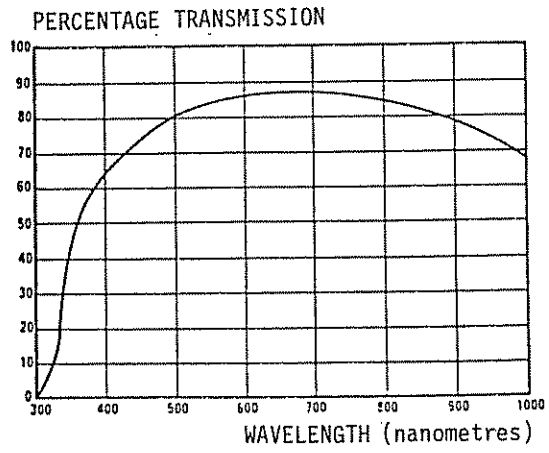


Figure 74. Federal Republic of Germany: Spacelab optical window transmission



In the present operations plan, which is valid for a launch in June 1983, 36 cycles of operation with an average of 30 single exposures are foreseen. The time interval between two exposures is 10 seconds for most of the cycles and 5 seconds for only a few cycles. The 10-second interval yields a 60 per cent overlap and the 5-second interval an 80 per cent longitudinal overlapping of the photographs. The total operation time amounts to approximately three hours. A change of film type from one exposure series to the next would require a change of magazine and filter, and would take some time. This is not feasible because it places an excessive demand on the crew's time. Therefore, the films will be exposed one after the other in full length. Exchange of film magazine and filters thus, has only to be carried out once by the crew during the whole camera operation period. The further duties of the crew are: initial set up of the camera at the optical window with a thorough check-out; a second brief check-out after magazine exchange; and lastly, removal and stowing of the camera system.

The camera operation itself will be carried out automatically. In the automatic mode, all cycle control data are generated before launch and stored in the mass memory unit of CDMS from which they are loaded to the dedicated experiment processor (DEP) in the remote control unit. The cycle control data consist of: (a) number of images in one cycle operation; (b) overlap adjusment at 60 or 80 per cent; (c) f/stop for every exposure; (d) exposure time for every exposure. The start of one cycle of operation will be initiated by a pre-programmed software timeline command.

The pre-calculated cycle control data are based on normal and up to one hour delayed launch conditions. An updating of the data during the mission from the Payload Operation Control Center (POCC) at Houston is possible if the mission parameters have changed significantly.

During all automatic operations the crew is not involved, though they will remain informed about the camera operations on the payload activity plan. The crew will intervene in automatic operations only in the case of malfunction of the experiment. Manual operations are carried out only as contingency actions when control of the camera via CDMS is no longer possible.

Monitoring of the experiment occurs mainly in POCC. From there, direct interaction with the experiment by radio telecommand will be possible. If a malfunction is recognized at POCC, corrective measures can be tried by telecommand from the ground or the crew will be informed by a voice uplink on how th react to the malfucntion.

For monitoring the experiment status, a 3-minute stand-by is planned before every cycle of operation; 16 camera housekeeping data will be monitored indicating, for instance, remaining pictures on the film, temperatures and currents of the motors.

EXPERIMENT PARAMETERS

The focal length of 305 mm and the nominal orbit altitude of 250 km yield the image scale 1:820,000, which results, for the 23 x 23-cm image format, in a ground coverage of approximately 189 x 189 km per image.

During operation of the camera, the Space Shuttle must be in such an attitude that the optical axis of the camera looks exactly vertical to Earth. This orientation will be done with an accuracy of 0.5 degree.

With a relative forward velocity between the spacecraft and Earth of approximately 7.55 km per second, it becomes necessary to restrict exposure times between 1/500 and 1/1,000 second in order to minimize image motion. This amounts at the ground to 15 m or 7.5 m, respectively, for the two exposure times.

FILMS AND EXPOSURE CONTROL

For selection of proper film/filter combinations for the Spacelab mission, a test programme with 16 aerial film types was carried out. 1/ In this programme, aerial photographs were obtained with a Zeiss RMK A 30/23 from an altitude of 10.5 km. The photographs were taken with short exposures times (1/500-1/1,000 second) and under sun elevations between 15° and 70° to simulate Spacelab conditions. The photographs were evaluated by an international working group applying different ranking criteria. The result of this evaluation was that Kodak Double-x aerographic film 2405 and Kodak aerochrome infra-red film 2443 were selected for the Spacelab flight. Both films will be flown with a Zeiss D-filter with a cut-off wavelength of 535 mm. The spectral transmission of this filter is shown in figure 75. For the black-and-white film, the main application is topographic mapping; and for the colour infra-red film, photo-interpretation and thematic mapping.

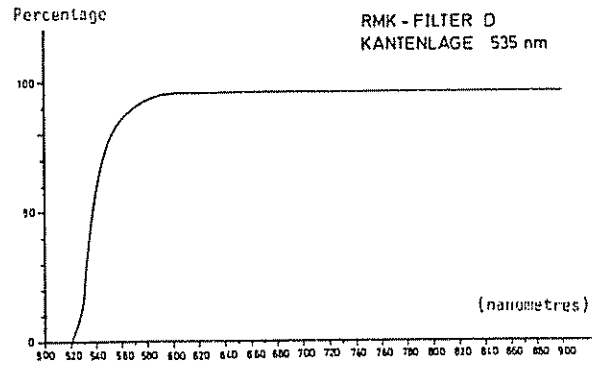
Automatic exposure control with a photometer is not practicable due to various amount of cloud cover in the field of view of the photometer. Therefore, proper exposure has to be predetermined from theoretical formulae, taking into account the illumination conditions at various sun elevations and the reflectance characteristics of the target. Nevertheless, measured photometer values will be recorded to compare them after the mission with the predetermined values.

The proper f/stop is found by a formula of the following type:

$$f/stop = \frac{1}{2} \sqrt{\frac{\underline{B} \cdot \underline{t}}{\underline{E_D}} \cdot \frac{\underline{C_1}}{\underline{C_2}}}$$ where

f/stop = aperture number;
$\underline{B}$ = irradiance in front of the lens, $(\frac{\text{u watts}}{\text{cm}^2})$;
t = exposure time (second);
$\underline{E_D}$ = exposure intensity to obtain a defined density $\underline{D}$ on the film, $(\frac{\text{u watts}}{\text{cm}^2}$ second);
$\underline{C_1}$ = correction factor taking into account the reflection coefficient of the earth surface; 1 for normal reflection;
$\underline{C_2}$ = filter factor taking into account filter, lens and optical window.

Figure 75. Federal Republic of Germany: transmission curve for Zeiss filter D



B depends upon the sun elevation angle h in the following manner:

$B = Bo\ (\sin h)^{C_3}$, where C_3 is a constant between 0.4 and 1.0.

The unknown values in this equation are currently derived by densitometric measurements in the above-mentioned high-altitude aerial test photographs.

AREAS TO BE PHOTOGRAPHED

The first Spacelab mission will take seven days, from which only approximately 40 hours are planned for earth observations.

Another limiting factor for space photography is the illumination conditions. From the high-altitude test flights, it was found that the selected films can be properly exposed when the sun elevation is greater than 15°. The areas where suitable illumination conditions exist depends upon the launch date and the launch time (hour of day).

The last operation plan for the Spacelab payload, issued in 1979, was scheduled for a launch in June 1983, at 14.00 Greenwich Mean Time (GMT). Areas foreseen to be photographed were in North Africa, Middle East and Europe, and some strips in Asia and in North and South America.

In the meantime, the launch was postponed, and it is now likely to take place between September and December 1983. The next operation plan will be issued in September 1982. As the attitude manoeuvres plan of the shuttle is also likeky to be changed, it is possible that the areas to be photographed will be completely revised.

It is expected that a certain percentage of target areas will be partially cloud-covered when they are to be photographed. Due, however, to the limited operation time for the camera and to the fixed timetable for all the experiments, there is no alternative to photographing only over cloud-free areas. In order to avoid film wastage over areas with significant cloud cover, a final selection of the pre-programmed operation cycles by ground control, based on global weather information, is held feasible. The decision which cycles to use or delete will be made about 12 hours ahead of each pass.

DATA DISTRIBUTION

To the selected experimenters (about 100), images pertaining to their experiments and additional mission flight data will be distributed free of charge some weeks after the mission. After this distribution, the data will be available for unrestricted distribution. They can be purchased from ESA at an affordable price. The products to be sold will be first-generation copies of the original images. An image catalogue will be issued by ESA after the mission.

CONCLUSION

The metric camera experiment is expected to provide the best space imagery for photogrammetric evaluation so for available. This is only a first experiment to demonstrate the capability of space photographs for mapping purposes; future Space Shuttle missions with improved camera systems may become an operational tool for mapping.

Note

1/ Papers submitted by Naudin, Schroeder, Sievers and Togliatti to the XIVth Congress of the Internaitonal Society for Photogrammetry, Hamburg, 1980; published in International Archives of Photogrammetry, vol. XXIII, part B.

DEVELOPMENT OF THE METHOD TO PRODUCE A COLOUR COMPOSITE ORTHOPHOTOMAP FROM LANDSAT DATA*

Paper submitted by Japan

RESUME

L'Institut géographique contribue au développement des techniques de télédétection depuis 1972 en particulier en ce qui concerne la correction géométrique des données de télédétection et la classification de l'occupation et de la couverture des sols.

L'étude est consacrée à la mise au point des méthodes de production d'orthophotocartes en composition colorées à partir des données LANDSAT. Elle a été réalisée par l'Institut géographique entre 1979 et 1981 sous l'égide de l'Agence des sciences et techniques.

Les méthodes de production d'orthophotocartes et de cartes thématiques au 1:500 000 et au 1:200 000 à partir des données du scanneur multibande (SMB) de LANDSAT et diverses autres données auxiliaires des cartes topographiques, des topographies aériennes et des données numériques nationales y sont décrites.

On a commencé par corriger les données du SMB de LANDSAT pour éliminer les différences de sensibilité entre les capteurs. Ensuite on a procédé à la correction analytique des distorsions géométriques à un nouvel échantillonnage sur certains plans de projection. Les distorsions géométriques dues aux variations altimétriques terrestres ont été corrigées sélectivement à l'aide des données numériques altimétriques recueillies sur le plan

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* The original text of this paper, prepared by Shintaro Yagi and Minoru Akiyama, Geographical Survey Institute, appeared as document E/CONF.75/L.102.

national. Pour les superficies couvertes par plusieurs images LANDSAT, nous avons mis au point une méthode d'assemblage numérique des mosaïques d'images permettant d'éliminer les lignes d'assemblage. Sur les orthophocartes en composition colorée établies à partir des données fournies par le SMB de LANDSAT, on peut analyser le couvert végétal ou l'occupation des sols par photo-interprétation mais les analyses quantitatives ne peuvent se faire que numériquement.

Une classification en 16 catégories de la couverture des sols a été réalisée par analyse numérique et on a comparé les résultats aux données numériques nationales.

La méthodologie exposée devrait être utilisée désormais pour obtenir des renseignements actualisés notamment sur l'occupation des terrains de grande superficie.

This report concerns the development of a method to produce colour composite orthophotomaps from LANDSAT data, which was carried out by the Geographical Survey Institute (GSI) of Japan, from 1979 to 1981.

This study composed a part of the general research on proving the usability of satellite image data as LANDSAT data conducted by the Agency of Science and Technology and carried out with several national research institutes.

In this study, the methods were developed to produce 1:500,000-1:200,000 orthophotomaps and thematic maps out of LANDSAT multispectral scanner (MSS) data together with several ancillary data as topographic maps, aerial photography and national digital information by using the general computer and image processing system which had been installed in GSI.

As a result of this study, several methods were developed to register LANDSAT MSS data on certain map co-ordinate systems quite accurately, to correct density levels, to extract certain features in the image, to produce orthophotomaps and thematic maps semi-automatically and to combine rasterized national digital information with the image data. These methods were then systematized and became available.

Through the study, as a case study, LANDSAT MSS scenes of Tokyo, Fuji-san, Wakasa, Wajima, Osaka and the Antarctic were processed; and experimental maps were produced from them.

Those data, except the Antarctic, used in this study were received at the Japanese receiving station. From now on, this method is supposed to be used to obtain comtemporary information on land-use patterns of large areas and so on.

CORRECTION OF LANDSAT MSS DATA DISTORTIONS

LANDSAT MSS data are distributed as films and computer-compatible tape (CCT) format. However, those raw data cannot be used in accurate analysis;

and it was necessary to correct geometrical distortions analytically and accurately when attempting to register LANDSAT data on topographic maps, cellular data and/or ground survey data and to output the analysed result as a map format.

In this study, a method was developed to correct geometrical distortions and resample data on the map projection plane by using just special image annotation tape (SIAT) data and some 10 ground control points (GCP) per scene. Even if no GCP is available, such as the scene of the Antarctic, by using just SIAT data alone it has become possible to correct geometrical distortions within some hundred metres over the scene.

Moreover, methods do correct radiometric distortions and to stretch and enhance the grey levels were developed, which is supposed to be helpful in improving the accuracy of feature extraction and classification.

Format transformation

The no-correction CCT distributed from the National Space Development Agency (NASDA) contains the image data as the format of BIP2 in four files. The fifth file contains the SIAT data as shown in figure 76. The BIP2 format does not fit for the analysis of the whole scene. Therefore, the image data are gathered in one file, as shown in figure 77. In the meantime, another magnetic-tape file is created for printing out the band-7 image; and the sixth set of data in the SIAT file, the annotation data for MSS, is compiled and printed out (figure 78).

One pixel of LANDSAT MSS data is composed of four-band data. One-band data are recorded in one byte and can take the values of 0-63. For the most of processing explained in this report, input and output files are supposed to be in such a format that one pixel data is recorded in one word (four byte), which consists of band 4, 5, 6 and 7 data in this order.

Correction of density levels

The LANDSAT MSS scans six lines at a time with 24 detectors. Since there is a slight difference in characteristics among those detectors, line noises cen be seen on the original image data. These line noises can affect the photographic quality of the image and the accuracy in classification of land-use classes.

Here the method to correct these inter-detector differences by means of statistical approach is shown (see figure 79). For this purpose, the following two assumptions are adopted:

(a) The satistical characteristics of the ground corresponding to each of the six detectors over one scene should be identical;

(b) Each detector responds linearly within the extent of output levels V of 1-62 for the incident radiation, R, and can be expressed as

Figure 76. Japan: format for no-correction BIP2 computer-compatible tape

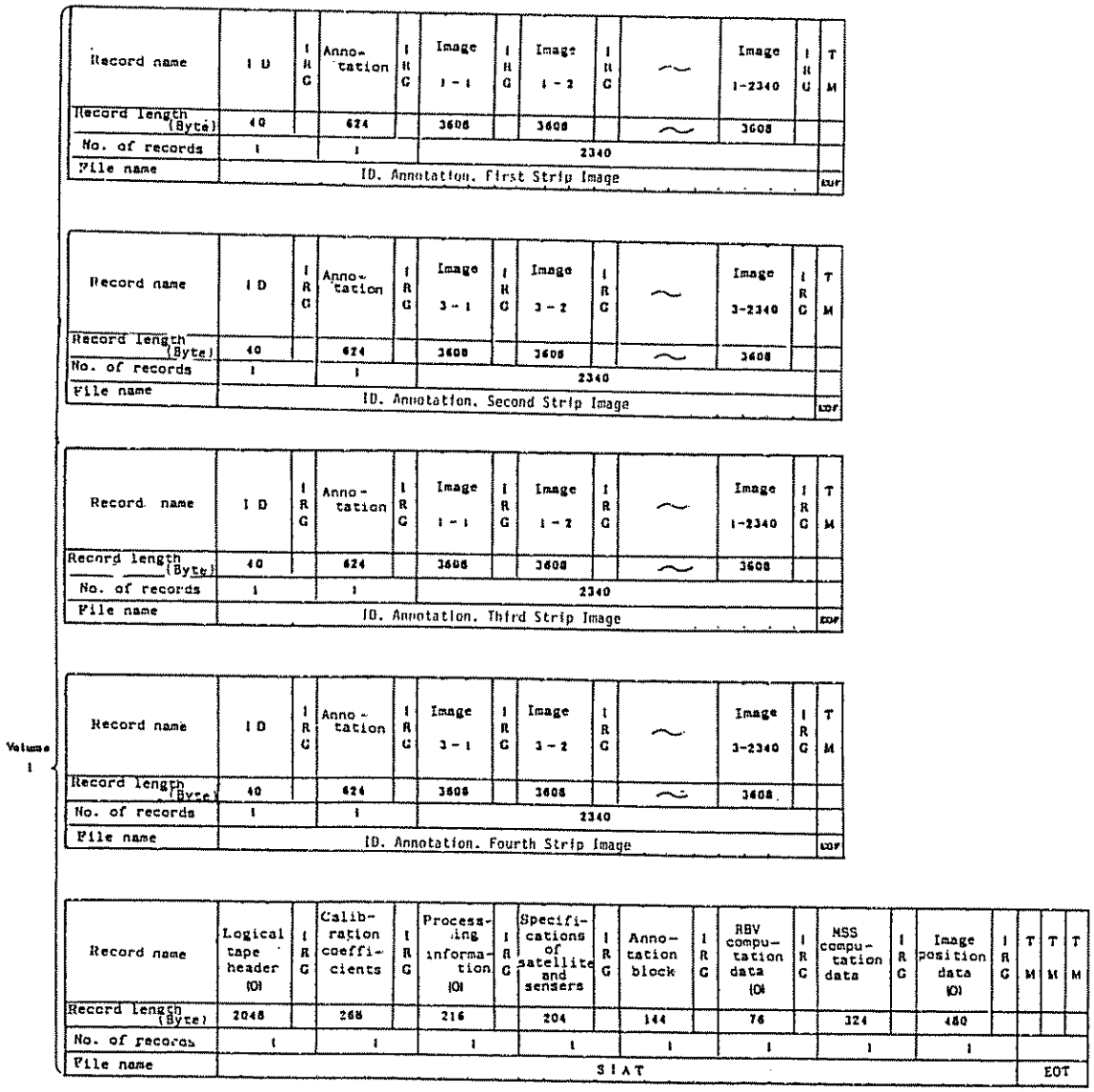


Figure 77. Japan: transformed image data format

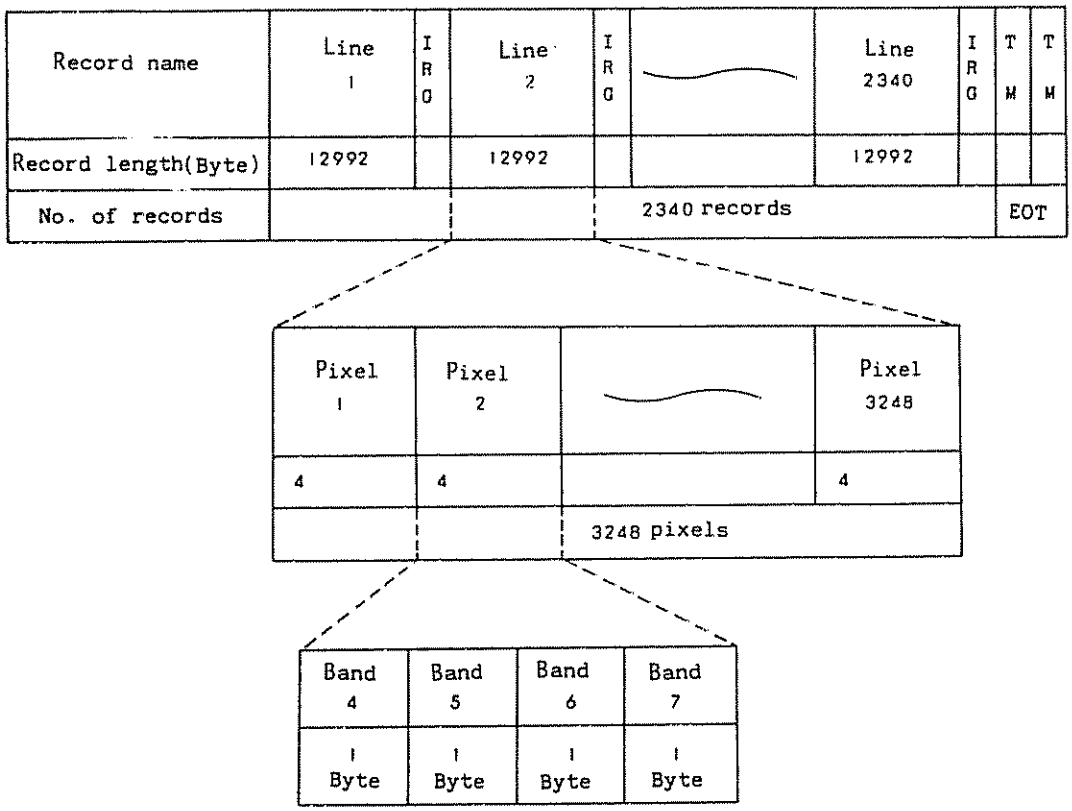


Figure 78. Japan: processing flow of no-correction BIP2 computer-compatible tape

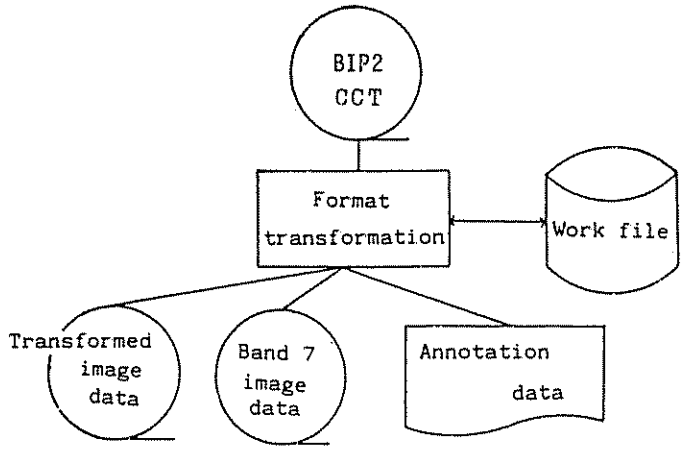
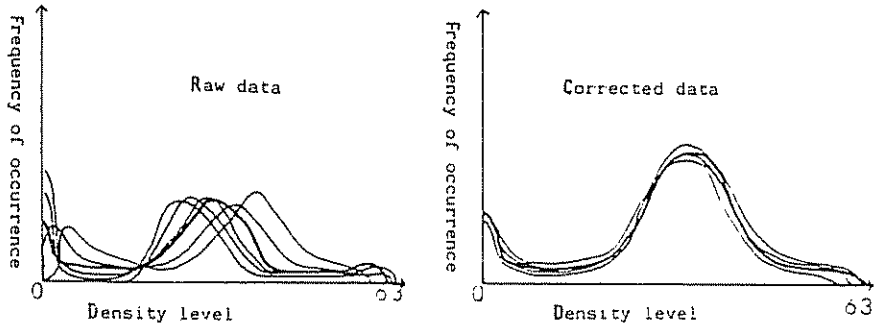
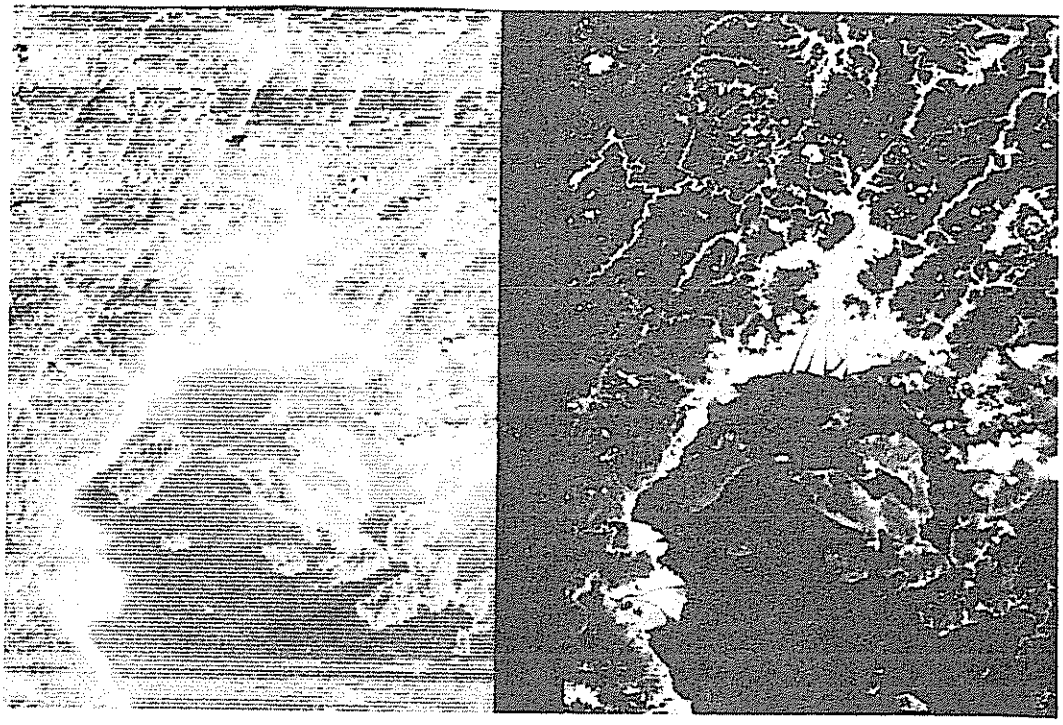


Figure 79. Japan: radiometric correction; normalization of density levels





$$V = a_i \cdot R + b_i \qquad (1\text{-}2\text{-}1)$$

where (a_i, b_i, (i = 1, 2, ..., 6) are constants determined for each detector independently).

From these assumptions, for any incident radiation R

$$V_1 = a_1 \cdot R + b_1$$
$$V_i = a_i \cdot R + b_i \quad (i = 2, 3, 4, 5, 6) \qquad (1\text{-}2\text{-}2)$$

Let f_i (V) be the probability density for outpout (density) level V of detector i; one obtains

$$\int_0^{V_1} f_1(V)\, d\, V = \int_0^{V_i} f_i(V)\, d\, V \qquad (1\text{-}2\text{-}3)$$

because accumulative probability density to a certain radiation level is identical among detectors. Therefore,

$$V_1 = A_i \cdot V_i + B_i \qquad (1\text{-}2\text{-}4)$$
$$(A_i = a_1/a_i,\ B_i = b_1 \cdot b_i/a_i).$$

Then, the density level distribution of detector i can be equalized as that of detector one. The coefficients A_i, B_i are obtained so as to minimize the following value:

$$\sum_j (A_i\, V_{ij} + B_i - V_{1j})^2 \qquad (1\text{-}2\text{-}5)$$

where V_{ij} is the value calculated from

$$\int_0^{V_{ij}} f_i\ (V)\ d\ V \Big/ \sum_{K=0}^{63} F_i\ (K) = P_j \qquad (1\text{-}2\text{-}6)$$
$$(P_j = 0.05, 0.1, \ldots\ldots 0.95).$$

F_i (K) is the number of occurrences for density level K of detector i, and f_i (V) is obtained by interpolating F_i, (K).

Relationship between the scanner co-ordinate system and the geodetic co-ordinate system

Geometrical distortion correction is performed by determining the transformation formula from the MSS co-ordinate system (scanner co-ordinate system) (L, I,) to the geodetic co-ordinate system (θ, λ) (see figure 80).

Suppose the following notations:

$\overline{R}$: radius vector of the satellite from Earth's centre;

Figure 80. Japan: relationship between satellite and Earth

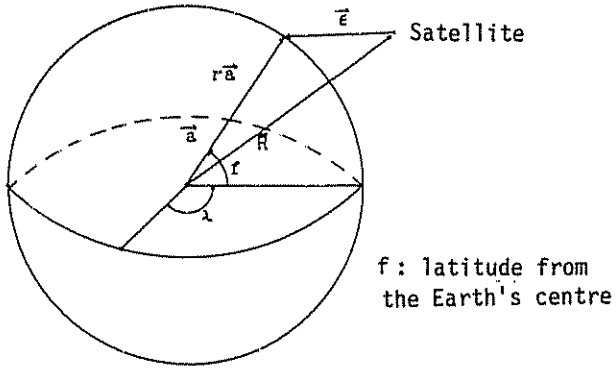


Figure 81. Japan: looking angle of the multispectral scanner

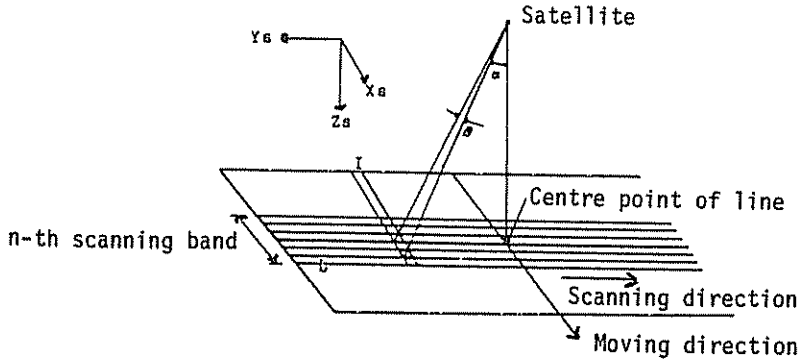
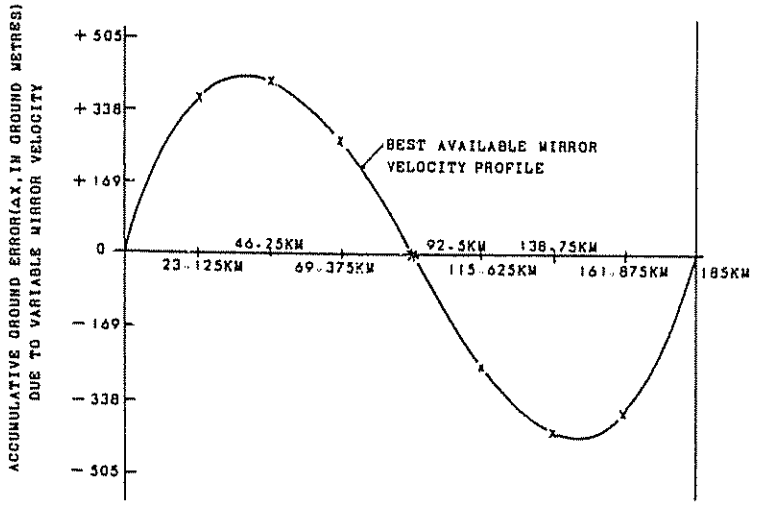


Figure 82. Japan: ground error due to variable mirror velocity



$\vec{\varepsilon}$: direction cosines of the scanner;

$\vec{a}$: direction cosines of the observed point from Earth's centre;

$r(\theta)$: earth radius at latitude θ (distance from Earth's centre to the speroid surface);

$H(\theta\ \lambda)$: altitude at latitude θ, longitude λ.

Then, one obtains

$$\vec{a} = \frac{1}{r\ (\theta) + H\ (\theta,\lambda)} \left[\vec{R} - \vec{\varepsilon} \left\{ (\vec{R} \cdot \vec{\varepsilon}) + \sqrt{(r + H)^2 - |R|^2 + (R \cdot \varepsilon)^2} \right\} \right] \quad (1\text{-}3\text{-}1)$$

Here, let $\vec{a} = (a_X, a_Y, a_Z)$;

then
$$\lambda = \tan^{-1} (a_Y / a_X) + \pi \quad (1\text{-}3\text{-}2)$$

$$\theta = \tan^{-1} \frac{(1.0067192 \cdot a_Z)}{1 - a_Z^2} \quad (1\text{-}3\text{-}3)$$

Let (α, β) be the looking angle of the scanner as shown in figure 81; then one obtains

$$\alpha = \left\{ 1 - \frac{2}{3{,}248} (I - 1) \right\} \Delta\alpha + \delta\alpha\ (I) \quad (1\text{-}3\text{-}4)$$

$$\beta = \left\{ - \frac{6 - 1}{2} + \mathrm{mod}\ (L - 1{,}6) \right\} \Delta\beta \quad (1\text{-}3\text{-}5)$$

where $\Delta\alpha = 0.101142\text{rad}$, $\Delta\beta = 8.62 \times 10^{-5}$ rad;

$$\delta\alpha\ (I) = -0.13756 \times 10^{-5} - 0.14613 \times 10^{-5} \times I + 0.13495 \times 10^{-8} \times I^2 - 0.27691 \times 10^{-12} \times I^3. \quad (1\text{-}3\text{-}6)$$

The symbol $\delta\alpha$ describes the irregularity of the scan mirror velocity and is obtained from the relationship between the pixel number and the corrective distance on the ground shown as a profile NASDA handbook on LANDSAT MSS data in CCT format. (See figure 82.)

$$\vec{\varepsilon} = \frac{1}{\sqrt{1 + \tan^2\alpha + \tan^2\beta}} (\tan\beta\ ,\ \tan\alpha, 1). \quad (1\text{-}3\text{-}7)$$

Formulae (1-3-1) - (1-3-7) show the relation between (L, I) and (θ, λ).

To transform (L, I) to (θ, λ) it is necessary to express $\vec{\varepsilon}$ written in the scanner co-ordinate system and $\vec{R}$ written in the orbit co-ordinate system in the Earth co-ordinate system, which is used to express $\vec{a}$.

The transformation from the scanner co-ordinate system to the Earth co-ordinate system T^{e}_{s} can be decomposed as

$$T^{e}_{s} = T^{e}_{i} \cdot T^{i}_{o} \cdot T^{o}_{b} \cdot T^{b}_{s} \qquad (1\text{-}3\text{-}8)$$

where subscripts e, i, o, b and s correspond to the Earth, inertial, orbit, body and scanner co-ordinate systems, respectively; and T^{e}_{i} represents the transformation from inertial to the Earth co-ordinate system, for example:

(a) Transformation from the scanner to the body co-ordinate system: T^{b}_{s}. In the case of LANDSAT scanner system, there is little difference between these two co-ordinate systems nor is there any information concerning this relationship. Therefore, one assumes

$$T^{b}_{s} = \begin{bmatrix} 1, & 0, & 0 \\ 0, & 1, & 0 \\ 0, & 0, & 1 \end{bmatrix} \quad ; \qquad (1\text{-}3\text{-}9)$$

(b) Transformation from the body to the orbit co-ordinate system: T^{o}_{b}. This transformation is expressed by using roll, pitch, yaw of the satellite as

$$T^{o}_{b} = \begin{matrix} \cos\phi \cos k & - \cos\phi \sin x & , \sin\phi \\ \cos w \sin x + \sin w \sin\phi \cos x, & \cos w \cos x - \sin w \sin\phi \sin x, & \\ - \sin (1) \cos\phi & & \\ \sin w \sin x - \cos w \sin\phi \cos x, & \sin w \cos x + \cos w \sin x, & \\ \cos w \cos\phi & & \end{matrix} \qquad (1\text{-}3\text{-}10)$$

(See figure 83.)

(c) Transformation from the orbit to the inertial co-ordinate system: T^{i}_{o} This transformation is expressed by using inclination i, ascending node Q, argument of perigee w and true anomaly V as

$$T^{i}_{o} =$$

$$\begin{matrix} - \sin (w + V) \sin Q - \cos (w + V) \cos i \sin Q, & - \sin i \sin Q, \\ - \sin (w + V) \sin Q + \cos (w + V) \cos i \cos Q, & \sin i \cos Q, \\ \cos (w + V) \sin i & - \cos i \end{matrix}$$

$$\begin{matrix} - \cos (w+V) \cos Q + \sin (w + V) \cos i \sin Q \\ - \cos (w+V) \sin Q - \sin (w + V) \cos i \cos Q \\ - \sin (w+V) \sin i \end{matrix} \quad ; \qquad (1\text{-}3\text{-}11)$$

(See also figure 84.)

(d) Transformation from the inertial to the earth co-ordinate system: T^{e}_{i} This transformation is expressed by using the Greenwich hour angle Gha, Earth rotation angular velocity w_e, scanned time t and Earth rotation angle γ_e as

Figure 83. Japan: orbit and body co-ordinate systems

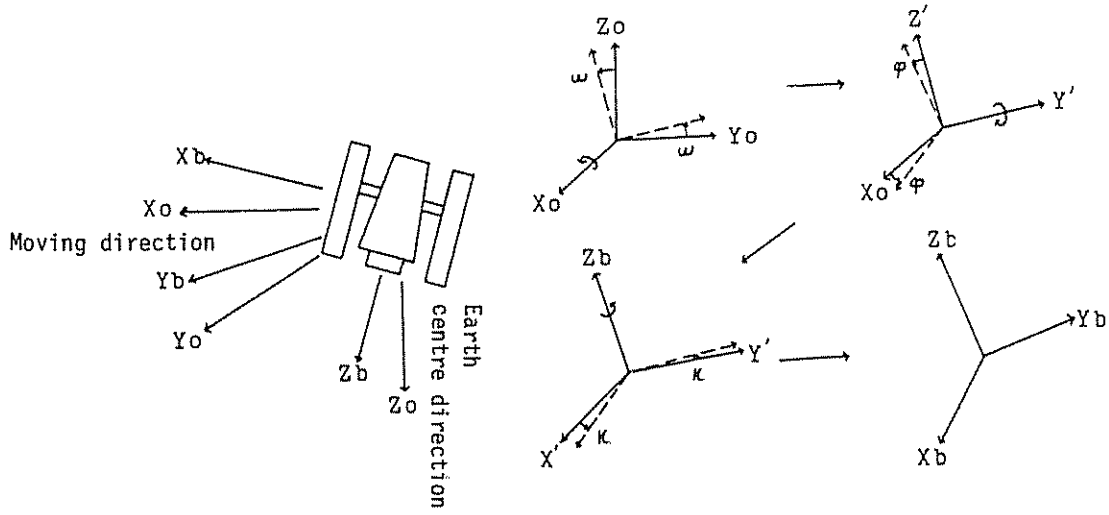
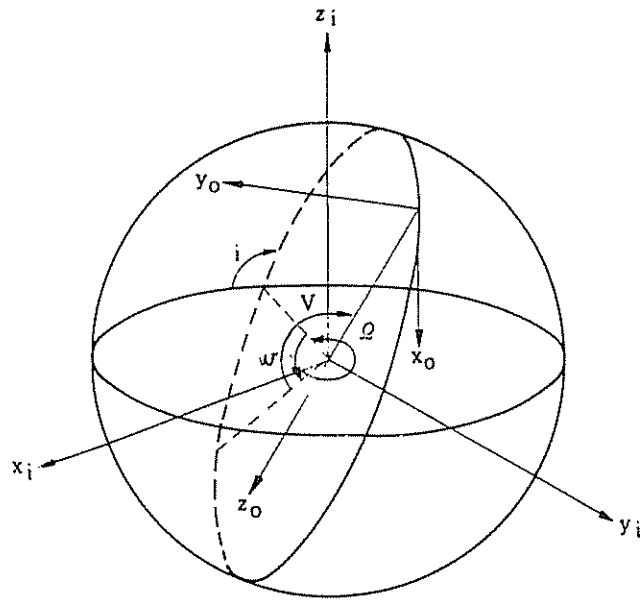


Figure 84. Japan: inertial and orbit co-ordinate systems



$$\underline{e} = \underline{Gha} + \underline{w_e} \times \underline{t}, \tag{1-3-12}$$

$$\underline{T_i^e} = \begin{bmatrix} \cos \underline{\gamma_e}, & \sin \underline{\gamma_e}, & 0 \\ -\sin \underline{\gamma_e}, & \cos \underline{\gamma_e}, & 0 \\ \underline{0}, & & \underline{0,1} \end{bmatrix} \tag{1-3-13}$$

(See also figure 85.)

Estimation of satellite attitude and orbit

To perform the transformation from ($\underline{L}$, $\underline{I}$) to (,) for each pixel, it is necessary to determine the satellite attitude (roll, pitch and yaw) and the consistent set of the satellite orbit parameters ($\underline{a}$, $\underline{e}$, $\underline{i}$, $\underline{w}$, $\underline{Q}$, $\underline{V}$). Those values can be estimated by approximate formula obtained from the annotation data recorded in the SIAT file. Here, $\underline{a}$ is the semi-major axis and $\underline{e}$ is eccentricity of the satellite orbit.

Estimation of satellite attitude

The SIAT file contains the information of roll, pitch and yaw at nine moments from $\underline{t}$ = -13.803 s to $\underline{t}$ = +13.803 s by every $\underline{t}$ = 3.45075 seconds. The origin of time ($\underline{t}$ = 0) corresponds to the scene centre.

It is assumed that each angle can be approximated with the third-order polynomial, which is obtained by means of the least-squares method.

Estimation of satellite orbit

SIAT file contains the information of geodetic longitude, latitude, (θ,λ) and altitude $\underline{h}$ of the satellite at 11 moments from $\underline{t}$ = -25 s to $\underline{t}$ = +25 s.

Let $\underline{f}$ be the latitude of the satellite from Earth's centre; as shown in figure 86, it is expressed as

$$\underline{f} = \underline{T_{an}^{-1}} \left(\frac{(\underline{h} + \underline{N}) \sin \theta}{\underline{A} \sqrt{1 - (\underline{N} \sin \theta / \underline{B})^2 + \underline{h} \cos \theta)}} \right) \tag{1-4-1}$$

where

$$\underline{N} = \frac{\underline{A} (1 - \underline{E}^2)}{1 - \underline{E}^2 \sin^2 \theta} \tag{1-4-2}$$

$\underline{A}$ = semi-major axis of the Earth spheroid, 6,377,397 m;
$\underline{B}$ = semi-minor axis of the Earth spheroid, 6,356,079 m;
$\underline{E}$ = eccentricity of the Earth spheroid, 0.081697.

One obtains the following equation from the relation $\underline{T_o^e} = \underline{T_i^e}, \underline{T_o^i}$:

Figure 85. Japan: inertial and Earth co-ordinate systems

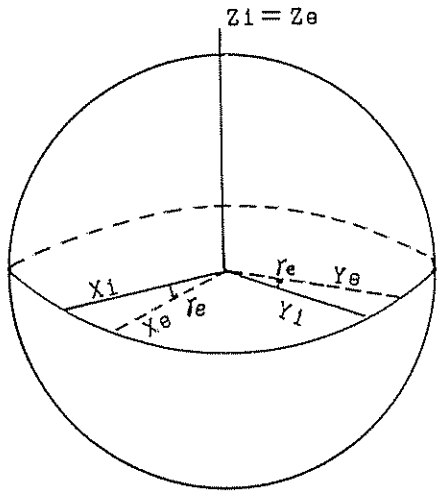


Figure 86. Japan: distance between satellite and Earth's centre

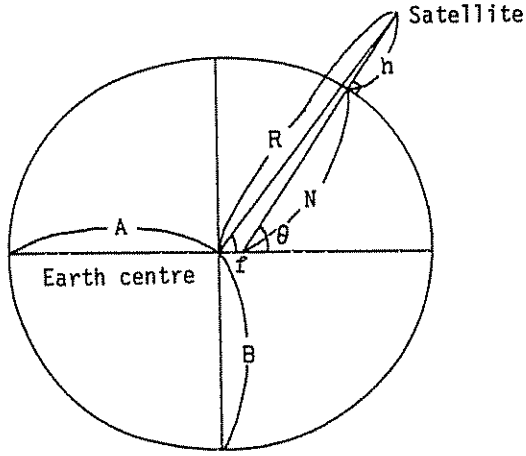
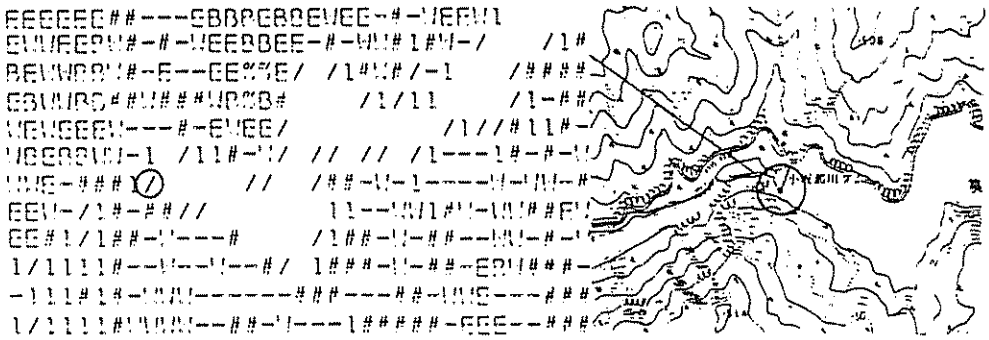


Figure 87. Japan: illustration of selection of ground control points



$$\begin{bmatrix} \cos \underline{f} \cos \lambda \\ \cos \underline{f} \cos \lambda \\ \sin \underline{f} \end{bmatrix} = \begin{bmatrix} \cos (\underline{w} + \underline{V}) \cos (\underline{Q} - \gamma_{\underline{e}}) - \sin (\underline{w} + \underline{V}) \cos i \sin (\underline{Q} - \gamma_{\underline{e}}) \\ \cos (\underline{w} + \underline{V}) \sin (\underline{Q} - \gamma_{\underline{e}}) + \sin (\underline{w} + \underline{V}) \cos (\underline{Q} - \gamma_{\underline{e}}) \\ \sin (\underline{w} + \underline{V}) \sin \underline{i} \end{bmatrix}. \quad (1\text{-}4\text{-}3)$$

The orbital equation of the satellite is

$$\underline{R} = \frac{\underline{a} (1 - \underline{e}^2)}{1 + \underline{e} \cos \underline{V}} \quad (1\text{-}4\text{-}4)$$

where $\underline{R} = |\vec{\underline{R}}|$.

The set of orbit parameters can be obtained by means of least-squares methods by using satellite positions at 11 moments and formulae (1-4-3) and (1-4-4).

The process of least-squares calculation should be explained in more detail. Let $(\underline{f}_{\underline{k}}, \lambda_{\underline{k}}, \underline{h}_{\underline{k}})$ $(\underline{k} = 1,2,.....,11)$ be the given data from the SIAT file, $(\underline{f}_{\underline{k}}, \lambda_{\underline{k}}, \underline{h}_{\underline{k}})$ $\underline{k} = 1,2.....11$ be the calculated values corresponding to a certain set of parameters and $\vec{\underline{R}}_{\underline{k}}$, $\vec{\underline{R}}_{\underline{k}}$ be the radius vectors of each point from Earth's centre. Then one obtains the optimum set of parameters, which makes the following value minimum:

$$\underline{F} = \sum_{k=1}^{11} \left| \vec{\underline{R}}_{\underline{k}} - \vec{\underline{R}}'_{\underline{k}} \right|^2, \quad (1\text{-}4\text{-}5)$$

which can be approximated as

$$\underline{F} = (\underline{R}_{\underline{k}} - \underline{R}'_{\underline{k}})^2 + \left\{ \frac{\underline{R}_6 (\sin \underline{f}_{\underline{k}} - \sin \underline{f}'_{\underline{k}})}{\cos \underline{F}_6} \right\}^2 + \left\{ \frac{\underline{R}_6 (\tan \lambda_{\underline{k}} - \tan \lambda'_{\underline{k}})}{1 + \tan^2 {}_6} \right\}^2 \quad (1\text{-}4\text{-}6)$$

where

$$\underline{R} = \frac{\sin \theta}{\sin \underline{f}} (\underline{N} + \underline{h}). \quad (1\text{-}4\text{-}7)$$

(See figure 86.)

By using equations (1-4-3) - (1-4-7), $\underline{F}$ can be expressed as a function of six parameters:

$$\underline{F} = \underline{F} (\underline{a}, \underline{e}, \underline{i}, \underline{Q}, \underline{w}, \underline{V}). \quad (1\text{-}4\text{-}8)$$

Here, one assumes that $\underline{a}$, $\underline{e}$, $\underline{i}$, $\underline{Q}$ and $\underline{w}$ are constant during the period of one scene scanning (29 seconds) and $\underline{V}$ alters linearly as time goes:

$$\underline{V} = \underline{V}_{\underline{o}} + \sigma_{\underline{t}} \quad (1\text{-}4\text{-}9)$$

where $\underline{V}_o$ is constant δ is an angular velocity.

Then the set of seven constants ($\underline{a}$, $\underline{e}$, $\underline{i}$, $\underline{\Omega}$, $\underline{w}$, $\underline{V}_o$,) which minimize $\underline{F}$ is being calculated.

Determination of transformation formula to the Earth co-ordinate system

The geodetic longitude and latitude (θ , λ) corresponding to the line and column number ($\underline{L}$, $\underline{I}$) of the MSS image are obtained by using the satellite attitude (w, ϕ, $\underline{x}$) and the orbital parameters ($\underline{a}$, $\underline{e}$, $\underline{i}$, $\underline{\Omega}$, $\underline{w}$, $\underline{V}_o$,) by the following procedure:

(1) α : looking angle along the scanning direction

$$\alpha = \left\{ 1 - \frac{2}{3248} (\underline{I} - 1) + \delta a (\underline{I}) \right\} \times 0.101142; \qquad (1\text{-}5\text{-}1)$$

(2) β : looking angle along the orbital direction

$$\beta = \left\{ - 2.5 + \text{mod} (\underline{L} - 1{,}6) \right\} \times 8.6 \times 10^{-5}; \qquad (1\text{-}5\text{-}2)$$

(3) $\vec{\varepsilon}$: direction cosines of the scanner expressed in scanner co-ordinate system

$$\vec{\varepsilon} = \frac{1}{\sqrt{1 + \tan^2\alpha + \tan^2\beta}} \begin{bmatrix} \tan\beta \\ \tan\alpha \\ 1 \end{bmatrix} ; \qquad (1\text{-}5\text{-}3)$$

(4) $\vec{\varepsilon}$ transformed into the Earth co-ordinate system

$$\vec{\varepsilon} = T_{\underline{i}}^{\underline{e}} \cdot T_{\underline{o}}^{\underline{i}} \cdot T_{\underline{b}}^{\underline{o}} \cdot \vec{\varepsilon} ; \qquad (1\text{-}5\text{-}4)$$

(5) $\underline{R}$: distance between Earth's centre and the satellite

$$\underline{R} = \frac{\underline{a} (1 - \underline{e}^2)}{1 + \underline{e} \cos \underline{V}} ; \qquad (1\text{-}5\text{-}5)$$

(6) $\overline{\underline{R}}$: vector from Earth's centre to the satellite

$$\overline{\underline{R}} = \underline{R} \begin{matrix} \cos(\underline{w} + \underline{V}) \cos(\underline{\Omega} - \gamma_{\underline{e}}) - \sin(\underline{w} + \underline{V}) \cos \underline{i} \sin(\underline{\Omega} - \gamma_{\underline{e}}) \\ \cos(\underline{w} + \underline{V}) \sin(\underline{\Omega} - \gamma_{\underline{e}}) + \sin(\underline{w} + \underline{V}) \cos \underline{i} \cos(\underline{\Omega} - \gamma_{\underline{e}}) \\ \sin \underline{w} + \underline{V}) \sin \underline{i} \end{matrix} ; \qquad (1\text{-}5\text{-}6)$$

(7) $\vec{\underline{a}}$: direction cosines from Earth's centre to the observed point on Earth's surface

$$\vec{a} = \frac{1}{r}\left[\vec{R} - \vec{\varepsilon}\left\{(\vec{R}\cdot\vec{\varepsilon}) + \sqrt{r^2 - R^2 + (\vec{R}\cdot\vec{\varepsilon})^2}\right\}\right] \qquad (1\text{-}5\text{-}7)$$

(8) λ : geodetical longitude

$$\lambda = T_{an}^{-1}\,(a_y / a_x) + \pi\,; \qquad (1\text{-}5\text{-}9)$$

(9) θ : geodetic latitude

$$\theta = T_{an}^{-1}\left(\frac{1.0067192 - a_z}{\sqrt{1 - a_z^2}}\right). \qquad (1\text{-}5\text{-}10)$$

Fine correction by using ground control points

After transforming the line-pixel numbers to longitude and latitude with the transformation formula derived from the annotation data, there still remain some hundred metres of errors, on average. These errors are supposed to be come from the error of annotation data itself and the differences between co-ordinate systems adopted in Japan and to express LANDSAT satellite positions. These errors can be diminished by using some seven or eight CCPs per scene to 30-30 m in root-mean-square (rms) values.

GCP selection (see figure 87) is performed by considering the following conditions; and their longitude, latitude and altitude are measured on a 1:25,000 topographic map: (a) every GCP should be clearly identifiable on both the topographic map and the LANDSAT image; (b) GCPs should be distributed randomly and evenly over the whole scene.

Suppose that the correction terms for longitude and latitude can be expressed as functions of L and I as

$$\delta\lambda = A_1 + A_2 L + A_3 I + A_4 L \cdot I \qquad (1\text{-}6\text{-}1)$$

$$\delta\theta = B_1 + B_2 L + B_3 I - B_4 L \cdot I \qquad (1\text{-}6\text{-}2)$$

where coefficients A_i, B_i, (i = 1 4) will be determined in such a way that the square sum of errors at GCPs is minimized.

Map projection transformation

Map projection of 1:500,000 and 1:200,000 scale maps produced by GSI are conformal conic projection and polycylindrical or Universal Transverse Mercator (UTM) projection, respectively. Therefore, if one wants to register LANDSAT images and/or their product on those maps, it is necessary to tranform the image co-ordinate system to the map projection co-ordinate system.

The mathematical expressions of this transformation are explained below.

Conformal conic projection

Conformal conic projection (figure 88) is to project a point on Earth to the cone surface whose axis is the same as the Earth axis and intersect Earth's surface at latitudes θ_1 and θ_2. The map co-ordinate system is the two-dimensional shrunken co-ordinate system on the developed cone surface.

Let $\underline{A}$ and $\underline{E}$ be the equatorial axis and eccentricity, respectively. Then one obtains the radius of parallel curvature $\underline{N}$ at latitude by

$$\underline{N} = \frac{\underline{A}}{\sqrt{1 - \underline{E}^2 \sin^2\theta}} . \qquad (1\text{-}7\text{-}1)$$

Let be the complementary angle of latitude , then one obtains

$$\frac{\chi}{2} = \left(\frac{\pi}{4} - \frac{\theta}{2}\right)\left(\frac{1 + \underline{E}\sin}{1 - \underline{E}\sin}\right)^{\frac{E}{2}} . \qquad (1\text{-}7\text{-}2)$$

Let θ_1, θ_2 be the standard paralleles and $\underline{N_i}$, $\underline{i}$ ($\underline{i} = 1, 2$) be the corresponding radius of parallel curvature and conformal complemental latitude. Then one obtains

$$\underline{N_i} = \frac{\underline{A}}{\sqrt{1 - \underline{E}^2 \sin^2\theta_{\underline{i}}}} , \qquad (1\text{-}7\text{-}3)$$

$$\frac{\chi_{\underline{i}}}{2} = \left(\frac{\pi}{4} - \frac{\theta_{\underline{i}}}{2}\right)\left(\frac{1 + \underline{E}\sin\theta_{\underline{i}}}{1 - \underline{E}\sin\theta_{\underline{i}}}\right)^{\frac{E}{2}} . \qquad (1\text{-}7\text{-}4)$$

Constants μ, $\underline{K}$ are obtained by using these values:

$$\mu = \frac{\ln\left(\underline{N_1}\cos\theta_1 \,/\, \underline{N_2}\cos\theta_2\right)}{\ln\left(\tan\frac{\chi_1}{2} \,/\, \tan\frac{\chi_2}{2}\right)} , \qquad (1\text{-}7\text{-}5)$$

$$\underline{K} = \frac{\underline{N_1}\cos\theta_1}{\mu\left(\tan\frac{\chi_1}{2}\right)^{\mu}} . \qquad (1\text{-}7\text{-}6)$$

Let (θ_o, λ_o) be the origin; then the transformation from (θ, λ) to $(\underline{x}, \underline{y})$ is performed as

$$\frac{\underline{\varphi}_o}{2} = \left(\frac{\pi}{4} - \frac{\theta_o}{2}\right)\left(\frac{1 + \underline{E}\sin\theta_o}{1 - \underline{E}\sin\theta_o}\right)^{\frac{\underline{E}}{2}} ; \qquad (1\text{-}7\text{-}7)$$

$$\rho o = K\,(\tan\frac{\underline{\varphi}_o}{2})^{\mu} , \qquad (1\text{-}7\text{-}8)$$

$$\rho = K\,(\tan\frac{\underline{\varphi}}{2})^{\mu} , \qquad (1\text{-}7\text{-}9)$$

$$\varphi = \mu(\lambda - \lambda_o) , \qquad (1\text{-}7\text{-}10)$$

$$\underline{x} = \rho \cdot \sin\phi \qquad (1\text{-}7\text{-}11)$$

$$\underline{y} = \rho_o - \rho\cos\phi. \qquad (1\text{-}7\text{-}12)$$

The origin is determined so that the $\underline{x}$ axis may be nearly parallel to the column direction of the input image (see figure 89), and the common origin is adopted when two scenes are being mosaicked.

Polycylindrical projection

The polycylindrical projection adopted for the 1:200,000 scale map in Japan is a cylindrical projection which projects on to a cylinder which includes circles of longitude of both ends of the area to be projected (see figure 90).

Let λ_1, λ_2, be the longitude of both ends and θ_1 be the standard parallel, and $\Delta\,\underline{l}$, $\Delta\,\underline{x}$, $\Delta\,\underline{y}$ and the origin be as shown in figure 91. One obtains the following formula in the extent of $|\Delta\theta| < \pi / 270, |\lambda_1 - \lambda_2| = \pi / 180$:

$$\Delta\,\underline{l} = \underline{A}\,(1 - \underline{E}^2)\cdot(\underline{C}_1\,\Delta\theta - \underline{C}_2\sin\Delta\theta\cos 2\theta + \frac{\underline{C}_3}{2}\sin 2\Delta\theta\cos 4\theta - \frac{\underline{C}_4}{3}\sin 3\Delta\theta\cos 6\theta), \qquad (1\text{-}7\text{-}13)$$

$$\Delta\theta = \theta - \theta_o \qquad (1\text{-}7\text{-}14)$$

$$\Delta x = \Delta\lambda\cdot\underline{N}\cos\theta, \qquad (1\text{-}7\text{-}15)$$

$$\underline{N} = \frac{\underline{A}}{\sqrt{1 - \underline{E}^2\sin^2\theta}} , \qquad (1\text{-}7\text{-}16)$$

$$\Delta\lambda = \lambda - \frac{\lambda_1 + \lambda_2}{2} , \qquad (1\text{-}7\text{-}17)$$

$$\Delta y = \frac{1}{4}\underline{N}\,(\lambda_2 - \lambda)\,(\lambda - \lambda_1)\sin 2\theta. \qquad (1\text{-}7\text{-}18)$$

Figure 88. Japan: conformal conic projection

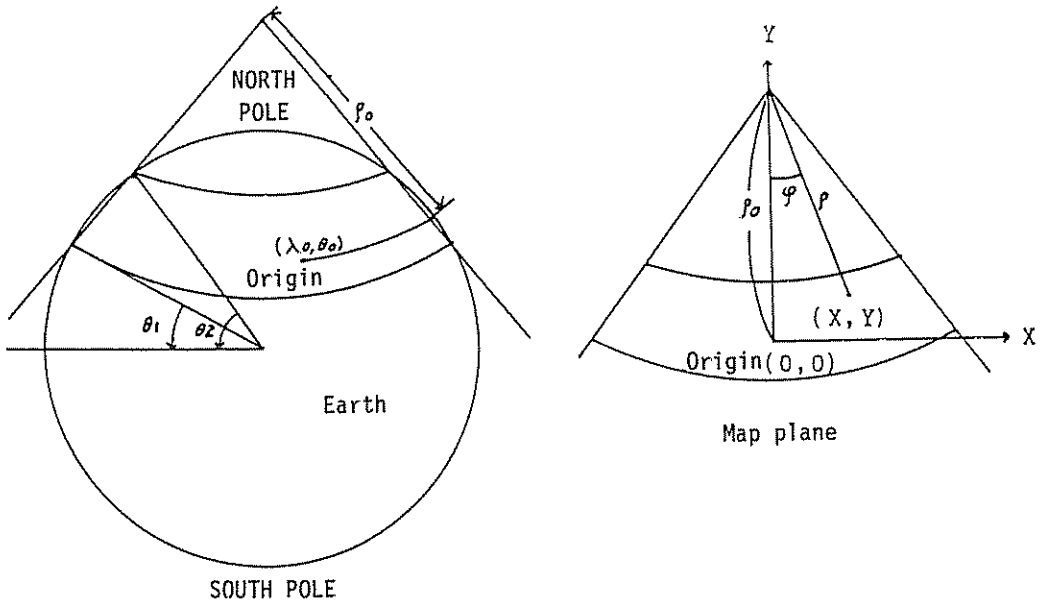


Figure 89. Japan: determination of origin of the co-ordinate systems

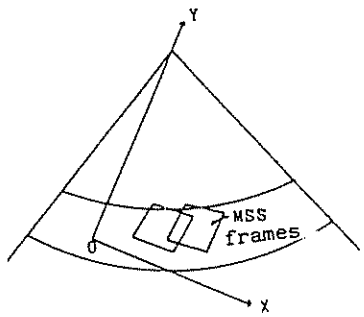


Figure 90. Japan: polycylindrical projection

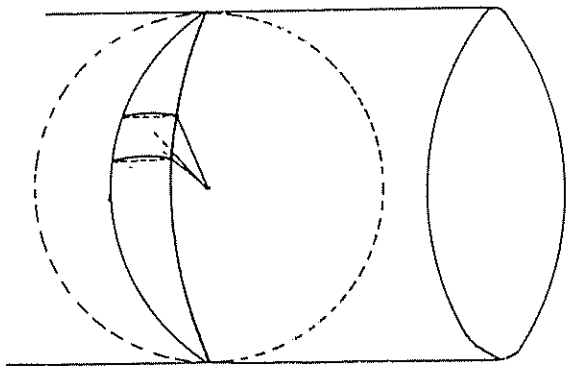


Figure 91. Japan: polycylindrical projection to produce a plane map

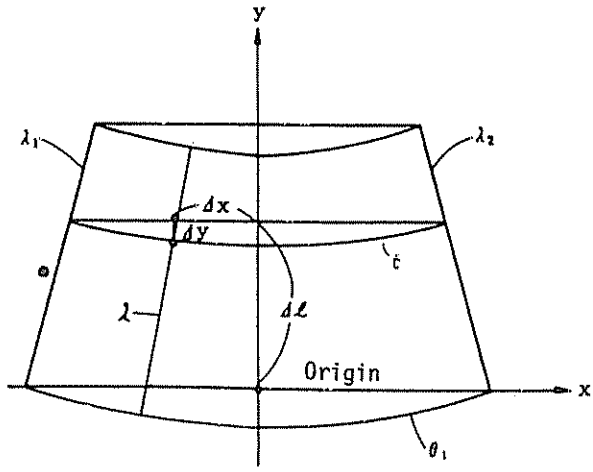
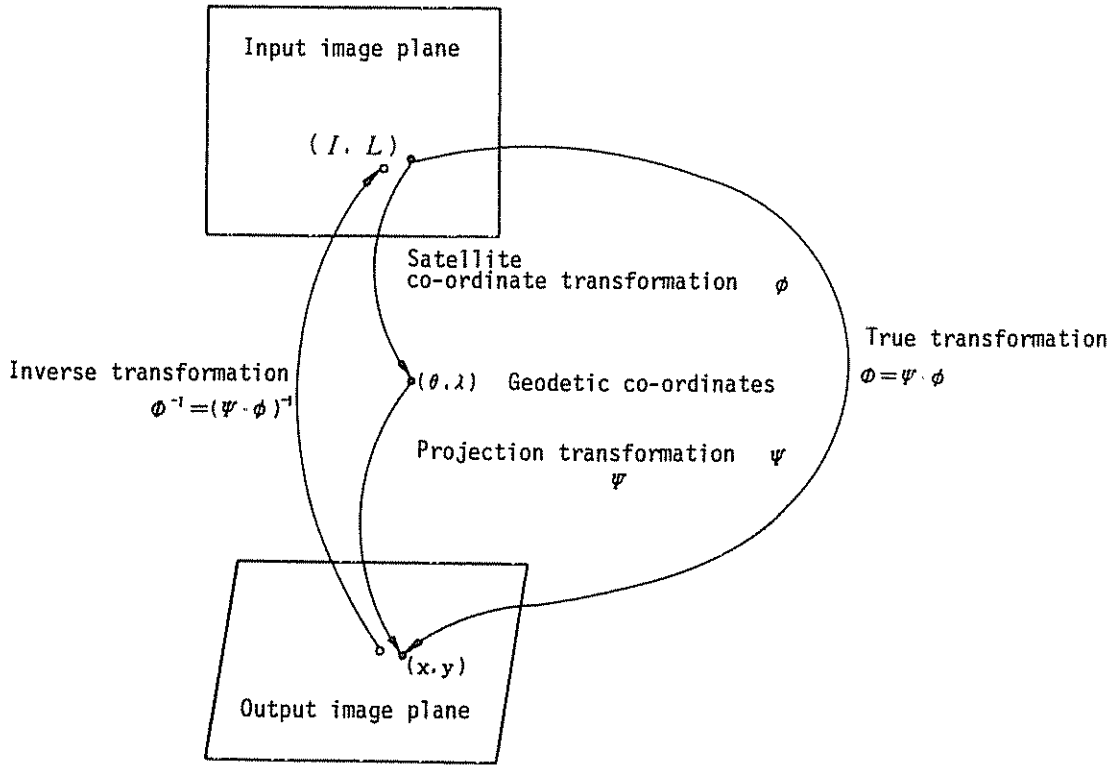


Figure 92. Japan: inverse transformation



The transformation from (θ , λ) to ($\underline{x}$, $\underline{y}$) is expressed by

$$\underline{x} = \Delta \underline{x} \qquad (1\text{-}7\text{-}19)$$

$$\underline{y} = \Delta \underline{l} - \Delta \underline{y} \qquad (1\text{-}7\text{-}20)$$

where $\underline{C}_1 \sim \underline{C}_4$ are constants to determine the length of arc of longitude:

$$\underline{C}_1 = 1.0050373 \qquad \underline{C}_2 = 5.04785 \times 10^{-3}$$

$$\underline{C}_3 = 1.0564 \times 10^{-5} \qquad \underline{C}_4 = 2.06 \times 10^{-8} \quad ,$$

Universal Transverse Mercator projection

The UTM projection is adopted in the 1:25,000 and 1:50,000 scale topographic maps and the 1:200,000 scale map published after 1981; it also is adopted in geometrically corrected MSS data distributed from NASDA. The transformation formula for this projection is explained in the tables of frame lenghts of topographic maps at 1:25,000 scale (UTM) prepared by GSI.

Inverse transformation

When one intends to output image by the sequence of output co-ordinate system, it is necessary to determine the position on the input image corresponding to each pixel on the output image. This is performed by the inverse transformation (see figures 92 and 93).

However, it is rather more difficult to obtain the inverse transformation function by analytical means than to obtain the true transformation function previously described. Therefore, one performs the inverse transformation such that in a local area, which includes the object pixel, the input pixel ($\underline{L}$, $\underline{I}$) is obtained by linear approximation of the output image co-ordinates $\underline{x}$, $\underline{y}$.

The actual procedure of inverse transformation includes two steps:

First, divide the input image into $\underline{K}$ x $\underline{K}'$ and perform the true transformation for each gridded point $\underline{P}$ ($\underline{L}$, $\underline{I}$), then obtaining corresponding points $\underline{P}'$ ($\underline{x}$, $\underline{y}$) on the output image. That is, one assumes

$$\phi(\underline{P}) = \underline{P}' \ . \qquad (1\text{-}7\text{-}21)$$

Then, assume that the inverse transformation function $_{o}^{-1}$ can be described as

$$\phi_{\underline{0}}^{-1}(P') = \sum_{m=o}^{2} \sum_{n=o}^{2} \underline{a}_{m\,n}\ \underline{x}^{m}.\underline{y}^{n},\ \sum_{m=o}^{3} \sum_{n=0}^{2} \underline{b}_{m\,n}\ \underline{x}^{m}.\underline{y}^{n}) = (\underline{I}_0,\ \underline{L}_0). \qquad (1\text{-}7\text{-}22)$$

The coefficients $\underline{a}_{m\,n}$, $\underline{b}_{m\,n}$ are determined such that the square sum of errors at $\underline{P}_{ij}$ ($\underline{i}$ = 1 $\underline{k}$, $\underline{j}$ = 1 $\underline{k}'$) is minimized.

Figure 93. Japan: configuration of inverse transformation

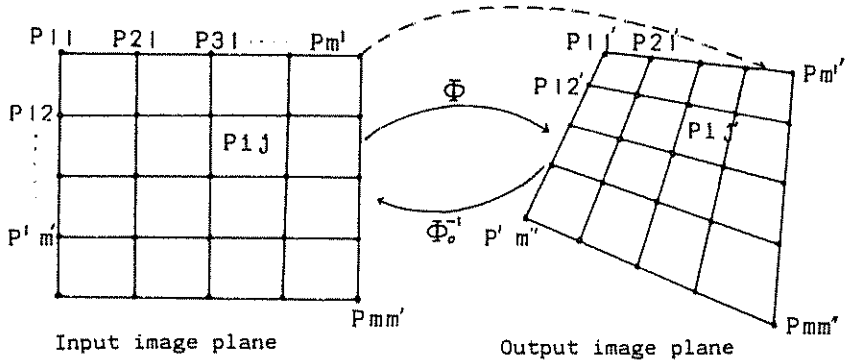


Figure 94. Japan: configuration of terrain adjustment

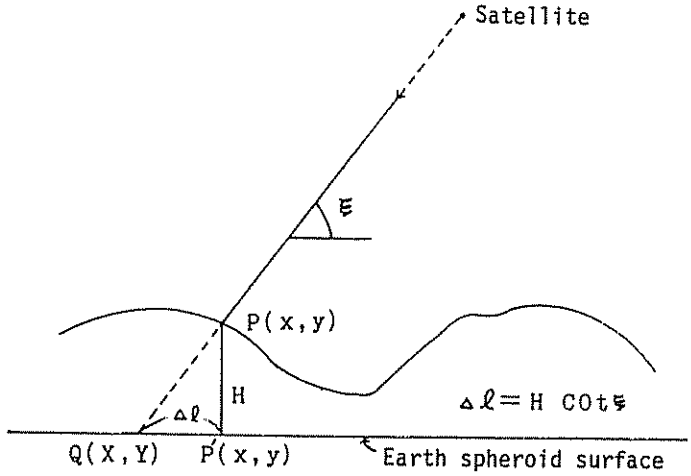
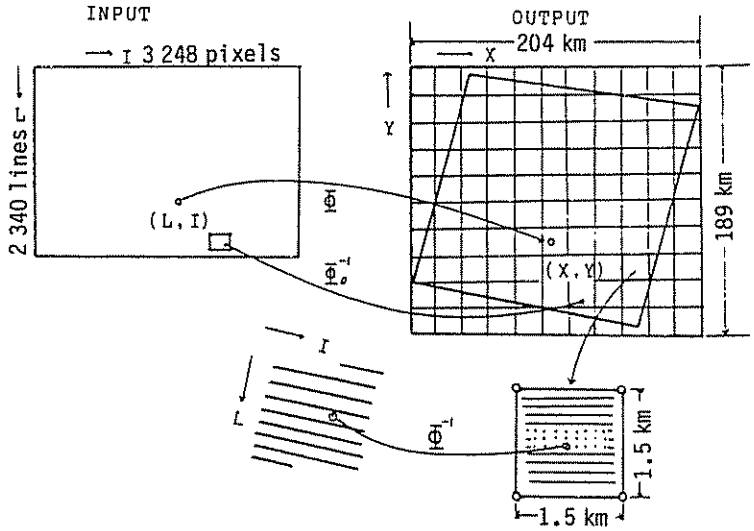


Figure 95. Japan: illustration of resampling



Inverse transformation with linear approximation

Let ΔL, ΔI be the errors for L, I, determined by ϕ_o^{-1}, then $L \geq 2.0$ $I \geq 6.0$. Within the area, one can determine the following transformation formula which makes the positional errors within 7 metres.

$$L = C_1 x + C_2 y + C_3, \tag{1-7-23}$$

$$I = d_1 x + d_2 y + d_3 + \left\{ IFIX\left(\frac{L}{6}\right) - IFIX\left(\frac{L_o}{6}\right) \right\} \cdot S \tag{1-7-24}$$

where constants c_i, d_i ($i = 1 \sim 3$) are determined so that the square sum of errors at four corners of the area calculated by $\phi(P) = P'$ is minimized. The constant S takes the value of 0.47 around Japan and 0.20 in the Antarctic continent of 69° South.

Terrain adjustment

The input image co-ordinates (L, I) can be transformed to longitude and latitude through the procedure shown above. However, since it is assumed in this method that Earth's surface is flat without any ups and downs, there still remain some errors derived from the terrain features. These errors cannot be ignored when a mountainous area is observed near the fringe of the scanner.

Figure 94 shows this situation, where ε is an angle of altitude of the satellite and H is the elevation of the observed point. The displacement ℓ is obtained as

$$\Delta \ell = H \cot \varepsilon \tag{1-9-1}$$

Therefore, the input image co-ordinates (L, I) corresponding to the point P can be obtained by calcualting $\phi^{-1}(Q)$ instead of $\phi^{-1}(\quad')$. Let ε, η be the altitude and azimuth angles of the satellite respectively, then let (x, y), (X, Y) be the planimetric co-ordinates for P, Q, respectively. Then one obtains

$$(X, Y) = (x - H \cot\varepsilon \cos\eta,\ y - H \cot\varepsilon \sin\eta). \tag{1-9-2}$$

Terrain adjustment can be performed by replacing (x, y) by (X, Y) in the transformation formula.

Resampling

As mentioned in the previous sections, the inverse transformation is performed to obtain the position on the input image corresponding to each point on the output image. A huge amount of time is needed to calculate in this way for every output point.

Therefore, the output image is divided by a small section (about 1.5 km square), and the inverse transformation is performed for four corner pixels; linear interpolation is performed for the other points inside the section.

The interpolation is performed as

$$\underline{L} = \underline{a}_1 \underline{x} + \underline{b}_1 + \underline{c}_1, \tag{1-10-1}$$

$$\underline{I} + \underline{a}_2 \underline{x} + \underline{b}_2 \underline{y} + \underline{y} + \underline{c}_2 + \left\{ \underline{IFIX} \left(\frac{L}{6}\right) - \underline{IFIX} \left(\frac{L'}{6}\right) \right\} \times 0.47 \tag{1-10-2}$$

where the notations are as shown in figure 95, and $\underline{a}$, $\underline{b}$, ($\underline{i}$ = 1, 2) are obtained as to minimize the following values:

$$\varepsilon_1 = \sum_{\underline{k}=1}^{4} (\underline{a}_1 \underline{x}_{\underline{k}} + \underline{b}_1 \underline{y}_{\underline{k}} + \underline{c}_1 - \underline{L}_{\underline{k}})^2, \tag{1-10-3}$$

$$\varepsilon_2 = \sum_{\underline{k}=1}^{4} (\underline{a}_2 \underline{x}_{\underline{k}} + \underline{b}_2 \underline{y}_{\underline{k}} + \underline{c}_2 - \underline{I}_{\underline{k}} + \left\{ \underline{IFLX} \left(\frac{\underline{L}_{\underline{k}}}{6}\right) - \underline{IFIX} \left(\frac{\underline{L}_{\underline{i}}}{6}\right) \right\} \times 0.47)^2. \tag{1-10-4}$$

Terrain adjustment is performed by replacing ($\underline{x}$, $\underline{y}$) in equations (1-10-1) and (1-10-2) by the following ($\underline{X}$, $\underline{Y}$)

$$\underline{X} - \underline{x} - \underline{H} \cot \xi_o \cos \eta_o \tag{1-10-5}$$

$$\underline{Y} = \underline{y} - \underline{H} \cot \xi_o \sin \eta_o \tag{1-10-6}$$

where $\underline{H}$ is altitude of the satellite and ξ_o, η_o are angles of altitude and azimuth of the satellite from the centre of the section.

Here it is assumed that ξ and η at each point inside the section can be represented by ξ_o and η_o. In fact, the maximum error derived from this assumption is only 7.8 m when the section size is 3 x 3 km and elevation of the ground is 3,000 m (see figure 96).

Grey-level determination during resampling

Input image co-ordinates ($\underline{L}$, $\underline{I}$) calculated by the inverse transformation are not always integers. Therefore, it is necessary to interpolate the grey level at ($\underline{L}$, $\underline{I}$).

For this interpolation, the nearest neighbourhood method is adopted for the 1:500,000 map, and linear interpolation using neighbouring pixels is adopted for the 1:200,000 map.

Figure 96. Japan: maximum error in terrain adjustment

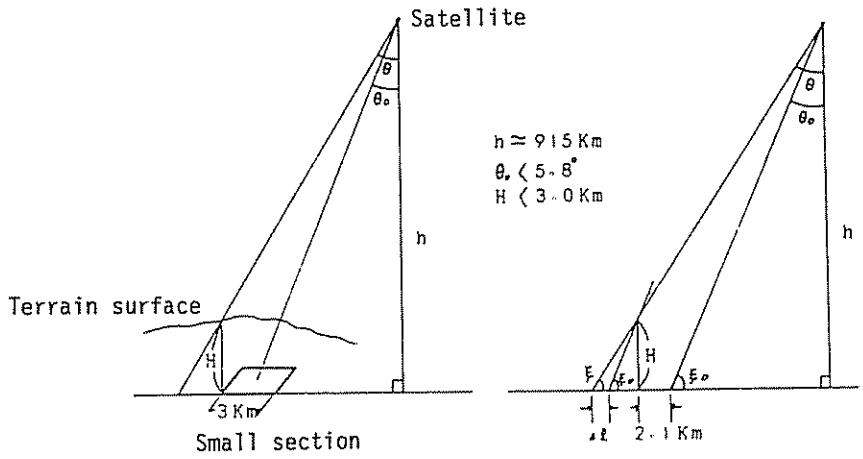
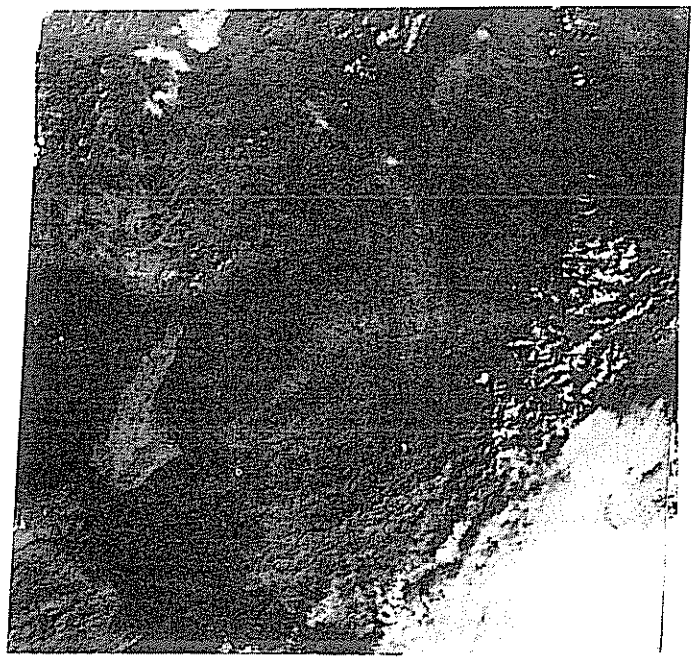


Figure 97. Japan: LANDSAT-2 multispectral scanner image of Osaka



Case study

For the case study of LANDSAT MSS data correction, the LANDSAT-2 Osaka scene (figure 97) was processed. The specifications of these data are:

(a) Date taken: 15 October 1979;

(b) Scene number: 118-36 (Osaka);

(c) Longitude and latitude of scene centre: $34^{o}29'$ N, $135^{o}32'$ E;

(d) Number of pixels: 3,248 columns x 2,340 lines;

(e) CGT format: BIP2, no correction.

Density-level correction

Table 31 shows the correction coefficients $\underline{A}_i$, $\underline{B}_i$ of equation (1-2-4) for this scene. Those coefficients are calculated as to minimize the value expressed by equation (1-2-5) with the accumulative probability density of 5 per cent increment. Since 15 per cent of the scene represents clouds and 20 per cent represents water, the accumulative probability densities from 5 to 85 per cent are utilized for the calculation of $\underline{A}$ and $\underline{B}$ for bands 4 and 5, and 20 to 85 per cent for bands 6 and 7.

Figure 98 shows the histograms before and after correction, and figure 99 shows the images before and after correction.

Estimation of satellite attitude

The information for the satellite attitude are recorded on the SIAT file. Table 32 shows these data of this scene. This table shows that roll, pitch and yaw angles fluctuate as functions of time. Those functions were approximated by the third-order polynomials as follows:

Roll angle (rad)

$$\omega = 0.260981 \cdot 10^{-2} + 0.306423 \cdot 10^{-4}\ \underline{t} + 0.558889 \cdot 10^{-6}\ \underline{t}^2 - 0.245377 \cdot 10^{-7}\ \underline{t}^3 \qquad (1\text{-}11\text{-}1)$$

Pitch angle (rad)

$$\phi = 0.549429 \cdot 10^{-2} - 0.394169 \cdot 10^{-5}\ \underline{t} - 0.163647 \cdot 10^{-6}\ \underline{t}^2 - 0.375100 \cdot 10^{-7}\ \underline{t}^3 \qquad (1\text{-}11\text{-}2)$$

Yaw angle (rad)

$$\underline{k} = 0.300189 \cdot 10^{-2} - 0.348856 \cdot 10^{-4}\ \underline{t} - 0.628230 \cdot 10^{-6}\ \underline{t}^2 - 0.264132 \cdot 10^{-7}\ \underline{t}^3 \qquad (1\text{-}11\text{-}3)$$

Figure 100 shows these approximate functions together with the point data recorded on the SIAT file.

Estimation of satellite orbit

The information for the satellite orbit are also recorded on the SIAT file which are shown by table 33. From those data, the orbit parameters

Figure 98. Japan: histograms of raw data and corrected data

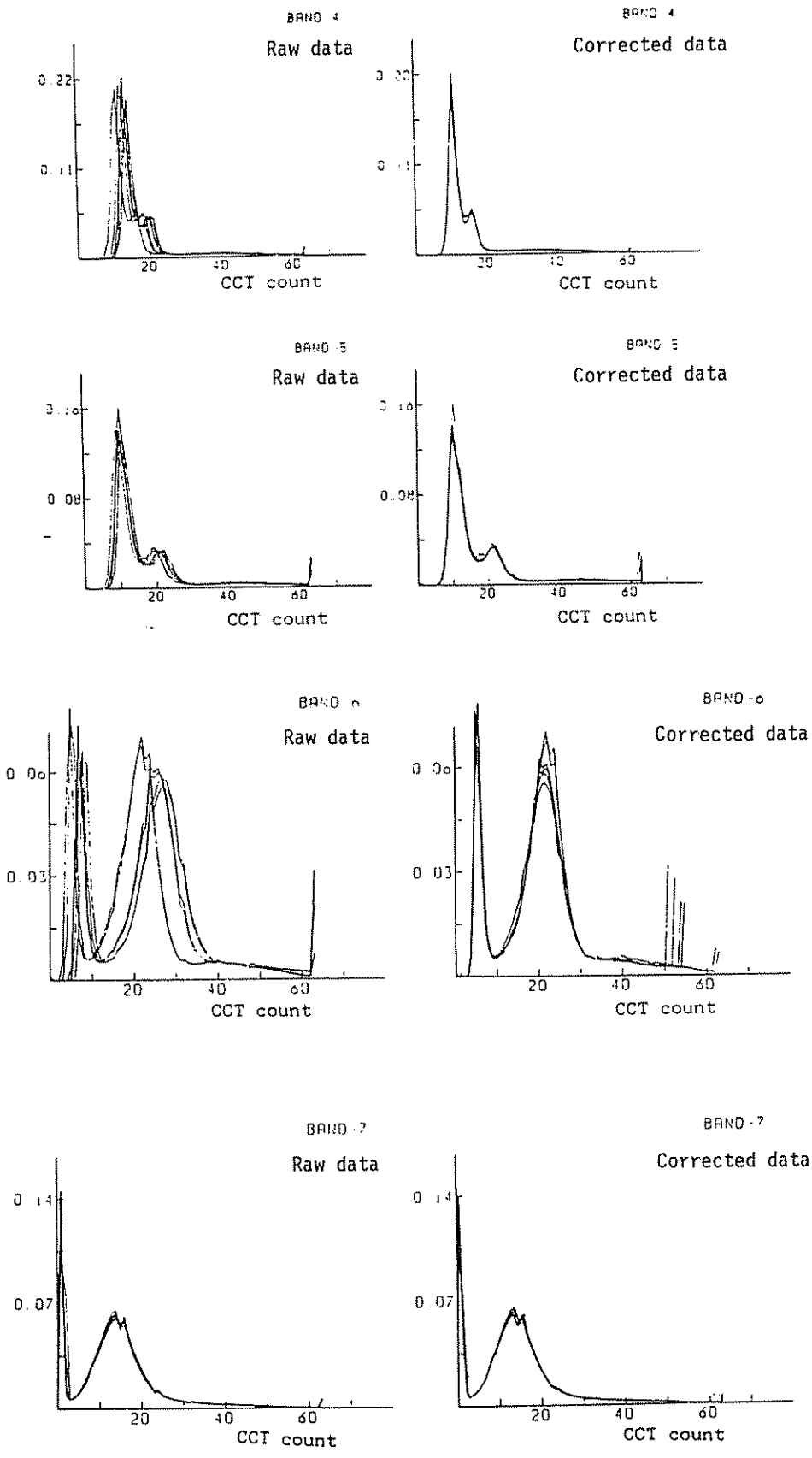


Table 31. Correction coefficients for density levels, LANDSAT scene of Osaka, Japan

Band	Detector	A	B	Correlation
4	1	1.000000	0.000000	1.000000
4	2	0.978365	- 1.359768	0.999709
4	3	0.882196	- 1.054110	0.999580
4	4	0.867818	- 1.609585	0.999521
4	5	0.997508	- 2.250335	0.999808
4	6	0.879850	- 1.478619	0.999691
5	1	1.000000	0.000000	1.000000
5	2	1.002469	- 0.710255	0.999964
5	3	1.076190	0.377070	0.999909
5	4	1.040012	- 0.126674	0.999962
5	6	1.177578	- 1.480458	0.999764
6	1	1.000000	0.000000	1.000000
6	2	0.973850	0.848930	0.999992
6	3	0.865024	- 1.925935	0.999136
6	4	0.885906	- 0.974558	0.999542
6	5	0.872587	- 0.924202	0.999524
6	6	0.823435	- 0.943685	0.999142
7	1	1.000000	0.000000	1.000000
7	2	0.994585	- 0.185621	0.999992
7	3	1.022303	- 0.676681	0.999987
7	4	1.049386	- 0.895799	0.999990
7	5	0.969753	- 0.221101	0.999981
7	6	0.975199	- 0.139879	0.999985

Figure 99. Japan: multispectral scanner images before and after correction

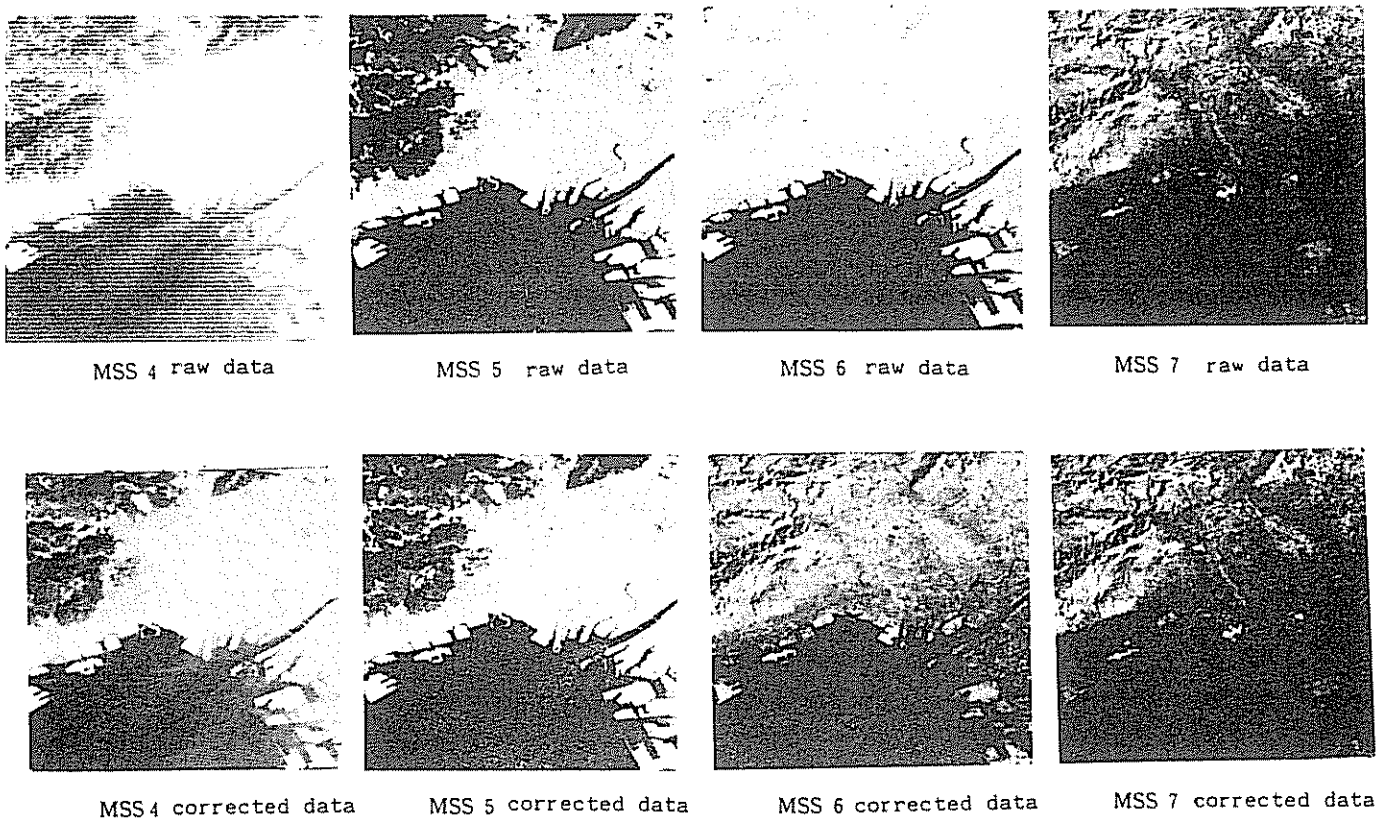


Figure 100. Japan: profiles of roll, pitch and yaw

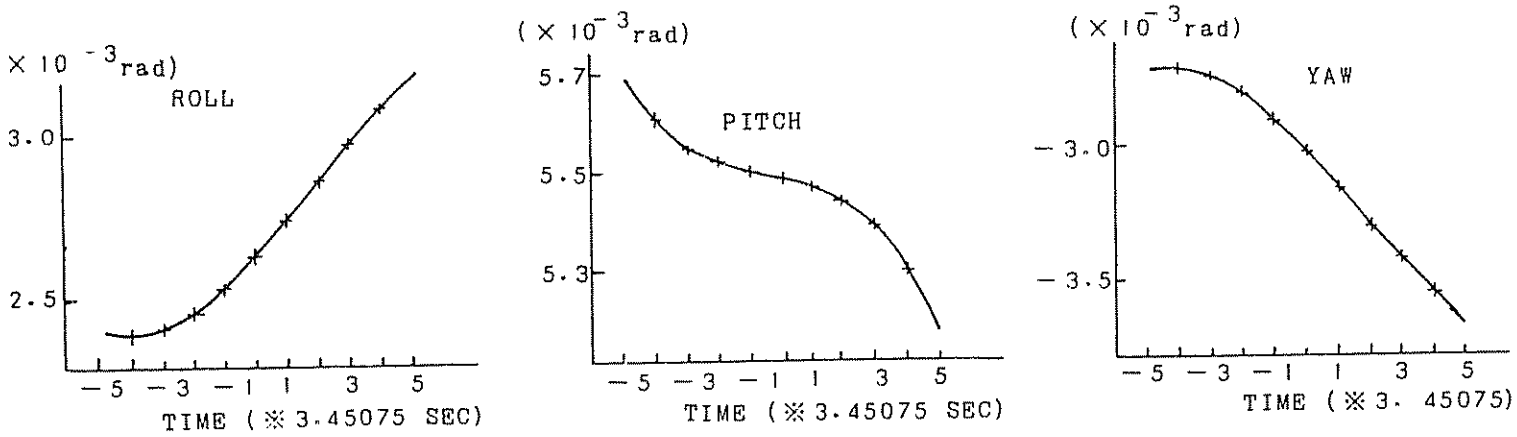


Table 32. Attitude data for LANDSAT multispectral scanner scene of Osaka, Japan

	Elapsed time	Roll	x 10^{-3}rad	Pitch	x 10^{-3}rad	Yaw	x 10^{-3}rad
	(seconds)	SIAT	Estimated	SIAT	Estimated	SIAT	Estimated
1	-13.80300	2.357	2.358	5.615	5.616	-2.708	-2.710
2	-10.35225	2.380	2.380	5.562	5.559	-2.739	-2.737
3	- 6.90150	2.434	2.433	5.524	5.526	-2.800	-2.800
4	- 3.45075	2.510	2.512	5.508	5.507	-2.892	-2.890
5	0.0	2.609	2.610	5.493	5.494	-2.998	-3.002
6	3.45075	2.724	2.721	5.478	5.477	-3.128	-3.129
7	6.90150	2.838	2.840	5.447	5.447	-3.265	-3.264
8	10.35225	2.960	2.960	5.394	5.394	-3.403	-3.401
9	13.80300	3.075	3.075	5.310	5.310	-3.532	-3.534
Root mean square of error		1.5 x 10^{-6}rad		1.4 x 10^{-6}rad		2.1 x 10^{-6}rad	

Note: SIAT = special image annotation tape.

Table 33. Positional data for LANDSAT multispectral scanner scene of Osaka, Japan

	Elapsed time (seconds)	Geodetic latitude (rad)	Geodetic longitude (rad)	Satellite altitude (metres)
1	-25	0.627390	2.373085	919568
2	-20	0.622408	2.371500	919487
3	-15	0.617425	2.369924	919407
4	-10	0.612441	2.368356	919326
5	- 5	0.607456	2.366797	919246
6	0	0.602470	2.365247	919165
7	5	0.597484	2.363704	919085
8	10	0.592496	2.362169	919004
9	15	0.587507	2.360641	918924
10	20	0.582518	2.359121	918843
11	25	0.577528	2.357607	918762

($\underline{a}$, $\underline{e}$, $\underline{i}$, $\underline{Q}$, $\underline{w}$, $\underline{V_O}$,σ) for this scene were obtained as follows by means of the least-squares method:

(a) Semi-major axis: $\underline{a} = 7.274496 \cdot 10^7$ m;

(b) Eccentricity: $\underline{e} = 2.155527 \cdot 10^{-3}$;

(c) Inclination: $\underline{i} = 1.7305128$ rad.

Ascending node $\underline{Q} = -0.8867158$ rad

Argument of perigee $\underline{w} = -0.3757822$ rad

True anomaly $\underline{V} = 2.908792 + 1.014159 \cdot 10^{-3}\ \underline{t}$

Table 34 compares the satellite positions at 11 moments in the scene recorded on the SIAT file with the estimated values. Positions of the satellite are expressed by the polar co-ordinate system from Earth's centre, and the distances $\underline{S}$ for the error evaluation are obtained by the following formula:

$$\underline{S} = (\underline{R} - \underline{R}')^2 + \underline{R}^2 (\underline{f} - \underline{f}')^2 + \underline{R}^2 \cos^2 \underline{f} (\lambda - \lambda')^2 \qquad (1\text{-}11\text{-}4)$$

This table shows that the satellite position of any time during scene observation can be estimated within about 6 m accuracy.

Fine correction by using ground control points

Eighteen GCPs were selected over the scene for fine correction. Figure 101 and table 35 show the distributions and co-ordinates of GCPs. Those points were selected at the waterfront.

The image co-ordinates for a GCP are given as line and column number of the original image, and the corresponding geodetic co-ordinates are measured on the 1:25,000 scale topographic map by 1/10-second precision.

After each GCP has been transformed from ($\underline{L}$, $\underline{I}$) to (θ , λ) through the procedure explained above, the root mean square of the residuals is about 669 m, as shown in table 36.

Figure 101 shows that displacement errors given in table 36 look linearly distributed over the scene. Therefore, the following three functions were examined as appropriate functions for fine correction:

Linear function ($\underline{A}$)

$$\Delta\ \underline{x} = A\underline{x} + B\underline{y} + \underline{C}$$
$$\Delta\ \underline{y} = A\underline{y} - B\underline{x} + \underline{D} \qquad (1\text{-}11\text{-}5)$$

Table 34. Performance of satellite orbit estimation, LANDSAT scene

	Elapsed time (seconds)	Polar latitude (rad) SIAT	Polar latitude (rad) Estimated	Polar longitude (rad) SIAT	Polar longitude (rad) Estimated	Polar radius (mètres) SIAT	Polar radius (mètres) Estimated	Error (mètres)
1	-25	0.624612	0.624612	2.373085	2.373085	7289655	7289655	2.3
2	-20	0.619639	0.619639	2.371500	2.371501	7289674	7289675	3.7
3	-15	0.614666	0.614666	2.369924	2.369924	7289695	7289695	2.5
4	-10	0.609691	0.609691	2.368356	2.368357	7289714	7289714	4.8
5	- 5	0.604716	0.604717	2.366797	2.366797	7289733	7289733	2.6
6	0	0.599741	0.599741	2.365247	2.375246	7289751	7289752	6.5
7	5	0.594765	0.594765	2.363704	2.363703	7289770	7289770	7.2
8	10	0.589788	0.589788	2.362169	2.362168	7289788	7289788	8.0
9	15	0.584810	0.584811	2.360641	2.360641	7289806	7289805	4.8
10	20	0.579833	0.579833	2.359121	2.359121	7289822	7289822	1.8
11	25	0.574855	0.574854	2.357607	2.357601	7289838	7289839	11.5

Root mean sqaure of error = $\sqrt{F / 11}$ - 5.8 mètres

Note: SIAT = special image annotation tape.

Table 35. Image and geodetic co-ordinates of ground control points, LANDSAT data

No.	Image co-ordinates		Geodetic co-ordinates	
	Column number	Line number	Longitude (E)	Latitude (N)
1	1267	927	135° 21' 46".3	34° 41' 52".5
2	1981	268	135° 57' 1".5	34° 5' 27".4
3	721	1078	135° 59' 33".5	34° 38' 31".2
4	359	1630	134° 39' 23".3	34° 17' 17".4
5	339	1775	134° 36' 53".7	34° 11' 21".1
6	66	91	134° 47' 37".8	35° 23' 31".8
7	1161	140	135° 27' 50".8	35° 15' 31".7
8	1413	1168	135° 24' 11".5	34° 30' 56".8
9	1157	1630	135° 8' 51".8	34° 12' 57".5
10	3119	311	136° 38' 41".0	34° 57' 4".8
11	186	956	134° 41' 17".0	34° 46' 30".8
12	112	1109	134° 36' 41".4	34° 40' 29".0
13	607	2213	134° 41' 22".1	33° 51' 32".1
14	1328	2099	135° 9' 22".0	33° 52' 21".0
15	3064	709	136° 31' 19".8	34° 40' 43".0
16	3180	1317	136° 27' 32".7	34° 14' 34".0
17	2213	1731	135° 46' 45".7	34° 2' 48".1
18	1946	797	135° 48' 50".3	34° 43' 30".5

Figure 101. Japan: distribution of ground control points and their errors before correction

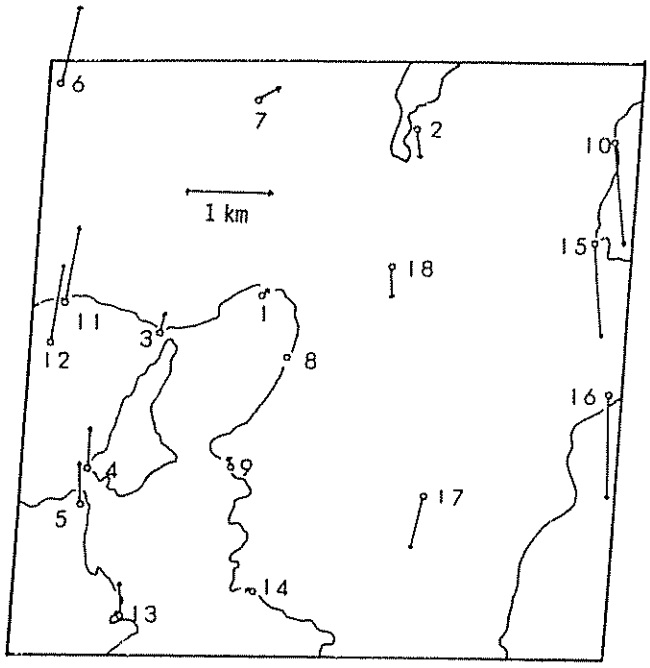


Figure 102. Japan: illustration of image duplication

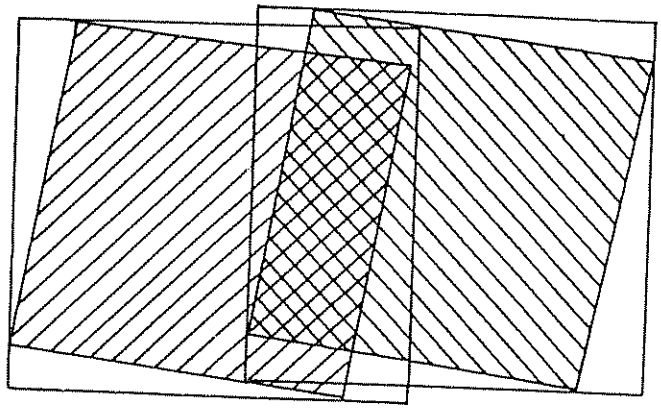


Figure 103. Japan: mosaicking procedure

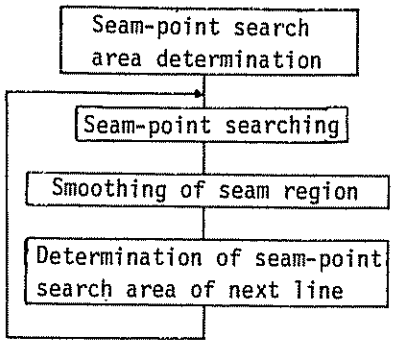


Figure 104. Japan: seam-point search area

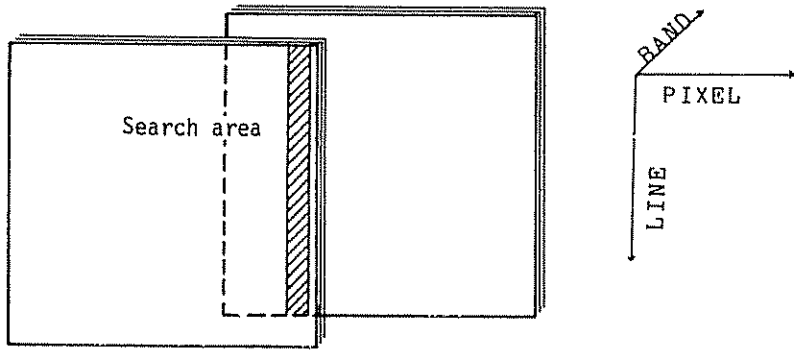


Table 36. Results of fine correction of displacement errors in LANDSAT data

Corrective method	Ground control point used		Root mean square of errors at 18 ground control points (metres)
	Number of points	Point numbers	
No correction	0	-	668.8
Co-linear	4	1, 6, 14, 15	107.4
$\Delta\lambda = \underline{a}_1 + \underline{a}_2 \underline{L} + \underline{a}_3 \underline{I} + \underline{a}_4 \underline{L} \cdot \underline{I}$	18	All	50.2
$\Delta\theta = \underline{b}_1 + \underline{b}_2 \underline{L} + \underline{b}_3 \underline{I} + \underline{b}_4 \underline{L} \cdot \underline{I}$	4	6, 10, 13, 16	71.8
Linear B	3	11, 13, 15	92.7
$\Delta\lambda = \underline{a}_1 + \underline{a}_2 \underline{L} + \underline{a}_3 \underline{I}$	18	All	53.6
$\Delta\theta = \underline{b}_1 + \underline{b}_2 \underline{L} + \underline{b}_3 \underline{I}$	3	6, 10, 16	101.9
Linear A	2	5, 10	477.8
$\Delta\ \underline{x} = \underline{ax} + \underline{by} + \underline{c}$	18	All	369.1
$\Delta\ \underline{y} = \underline{ay} - \underline{bx} + \underline{d}$	2	4, 15	474.5

Linear function (B)

$$\Delta\lambda = \underline{A}_1 + \underline{A}_2 \underline{I} + \underline{A}_3 \underline{L}$$
$$\Delta\theta = \underline{B}_1 + \underline{B}_2 \underline{I} + \underline{B}_2 \underline{L} \qquad (1\text{-}11\text{-}6)$$

Co-linear function

$$\Delta\lambda = \underline{A}_1 + \underline{A}_2 \underline{I} + \underline{A}_3 \underline{L} + \underline{A}_4 \underline{IL}$$
$$\Delta\theta = \underline{B}_1 + \underline{B}_2 \underline{I} + \underline{B}_3 \underline{L} + \underline{B}_4 \underline{IL} \qquad (1\text{-}11\text{-}7)$$

Since the accuracy of correction is affected by number and distribution of GCPs, three cases for each function are examined. The results of fine correction are shown in table 36. On the basis of this table, the following conclusions were reached:

(a) Linear function (B) (1-11-6) can be sufficient as a corrective function:

(b) It is better to take more points in use, however, the number of GCPs can be reduced to three points if selected evenly over the whole scene.

MOSAIC OF LANDSAT MULTISPECTRAL SCANNER DATA

One frame of LANDSAT MSS data covers the limited area which is determined by the satellite orbit, scanning width and observing date. Therefore, when one attempts to create a color composite orthophotomap for a large area in one sheet, it is necessary to mosaic multiple frames of LANDSAT data. It can be performed manually by cutting and putting together multicoloured orthophotomaps produced separately by each frame. However, this method tends to make the seam line be visible and reduce the photo quality.

To solve this problem, a digital method of mosaicking multiple LANDSAT frames has been developed by modifiying the method developed in 1977 at GSI for creating colour photo mosaics of aerial photographs.

Image registration

It is unnecessary to register two successive frames taken in the time sequence; however, the precise image registration is necessary for the neighbouring frames of different passes.

In this study, image registration was performed so that in the step of geometrical correction and map projection transformation, the same GCPs were selected from both frames over the duplicated area so that the axes of output image of both frames may be parallel and registration can be performed by parallel displacement only.

Moreover, to select the same GCP from the two frames, a pattern-matching technique was adopted so that this process can be performed automatically.

Image pattern matching: pattern matching between two functions, $\underline{f}$ and $\underline{g}$, can be evaluated by using correlation $\underline{C_{fg}}$:

$$\underline{C_{fg}} = \int\int_{-\infty}^{+\infty} \underline{f}\ (\underline{x},\ \underline{y})\ \ \underline{g}\ \ (\underline{x} + \underline{u},\ \underline{y} + \underline{v})\ \underline{dx}\ \underline{dy}. \qquad (2\text{-}1\text{-}1)$$

Density-level adjustment for image mosaicking

There appear to be some grey-level differences between two neighbouring frames of different passes because of variation of the looking angle, meteorological conditions and/or the sun angle. Therefore, it is necessary to examine the density-level characteristics over duplicated area and to adjust the grey-level distribution of both images.

Density-level adjustment is performed by the following procedure:

(a) Obtain correction function for inter-detector grey-level fluctuations along the process previously described:

$$\begin{aligned} \underline{V}_{1\underline{i}} &= \underline{A}_{1\underline{i}}\, \underline{V}_{1\underline{i}} + \underline{B}_{1\underline{i}} \\ \underline{V}_{2\underline{i}} &= \underline{A}_{2\underline{i}}\, \underline{V}_{2\underline{i}} + \underline{B}_{2\underline{i}} \end{aligned} \qquad (\underline{i} = 2 \sim 6) \qquad (2\text{-}2\text{-}1)$$

(b) Among the duplicated area density-level distributions of detector 1 of each land, each image is calculated;

(c) Obtain the corrective function for adjusting density-level distributions without cloud and water between two frames for each band by using the same method described in the first section of this paper:

$$\underline{V}_{11} = \underline{C}\underline{V}_{21} + \underline{D}. \qquad (2\text{-}2\text{-}2)$$

(d) Correct density levels of both images by the following formula:

$$\underline{V}_{1\underline{i}} = \underline{A}_{1\underline{i}}\, \underline{V}_{1\underline{i}} + \underline{B}_{1\underline{i}} \quad (\underline{i} = 2 \sim 6) \qquad (2\text{-}2\text{-}3)$$

$$\underline{V}_{2\underline{i}} = \underline{a}_{\underline{i}}\, \underline{V}_{2\underline{i}} + \underline{b}_{\underline{i}} \quad (\underline{i} = 1 \sim 6) \qquad (2\text{-}2\text{-}4)$$

where $\underline{a}_1 = \underline{C}$, $\underline{b}_1 = \underline{D}$, $\underline{a}_{\underline{i}} = \underline{C} \cdot \underline{A}_{2\underline{i}}$, $\underline{b}_{\underline{i}} = \underline{C} \cdot \underline{B}_{2\underline{i}} + \underline{D}$.

Mosaicking

Two neighbouring frames of the neighbouring passes duplicate as shown in figure 102 after being transformed on to a certain map projection.

Mosaicking is performed by repeating the procedure shown in figure 103 line by line:

(a) Determining the examining area for seam-point searching (figure 104); the examining area should be selected in a flat area excluding clouds;

(b) Seam-point searching (figure 105). The seam point is selected at the point of the least grey-level difference so that the seam point may hardly be seen.

Figure 105. Japan: seam-point searching

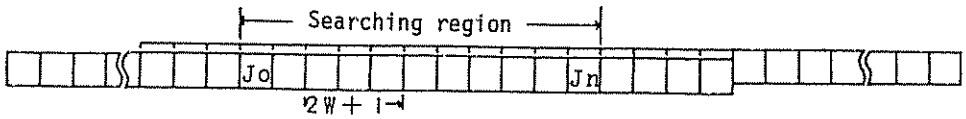


Figure 106. Japan: smoothing of seam region

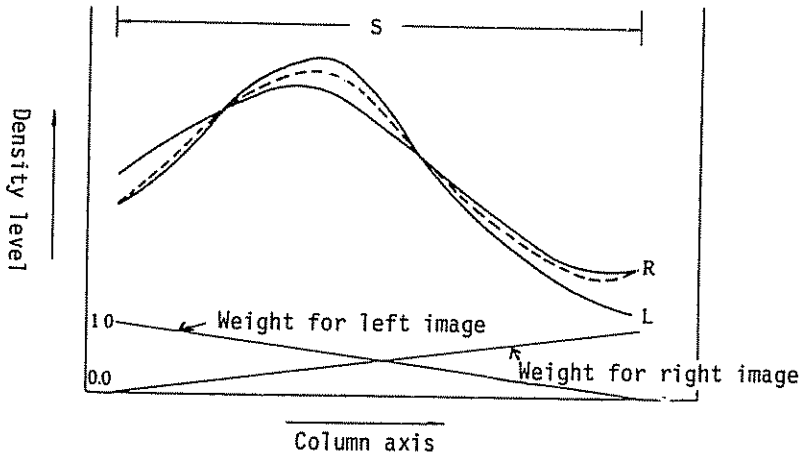
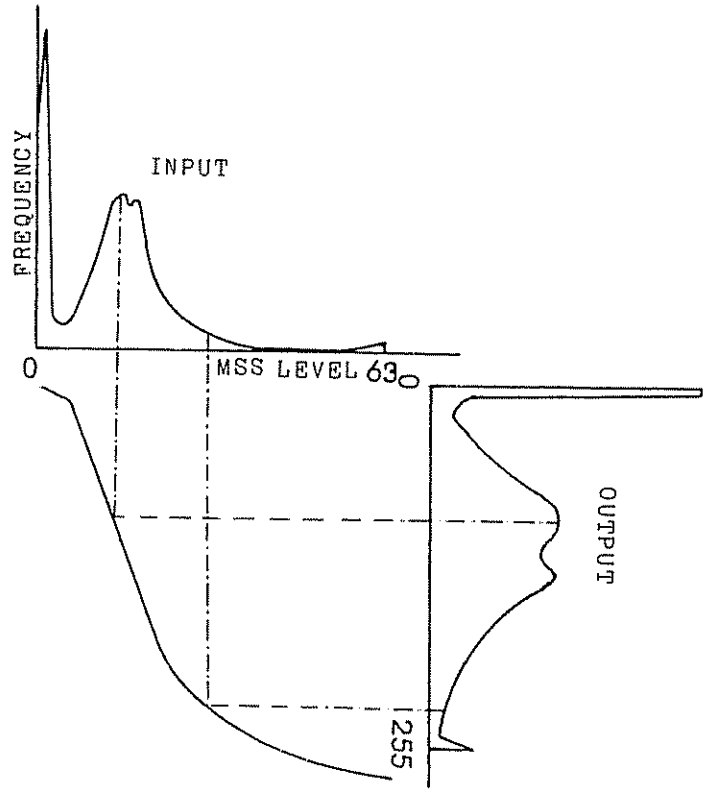


Figure 107. Japan: density-level transformation



Let J_o J_n be the initial and final column nunbers of the region where the seam is being searched, $2w + 1$ be the width where the grey-level difference is being calculated and m be the number of bands. Then, the sensity-level difference D_j for each pixel j is obtained by

$$D_j = \sum_{i=j-w}^{j+w} \sum_{k=1}^{m} (L_{i\,k} - R_{i\,k}) / (2w + 1)$$

$$j = J_o \sim J_n \qquad (2\text{-}3\text{-}1)$$

where $L_{i\,k}$ = density level of the ith pixel, kth band of the left image;
$R_{i\,k}$ = density level of the ith pixel, kth band of the right image.
The seam point is determined where D_j is minimum.

After determining the seam point, the following smoothing procedure is performed to diminish the colour-tone discontinuity. Let $D\ min$ be the density-level difference at the seam point:

$$D\ min = MIN\ (D_j) \quad j = J_o \sim J_n.$$

The smoothing width S is determined by using $D\ min$ as

$$S = D\ min\ /\ R \qquad (2\text{-}3\text{-}2)$$

where R is constant.

For each pixel between $-\frac{S}{2}$ and $\frac{S}{2}$, output density M_i is determined by the following formula, as shown in figure 106:

$$M_i = R_i \frac{(S/2 - i)}{S} + L_i \frac{(S/2 + i)}{S}$$

$$(i = -\frac{S}{2} \sim \frac{S}{2}). \qquad (2\text{-}3\text{-}3)$$

The next step is determination of the region on the next line where the seam point is being searched. If the seam point is searched independently for each line, there can appear a horizontal edge between two seam points of the successive two lines. Therefore, one needs to restrict the searching region of the next line around the seam point of the previous line with the width that widens when $D\ min$ is small and narrows when $D\ min$ is large.

Let j be the seam point of the previous line; the searching region is determined from $j - T$ to $j + T$, where T is obtained as

$$T = B\ /\ (D\ min + A) + C \qquad (2\text{-}3\text{-}4)$$

where A, B, and C are constants.

COLOUR-COMPOSITE ORTHOPHOTOMAP CREATION

Among four bands of LANDSAT MSS data, two bands correspond to the green and red bands, and the other two bands are infra-red bands. Therefore, there is no way to get a true composite image by any colour assignation to each band. Here, one assigns green to the infra-red band so that the forest region looks green as natural.

Image enhancement

Through the procedure described in the foregoing sections, one can get the image corrected geometrically and radiometrically. However, if these images are printed directly on film, one obtains an image with little contrast, and it may be hard to classify land-use patterns by means of photo-interpretation. Therefore, it is necessary to check the density-level histograms and to convert density levels so that the meaningful objects without cloud, snow and water may be enhanced before printing.

Density-level conversion is performed by a line graph as shown in figure 107.

Image output

The procedure from film output through printing is described below:

(a) Creation of magnetic-tape file for output. The image data format is converted to the format of the film output device. In this step, the images of register marks for printing are also being created.

(b) Film output. Each band image is output on to film as a black-and-white image. In the case of 1:500,000 scale map creation, the film output image is created at 1:1,000,000 scale with 50-μm pixel size; and for 1:200,000 scale map creation, the film image is created at 1:500,000 with 50-μm pixel size;

(c) Image enlargement and plate-making. Negative films created by each band are enlarged twice or 2.5 times and printing-plates are made;

(d) Annotation plate-making. Longitude and latitude grids and register marks are put on to tracing film by automatic drafter. This film is then put upon the 1:500,000 or 1:200,000 scale map published by GSI, and annotation data, such as place names and longitude and latitude, are composed on the film; adequate marginal design is performed. The annotation plate is made from this film;

(e) Printing. Three bands out of four are selected; adequate colours are assigned for each band; they are then printed together with the annotation data. The standard colour assignment is cyan for band 4, yellow for band 5, magenta for band 7 and black for annotations.

CREATION OF THEMATIC MAPS

LANDSAT MSS colour-composite orthophotomaps make it possible to analyse plant or land-use patterns by means of photo-interpretation. However, land-use patterns etc. can be analysed more accurately and quantitatively by means of digital analysis.

Here, digital land-use classification was performed, and the classified results were stored as a digital information file and printed out as a thematic map at 1:200,000 scale.

Transformation into national digital information format

Throughout Japan, GSI has collected several types of information in digital format--topographic, geographical, geological and political. In this study, therefore, the LANDSAT MSS data were resampled along the grid of this information system so that the LANDSAT data could be compared with national digital data during classification.

The LANDSAT MSS data were resampled and compiled to the format shown in figure 108. Land-use, elevation and slope data in the national information system are also compiled to the same format so that they can be used as ancillary data in classification.

The original cell size of elevation and slope data is about 250-m square, so those data were interpolated and compiled to a 50-m square cell. The original cell size of land-use information is 10-m square, so the category of the largest occupancy was taken as the category of the 50-m square cell.

Determination of discriminative classes

The discriminative classes should satisfy the following conditions: (a) they should include the user-oriented classes; (b) the training area can easily be selected and ground truth data can be collected. Classes nomimated at first may be rearranged after classification is performed, so that inseparable classes are unified and complex classes are separated.

Training area selection

Usually, training areas are selected by using topographic maps, land-use maps, aerial photographs and/or ground survey, as the area covered by one category on the image co-ordinate system. However, to optimize the classification procedure so as to make good use of the white coverage and repetitiousness of LANDSAT data, it is necessary to store training-area information and utilize the same training area for the different dates of MSS data. Here, some four or five training areas for each class in one compiled frame (the first-level cell of the national digital information: longitude x latitude = 1° x 40') were selected and recorded on punch cards, as shown in figure 109.

Figure 108. Japan: resampling of LANDSAT multispectral scanner data

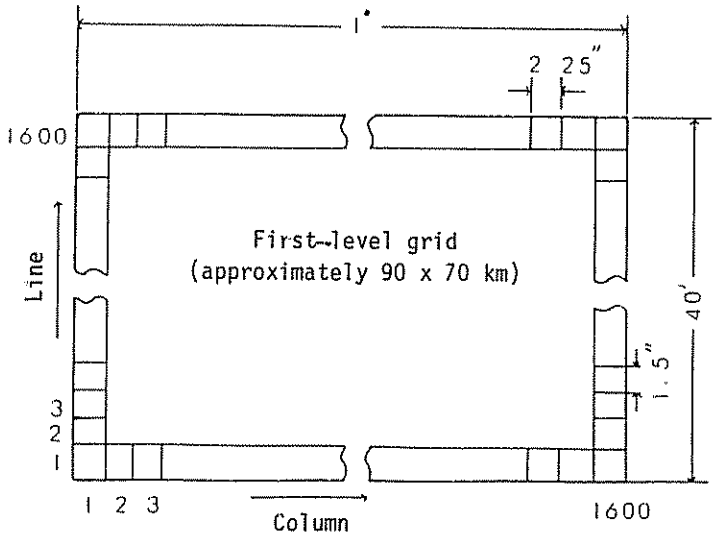


Figure 109. Japan: punch-card format for training-area data

Training area number	Cont. code	Second-level grid code	Line 1					Line 7				
			Line number	Blank	Column numbers			Line number	Blank	Column numbers		
					Start point	End point				Start point	End point	
9(3)	9	9(3)	9(3)	X	9(3)	9(3)		9(3)	X	9(3)	9(3)	
		10 11					20	71				80

The practical procedure for training-area selection is performed as follows:

(a) Newly flown aerial photography that covers a large area in one sheet is collected;

(b) If there is no anti-aerial photography mark on the image, a clearly identifiable identification point or object around the point is used as CGP. Those points are pricked on an enlarged photo print;

(c) In order to select training areas evenly over the entire compiled frame, multiple stereo models of aerial photographs are made by aerotriangulation;

(d) The training areas in each class are plotted by using a stereoplotter on a 1:25,000 scale photographic map (see figure 110). Then the pixels included in the plotted area are calculated and stored on punch cards as line-column numbers in the compiled frame.

Collection of ground-truth data

Ground-truth data are collected by the following procedure:

(a) Examination of training areas. Statistical caracteristics of MSS data corresponding to each training area are examined to see if they are supposed to be unique or mixed. If they are supposed to be composed of multiple classes, pixels of other classes are being omitted;

(b) Separability calculation and class rearrangement. As for the indicator of separability, the following divergence is calculated:

$$\underline{J_{ij}} = \int \log \frac{\underline{f_i}}{\underline{f_j}\ (\underline{x})} \left\{ \underline{f_i}\ (\underline{x}) - \underline{f_j}\ (\underline{x}) \right\} \underline{dx}. \tag{4-1}$$

Then the separability $\underline{D_{ij}}$ between classes $\underline{i}$ and $\underline{j}$ is

$$\underline{D_{ij}} = 2{,}000 \times (1 - \exp(-\underline{J_{ij}}/8)) \tag{4-2}$$

where $\underline{f_j}\ (\underline{x})$ is the probability density function of $\underline{x}$

$$\underline{x} = (\underline{x_4}, \underline{x_5}, \underline{x_6}, \underline{x_7}) \tag{4-3}$$

for class $\underline{j}$.

If $\underline{f_i}$, $\underline{f_j}$ are assumed to behave as Gaussian distribution, one obtains

$$\underline{J_{ij}} = \frac{-1}{2} \underline{\mathrm{tr}} \left\{ (\underline{S_i} - \underline{S_j})(\underline{S_i^{-1}} - \underline{S_j^{-1}}) \right\}$$

$$+ \frac{1}{2} \underline{\mathrm{tr}} \left\{ (\underline{S_i^{-1}} + \underline{S_j^{-1}})(\underline{\bar{x}_i} - \underline{\bar{x}_i} - \underline{\bar{x}_j})\underline{t}(\underline{\bar{x}_i} - \underline{\bar{x}_j}) \right\} \tag{4-4}$$

Figure 110. Japan: configuration of training-area digitization

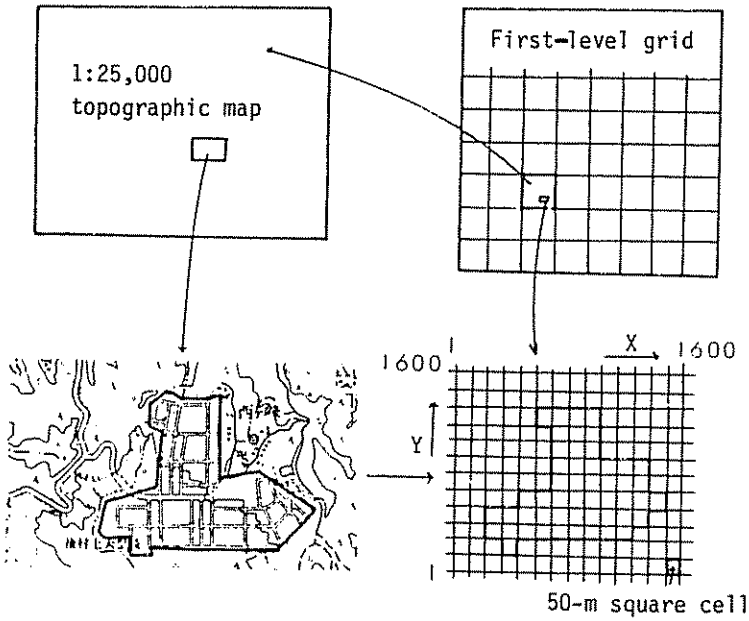
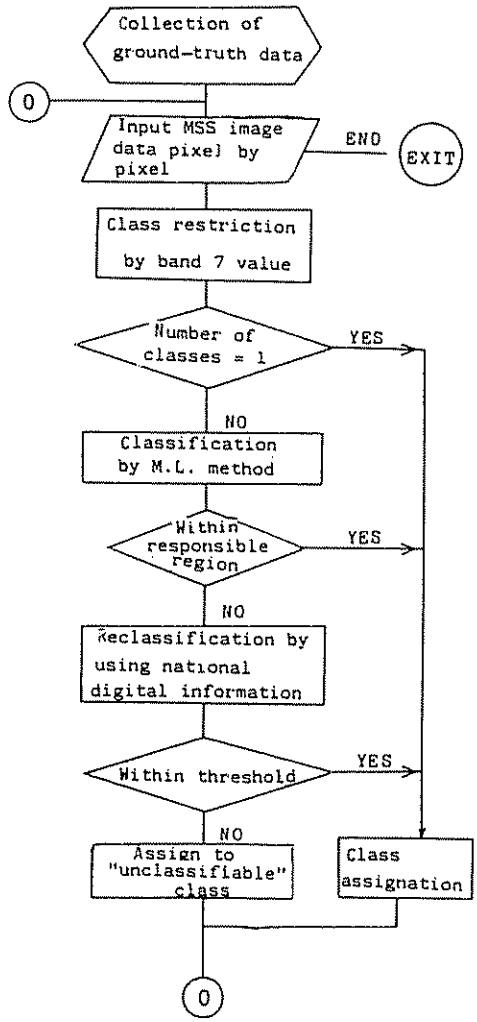


Figure 111. Japan: algorithm of classification



where

$\underline{S_i}$ = correlation matrix of class $\underline{i}$;

$\underline{x_i}$ = mean vector of class $\underline{i}$.

Separability is calculated for every pair of classes. If it is supposed that a pair of classes is not separable, those classes are combined. A class that is considered inseparable from several classes is deleted or divided.

Texture analysis

The following parameters, representing spatial information, are examined for their efficiency, and the most efficient parameter is utilized as the fifth channel data. Those parameters are computed with a 3 x 3 window by using band-7 data:

(a) Mean value $\bar{\underline{x}}$ $\quad \sum \underline{x} / \sum$;

(b) Standard deviation $\quad \sqrt{\sum (\underline{x_i} - \underline{x})^2 / \sum}$;

(c) Differential operator $\quad \begin{bmatrix} 1/9, & -8/9, & 1/9 \\ -8/9, & 37/9, & -8/9 \\ 1/9, & -8/9, & 1/9 \end{bmatrix}$;

(d) Contrast $\quad \sum |\underline{x_i} - \underline{x_c}| / \sum$ ($\underline{x_c}$ = level of the central pixel).

Assignation to "unclassifiable" class

Even though the discriminative classes are well defined, some pixels do not belong to any defined classes. A point $\underline{x}$ in the feature space is assigned ot a class of the most probability. This assignment, however, may lead misclassification in the case of little probability. Therefore, if the probability of the most probable class is less than certain threshold, it is being assigned to the class of "unclassifiable".

Let $\bar{\underline{x_i}}$ be the mean vector of class $\underline{i}$ which is most probable for $\underline{x}$, and $\underline{S_i}$ be the correlation matrix of class $\underline{i}$, then one calculates

$$\underline{t}(\underline{x} - \bar{\underline{x_i}})\ \underline{S_i}\ (\underline{x} - \bar{\underline{x_i}}). \tag{4-5}$$

This value behaves as $\underline{x}^2$ distribution. Then the point $\underline{x}$ is assigned to "unclassifiable" class when this value exceed the responsible region given by the $\underline{x}^2$ distribution table.

Determination of the classification procedure

Each class is not always distributed as Gaussian distribution, and their variances are not identical. Therefore, it is always a good idea to classify by means of the greatest probability method because one cannot expect high accuracy and it requires much computation time. Here, the hybrid method of decision-tree algorithm and greatest probability is adopted to improve accuracy and save computation time. The practical procedure of this method is described below:

(a) The nominated classes are sorted in the order of their means of band 7 and are stored with their variant;

(b) A reference table is prepared to show the numerous classes for each level, 0-63, of band 7;

(c) Each pixel is classified by the greatest probability method. If the classified result exceeds the margin of error of the x^2 test, reclassification is performed using national digital information;

(d) Reclassification is done with the assumption that the pixel is composed of multiple classes. If the reclassified result also exceeds a certain threshold, the pixel is assigned to the "unclassifiable" group (figure 111).

Greatest probability method

Each class is assumed to behave as multivariant normal distribution. Then each point is assigned to the class of greatest probability. The probability $P_j(x)$ that a point x belongs to class j is obtained by

$$P_j(x) = \frac{1}{(2\pi)^{\frac{k}{2}} |S_j|^{\frac{1}{2}}} \exp\left\{-\frac{1}{2}(x - \bar{x}_j)^t S_j^{-1}(x - \bar{x} - \bar{x}_j)\right\} \qquad (4\text{-}6)$$

where k is the number of channels and $|S_j|$ is the determinant of S_j.

Classification in test areas

Before the entire area is classified, the classification performance is examined in selected training areas. If the classification is not satisfactory, the procedure given above in the section on collection of ground truth data is repeated. The classification is again examined in a few small areas (200 x 200 pixels) by referring to a topographic map, a land-use map and aerial photographs. If performance is still not acceptable, the procedure is again repeated. Since there are only 200 x 200 pixels in a test area, it is possible to perform this step as interactive processing by using an image-processing system with colour display.

Classification of entire area and image output

After examining the classification in test areas, the entire area (1,600 x 1,600 pixels) is classified. Because the cell size of the data corresponds to longitude and latitude increments (2.25" x 1.5") and does not ahve an equal area over the entire frame, it is necessary to resample the classified results into 50-m square cell data on the map projection adopted on a 1:200,000 scale map:

(a) Projection transformation. Resampling is done by 50-m cell on a map projection plane of polycylindrical or UTM projection. It is performed so that the resampling axis is parallel to the x axis;

(b) Film output. Resampled data are printed on colour film with an aperture size 100 x 100 μm by using a colour photo-printer. Colour is assigned to each class by giving a certain value from 0 to 255 for red, green and blue light;

(c) Image enlargement and plate-making. The film image produced in process (b) is a 1:500,000 scale colour positive which is decomposed into three black-and-white negatives corresponding to each primary colour. These negatives are enlarged and transferred to 1:200,000 black-and-white positives for plate-making. Printing-plates are made from them;

(d) Annotation plate-making. Annotation plate is made by extracting the necessary information from the 1:200,000 map;

(e) Printing. Cyan, yellow, magenta to red, green and blue plates, and black for the annotation plate are made; offset printing is then done.

Case-study

For a case-study, a land-cover map of Ishikawa-ken at 1:200,000 scale was produced. The process is described below.

Data used

The data used are listed in table 37. The area corresponding to Ishikawa-ken is composed of two LANDSAT frames--Wakasa and Wajima. Because the rice-fields, mountain shadow and forest could not be well classified with the data taken on 2 November 1979, two other frames--Johetsu and Takayama--taken on 17 June 1981 also were partially utilized.

Selection of discriminative classes

The classes first selected were:

Class No.	Class name
1	Dense residential area
2	Residential area

Table 37. Data utilized for land-cover map of Ishikawa-ken

	LANDSAT frame			
	Wajima	Wakasa	Johetsu	Takayama
Path - row numbers	1 1 8 - 3 4	1 1 8 - 3 5	1 1 7 - 3 4	1 1 7 - 3 5
Date data taken	2 November 1979	2 November 1979	17 June 1981	17 June 1981
Image centre	East 136° 27' North 37° 20'	East 135° 59' North 35° 54'	East 137° 45' North 37° 21'	East 137° 17' North 35° 56'

Class No.	Class name
3	New residential area A
4	New residential area B
5	Factory
6	Rice field
7	Field A
8	Field B
9	Fruit orchard A
10	Fruit orchard B
11	Open space A
12	Open space B
13	Golf links
14	Cemetery A
15	Cemetery B
16	Coniferous forest
17	Deciduous forest
18	Mixed forest
19	Bamboo forest
20	Park
21	Rough grassland
22	Grassland
23	Shore
24	Sand or gravel
25	Quarry
26	Bare land
27	Water

The classes listed above were reduced to the following classes through the analysis:

Class No.	Class name
1	Dense residential area
2	Residential area
3	Rice field
4	Field
5	Open space
6	Golf links
7	Coniferous forest
8	Deciduous forest
9	Mixed forest
10	Bamboo forest
11	Grassland
12	Sand
13	Water

Selection of training areas

All together, 98 training areas were selected (for example, see figure 112), taking into consideration that over 0.1 km of area would be taken up by one class on the aerial photographs. Because the aerial photographs used were taken in 1977, a ground survey of every area was done to check changes.

Plotting of training areas and digitization

After GCPs were pricked, aerotriangulation and plotting of training areas were done, and the plotted areas were digitized by a table digitizer. Pixels included in the area also were counted and recorded on punch cards. After digitization, the area of a small number of pixels (fewer than 10) and the area considered unsuited for a training area were deleted.

Collection of ground-truth data

Tables 38 and 39 show the statistical characteristics of MSS data for 2 November 1979 and 17 June 1981 for each training area. Here, the MSS data were stretched from 0 to 255.

Texture analysis

From a comparison of classification performance using each texture parameter, the mean values of band 7 were employed for 2 November 1979 data and variants of band 7 were employed for 17 June 1981 data, as texture channel. Tables 40 and 41 compare the inter-class separabilities with and without texture channel. Tables 42 and 43 compare the Maharanobis distances with and without texture channel.

Determination of classification algorithm

It takes more than 10 hours with the large GSI computer to classify all the Ishikawa-ken data by the greatest probability method. Therefore, a decision-tree algorithm also was utilized with band-7 levels. Moreover, water and cloud (including snow) had been classified by level-slicing before the 13 classes

Figure 112. Japan: example of training area

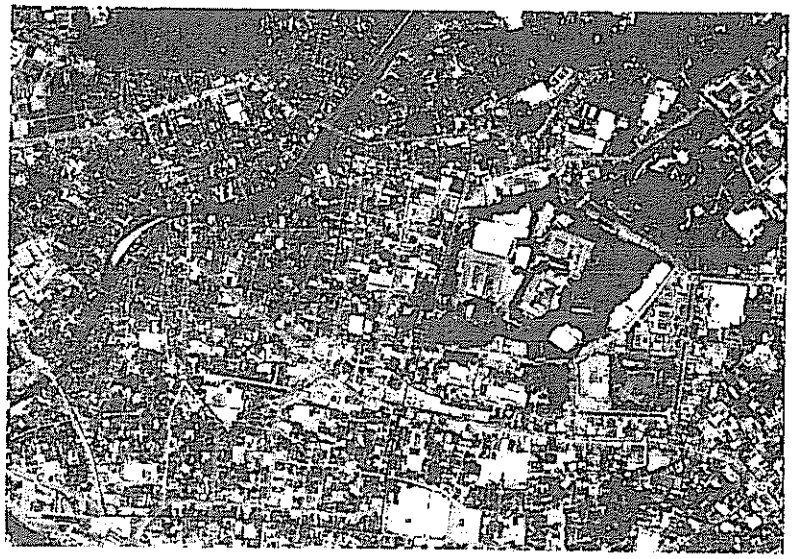


Table 38. Characteristics of multispectral scanner data obtained on 2 November 1979, by training area, Japan

	Band 4	Band 5	Band 6	Band 7	Band 7 mean
	Class 1. Dense residential area: 991 pixels				
Mean value	54.61	70.69	60.80	25.91	26.37
Variant-covariant matrix					
Band 4	14.06	16.40	11.31	5.19	2.13
Band 5	16.40	33.31	22.20	11.85	6.25
Band 6	11.31	22.20	32.73	19.75	14.99
Band 7	5.19	11.85	19.75	19.18	13.28
Band 7 mean	2.13	6.25	14.99	13.28	16.26
	Class 2. Residential area: 175 pixels				
Mean value	51.91	67.17	67.00	33.18	34.71
Variant-covariant matrix					
Band 4	18.07	23.14	10.93	2.86	3.31
Band 5	23.14	44.20	19.33	4.76	4.33
Band 6	10.93	19.33	32.45	23.36	18.79
Band 7	2.86	4.76	23.36	27.10	19.37
Band 7 mean	3.31	4.33	18.79	19.37	22.89
	Class 3. Rice-field: 1,113 pixels				
Mean value	54.90	75.59	78.78	44.04	43.80
Variant-covariant matrix					
Band 4	11.61	14.19	14.76	11.84	10.96
Band 5	14.19	33.55	22.04	16.50	15.26
Band 6	14.76	22.04	43.93	36.77	30.00
Band 7	11.84	16.50	36.77	39.59	28.96
Band 7 mean	10.96	15.26	30.00	28.96	28.75

Table 38 (continued)

	Band 4	Band 5	Band 6	Band 7	Band 7 mean
		Class 4.	Field: 490 pixels		
Mean value	50.63	68.27	80.70	52.91	52.91
Variant-covariant matrix					
Band 4	18.35	27.54	5.82	-8.41	-8.11
Band 5	27.54	57.06	6.47	-19.57	-16.09
Band 6	5.82	6.47	39.22	42.39	34.92
Band 7	-8.41	-19.57	42.39	82.09	69.01
Band 7 mean	-8.11	-16.09	34.92	69.01	69.64
		Class 5.	Open space: 29 pixels		
Mean value	65.31	98.48	92.00	52.34	48.00
Variant-covariant matrix					
Band 4	22.29	39.63	25.43	13.28	4.99
Band 5	39.63	103.90	59.57	32.26	7.40
Band 6	25.43	59.57	51.36	42.57	14.71
Band 7	13.28	32.26	42.57	53.16	19.16
Band 7 mean	4.99	7.40	14.71	19.16	30.28
		Class 6.	Golf links: 759 pixels		
Mean value	49.65	64.14	88.45	59.72	58.79
Variant-covariant matrix					
Band 4	17.35	25.72	29.51	29.75	15.49
Band 5	25.72	55.39	54.62	54.37	28.60
Band 6	29.51	54.62	89.71	92.42	47.74
Band 7	29.75	54.37	92.42	107.10	53.05
Band 7 mean	15.49	28.60	47.74	53.05	57.77

Table 38 (continued)

	Band 4	Band 5	Band 6	Band 7	Band 7 mean
		Class 7. Coniferous forest: 156 pixels			
Mean value	42.10	47.10	64.12	35.49	36.03
Variant-covariant matrix					
Band 4	17.84	29.94	23.03	18.83	18.24
Band 5	29.94	61.70	45.72	36.13	33.21
Band 6	23.03	45.72	72.29	58.32	48.43
Band 7	18.83	36.13	58.32	55.72	42.84
Band 7 mean	18.24	33.21	48.43	42.84	46.97
		Class 8. Deciduous forest: 666 pixels			
Mean value	40.33	44.79	68.59	43.02	43.31
Variant-covariant matrix					
Band 4	17.24	29.55	28.20	24.21	15.74
Band 5	29.25	67.03	58.37	51.69	34.69
Band 6	28.20	58.37	147.22	147.12	87.04
Band 7	24.21	51.69	147.12	161.34	93.12
Band 7 mean	15.74	34.69	87.04	93.12	92.33
		Class 9. Mixed forest: 629 pixels			
Mean value	41.09	45.22	65.68	38.90	39.40
Variant-covariant matrix					
Band 4	14.85	25.30	26.27	19.40	14.40
Band 5	25.30	57.13	54.25	39.96	29.47
Band 6	26.27	54.25	112.58	99.34	60.00
Band 7	19.40	39.96	99.34	101.44	56.27
Band 7 mean	14.40	29.47	60.00	56.27	58.31

Table 38 (continued)

	Band 4	Band 5	Band 6	Band 7	Band 7 variant
		Class 10.	Bamboo forest: 40 pixels		
Mean value	41.07	43.70	78.45	58.22	56.63
Variant-covariant matrix					
Band 4	3.10	1.56	3.86	3.91	-0.52
Band 5	1.56	8.22	4.24	3.17	0.50
Band 6	3.86	4.24	25.23	27.00	4.72
Band 7	3.91	3.17	27.00	41.00	7.44
Band 7 variant	-0.52	0.50	4.72	7.44	10.20
		Class 11.	Grassland: 148 pixels		
Mean value	50.40	68.69	78.02	48.29	47.30
Variant-covariant matrix					
Band 4	14.47	19.31	6.21	-1.40	-3.07
Band 5	19.31	46.91	31.26	13.25	9.17
Band 6	6.21	31.26	68.95	55.74	41.10
Band 7	-1.40	13.25	55.74	64.38	42.17
Band 7 variant	-3.07	9.17	41.10	42.17	44.41
		Class 12.	Sand: 101 pixels		
Mean value	70.42	101.53	84.13	41.22	40.89
Variant-covariant matrix					
Band 4	16.37	27.40	31.68	23.82	11.28
Band 5	27.40	71.47	79.49	61.42	27.92
Band 6	31.68	79.49	104.81	78.30	35.02
Band 7	23.82	61.42	78.30	67.83	29.35
Band 7 variant	11.28	27.92	35.02	29.35	20.96

Table 38 (continued)

	Band 4	Band 5	Band 6	Band 7	Band 7 variant
		Class 13. Water: 18 pixels			
Mean value	42.50	46.50	44.61	17.44	24.98
Variant-covariant matrix					
Band 4	4.85	2.50	-6.21	-7.47	-1.20
Band 5	2.50	4.74	-5.91	-7.76	-1.33
Band 6	-6.21	-5.91	58.25	50.12	10.57
Band 7	-7.47	-7.76	50.12	51.20	14.01
Band 7 variant	-1.20	-1.33	10.57	14.01	11.45

Table 39. Characteristics of multispectral scanner data obtained on 17 June 1981, by training area, Japan

	Band 4	Band 5	Band 6	Band 7	Band 7 variant
	Class 1. Dense residential area: 991 pixels				
Mean value	87.30	112.01	98.35	52.87	2.87
Variant-covariant matrix					
Band 4	17.77	24.22	16.26	11.05	0.15
Band 5	24.22	60.41	32.10	22.68	0.61
Band 6	16.26	32.10	41.39	27.20	0.58
Band 7	11.05	22.68	27.20	31.12	0.04
Band 7 variant	0.15	0.61	0.58	0.04	4.12
	Class 2. Residential area: 175 pixels				
Mean value	83.67	104.24	104.10	61.45	2.30
Variant-covariant matrix					
Band 4	27.11	35.24	7.05	-5.19	-2.79
Band 5	35.24	56.61	10.41	-9.83	-4.13
Band 6	7.05	10.41	29.07	20.32	1.85
Band 7	-5.19	-9.83	20.32	27.85	3.12
Band 7 variant	-2.79	-4.13	1.85	3.12	3.12
	Class 3. Rice-field: 1,113 pixels				
Mean value	84.33	105.07	105.45	59.32	2.95
Variant-covariant matrix					
Band 4	38.27	60.80	59.81	68.35	2.85
Band 5	60.80	109.88	105.08	117.77	5.02
Band 6	59.81	105.08	173.06	136.55	6.98
Band 7	68.35	117.77	136.55	166.58	5.53
Band 7 variant	2.85	5.02	6.98	5.53	5.95

Table 39 (continued)

	Band 4	Band 5	Band 6	Band 7	Band 7 variant
		Class 4.	Field: 490 pixels		
Mean value	97.67	124.00	134.85	97.05	4.81
Variant-covariant matrix					
Band 4	62.87	75.82	56.69	49.97	-1.57
Band 5	75.82	108.50	60.08	42.04	-2.70
Band 6	56.69	60.08	90.31	100.71	0.46
Band 7	49.97	42.04	100.71	135.90	2.06
Band 7 variant	-1.57	-2.70	0.46	2.06	9.91
		Class 5.	Open space: 29 pixels		
Mean value	89.14	119.59	116.97	72.07	5.31
Variant-covariant matrix					
Band 4	39.34	70.02	37.15	25.95	-5.20
Band 5	70.02	150.11	85.52	59.99	-9.22
Band 6	37.15	85.52	71.39	70.50	-2.93
Band 7	25.95	59.99	70.50	105.64	-3.47
Band 7 variant	-5.20	-9.22	-2.93	-3.47	3.45
		Class 6.	Golf links: 759 pixels		
Mean value	82.11	99.83	120.18	86.62	4.53
Variant-covariant matrix					
Band 4	29.39	37.49	33.80	29.20	-1.44
Band 5	37.49	60.74	51.83	44.68	-1.19
Band 6	33.80	51.83	88.81	87.75	-1.07
Band 7	29.20	44.68	87.75	102.26	-1.81
Band 7 variant	-1.44	-1.19	-1.07	-1.81	5.61

Table 39 (continued)

	Band 4	Band 5	Band 6	Band 7	Band 7 variant
		Class 7.	Coniferous forest: 156 pixels		
Mean value	74.09	85.26	109.28	77.19	5.45
Variant-covariant matrix					
Band 4	27.35	41.03	13.72	9.23	2.82
Band 5	41.03	75.74	23.45	11.91	2.99
Band 6	13.72	23.45	38.95	43.50	2.58
Band 7	9.23	11.91	43.50	68.35	4.22
Band 7 variant	2.82	2.99	2.58	4.22	7.73
		Class 8.	Deciduous forest: 666 pixels		
Mean value	75.82	87.14	132.37	108.22	7.47
Variant-covariant matrix					
Band 4	55.14	80.25	4.26	-23.31	-9.93
Band 5	80.25	128.36	0.84	-41.84	-14.23
Band 6	4.26	0.84	140.86	77.52	14.95
Band 7	-23.31	-41.84	77.52	283.67	-39.17
Band 7 variant	-9.93	-14.23	14.95	-39.17	85.21
		Class 9.	Mixed forest: 629 pixels		
Mean value	75.99	87.61	123.27	94.10	5.96
Variant-covariant matrix					
Band 4	17.13	26.02	13.44	9.39	-1.20
Band 5	26.02	51.98	20.52	10.69	-1.83
Band 6	13.44	20.52	87.04	116.89	3.75
Band 7	9.39	10.69	116.89	180.82	4.78
Band 7 variant	-1.20	-1.83	3.75	4.78	8.54

Table 39 (continued)

	Band 4	Band 5	Band 6	Band 7	Band 7 variant
		Class 10.	Bamboo forest: 40 pixels		
Mean value	72.27	85.38	129.80	102.85	4.58
Variant-covariant matrix					
Band 4	3.33	1.36	2.67	1.79	-0.87
Band 5	1.36	7.98	4.72	7.08	0.41
Band 6	2.67	4.72	17.70	14.07	3.18
Band 7	1.79	7.08	14.07	22.44	2.56
Band 7 variant	-0.87	0.41	3.18	2.56	7.41
		Class 11.	Grassland: 148 pixels		
Mean value	82.84	103.41	118.95	81.95	9.27
Variant-covariant matrix					
Band 4	25.39	25.13	-29.18	-49.18	17.01
Band 5	25.13	68.35	-7.02	-38.69	10.37
Band 6	-29.13	-7.02	160.88	215.90	-47.98
Band 7	-49.13	-38.69	215.90	327.47	-60.59
Band 7 variant	17.01	10.37	-47.98	-60.59	49.46
		Class 12.	Sand: 101 pixels		
Mean value	98.39	128.50	107.56	59.14	9.00
Variant-covariant matrix					
Band 4	114.56	156.76	151.91	132.28	-22.30
Band 5	156.76	253.61	242.36	214.87	-39.16
Band 6	151.91	242.36	276.05	237.58	-40.52
Band 7	132.28	214.87	237.58	220.28	-38.39
Band 7 variant	-22.30	-39.16	-40.52	-38.39	15.61

Table 39 (continued)

	Band 4	Band 5	Band 6	Band 7	Band 7 variant
		Class 13. Water: 18 pixels			
Mean value	69.78	78.06	96.06	58.06	14.34
Variant-covariant matrix					
Band 4	3.01	0.66	-1.10	-1.63	-1.81
Band 5	0.66	7.35	-18.71	-26.83	4.18
Band 6	-1.10	-18.71	131.47	181.06	-15.27
Band 7	-1.63	-26.83	181.06	264.64	-25.57
Band 7 variant	-1.81	4.18	-15.27	-25.57	22.10

Table 40. Inter-class separability of LANDSAT data, without texture

Class	Class 1	2	3	4	5	6	7	8	9	10	11	12	13
2 November 1979													
1	–	898	1 762	1 979	1 977	2 000	1 974	1 996	1 991	2 000	1 903	1 951	2 000
2	–	–	1 005	1 598	1 908	1 920	1 580	1 801	1 735	2 000	1 233	1 993	2 000
3	–	–	–	1 233	1 602	1 835	1 856	1 954	1 932	2 000	926	1 997	2 000
4	–	–	–	–	1 786	1 020	1 733	1 625	1 721	1 999	351	2 000	2 000
5	–	–	–	–	–	1 994	1 990	1 996	1 996	2 000	1 808	1 778	2 000
6	–	–	–	–	–	–	1 426	1 221	1 202	1 991	1 225	2 000	2 000
7	–	–	–	–	–	–	–	669	264	1 906	1 590	2 000	1 855
8	–	–	–	–	–	–	–	–	149	1 457	1 632	2 000	1 913
9	–	–	–	–	–	–	–	–	–	1 610	1 654	2 000	1 841
10	–	–	–	–	–	–	–	–	–	–	1 999	2 000	1 999
11	–	–	–	–	–	–	–	–	–	–	–	2 000	2 000
12	–	–	–	–	–	–	–	–	–	–	–	–	2 000
13	–	–	–	–	–	–	–	–	–	–	–	–	–
17 June 1981													
1	–	1 193	1 394	1 997	1 717	1 997	1 994	2 000	2 000	2 000	1 977	1 331	2 000
2	–	–	1 353	1 993	1 619	1 845	1 606	1 999	1 956	2 000	1 750	1 877	2 000
3	–	–	–	1 827	1 375	1 911	1 965	2 000	1 996	2 000	1 810	1 865	2 000
4	–	–	–	–	1 751	1 383	1 897	1 928	1 889	2 000	1 739	1 982	2 000
5	–	–	–	–	–	1 845	1 810	1 996	1 972	2 000	1 504	1 780	2 000
6	–	–	–	–	–	–	393	1 854	1 096	2 000	900	1 999	2 000
7	–	–	–	–	–	–	–	1 858	909	1 986	1 421	1 999	1 928
8	–	–	–	–	–	–	–	–	1 488	1 980	1 613	2 000	2 000
9	–	–	–	–	–	–	–	–	–	1 768	1 218	2 000	1 983
10	–	–	–	–	–	–	–	–	–	–	2 000	2 000	2 000
11	–	–	–	–	–	–	–	–	–	–	–	1 990	2 000
12	–	–	–	–	–	–	–	–	–	–	–	–	2 000
13	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 41. Inter-class separability of LANDSAT data, with texture

Class	Class 1	2	3	4	5	6	7	8	9	10	11	12	13
						2 November 1979							
1	–	1 031	1 841	1 988	1 989	2 000	1 982	1 998	1 995	2 000	1 932	1 976	2 000
2	–	–	1 042	1 683	1 928	1 956	1 612	1 848	1 782	2 000	1 320	1 994	2 000
3	–	–	–	1 497	1 741	1 924	1 868	1 973	1 950	2 000	1 077	1 998	2 000
4	–	–	–	–	1 845	1 186	1 776	1 692	1 770	1 999	544	2 000	2 000
5	–	–	–	–	–	1 996	1 994	1 997	1 997	2 000	1 818	1 821	2 000
6	–	–	–	–	–	–	1 624	1 304	1 416	1 994	1 350	2 000	2 000
7	–	–	–	–	–	–	–	905	405	1 991	1 647	2 000	1 911
8	–	–	–	–	–	–	–	–	203	1 847	1 665	2 000	1 979
9	–	–	–	–	–	–	–	–	–	1 930	1 683	2 000	1 933
10	–	–	–	–	–	–	–	–	–	–	2 000	2 000	2 000
11	–	–	–	–	–	–	–	–	–	–	–	2 000	2 000
12	–	–	–	–	–	–	–	–	–	–	–	–	2 000
13	–	–	–	–	–	–	–	–	–	–	–	–	–
						17 June 1981							
1	–	1 249	1 401	1 997	1 766	1 997	1 995	2 000	2 000	2 000	1 996	1 784	2 000
2	–	–	1 091	1 994	1 740	1 862	1 664	2 000	1 961	2 000	1 974	1 987	2 000
3	–	–	–	1 835	1 652	1 920	1 971	2 000	1 997	2 000	1 936	1 944	2 000
4	–	–	–	–	1 817	1 408	1 908	1 954	1 890	2 000	1 843	1 986	2 000
5	–	–	–	–	–	1 902	1 887	2 000	1 986	2 000	1 949	1 966	2 000
6	–	–	–	–	–	–	962	1 940	1 133	2 000	1 496	2 000	2 000
7	–	–	–	–	–	–	–	1 934	936	1 992	1 630	2 000	1 980
8	–	–	–	–	–	–	–	–	1 684	1 992	1 729	2 000	2 000
9	–	–	–	–	–	–	–	–	–	1 830	1 547	2 000	1 993
10	–	–	–	–	–	–	–	–	–	–	2 000	2 000	2 000
11	–	–	–	–	–	–	–	–	–	–	–	1 994	2 000
12	–	–	–	–	–	–	–	–	–	–	–	–	2 000
13	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 42. Inter-class Maharanobis distance, LANDSAT data, without texture

Class	Class 1	2	3	4	5	6	7	8	9	10	11	12	13
						2 November 1979							
1	–	1.7	3.7	3.8	4.9	6.4	5.1	4.9	5.3	14.3	3.0	5.2	13.8
2	2.4	–	2.1	2.6	3.5	4.5	3.5	3.8	4.0	11.6	2.0	7.7	12.6
3	4.4	2.4	–	1.3	2.4	4.2	3.9	4.4	4.5	13.5	1.4	8.0	18.3
4	7.2	4.0	3.1	–	3.7	2.1	3.3	3.0	3.5	9.8	0.7	11.9	15.9
5	6.5	5.8	4.0	4.2	–	7.4	7.0	7.3	7.7	22.1	4.5	4.1	31.4
6	9.5	5.3	4.6	1.7	6.0	–	3.4	2.4	2.7	7.9	2.4	14.8	14.6
7	6.4	3.3	5.1	4.1	5.5	2.7	–	1.0	0.6	4.3	3.7	13.7	3.1
8	8.3	4.2	6.1	3.8	6.3	2.8	1.8	–	0.6	2.5	3.8	16.0	3.8
9	7.4	3.7	5.6	4.0	5.8	2.7	0.9	0.5	–	3.4	3.8	14.9	3.7
10	11.8	6.4	8.0	3.5	7.5	3.9	4.6	1.8	2.6	–	4.6	19.5	4.8
11	6.1	3.1	2.3	0.5	3.4	2.6	3.1	3.2	3.5	10.1	–	10.8	15.3
12	5.5	5.3	6.1	4.7	3.4	9.8	8.5	8.6	9.2	25.3	5.6	–	32.0
13	4.2	4.2	5.9	6.5	6.9	5.4	3.2	2.8	3.0	8.3	4.6	9.7	–
						17 June 1981							
1	–	1.8	2.4	4.7	3.4	5.4	4.7	4.3	5.2	22.1	2.0	1.6	17.8
2	2.8	–	0.6	3.8	1.6	3.5	3.2	3.4	3.7	17.1	1.3	4.0	14.2
3	2.5	1.1	–	3.9	1.6	3.9	3.6	3.5	3.8	17.9	1.4	3.7	14.8
4	8.6	8.3	3.4	–	4.7	3.3	5.2	3.3	5.4	20.5	4.2	6.9	27.4
5	3.9	3.9	2.0	2.2	–	4.7	4.5	4.5	5.1	20.9	2.0	1.5	22.4
6	8.4	5.0	5.3	2.4	3.8	–	2.0	1.8	1.9	10.2	0.4	8.6	13.1
7	8.3	3.6	6.5	4.2	3.9	1.9	–	2.3	1.6	6.9	2.6	9.3	4.9
8	14.3	9.1	11.0	4.3	8.1	4.1	4.1	–	1.1	2.3	2.2	14.0	7.9
9	11.4	6.3	8.7	3.7	6.2	2.6	2.4	1.0	–	3.7	1.9	11.6	7.3
10	13.7	8.0	10.8	4.4	7.6	3.9	3.8	1.1	1.7	–	2.4	13.3	6.4
11	7.1	4.1	4.0	2.1	2.9	1.2	2.4	2.4	2.5	12.3	–	7.3	14.6
12	2.7	3.4	4.8	4.5	3.6	6.9	5.9	4.6	6.9	28.5	3.5	–	27.6
13	6.2	4.2	5.1	5.8	3.5	3.4	2.4	3.9	3.0	10.1	4.4	7.5	–

Table 43. Inter-class Maharanobis distance, LANDSAT data, with texture

Class	Class 1	2	3	4	5	6	7	8	9	10	11	12	13
						2 November 1979							
1	–	2.0	4.1	3.9	5.5	7.0	5.5	5.2	5.7	15.6	3.4	5.6	14.0
2	2.5	–	2.1	2.6	3.8	4.9	3.6	3.9	4.1	12.4	2.1	7.7	12.6
3	4.7	2.4	–	1.4	2.4	4.4	4.0	4.4	4.6	13.6	1.4	8.1	18.3
4	7.7	4.4	3.7	–	3.7	2.2	3.5	3.0	3.6	9.8	1.1	12.5	16.1
5	6.7	5.8	4.4	4.4	–	7.6	7.2	7.4	7.9	22.1	4.5	4.3	31.5
6	9.8	5.6	5.3	1.7	6.1	–	3.6	2.5	3.0	8.1	2.6	15.6	15.5
7	6.4	3.3	5.1	4.1	5.7	3.2	–	1.2	0.8	6.8	3.9	13.7	3.8
8	8.3	4.2	6.4	3.8	6.3	3.0	2.0	–	0.8	4.4	3.9	16.1	5.6
9	7.4	3.7	5.8	4.1	6.0	3.1	1.0	0.6	–	5.6	3.9	15.0	4.5
10	11.9	6.6	8.8	3.5	7.5	3.9	5.1	2.0	3.1	–	4.7	20.2	9.5
11	6.2	3.2	2.5	0.8	3.4	2.8	3.1	3.2	3.5	10.2	–	11.1	15.4
12	5.9	5.3	6.5	4.8	3.4	10.0	8.9	8.7	9.4	25.3	5.6	–	32.3
13	4.4	4.3	6.1	6.6	7.3	5.8	3.3	2.9	3.1	11.2	4.6	9.7	–
						17 June 1981							
1	–	2.0	2.4	4.7	3.4	5.5	4.8	4.4	5.2	22.8	3.1	3.0	18.2
2	2.8	–	0.6	3.9	2.5	3.6	3.3	3.5	3.7	17.6	2.2	4.6	14.6
3	2.5	1.1	–	3.9	2.7	4.0	3.6	3.5	3.8	18.3	2.1	4.4	15.3
4	8.6	8.3	3.4	–	4.9	3.3	5.4	3.3	5.4	21.0	4.4	6.9	27.6
5	4.0	4.1	2.2	2.3	–	4.7	4.5	4.5	5.1	21.4	2.3	3.5	22.7
6	8.4	5.0	5.3	2.4	4.5	–	2.1	1.8	2.0	10.6	1.0	8.7	13.4
7	8.4	3.7	6.7	4.2	4.4	1.9	–	2.4	1.6	7.4	2.7	9.4	5.2
8	14.5	9.1	11.2	4.3	8.5	4.3	4.1	–	1.1	2.7	2.3	14.1	7.9
9	11.5	6.4	8.8	3.7	6.9	2.7	2.4	1.0	–	4.1	1.9	11.6	7.5
10	13.7	8.2	10.8	4.5	9.1	3.9	3.8	1.3	1.9	–	2.4	13.3	6.8
11	7.8	5.0	4.8	2.5	3.2	2.3	2.7	2.4	2.9	13.3	–	7.4	14.7
12	4.0	6.0	5.3	4.8	5.9	7.2	6.0	4.6	7.3	29.9	3.9	–	27.7
13	8.5	7.7	7.4	6.5	5.4	5.2	4.5	3.9	4.4	12.2	4.6	7.5	–

were selected. In this way, it was possible to reduce processing (CPU) time to one quarter. A decision tree was constructed by assigning a considerable number of classes to each MSS level of band 7. Classification of a test area (corresponding to a 1:50,000 scale topographic map of Kanazawa) showed that the rice-fields and mountain shadow were difficult to classify. Therefore, the corresponding pixels were reclassified, using different LANDSAT data taken in June 1981. The pixels that were inconsistent with the national digital information were reclassified.

Image output

The classified results were resampled on a polycylindrical projection plane with 60-m interval and with the colour assigments shown in table 44. The resampled data were printed on film with aperture size 100 x 100 mm (1:600,000 scale), enlarged by photo-processing and printed with annotation data.

Table 44. Colour assignment for each class of training area

Class	Light amplitude for photo-printer		
	R	O	B
Dense residential area	255	0	0
Residential area	240	60	120
Rice-field	200	230	80
Field	180	120	40
Open space	110	110	110
Golf links	60	200	120
Coniferous forest	0	160	40
Deciduous forest	80	255	0
Mixed forest	60	180	40
Bamboo forest	40	255	100
Grassland	250	240	0
Sand	180	180	180
Fresh water	0	255	255
Sea	0	0	255
Cloud	255	255	255
Unclassifiable	40	0	80

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THEMATIC MAPPING: THE BASE OF SPACE STUDIES OF NATURE*

Paper submitted by the Union of Soviet Socialist Republics

RESUME

Le document décrit les réalisations de l'Union des républiques socialistes soviétiques dans le domaine de l'étude de la nature à partir de l'espace. On y examine le système spatial utilisé pour l'étude des ressources naturelles et de l'environnement. Ce système comprend des engins habités, des engins du type Meteor, des satellites de la série Cosmos, des laboratoires aéroportés, un réseau de bases maritimes et terrestres, des centres interdépartementaux de réception et de traitement des données spatiales ainsi que des organisations et agences départementales chargées d'étudier et d'utiliser les informations spatiales. Le document contient également un exposé des méthodes et des domaines d'application pratique de la cartographie thématique fondée sur les données de télédétection dans l'intérêt des différentes branches de l'économie nationale.

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Little time has passed since the Union of Soviet Socialist Republics launched its first artificial satellite of Earth and the first manned flight into space. Already, however, owing to the results obtained, it is possible to speak of the formation of a new branch of study of Earth and its natural resources—"space studies of nature". The most varied fields of science and technology, including almost all branches of the geosciences, are organically combined in this new branch of general and applied research of Earth from space.

The development of the study of nature from space is advancing successfully. Such studies are being applied over increasingly broad areas to ensure the effectiveness of the study and the use of natural resources to promote development of the national economy and growth of the prosperity of the Soviet people. Considerable experience has already been gained in applying space information in many branches of the national economy.

The USSR is currently engaged in international collaboration in the study of natural resources from space, both on a multilateral basis in the framework of the Intercosmos programmes and on the basis of bilateral agreements.

BASIC ELEMENTS OF NATURE STUDIES FROM SPACE

The system of studying natural resources and the environment from space includes the following basic elements:

(a) Manned spacecraft;

(b) Spacecraft of the Meteor type;

(c) Spacecraft of the Cosmos series;

(d) Aircraft-laboratories;

(e) Network of ground and marine test areas;

(f) Interdepartmental centres to receive and process space information;

(g) Departmental organizations and agencies for purposive processing and use of space information.

Manned spacecraft

In addition to performing many other scientific and technical tasks, manned spacecraft are intended to conduct a complex of experimental and test-production works on the remote sensing of Earth, working out the on-board measuring and survey instruments and carrying out visual and visual-instrumental research. The dimemsions of space orbital stations of the Salyut type permit allocation of a complex of different instruments, having considerable weights, dimensions and power consumption, in order to realize, under compared conditions, the concrete tasks of sensing through application of various receivers and to work out with a crew the optimal conditions for exploiting the on-board means of obtaining information on Earth.

Many experiments carried out by Soviet cosmonauts in orbit became a base for the technical requirements for new instruments, for survey methods and for determination of new fields of space techniques applications in the national economy. On the condition of proper equipping, ensuring the required inclination of orbit, increasing the period of active life and promoting the role of cosmonauts, the importance of orbital stations for obtaining both long-term and operative information from space will increase.

Spacecraft of the Meteor type

At the first stage of exploitation, spacecraft of the Meteor type carried out, in particular, hydrometeorological tasks. However, the methods of obtaining operative space information applicable also for study of Earth's natural resources were worked out for such satellites while carrying out the primary functions.

Satellites of the Meteor type were constantly being improved, the quality and resolution of data were being raised and the range of sensing was being extended. Thus, with the data obtained, it became possible to find more amd more applications in space studies of natural resources. This use of space techniques is one of the most efficient, from the technical-economic point of view, for studying rapidly changing natural processes and performing tasks that require a great field of observation in a comparatively moderate resolution. The trend in the development of this branch of remote sensing promises a further increase in the resolution of the video-information obtained and the satisfaction of a greater number of the demands of various branches of the national economy in both operative and long-term tasks.

Spacecraft of the Cosmos series

Spacecraft of the Cosmos series, which are used for studying Earth's natural resources, are equipped with various remote-sensing instruments. They ensure the systematic receipt of large multi-band photographic materials of high spatial resolution, which are required by the different branches of the Soviet national economy.

Aircraft-laboratories

Aircraft-laboratoires are used to conduct research works connected with formulation of the methods and technical means of remote sensing, the fulfilment of subsatellite (air and ground) experiments and the receipt of data with particularly high resolution. These laboratoires have high-quality navigation instruments as well as the needed carrying capacity, range of action, practical ceiling and power capacity.

Network of ground and marine test areas

The network of ground and marine test areas covers the sections of Earth's surface that are selected in typical physical-geographical zones of the USSR and are sufficiently uniformly allocated throughout its territory.

The test areas are provided with scientific-technical documentation describing the natural formations in the area and giving their parameters so as to facilitate evaluation, at reasonable expense, of the data obtained through remote sensing. The subsatellite (air and ground) observations and measurements and complex interdepartmental research on formulation of means of sensing and of methods for interpretation of space information etc. are carried out at those test areas.

Subsatellite (air and ground) observations are done with both mobile and stationary complexes and the means of contact and near-ground measurements, which permit determination of the parameters of the atmosphere, the spectral reflectiveness of natural formations and the resolution of remote-sensing data, in order to work out technical requirements for advanced instruments, methods of interpretation etc.

Interdepartmental centres and organizations

The major general and applied tasks to be performed with the assistance of space study of Earth's natural resources were developed and formualted by the Academy of Sciences of the USSR, together with specialized scientific-production centres and departmental institutes, in the course of realizing the programme for establishment of the system.

One of these tasks is to develop methods of thematic mapping on the base of remote-sensing data in the interests of various branches of the national economy: study of global and local structures of Earth's crust to ascertain the laws of forming and allocating areas with deposits of ore or oil and gas; study of the dynamics of modern geological-geographical processes, discovery and forecasting of areas of the shelf and the ocean with high bioproductivity; forecasting of crop production, soil moisture, damage to agricultural areas and forest tracts; surveying and civil engineering design for large hydro-technical complexes, high-altitude dams, gas mains etc.; topographic and thematic mapping and revision, and development of new cartographic products.

The data obtained from space are multi-purpose and can be used repeatedly. This information is broadly used in geographical studies and geological prospecting, in oceanography, in agriculture, in study of forest inventory, in development of projects for large engineering structures and in topographic mapping and surveying.

Use of data

Despite the short period in which space techniques have been used to study natural resources and the environment, important scientific and practical results have been obtained. New glaciers were detected and known glaciers verified with the help of space data. Important features of the landscapes in western Siberia and the areas near the Angara River were identified. Bathymetric geomorphological maps and maps of the soil and underwater vegetation were verified through use of multiband images of the Gaspian Sea, which clearly show the undersea relief and vegetation of the north-eastern part of that sea.

Considerable success has been achieved in applying space survey materials to solve theoretical and practical problems in geology. The use of space information made it possible to obtain principally new ideas on the structure of not only the upper layer but the abyssal horizons of Earth's crust. The latter information is particularly important.

In compiling the map of fracture tectonics of the USSR at 1:2,500,000 scale, aerospace materials were broadly used.

In the Aral-Caspian area, the circular structure is identified. It is important for oil/geological division into districts and for selection of methods of prospecting and exploring oil deposits in this area.

In the areas of Siberia near the Enisei River, new structure forms have been discovered. They are of great interest in prospecting oil and gas traps and offer the possibility of a new way of directing further oil and gas prospecting in this vast area.

Space oceanography has been actively developed in recent years. In studying the world's oceans, major problems of great theoretical and practical significance can be solved by this branch of science. Furthermore, maps of ice conditions, which aid mariners in selecting optimum routes for their vessels, are compiled with data from satellites.

Remote-sensing methods are being intensively introduced to solve problems in agriculture. Forestry also has benefited from a new rapid method of forest inventory: determination of their state; evaluation of timber resources; discovery of forest diseases spread by pests; location of seats of forest fires and evaluation of the post-fire condition of vegetation in the large taiga areas.

A great volume of research and production using remote-sensing materials is carried out in the field of cartography. Currently, space data are effectively used in mapping the high-mountain areas of the Pamirs and Tien-Shan, the separate territories of the north-eastern USSR and some polar islands. The photographic information is broadly used in revising small-scale topographic maps and in thematic mapping.

Space information is, as previously stated, multi-purpose, interdepartmental and of repeated usefulness. In the USSR, it serves as a base for the complex mapping of natural resources.

SOME APPLICATIONS OF SATELLITE IMAGERY TO SMALL-SCALE MAPPING FOR DEVELOPMENT PLANNING*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RESUME

Avec l'apparition des satellites imageurs, comme ceux de la série LANDSAT, il est devenu possible d'établir des cartes à petite échelle aux fins de la planification administrative et du développement sans passer par les levés et les cartes à plus grande échelle. La Direction des services cartographiques outre-mer a obtenu un certain nombre de produits cartographiques à partir des ces images à l'aide de techniques manuelles et photographiques. On estime que ces dernières techniques continueront d'être plus adaptées à l'établissement de ces cartes, bien que les installatins de traitment numérique des images se multiplient.

Topographic mapping agencies in developed countries have traditionally worked from the part to the whole. Where the necessary resources existed, they have given first priority to construction and maintenance of a national basic map series from which small-scale and other special purpose maps could be derived. In many less developed countries, such basic topographic cover is incomplete; and where it exists, it may be seriously out of date for lack of resources for maintenance. Small-scale maps for administration, development planning and presentation of thematic data have often to be improvised from a variety of source materials, with the consequence that they are of very uneven quality and may contain significant errors, even where complete topographic cover on such scales as 1:50,000 or 1:100,000 exits.

When the United States National Aeronautics and Space Administration (NASA) announced plans for the first imaging Earth resources satellite, ERTS A, later LANDSAT 1, it provoked a debate within the map-making community as to the utility of ERTS for making good the shortcomings in world map coverage. Advocates emphasized the speed and regularity with which data could be captured and the advantages of a system that would generalize topographic information automatically and present it on a near-orthographic projection. Sceptics pointed out that the very low resolution levels would be incompatible with the geometrical standards of accuracy specified for medium-scale topographic maps and would not permit the recognition of many features required by their users. Furthermore, until an imaging satellite could produce satisfactory stereoscopic cover such systems could not produce contours. This debate continues; and although a new generation of imaging satellites should provide higher quality data, it remains to be seen how far they will contribute, in the immediate future, to the extension and maintenance of basic topographic coverage. A recent

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* The original text of this paper, prepared by C. I. M. O'Brien, Directorate of Overseas Surveys, appeared as document E/CONF.75/L.104.

review of these issues 1/ concludes that problem areas were the geometrical accuracies that might be achieved, particularly where contours were to be plotted; the completeness of the information that could be obtained from very small-scale images, particularly with regard to man-made detail; and uncertainty as to whether it would be possible to rely upon future photographic imaging satellite systems to produce timely data. Considering the first and second of these issues, it appeared that economies in image capture, ground control and photographic processes might need to be offset by an increased requirement for field completion. Nevertheless, it was recognized that in many situations, there was a requirement for small-scale mapping in which up-to-date information was more important than geometrical accuracy and that satellite imagery could contribute directly to its provision.

Notwithstanding the problems mentioned above, imaging satellites have already made a considerable impact on the production of such small-scale maps. For the first time, such mapping is no longer dependent upon reduction of data first produced for mapping on larger scales. When the LANDSAT series of satellites was inaugurated, it was anticipated that multispectral scanner (MSS) imagery would be used for the capture of thematic data, whereas perspective images obtained from the return beam vidicon (RBV) cameras would be employed for most mapping tasks. For some years, however, very little RBV imagery was captured; and the Directorate of Overseas Surveys (DOS), like many other mapping agencies, was obliged to explore the application of MSS imagery to provide base maps for scientific and resource investigations and planning documents in areas where conventional topographic mapping was lacking. For example, base maps were prepared on the scale 1:100,000, with skeleton detail, of areas in south-western Ethiopia for field use in forest inventory. The basic framework was derived from 1:250,000 enlargements of MSS scenes augmented by detail derived from 1:60,000 aerial photography. These were line maps, but for many purposes it was evident that planning maps would be much more valuable if they could incorporate the original MSS images themselves. In developing techniques to do this, DOS was able to build upon its extensive experience in the construction of photomaps from aerial photographs. 2/ The first area in which this process was applied to a production task was the Antarctic Peninsula, where seven sheets were required in both photomap and line-map form at 1:250,000 scale for the British Antarctic Survey. 3/ Many problems were experienced. Bulk-processed imagery was obtained on 70-mm "chips", which had to be enlarged 13.4 times; and great difficulty was experienced in preserving the narrow tonal range of snow and ice terrain and accommodating the very large contrast between it and open water or rock areas. Seasonal differences made it difficult to match some adjacent scenes. Accurate scaling and orientation were hindered by uncorrected geometrical errors in the imagery and by the difficulty in precisely identifying such ground control points as existed in the project area. In addition, the photomaps, being monochrome, were only capable of reproducing detail from a single spectral band (band 7), whereas in the line maps derived fron them it was possible to introduce information interpreted from other bands.

Although the Antarctic requirement was exceptional in terms of the subject terrain, it did highlight many of the key problems in the production of small-scale maps directly from satellite images. As is described below, more recent DOS projects have applied these manual photographic techniques to a wide range

of terrain types to meet a variety of user needs. During this period, experimentation has also progressed at many other centres with a view to producing a more refined product; and a significant proportion of this work has been based on the direct exploitation of digital data as opposed to the manipulation of the photographic output derived from it. In the United Kingdom of Great Britain and Northern Ireland, some of the most important work has been carried out by the National Remote Sensing Centre at the Royal Aircraft Establishment, where a fully controlled composite image, of the 43 scenes covering the country has been produced by wholly digital means. 4/ It is clear that such techniques will be increasingly applied where demands justify the substantial costs arising from the adoption of such sophisticated procedures. Nevertheless, DOS recognizes that many of the most pressing demands for satellite image mapping will continue to arise in countries with limited financial resources and in support of projects with restricted budgets. It has seemed proper, therefore, to continue and maintain simpler techniques which can be used in such countries or to aid such projects. The remainder of this paper discusses a number of cases where this approach has been applied.

There are still many areas where it is necessary to plan survey operations without reliable base maps. In the past, when aerial photographs have been available, DOS has mosaicked these into "print laydowns", but these frequently display distortions in scale and azimuth due to the effect of relief or lack of control; and where such activities as the planning of new mapping photography are necessary, distortions in the planning base can lead to subsequent errors in photo-navigation and through these to an undesired increase in project working costs. It is now regular DOS practice in all such cases to produce an image mosaic from enlarged prints of MSS imagery, usually at 1:500,000 or 1:250,000 scale, at a planning stage, from which half-tone copies can be reproduced rapidly and cheaply by the diazo process. Such mosaics were prepared recently for an extension to the DOS 1:50,000 mapping commitment in Yemen. These mosaics were used for subsequent photo-navigation, with the result that despite the complexity of the terrain and substantial variations in relief, the contractor was able to complete photography in accordance with the DOS pre-planned flight lines without deviating from the latter by more than the 5 per cent tolerance permitted by the specification.

One of the recent research projects undertaken by the Institute of Geological Sciences (IGS) (United Kingdom) was an investigation of the South-East Asia orogenic arc, which extends from Burma and Thailand in the north to Sumatera in the south. Its aims was to provide a synopsis of geology and mineralization in relation to the arc, with particular attention to the location of tin-bearing granite bodies. IGS proposed to use LANDSAT MSS imagery both as a primary source of data (supplemented by aerial photography where available and accessible) and as the base on which their findings might be recorded. DOS was requested to produce a series of 12 mosaics, each covering an area 6° latitude x 6° longitude at 1:1,000,000 scale. Band-6 and band-7 imagery was to be used, with control to be provided by aviation charts existing at this scale. Additional cartographic work needed consisted of the preparation of an overlay to show major rivers, towns and principal towns which were to be named, political boundaries and a graticule. The major difficulties experienced in the production of these sheets arose from the problem of finding satisfactory imagery of an area in which completely cloud-free conditions are

rare. Some gaps were found between nominally adjacent scenes, not all of which could be filled with alternative cover. As only a limited number of copies were required for the project, these were supplied as continuous-tone prints with separate film overlays carrying names and line-work. It is evident that by no other means could homogeneous base mapping have been produced within an acceptable time-frame.

Several British organizations have been engaged in development work in Nepal, in co-operation with the Nepalese Government. Although contoured topographic maps at 1:63,360 scale covered much of that country, they were seriously out of date and as very few copies existed, frequently inaccessible. For an overview, development personnel had to fall back on older medium-scale maps, which were both out of date and inaccurate, or on aviation charts, which provided little information beyond the overall relief and drainage pattern. The The Nepalese Topographic Survey Department was preparing a series of 1:250,000 zonal maps, but as these maps were to use Nepali script they were of limited use for foreign experts. DOS was requested to provide a planning map to cover the entire country in sufficient detail for users to locate schemes and access routes but sufficiently uncluttered to allow users to add their own annotations.

It was decided that in view of the considerable east-west extent of Nepal, the sheets should be produced on the scale 1:500,000, but while relief could not be ignored in such a mountainous country its conventional representation by contours, possibly supplemented by shading, or layers, would produced a very crowded map, at considerable expense, using source material which was not of uniform quality. It was recognized, however, that over such a country the consistent shadow pattern on LANDSAT imagery could provide users with the equivalent of oblique hill-shading; it was therefore decided to use it to provide the essential topographic base. As suitable RBV cover was not available for the entire country, a mosaic of the best available MSS (band 6) imagery was constructed. This was related to the graticule using selected points of detail taken from the best available topographic maps. Rivers and lines of communications were interpreted using RBV imagery and aerial photographs as a supplementary source (where they were available); names and administrative boundaries were taken from the Nepalese maps mentioned above. The base mosaic was screened and within the boundaries of Nepal, it was printed in colour so as to distinguish between the main types of terrain. Outside Nepal, topographic detail appears in grey half-tone only. Techniques applied include the use of density reduced half-tones and the reversal of the sun azimuth in the mountainous areas so as to create the impression of illumination from the north-west as adopted in conventional hill-shading procedures. As this is development planning map, if differs from most maps covering the Himalayas in that it gives the higher ranges a very subdued treatment, with main emphasis on the intermediate moutain zone, the traditional home of the Nepalese people, and on the lowlands of the Terai, where very extensive agricultural settlement has taken place over recent decades. Names were transliterated from Nepali by the staff of the Permanent Committee on Geographical Names for British Official Use.

During the 1960s, DOS produced seven sheets of the International Map of the World on the Millionth Scale (IMW), which covered a substantial part of East Africa. At that time, substantial areas were not covered by detailed topographic surveys; and in any case, many sbsequent changes are nnot recorded on these maps. The Regional Centre for Service in Surveying, Mapping and Remote

Sensing at Nairobi saw the need for these maps to be replaced by a more up-to-date series and proposed that a pilot sheet should be prepared of sheet SB 36 (Tabora). Rather than recompiling, using larger scale source material derived from many different mapping projects executed over the past two decades, they proposed that the topographic framework be derived from LANDSAT imagery. The Regional Centre invited DOS to co-operate in this project. A base mosaic was to be produced using LANDSAT MSS and/or RBV imagery; drainage and communications were to be compiled from these sources supplemented by existing map material. In addition, forested areas and swamps were to be interpreted from the satellite imagery and an attempt made to relate the contour plate from the existing IMW sheets to the new image base to see if the latter could be overprinted on the former.

Following this request, DOS produced a pilot sheet in the course of which it was found that it would not be practical to use RBV imagery for the base mosaic both because it did not cover the whole sheet and in view of the confusion that could be caused by the reseau crosses. The base mosaic was therefore compiled from MSS imagery, and RBV was used for interpreting drainage patterns, communications and vegetation classification. Existing map material had to be used, however, for the location and identification of towns and villages. It was recognized that both the communication and settlement would require subsequent field verification and classification. The combination of the existing contour plate, prepared during the early 1960s from heterogeneous sources, with the new image base was found to be quite impracticable; and it was accepted that at that stage, the maps would have to be issued without contours. It remains to be seen wether most users will recognize that the additional information on the quality of the terrain provided by an image-based map will easily offset the loss of some of the quantitative information provided by its predecessor. Work on this project still continues. One difficulty that can be foreseen is that currently, in the absence of a regional receiving station, available LANDSAT imagery for east Africa is aging, so that some of the promise of satellite image mapping as a source of up-to-date information is fading.

In addition to production tasks, such as those described above, DOS has continued to work on improving its image-mapping techniques. It undertook a series of experiments in the combination of thematic data, such as geological formations, with a topographic base in the form of a subdued LANDSAT MSS image. These demonstrated that such a map could be produced for subsequent multi-colour lithographic printing. It is considered that such techniques would be very advantageous where the thematic data need to be directly related to topographic features recognizable on the ground, which is often difficult to achieve on conventional thematic line maps without excessive overcrowding.

DOES has assisted the Regional Centre at Nairobi in running a training course in mapping for satellite imagery, and it has been asked to co-operate with that Centre in the production of a training manual which would incorporate and utilize its experience in this field. It is hoped that through these means and others that there will be an increasing appreciation, particularly in medium-sized and smaller developing countries, that given basic skills it is possible to produce satellite image mapping which meets a wide range of development needs without further substantial capital investments. Although the projects described above used LANDSAT MSS or RBV imagery, there is no reason that the same techniques should not be used to exploit photographic

output from the next generation if imaging satellites, such as SPOT and the LANDSAT 4 thematic mapper. While the fullest use of the data the latter are to supply will require digital-processing facilities, there will continue to be many circumstances where simpler and more economical procedures will be more appropriate.

Notes

1/ Summarized in I. J. Dowman, "Topographic mapping from space imagery, progress and potential", in Matching Remote Sensing Technologies and their Applications (Remote Sensing Society, 1981), pp. 529-539.

2/ See, for example, "Photo mapping at the Directorate of Overseas Surveys", prepared by A. G. Dalgleish and A. B. Whitelegg, in Seventh United Nations Regional Cartographic Conference for Asia and the Far East, vol. II, Technical Papers (United Nations publication, Sales No. E.74.I.25), pp. 262-265; and Directorate of Overseas Surveys, Photomap Techniques, Technical paper 1/77 (Londong, 1977).

3/ D. Read and C. J. B. Lane, "Two slated views of Antarctica", The Photogrammetric Record, vol. VIII, No. 48 (October 1976), pp. 726-747.

4/ See A. H. Benny, "Automatic relocation of ground control points in Landsat imagery"; M. R. Gordon, "Ground control point of the UK"; and R. H. Merson, "A complete Landsat image of the UK", all in Matching Remote Sensing Technologies and their Applications, pp. 307-315, 301-306 and 329-337, respectively.

REMOTE SENSING ACTIVITIES IN INDIA*

Paper submitted by the Committee on Space Research

Conscient de l'importance des applications de la télédétection à la gestion des ressources naturelles, le Gouvernement indien a décidé de créer en 1975 une agence nationale de télédétection.

Elle avait pour objectifs:

a) Réaliser, aider, promouvoir, guider et coordonner les recherches en télédétection;

b) Exploiter des installations aéroportuaires avec un ou plusieurs appareils;

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* The original text of this paper, prepared by L. R. A. Narayan, Head, Application Division, National Remote Sensing Agency, Balangar, Hyderabad, appeared as document E/CONF.75/L.106.

c) Fournir aux agences nationales utilisatrices des services consultatifs et des équipements de levés photogrammétriques;

d) En utilisant les techniques télédétection pour faire l'inventaire diverses ressources naturelles;

e) Créer, tenir à jour et gérer des banques de données de télédétection;

f) Coopérer et collaborer avec d'autres institutions et organisations internationales, nationales ou étrangères travaillant dans le domaine de la télédétection et des sciences connexes.

Constituée en organisme autonome créé à Hyderabad en avril 1975, l'Agence nationale de télédétection s'est considérablement développée. Ses travaux s'inscrivent dans le cadre du Programme spatial indien géré par le Département de l'espace du Gouvernement indien. L'Organisation indienne de recherche spatiale relève du même Département. Elle dispose d'un centre pour les applications spatiales situé à Ahmedabad, chargé de toutes les applications spatiales y compris la télédétection.

L'Agence nationale de télédétection comprend une division des applications, qui s'occupe principalement de toutes les applications et assure la liaison avec tous les organismes utilisateurs. Une division technique s'occupe de toutes les questions concernant les ordinateurs et le matériel en général. Une autre division a pour responsabilité d'exploiter la station terrienne de réception des données construite en 1979 et de la moderniser pour lui permettre de recevoir les données des satellites de l'avenir selon que de besoin. Il y a à Bangalore des installations aéroportuaires avec quatre avions équipes de divers capteurs caméras, scanneurs etc.).

L'Institut indien de photo-interprétation de Dehradum est chargé de la formation, de la recherche développement et de l'expertise-conseil dans le domaine de la photo-interprétation et de la télédétection. Cet institut fut créé en 1966 et par la suite intégré à l'Agence nationale de télédétection.

La Division d'hydrologie s'occupe des ressources en eau.

Il faut également mentionner une équipe de spécialistes en logiciel, une équipe de géophysiciens spécialisés dans les activités aéroportées, d'un laboratoire de photographie moderne, d'un centre de distribution et de stockage des données, des services cartographiques d'appui, un petit groupe de formateurs etc. Les effectifs de l'Agence comptent près de 500 personnes.

A ce jour, l'Agence a mené à bien l'interprétation et l'analyse de plus de 70 scènes LANDSAT correspondant à diverses régions de l'Inde dans le but d'établir des cartes au 1:250 000. Elles portent sur les thèmes suivants: géologie, foresterie, pédologie, hydrologie, géomorphologie, occupation des sols.

L'Agence nationale de télédétection joue également un rôle actif dans la formation et le transfert de technologie aux divers utilisateurs en Inde. Il existe déjà quelques centre régionaux d'application de la télédétection.

Certaines universités et des instituts techniques offrent d'ores et déjà des cours avancés de télédétection.

L'Agence qui relève du Département de l'espace du Gouvernement indien, peut mettre à la disposition de tout pays qui en fait la demande ses installations de formation en télédétection et en interprétation des photographies aériennes. Elle peut offrir des services consultatifs à tout pays intéressé. Le programme spatial indien prévoit pour 1985-1986, le lancement de satellites indiens de télédétection et les préparatifs sont en cours.

Realizing the importance of the applications of remote sensing for the management of the natural resources, the Government of India decided to establish the National Remote Sensing Agency (NRSA) in 1975.

The objectives were:

(a) To undertake, aid, promote, guide and co-ordinate research in the field of remote sensing;

(b) To operate a flight facility with one or more aircraft;

(c) To provide consultancy services and airborne survey facilities to user agencies in the country;

(d) To carry out surveys by using remote-sensing technology for various natural resources;

(e) To establish, maintain and manage data banks for remote-sensing data;

(f) To co-operate and collaborate with other national and/or foreign institutions and international organizations in the field of remote sensing and allied sciences.

NRSA came into existence as an autonomous organization at Hyderabad and has progressed considerably. NRSA comes within the overall space programme activities in India, controlled by the Department of Space, Government of India. The Indian Space Research Organisation (ISRO) is also a part of the Department of Space. ISRO has a Centre for Space Applications at Ahmedabad, which covers all applications, including remote sensing.

The Applications Division of NRSA is mainly concerned with all applications and interacts with all the user agencies. There is a technical division, which manages all the computers and other hardware items. An Earth station division is reponsible for the operation of the LANDSAT receiving station, which was established in 1979. It also undertakes updating of the existing station to receive future satellite data, as and when required. An aircraft flight facility exists at Bangalore, with a fleet of four aircraft and various sensors, such as cameras and scanners. The Indian Photo-interpretation Institute at Dehradum undertakes training, research and development, and consultancy in the field of photo-interpretation and remote sensing. This institution was established in 1966 and later became a part of NRSA.

There is a separate hydrology division, which deals with problems related to water resources.

In addition to the bodies mentioned above, NRSA has a group of scientists engaged in software activities, a group of scientists engaged in airborne geophysical activities, an up-to-date photo-lab, a data distribution and storage centre, cartographic support services, a small training group etc. There are nearly 500 personnel in NRSA.

To date, NRSA has completed interpretation and analysis of over 70 LANDSAT scenes in various parts of India, to provide information at 1:250,000 scale. The disciplines covered include geology, forestry, soils, hydrology, geomorphotology and land use.

NRSA has also been actively engaged in the training and transfer of technology to various users in India. A few regional remote-sensing applications centres have already come up. Some of the universities and institutes of technology have already instituted courses in remote sensing at post-graduate levels.

NRSA, under the Department of Space, Government of India, can offer training facilities in remote sensing and aerial photo-interpretation to any countries desiring them. In addition, NRSA can provide consultancy services. The Indian space programme includes launching of Indian remote-sensing satellites, scheduled for 1985/1986; and preparations are under way.

REVIEW OF SATELLITE REMOTE-SENSING PROGRAMMES*

Paper submitted by the International Society for Photogrammetry and Remote Sensing

RESUME

Plusieurs pays se sont lancés dans la mise au point de systèmes de télédétection par satellite. LANDSAT-4, lancé par la NASA en juillet 1982, transmet des données de haute qualité fournies par le scanneur multibande et l'instrument de cartographie thématique. Plusieurs missions de la navette spatiale seront équipées d'appareils de télédétection: radar à synthèse d'ouverture, caméras et détecteurs électro-optiques. L'Union des républiques socialistes soviétiques a placé des caméras sur Salyout-7 et des détecteurs électro-optiques sur l'engin spatial Meteor. La France lancera le satellite SPOT qui sera équipé de détecteurs électro-optiques à haute résolution. L'Agence spatiale européenne et le Japon mettront en orbite des satellites d'observation des mers, puis des satellites d'observation des terres.

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* The original text of this paper, prepared by F. J. Doyle, President, International Society for Photogrammetry and Remote Sensing, appeared as document E/CONF.75/L.68. It was extensively revised from an earlier version of April 1982.

L'Inde exploite de petits satellites de télédétection et le Brésil, le Canada et les Pays-Bas étudient de futurs systèmes.

World-wide experience of many individuals and organizations with remote-sensing data acquired from space, primarily LANDSAT-1, -2 and -3, has demonstraded its utility for land-use classification, agricultural assessment, energy and resource exploration and many other applications. On the basis of this favorable experience, several countries are developing new systems for operation in the decade of the 1980s. This review presents the situation at the beginning of 1983. Only systems designed for imaging Earth are included; meteorological satellites and other types of non-imaging remote-sensing satellites are not covered.

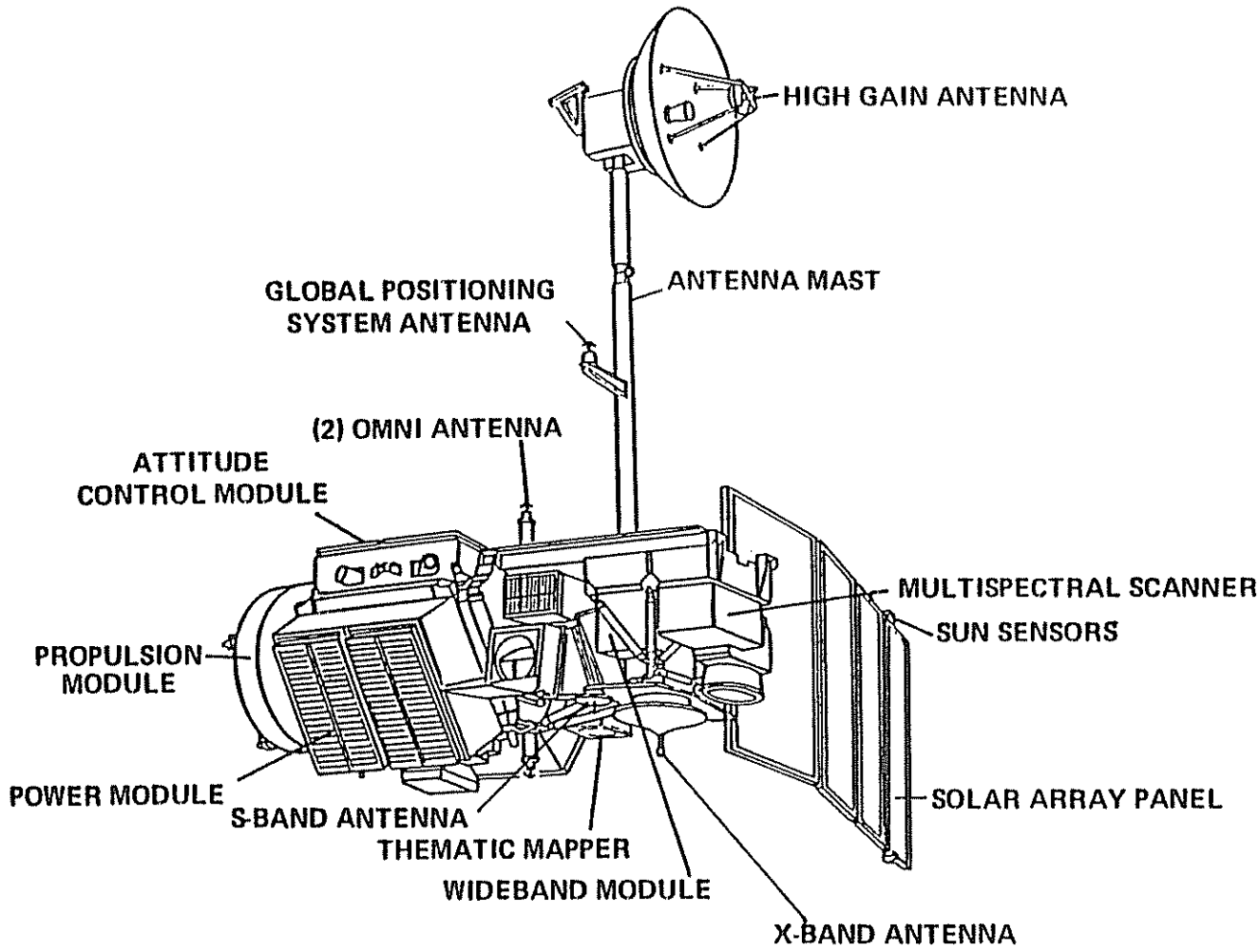
LANDSAT-4

The most significant recent event in satellite remote sensing was the successful launch of LANDSAT-4 on 16 July 1982. The spacecraft was launched by the Delta 3920 expendable vehicle into a 705-km altitude, 98.2° inclination sun-synchronous orbit. As is shown in figure 113, the basic vehicle is the multi-mission modular spacecraft (MMS), which provides power supply, attitude control, command and data handling, and on-orbit propulsion. The payload consists of the multispectral scanner (MSS) and the thematic mapper (TM). MSS is essentially the same as the instrument carried on LANDSAT-1, -2 and -3, with four spectral bands, 80-m pixel and 185-km swath. The thematic mapper is a second-generation multispectral scanner having six spectral bands in the visible and short-wave infra-red wavelengths with a 30-m pixel, and one band in the thermal infra-red wavelength with 120-m pixel. The TM swath width is also 185 km. The spacecraft has a solar array for power, an antenna for use with the Global Positioning System (GPS) 1/ and a large steerable antenna for communication with the Tracking and Data Relay Satellite System (TDRSS). 2/

There are no on-board tape recorders for either MSS or TM. In operation, the two sensors can record data independently or simultaneously. When within range of a ground station equipped to receive it, data can be transmitted directly--MSS data on S-band at 15 megabytes per second and TM data on X-band at 85 megabytes per second. At all other times, data will be relayed to TDRSS and from there to the ground station at White Sands. After some preliminary processing, it will then be sent by domestic communication satellite (DOMSAT) to Goddard Space Flight Center (GSFC) for product generation.

The MSS data are compatible with the network of foreign LANDSAT receiving stations; and the National Aeronautics and Space Administration (NASA) is providing ground tape-recorders at the ground stations in Australia, Brazil, India, Japan, Sweden and Thailand, to assure that coverage is obtained from certain high-priority areas. These tapes are shipped to GSFC for processing. GSFC transmits high-density digital tape data (HDDT) via DOMSAT to the EROS Data Center (EDC) at Sioux Falls, South Dakota. EDC produces both film and computer-compatible tapes (CCT) for distribution to users. The MSS ground processing system at GSFC is capable of processing about 200 scenes per day. In the first quarter of 1983, the National Oceanic and Atmospheric Agency (NOAA)

Figure 113. International Society for Photogrammetry and Remote Sensing: LANDSAT-4 equipment



Note: LANDSAT-4 will use the multi-mission modular spacecraft to carry the multispectral scanner and the thematic mapper with antennae for communication with the Tracking and Data Relay Satellite System and the Global Positioning System.

will assume responsability for command and control of the spacecraft and distribution of MSS data.

The first few scenes of TM data clearly demonstrated the utiliy of the additional spectral bands and the increased spatial resolution. At first, the thematic mapper will be operated as a NASA experimental sensor. TM data will be transmitted on X-band directly to the ground station at GSFC until TDRSS is operational. No foreign ground stations are currently configured to receive and process the 85 megabytes per second X-band data, though several have indicated their intention to do so. First will be the Canadian station at Prince Albert, to provide TM coverage of the western United States. The seaprate TM processing system at GSFC will be operated by NASA, at first on an experimental basis producing one or two scenes per day by the first quarter of 1983 and full capacity of 50 scenes per day by 1985. GSFC will produce both film and CCT products. EDC will receive film from GSFC and will supply photographic products to users, but CCTs will be supplied directly by GSFC. NOAA will assume operational responsability for TM data when full capacity of the ground processing system has been adequately demonstrated.

An identical spacecraft, LANDSAT-D prime, will be ready for launch about July 1983. It is hoped to add wide-band video tape recorders for MSS on this spacecraft, but funds have not yet been provided for this modification. According to current plans, the spacecraft will not be launched until LANDSAT-4 begins to fail. Since the specification lifetime for TM is two years and for MMS is three years, this plan should provide data from 1986 to 1988. By that time, NOAA is expected to have reached an agreement for commercial operation of the Earth observation satellite systems. Both LANDSAT-4 and D prime are equipped for recovery and possible relaunch by the Shuttle and a Shuttle mission has been designated for this purpose in 1986/87. However, this may not actually be done because of the prospect of commercial operation using a different system configuration. NOAA has proposed that it be authorized to operate the system if an acceptable contract cannot be reached with a commercial venture, but this proposal has not been approved and no federal funding is anticipated after LANDSAT-D prime.

EXPERIMENTAL ELECTRO-OPTICAL SENSORS

One of the most promising imaging sensors is the linear array of charge coupled detectors (CCD). These arrays consist of several thousand elements and they can be butt-joined to provide more than 10,000 detectors per line. An optical system images a line from the ground scene to the line of detectors. Ground resolution in the cross-track direction depends upon detector size and the ratio of optical system focal length to flight altitude; in the long-track direction, it depends upon the time in which the signals can be recorded as the vehicle moves along the orbit. NASA has undertaken several studies of possible sensor instruments using this concept. Recently completed is the multispectral linear array (MLA) instrument definition study. The study proposes use of MMS launched by Shuttle into a LANDSAT-4 orbit. The sensor instrument would provide six spectral bands in the visible and short-wave infra-red. Five of these bands would have a 30-m instantaneous field of view (IFOV) and one band in the red would have a 15-m IFOV for recording cultural features. The optical system would provide +/-26° fore-and-aft stereo-viewing

and +/-30° across track pointing for missed-scene recovery. The data rate would be 200 megabytes per second with on-board storage and data compression, and transmission direct to ground and via TDRSS. NASA has awarded several contracts for the design of an experimental demonstration instrument to be available for flight on the Shuttle by about 1988

MAPSAT

The United States Geological Survey, concerned about the technical and economic viability of systems as complex as LANDSAT-4 or the NASA multispectral linear array (MLA) instrument concept, has completed a study for a system called MAPSAT, which would provide data adequate for compilation of 1:50,000 scale maps with 20-m contour intervals. The orbit would be the same as LANDSAT-1, -2 and -3. Three MLAs would look in the vertical and +/-23° fore and aft to provide stereo data. Each array would have three spectral bands and a minimum 10-m IFOV, but the information could be clustered by on-board processing to provide lower resolution at multiples of the 10-m IFOV. On-board data compression and selected acquisition would reduce the data rate to 48 megabytes per second, which can be accommodated by minor modifications to the existing world-wide network of LANDSAT ground receiving-stations. A highly stable spacecraft would permit a simple algorithm to be employed in the ground data reduction for correlating the stereo records in order to produce digital terrain elevation data. MAPSAT is not an approved programme and has no funding beyong the feasibility study. It is hoped that eventually a commercial operator will consider the MAPSAT concept.

SHUTTLE REMOTE-SENSING MISSIONS

For the past 10 years, the largest NASA programme has been the development of the Space Transportation System (STS). The major advantage of this system is that its principal component, the Shuttle Orbiter vehicle, can be returned to Earth and reused on successive missions. The back of the vehicle opens up to a cargo bay in which manned modules and instrument pallets can be installed and operated while the Shuttle is on sortie missions in space. Initial launches of the Shuttle are due east from Kennedy Space Center (KSC) in Florida, permitting remote-sensor coverage from latitudes 28.5° North to 28.5° South. Because of range safety conditions, the maximum orbit inclination available from KSC is 57°, which permits coverage of most of the world's populated areas. Polar orbits for the Shuttle will not be available until 1985, when the western test range at Vandenberg Air Force Base should become operational. Shuttle missions launched from KSC are designated as "STS", followed by the sequential flight number. Missions launched from Vandenberg will be designated as "V", followed by sequential flight number. Five successful Shuttle flights have been completed, and the system has been declared operational.

A number of STS missions will have remote sensing as part of their payload. The second Shuttle mission, STS-2, which operated from a 275-km orbit at 40.3° inclination in November 1981, carried the Earth observation payload package called "OSTA-1", developed by the NASA Office of Space and Terrestial Applications. The instruments were: (a) Shuttle multispectral infra-red radiometer (SMIRR); (b) measurement of air pollution from satellite (MAPS); (c) ocean

colour experiment (OCE); (d) feature identification and location experiment (FILE); (e) Shuttle imaging radar (SIR-A). All of the instruments operated successfully, with the data from SIR-A being of greatest interest. 3/ This instrument was a modification of the SEASAT radar with a 47° look angle, 56-km swath, 40-m resolution and optical recording of the data on film.

STS-7, scheduled for April 1983, will be the first flight of the Shuttle Pallet Satellite (SPAS-01). This small structure will be the first payload to be launched into an independent orbit and subsequently be recovered and returned to Earth by the Shuttle. Among other experiments, it will carry a modular opto-electronic multispectral scanner (MOMS), which will have two linear array detectors operating in the visible and near infra-red wavelengths with a 20-m pixel and 140-km swath. Data will be stored by an on-board tape recorder for post-flight analysis. STS-7 will be at 296-km altitude and 28.5° inclination.

A major Shuttle payload is Spacelab, which is a joint venture between the European Space Agency (ESA) and NASA. It is currently scheduled for launch on STS-9 in October 1983 at 250-km altitude and 57° inclination. The payload will consist of both manned experiment modules and pallets for other instruments.

The metric camera (MC) experiment, which is a standard Zeiss 30/23 aerial camera with 30-cm focal length and 23 x 23-cm format, will be operated through a window in the manned module. From the anticipated altitude, these pictures will cover an area of 190 x 190 km, with a ground resolution of approximately 20 m. The mission will be nine days duration, and three film cassettes providing a total of 1,650 frames will be carried. The principal objective is to determine the applicability of such photographs for topographic mapping on scales as large as 1:50,000.

The second Earth observation instrument aboard Spacelab is the microwave remote-sensing experiment (MRSE), which consists essentially of a parabolic reflector, a sub-reflector and a feed horn. The instrument can operate as a two-frequency scatterometer to measure ocean wave spectrum, as a passive thermal radiometer to measure surface temperature with sensitivity of +/-1° K, or as a synthetic aperture radar providing 25-m ground resolution over a 9-km swath.

There will be subsequent Spacelab missions with various objectives, such as life sciences and materials processing. One of these missions has been designated for Earth and atmospheric observations, but a final selection of instruments has not been made.

Shuttle mission STS-11 at 296-km altitude and 28.5° inclination has the primary mission of launching three communication satellites. It will also carry the large-format camera (LFC) built by NASA. The essential parameters of the camera are a 30.5-cm focal length with a 23 x 46-cm format. The camera has automatic exposure sensors and forward motion compensation, permitting use of high-resolution fine-grain film. The magazine has capacity for 2,400 frames. A ground resolution of from 10 to 15 m can be obtained from the nominal Shuttle altitudes. By using 80 per cent forward overlap, a base-height ratio

of 1.2 can be obtained, permitting contours of 20-m interval to be compiled. An Attitude Reference System (ARS) is also being built for addition to LFC. This system will consist of two stellar cameras of 152-mm focal length operating on a single 70-mm film web. The cameras will be directed horizontally when LFC is looking vertically and will be aimed 45° fore and aft of the normal to the flight path. The lock angles between the ARS cameras and LFC will be determined by calibration. The mid-point of exposure of the star cameras will be synchronized with the LFC exposure. Post-flight mensuration of the star photographs will permit determination of the three attitude angles for LFC with a precision of about +/-5 arc seconds.

LFC/ARS will be mounted on the multi-purpose experiment support structure (MPESS) shown in figure 114. This is conceived as a standard payload which can be carried in the cargo bay of any Shuttle mission with substantial Earth-viewing time.

Shuttle mission STS-17 is currently scheduled for August 1984 at 296-km altitude and 57° inclination. Its principal objective will be to carry the OSTA-3 Earth observation payload. The primary instrument will be a new imaging radar, identified as SIR-B, which will have a folding antenna mounted on a cargo bay pallet. The radar will operate in L-band, with an incident angle variable from 15° to 65°, and corresponding swath widths of 30-55 km. The ground resolution will vary from 30 to 110 m, depending upon the look angle. At 46 megabytes per second, digital data will be transmitted via TDRSS, but a back-up optical recording on film will also be provided.

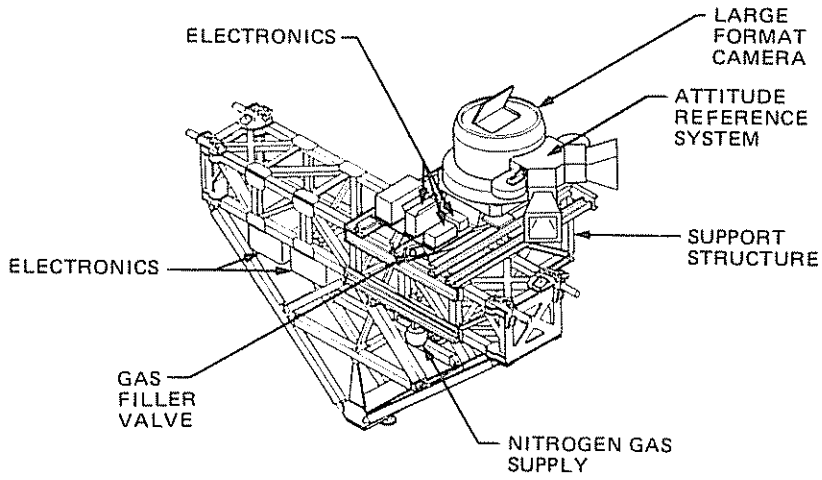
The second instrument in the OSTA-3 payload will be LFC/ARS. At first, it was planned to mount this on the pallet that will carry SIR-B, but later developments make it probable that the same MPESS structure used on STS-11 will be employed. MAPS, and possibly the FILE experiment from STS-2, also will be carried on the pallet.

NASA has received a request to refly MRSE from Spacelab and is investigating how to include it in the STS-17 payload. The most probable installation will be to mount it on the MPESS structure that will carry LFC/ARS.

SPACE STATION

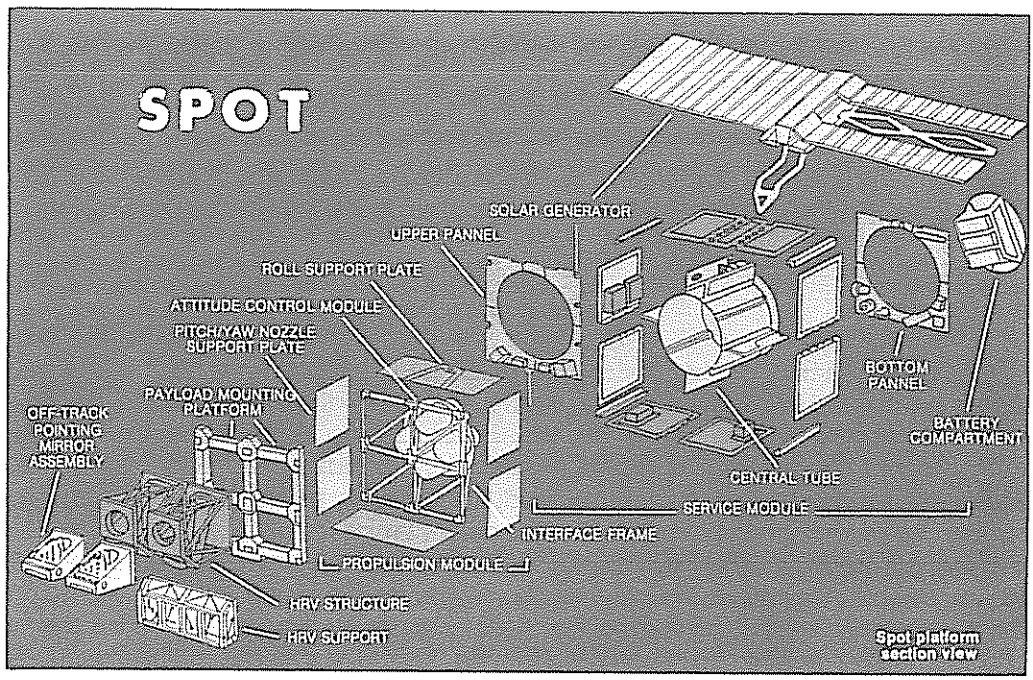
The next major thrust of NASA will be permanently manned space stations, at first in low Earth orbit and eventually in geosynchronous orbit. A number of study contracts have been let to industry to determine the feasibility, utility, configuration and cost of such structures. Most of the designs are modular in concept, using manned modules and instrument pallets from Spacelab and often employing refurbished external tanks from the Shuttle. Crews of from 9 to 12 people are contemplated. Earth observation is one of the advertised users of a manned space station, although most remote-sensing specialists believe these observations are more efficiently accomplished from unmanned platforms. The space station is not an approved project and no NASA funds have been allocated beyond the initial studies. Some preliminary discussions have been held with ESA, Canada, France, the Federal Republic of Germany, Italy and Japan on the possibility of making the space station an international co-operative project.

Figure 114. International Society for Photogrammetry and Remote Sensing: Shuttle Mission STS-1 equipment



Note: The large format camera (LFC) and Attitude Reference Systems (ARS) will be mounted on the multi-purpose experiment support structure (MPESS).

Figure 115. International Society for Photogrammetry and Remote Sensing: equipment for Système probatoire d'observation de la Terre, SPOT



Note: The Système probatoire d'observation de la Terre (SPOT) being developed by the Centre national d'études spatiales in France will use a standard modular spacecraft and will carry two high-resolution optical sensors.

REMOTE-SENSING PROGRAMMES OF THE UNION OF SOVIET SOCIALIST REPUBLICS

The manned spacecraft Salyut-6 was launched by the Union of Soviet Socialist Republics in September 1977, into a 260-km altitude, 52°-inclination orbit and operated until July 1982. It has been replaced by the higher capability Salyut-7, which was launched in April 1982 and was occupied in May 1982 by a crew brought into space by the Soyuz-T vehicle. The unmanned Progress-14 vehicle brought supplies to Salyut-7 in July 1982 and adjusted the Salyut-7 orbit to 365-km altitude at 51.6° inclination. Salyut-6 carried remote-sensing instrumentation, and it is presumed that the same equipment is aboard Salyut-7.

The MKF-6 system comprises six separate cameras of 125-mm focal length, 160- ℓp/mm resolution and 55 x 81-mm format with appropriate dielectric filters to produce multispectral photographs in the range from 0.45 to 0.94 μm. The camera system employs a rocky mount for image compensation and is capable of ground resolution in the 15-20-m/ℓp range. An additive colour viewer and printer MSP-4 has been built for use with the MKF-6 photographs. Excellent results can be produced in black and white, conventional colour and colour infra-red response. The MKF-6 camera system was first used in space aboard the Soyuz-22 spacecraft in September 1976. A few frames have been released to the international community.

The second camera used on Salyut-6 is the KATE-140 mapping camera, which was used also on Salyut-4. This has a focal length of 140 mm and image format of 18 x 18 cm. From the Salyut-6 altitude, this camera should be capable of producing about 30-m ground resolution and each frame would cover about 335 x 335 km. Both the MKF-6 and the mapping camera are controlled from a single console which permits simultaneous or separate operation of the two systems. There is some indication in the literature that the KATE-140 camera was replaced by the MRB-9/2323. This is a standard Zeiss Jena super-wide angle aerial survey camera with a focal length of 90 mm and film format 23 x 23 cm.

Exposed film is collected and fresh film is supplied to Salyut by the Progress and Soyuz vehicles which transfer cosmonaut crews. Film is processed at the Priroda (Nature) State Centre of the USSR Council of Ministers Central Administration of Geodesy and Cartography. Salyut-6 acquired (January 1981) more than 50,000 photographs covering 48.6 million km^2.

During the growing season, from May to October, for the past several years, a number of missions in the Cosmos series have been designated as Earth resources observation spacecraft. Typically, they are launched into an orbit at 81-82° inclination and 220-270-km altitude. The spacecraft are recovered after 15-30 days of operation. Most probably the primary sensor system is the MKF-6 camera. In February 1979, Cosmos-1076 was identified as an ocean resources mission, but the sensor payload was not disclosed.

In June 1980, the USSR launched one of the Meteor weather satellites into a 589 x 678-km orbit at 98° inclination. In addition to the operational meteorological sensors, MSU-S and MSU-M, which provide low-resolution data, this spacecraft carried three experimental Earth observation sensors. The MSU-E uses charge coupled sensors to produce three spectral bands between 0.5 and

1.0 μm, a 30-m instantaneous field of view and a 30-km swath. The MSU-SK optical-mechanical scanner has four spectral bands between 0.5 and 1.0 μm, a 170-m IFOV and a 600-km swath. The third instrument, identifief as "Fragment", is also an optical-mechanical scanner with eight spectral bands between 0.4 and 2.4 μm, 80-m IFOV and 85-km swath. Data from the MSU-E and MSU-K are transmitted digitally to a receiving station at Obninsk; data from "Fragment" are transmitted digitally to a receiving station at the Moscow Institute of Power Engineering.

A second Meteor Earth observation spacecraft was launched into a similar orbit in July 1981. Its sensors were identified as a multispectral scanning television system and a three-channel microwave radiometer. Also carried were a Bulgarian single-channel microwave radiometer and a visible and near infrared spectrometer.

The USSR enters into bilateral agreements with other countries to acquire Earth resources information. Extensive topographic and thematic mapping of the Soviet Union at 1:100,000 scale is reported to have been accomplished. The USSR has announced its intention to build permanent manned space stations, one of whose purposes would be Earth resources observation. As a first step towards this objective, in summer 1981, Salyut-6 was raised to a 400-km orbit, where an automated docking was performed with Cosmos 1267. It is possible that Salyut-7 is the second step towards this objective since it is equipped with multiple docking parts. The USSR is also developing a winged reuseable manned spacecraft to support space station operations. It is expected to be available in about five years. The Soviet Union is also known to be developing a navigation satellite system.

SYSTEME PROBATOIRE D'OBSERVATION DE LA TERRE

The Centre national d'études spatiales (CNES) in France is developing the Système probatoire d'observation de la Terre (SPOT). This spacecraft, shown in figure 115, will be launched in October 1984 by the ESA Ariane expendable launch vehicle into a 98.7° inclination sun-synchronous orbit at 822-km altitude. Mission control, data reception and image processing will be at Toulouse, France.

The payload will consist of two instruments called "haute résolution visible" with reflective optics and CDD linear array detectors. A rotating mirror will permit a scene 60-km wide to be acquired by each instrument from areas up to 475 km left or right of the spacecraft track as well as in the vertical. This arrangement permits side-to-side stereo data acquisition and more frequent looks at high-priority areas. The instruments can operate in a three-band multispectral mode with a 20-m IFOV or in a panchromatic mode with a 10-m IFOV. There are two on-board tape recorders, each with capacity for 30 minutes of data. The transmission rate will be 25-m bits per second in X-band for each of the two instruments.

CNES has formed a commercial enterprise, Spotimage, which is responsible for negotiating with foreign receiving stations, currently anticipated in Australia, Bangladesh, Brazil, Burkina Faso, Canada, India and Sweden, although not all of those countries have approved funds. Soptimage will also be responsible for sales of both hard-copy images and digital data to users outside France. A policy of open dissemination to all customers has been established.

A SPOT-2 spacecraft will be available for launch in June 1985; and depending upon the demonstrated utility and marketability of the data, SPOT-3 and SPOT-4 missions would provide data continuity well into the next decade. CNES also plans to configure the Toulouse ground station to receive TM data from LANDSAT-4.

EUROPEAN SPACE AGENCY PROGRAMMES

Development of the Ariane expendable launch vehicle has been a principal concern of ESA. Ariane-1 is capable of delivering a 1,700-kg payload to geostationary transfer orbit. Further developments of the launch vehicle will increase the capability up to 4,300 kg on Ariane-4 about 1986. Eventually, a returnable manned vehicle, Hermès, is anticipated for Ariane-6. Three of the first four test launches from the facility at Kourou, French Guiana, were successful, but the first operational launch in September 1982 also failed. Nevertheless, the vehicle is expected to be fully operational in 1983, and its first remote-sensing payload will be SPOT-1 in October 1984.

ESA is committed to the development and launch of a European remote-sensing satellite, called the ESA Resources Satellite (ERS-1). The principal objective of ERS-1 is ice and ocean monitoring. Launch by Ariane-2 or -3 into a 675-km altitude, 98°-inclination sun-synchronous orbit is expected in late 1987 or early 1988.

As is shown in figure 116, the basic spacecraft will be the SPOT vehicle. The sensors will be:

(a) Synthetic aperture radar with 30 or 100-m resolution, 22° incidence angle and 80-km swath;

(b) Wind scatterometer with 50-km spatial resolution and 400-km swath to determine wind speed to +/-2 m per second and wind direction to +/-20°;

(c) Wave scatterometer to determine ocean wave length to +/-25 per cent and wave direction to +/-20°;

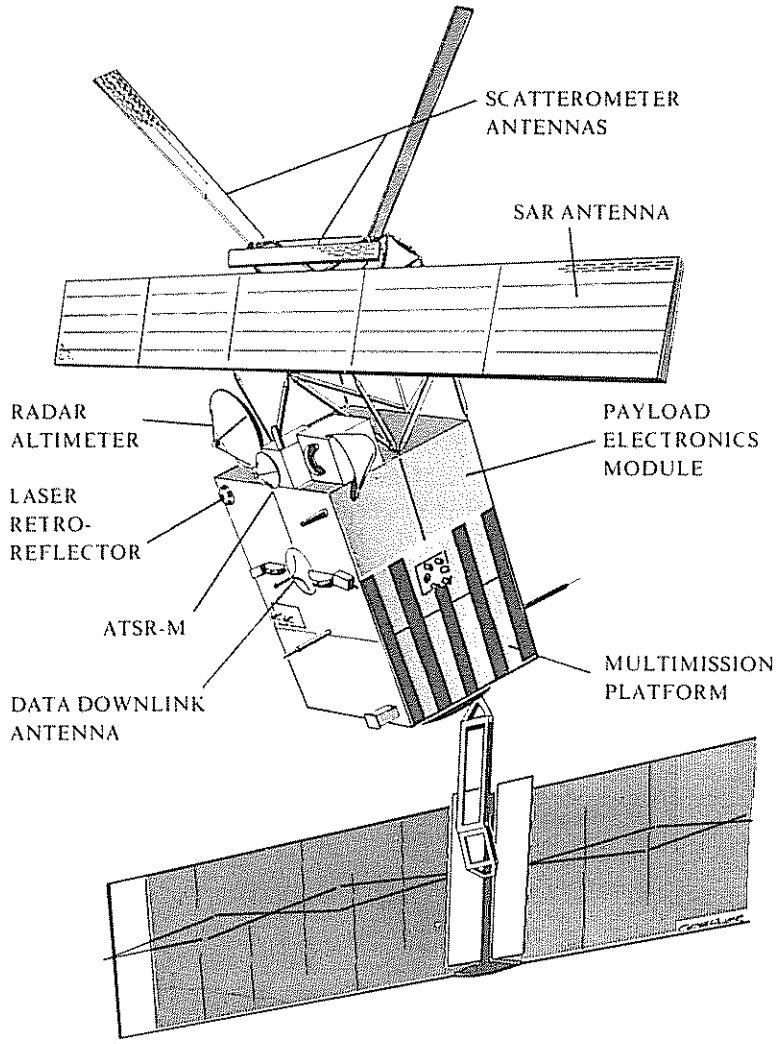
(d) Radar altimeter with a foot print of 1.6-20 km (depending upon sea state) to determine ocean wave heights +/-10 per cent;

(e) Along-track scanning radiometer with three infra-red channels to determine sea surface temperature and water vapour content for a 1-km pixel and 500-km swath.

The spacecraft will also carry laser retroreflectors for accurate tracking from the ground. On-board tape recorders will be provided for all instruments except the synthetic aperture radar. Data will be transmitted on X-band to the ESA Earthnet ground stations. A second identical spacecraft is contemplated for the 1989-1990 time-frame.

A second-generation spacecraft, Advanced ERS (AERS), designed principally for land observations, has been proposed for launch about 1989. It would use the SPOT vehicle and synthetic aperture radar from ERS-1, but the other

Figure 116. International Society for Photogrammetry and Remote Sensing: equipment for European Space Agency Resource Satellite, ERS-1



Note: The European Space Agency Resource Satellite (ERS-1) will carry synthetic aperture radar, wind and wave scatterometers, a radar altimeter and a along-track scanning radiometer as a scientific payload.

instruments would be replaced by an optical imaging instrument (OII) providing six spectral bands from 0.52 to 2.35 μm with a 30-m IFOV, and one panchromatic band with a 15-m IFOV and a 175-km swath.

JAPANESE EARTH OBSERVATION SPACECRAFT

In Japan, the Science and Technology Agency has undertaken an extensive study programme for a Marine Observation Satellite (MOS). The first spacecraft, MOS-1, shown in figure 117, will carry a multispectral electronic self-scanning radiometer (MESSR) to measure sea-surface colour with a 50-m IFOV for a 100-km swath in four spectral bands between 0.51 and 1.10 m. A visible and thermal infra-red radiometer (VTIR) will measure sea-surface temperature over a 500-km swath with one band in the visible providing 0.9-km IFOV and three bands in the infra-red between 6.0 and 12.5 m, providing a 2.6-km IFOV. The third instrument will be a two-frequency microwave scanning radiometer (MSR) to measure atmospheric water content. The spacecraft will be launched from Tanegashima in 1984 into a 909-km altitude, 99.1^{o}-inclination orbit. If MOS-1 is successfull a second and third spacecraft amy be launched as required.

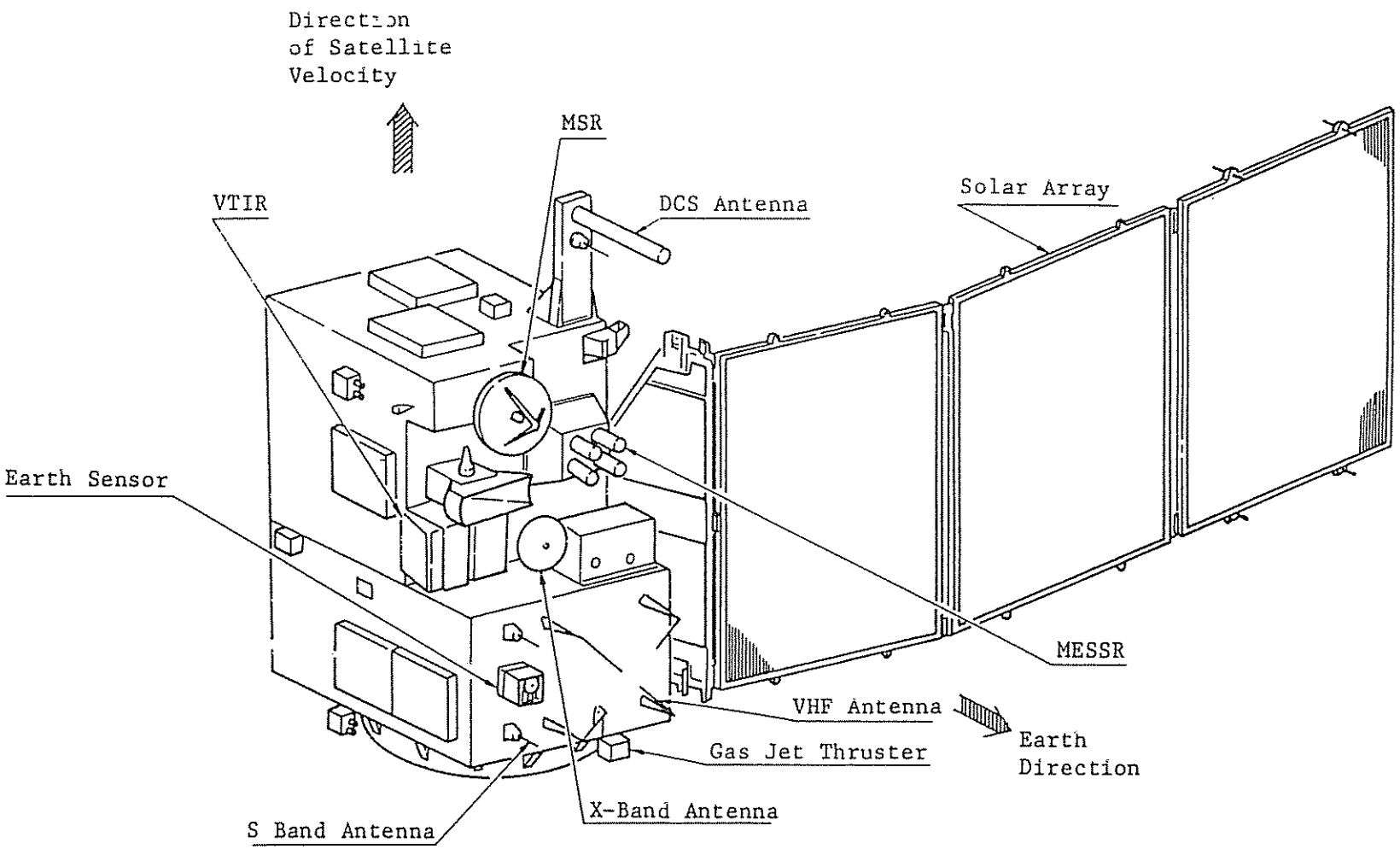
The Science and Technology Agency also conducted preliminary studies for a Land Observation Satellite (LOS) with a sensor complement designed primarily for land-use classification and vegetation analysis. Simultaneously, the Ministry of International Trade and Industry prepared a separate study for a Mineral and Energy Resources Exploration Satellite (MERES) with a sensor payload optimized for geological exploration. At the direction of the National Space Development Agency (NASDA), these two concepts have now been combined into a single Earth Resources Satellite (ERS-1), unfortunately the same designation employed by ESA. ERS-1 will carry a linear-array stereo camera with a 30-m IFOV in four spectral bands between 0.51 and 1.10 μm and an L-band synthetic aperture radar providing 25-m ground resolution for a 75-km swath. The probable launch date will be 1989-1990.

EARTH OBSERVATION SATELLITES IN CHINA

China has launched several satellites with Earth observation payloads. Chinasat-1, in July 1975, was in an orbit of 185 x 464 km with 69° inclination; and its payload was identified as "remote sensing". Chinasat-3, launched November 1975, had an orbit of 173 x 484 km at 63° inclination, with a "recoverable photocapsule" as payload. Chinasat-7 launched December 1967 into a 167 x 489-km, 59° orbit, had a "recovered photographic spacecraft" payload. No images from these missions have been made available to the international community.

Future announced Earth observation missions, include Chinasat-10, planned for 1983 to carry a two-channel, visible and infra-red bands, meteorological radiometer. Chinasat-11 will be a meteorological satellite in geostationary orbit. Chinasat-12, proposed for a 700-km polar orbit in 1985, will carry an 80-m IFOV Earth resources data transmission sensor. In November 1981, China announced that it is proceeding with the development of its own 11-band multispectral scanner, linear array sensor and synthetic aperture radar.

Figure 117. International Society for Photogrammetry and Remote Sensing: equipment for Japanese Marine Observation Satellite, MOS-1



Note: The Japanese Marine Observation Satellite (MOS-1) will carry sensors specifically designed to measure ocean surface parameters useful for fishing and navigation.

A spacecraft launched in September 1982 into a 383 x 172-km altitude, 63°-inclination orbit was described as a "reconnaissance satellite", but no information was given about the payload. It was recovered after five days in orbit.

China has contracted to install a LANDSAT-4 data-receiving station near Beijing and expects to be receiving and processing data by late 1983. This station may also be configured to receive data from the French SPOT.

OTHER PROPOSED NATIONAL SYSTEMS

The Indian Space Research Organization (ISRO) developed an Earth observation spacecraft, Bhaskara, which was launched by the USSR in June 1979 into a 550-km altitude, 51°-inclination orbit. It carried two television cameras providing 1-km resolution in two spectral bands for land observation and a two-frequency microwave radiometer for ocean survey. An identical spacecraft, Bhaskara-2, was launched by the USSR into the same orbit in November 1981. ISRO has also announced its intention to develop a second-generation Indian Resources Satellite (IRS-1) which would carry a three-spectral-band sensor with IFOV variable from 15 to 80 m and swath variable from 40 to 180 km.

The Netherlands Agency for Aerospace Programmes (NIRV) has initiated a study of a Tropical Earth Resources Satellite (TERS), which would carry a Netherlands-built multispectral linear array sensor in orbit. The sensor would have three spectral bands in the visible and near infra-red wavelengths, with a resolution of 20 m and a swath of 100 km. A forward-looking cloud sensor is planned to provide information for directing the primary sensor to look left or right of the ground track by means of a rotating mirror. The project is being planned in co-operation with Indonesia where the ground data reception station will probably be located.

The Canada Centre for Remote Sensing (CCRS) has undertaken a study to define a radar system for monitoring ice conditions in the polar seas. The proposed parameters are for C-band with incidence angle from 20° to 50°, resolution from 25 to 30 m and 175-km swath. The proposed altitude is 1,000 km at 99.5° inclination. An independent spacecraft launched about 1990 by Ariane or Shuttle is foreseen. The eventual programme might entail two or three satellites in orbit simultaneously to provide the necessary coverage for adequate monitoring of the arctic seas and coastlines.

The Space Research Institute (INPE) in Brazil has published its intention to develop a national remote-sensing satellite, which might be launched after 1985 or 1986. The sensors would include a multispectral linear array and a high-resolution panchromatic camera, but no details have been released.

SUMMARY AND CONCLUSION

It is useful to summarize the status of the various spacecraft and national programmes; this is done in table 45.

Table 45. Summary of Earth resources satellites as of January 1983

Country or agency	Concept	Design	Build	Operating
United States of America	MAPSAT Space station	MLA	LANDSAT-D Prime LFC/MPESS OSTA-3 SIR-B + LFC	LANDSAT-3 LANDSAT-4
USSR	..	..	Space station	Meteor Salyut-7 Cosmos series
France	..	SPOT-3 SPOT-4	SPOT-1 SPOT-2	..
European Space Agency	AERS Spacelab-D	ERS-1	SPAS-01/MOMS Spacelab-1 MC + MRSE	..
Japan	ERS-1	MOS-1	..	..
China	..	Chinasat 11 Chinasat 12	Chinasat 10	.. ..
Canada	..	Radarsat	..	..
India	IRS-1	..	..	Bhaskara 2
Netherlands	TERS	..	..	..

Note: AERS = Advanced Earth Resources Satellite; ERS = Earth Resources Satellite; IRS = Indian Resources Satellite; LFC = large-format camera; MC = metric camera; MLA = multispectral linear array; MOMS = modular opto-electronic multispectral scanner; MOS = Marine Observation Satellite; MPESS = multi-purpose experiment support structure; MRSE = microwave remote-sensing experiment; OSTA = Office of Space and Terrestrial Applications; SIR = Shuttle imaging radar; SPAS = Shuttle Pallet Satellite; SPOT = Système probatoire d'observation de la Terre; TERS = Tropical Earth Resources Satellite.

It is evident that there is a great deal of near duplication in the various proposals for future Earth observation satellites. Minor differences in orbit parameters, number and limits of spectral bands, resolution and swath widths result from the perceptions of research scientists and engineers in the various agencies; and different priorities are assigned to the use of space sensors for agriculture, mineral and energy exploration, environmental monitoring and marine sciences. However, it is inordinately expensive to build and operate space systems, and equally if not more expensive to process, disseminate and apply the data that can be acquired. Scientists and managers from all countries involved in space activities realize that satellites are inherently international in operation. Compatibility and complementarity of space and ground systems constituted a major discussion topic at the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space, which was held at Vienna, Austria, 1n 1982.

Remote sensing from space is probably the most important source of information required for solving global resource management problems. Developing the technical, administrative and particularly the political ability to operate competent systems will be the greatest challenge in the next decade.

Notes

1/ The Global Positioning System (GPS) will eventually consist of an array of 18 separate satellites arranged in six different orbital planes at 20,200-km altitude. By real time processing of the signals from the system, it will be possible to determine the position of LANDSAT-4 with a precision of about 15 m in all three co-ordinates. GPS should be fully operational in 1988.

2/ The Tracking and Data Relay Satellite System (TDRSS) will consist of two communications satellites in geostationary orbits at 41° and 171° West longitude and a single ground station at White Sands, New Mexico. Commands from the ground and data from manned and unmanned spacecraft in low Earth orbit will be transmitted via TDRSS, thus eliminating the need for the current Spacecraft Tracking and Data Network of the National Aeronautic and Space Administration. TDRSS should be operational by autumn 1983.

3/ A complete description of the experiments and their results is given in Science, vol. 218 (3 December 1982), pp. 993-1033.

(d) Automated cartography, computer mapping and digital terrain models

USE OF COMPUTERS TO PREPARE URBAN SOCIAL ATLASES*

Paper submitted by Australia

RESUME

La Division de cartographie a établi un atlas composé de cartes chorographiques établies par ordinateur présentant des données statistiques sur la population et le logement dans les principales zones urbanisées de l'Australie. Les résultats du recensement ont été classés à l'aide de graphiques de fréquence établis par ordinateur et les données ont été rectifiées pour éliminer toute distortion due aux zones non résidentielles. La sélection des thèmes cartographiques a été effectuée par traçage automatisé. Une version à jour et révisée de l'atlas est proposée.

The Division of National Mapping began urban social mapping with computer assistance in the late 1970s, and in 1981 it completed the seven-volume Atlas of Population and Housing, 1967 Census. The Atlas, which was produced in association with the Australian Bureau of Statistics, presents in 20-30 maps for each of the 11 major urban areas of Australia (cities of more than 100,000 inhabitants) information selected from the particularly wide range of demographic, economic and social statistics collected in the quinquennial census of 1976. The maps range in scale from 1:100,000 for some smaller cities to 1:180,000 for Melbourne, and nearly all are modified choropleth maps printed in one or two colours.

METHODS

The choropleth maps in the Atlas show classed information by census collection districts, the smallest areas for which census statistics are prepared (typically about 300 dwellings in urban areas). Classing was done by examination of computer-drawn frequency graphs. The computer-drawn boundaries of census collection districts are printed on the maps as thin black lines which supplement the open, grey (screened black) topographic base maps, helping users to locate small areas accurately. The statistical content of the maps is in five or six classes and shown by fine, computer-drawn stipples and hatchings printed in red.

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, appeared as document E/CONF.75/L.2.

These maps are known as modified choropleth maps because areas of non-residential and farm land exceeding about 50 ha are shown in pale, flat grey, without the thematic pattern. Because the proportion of such areas in the major cities ranges from 30 per cent for Melbourne to 50 per cent for Newcastle and Wollongong, the distributional patterns shown by the maps are markedly affected, particularly towards the fringes of the urban areas.

Many of the maps present information in terms of densities, for example, those showing numbers of young and old people or ethnic groups. Hence, a slow and tedious aspect of the preparatory work for each city was the estimation by eye of the percentage of each census collection district to be shown as partially non-residential, in order to weight the density calculations (done by computer using the digitized boundaries) to arrive at net densities. Since that time, a much faster and more precise method has been developed: non-residential and farm-land areas are drawn by hand on large-scale computer-drawn census collection district boundary plots; and the urban residential parts of partially non-residential census collection districts are digitized, thus redefining these districts for density calculations.

Most themes selected for mapping were common to all the major cities, such as distribution of total population, selected age groups, ethnic groups, occupations, income and characteristics of dwellings indicative of living conditions. Some themes, however, were mapped for only one city or a few cities; for example, certain ethnic groups are concentrated in only those cities. In view of the speed with which thematic overlays could be drawn by computer, any doubts as to whether such a theme was worth presenting could be quickly settled.

FUTURE DEVELOPMENTS

Preliminary work has begun on a similar urban social atlas based on the 1981 census. Resources permitting, il should appear sooner after the census than the previous Atlas and should be more widely used. New computer-driven plotting equipment should improve the quality of the finished product and reduce both production time and the amount of drawing materials and photomechanical processing required. Classed values represented by computer-drawn stipples and hatchings will again be used, often to represent net densities. Only minor changes in presentation are likely: a main aim will be to make it easy to compare corresponding maps in the 1976 Atlas, as well as maps of cities as at 1981.

DIGITAL TPOGRAPHIC MAPPING IN THE DIVISION OF NATIONAL MAPPING*

Paper submitted by Australia

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, appeared as document E/CONF.75/L.3.

RESUME

La Division de cartographie convertit progressivement sa production de cartes topographiques au 1:100 000 et au 1:250 000 en passant des techniques graphiques aux techniques numériques automatisées. Ce changement a notamment été motivé par le désir de réduire le coût et la durée de la production et de mettre à la disposition des utilisateurs des données numériques.

Deux systèmes fondés sur les mini-ordinateurs DEC ont été installés. Le matériel de numérisation comprend des traceurs stéréo avec des localisateurs triaxiaux ou des codeurs de position angulaire, de même des numériseurs de tables. La majeure partie de l'édition est effectuée à l'aide d'écrans graphiques interactifs. D'autres installations informatiques et éléments de matériel sont achetés au cours de l'exercice financier 1982-1983.

Le logiciel principal utilisé est une version de l'AUTOMAP de Systemhouse Ldt. (Canada). Un programme d'édition interactif (CARDIT) est également appliqué. La Division continue de développer le logiciel.

Certains programmes de formation du personnel ont été achevés et les travaux ont commencé sur les premières feuilles numériques. La production de cartes numériques augmentera progressivement, la majeure partie des travaux devant être effectuée sous contrat par des sociétés privées de photogrammétrie.

In 1977, the Division of National Mapping (Natmap) decided to convert progressively its manual topographic mapping techniques to computer-assisted digital techniques. The principal objectives are to decrease the cost of the fair-drawing aspects of map production, to reduce overall production time and to make digital map information available to other users.

In 1981, after detailed investigations and acquisition or modification of equipment, Systemhouse Limited (Canada) installed a version of their AUTOMAP software on computer systems in two Natmap offices, at Dandenong and Canberra. These two systems are now operating, with digital capture of required mapping data being undertaken from aerial photography using suitably modified stereoplotting equipment and from existing graphics using table digitizers. Interactive graphics and table digitizer-based editing systems have also been implemented.

HARDWARE

Dandenong system

It is the responsibility of the Dandenong office to supply the Canberra office with digital topographic information suited for the 1:100,000 and 1:250,000 National Topographic Map Series (NTMS).

At present, the Dandenong system (figure 118) uses a DEC PDP 11/40 (248 kilobyte) minicomputer which processes digital information from six digitizing stations. These stations comprise four stereodigitizers--two Wild B8 with tri-axis locators and two Zeiss Jena topocarts with optical shaft encoders--and two Altek table digitizers. Each station is interfaced to the PDP 11/40 through a specialized microprocessor. Two interactive editing stations are also available as part of the system--Tektronics 4010 and 4014 graphics screens. A Calcomp 960 verification plotter (0.88 x 1.52-m format) is used to verify initial data obtained at digitizing stations as well as to check the final edited product for accuracy and completeness before forwarding it to Canberra.

The proposed extension of this system centres on the acquisition of a WAX 750 (2 megabyte) minicomputer, additional table digitizers and graphics screens with programmable memory. This acquisition would cater for a higher level of interactive editing activity.

A voice entry/synthesis device for one of the stereodigitizing stations is under investigation.

Canberra system

The role of the Canberra office in digital topographic map production centres on the digitizing of existing graphics, editing and map derivation.

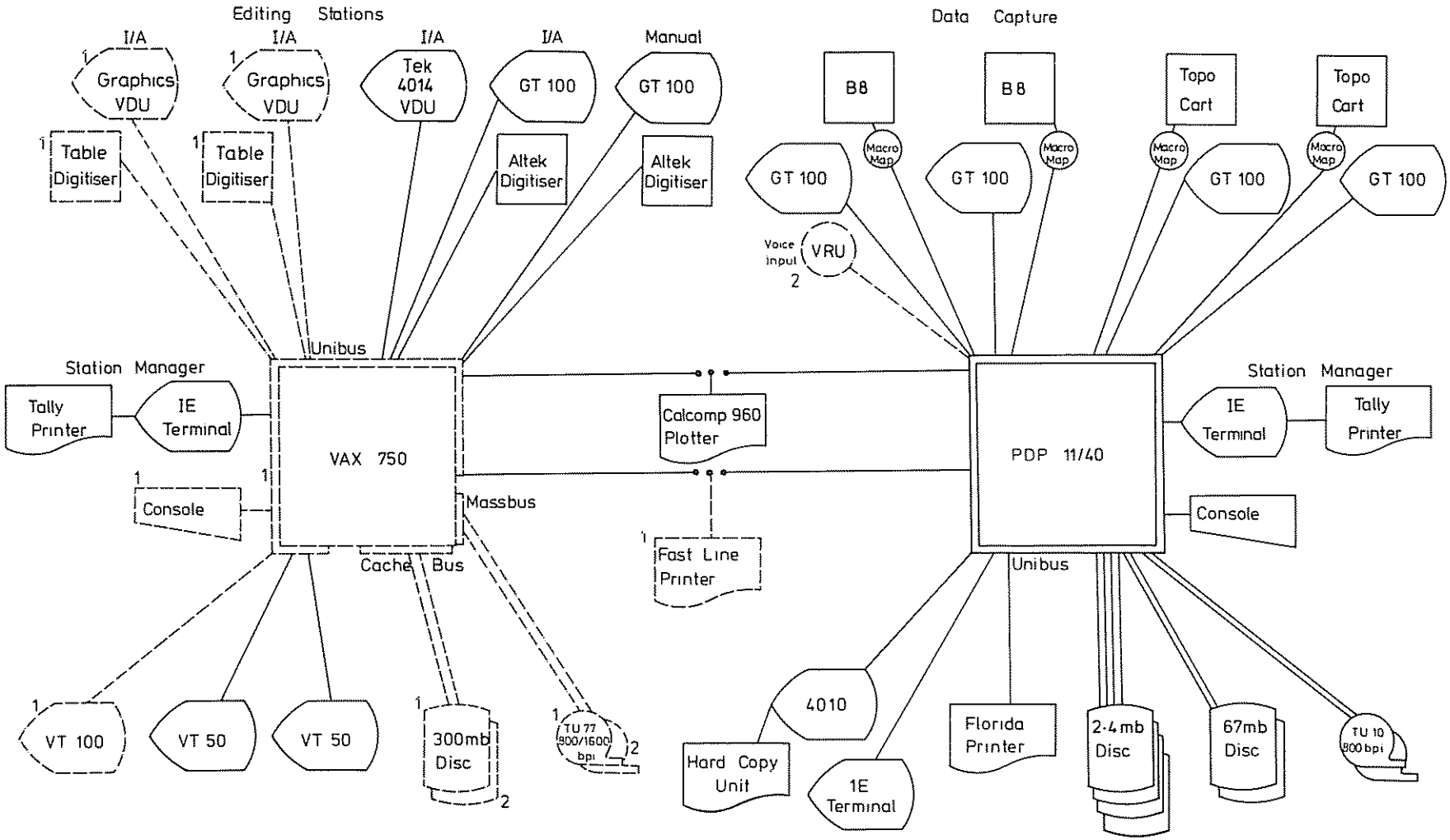
Currently, the Canberra system (figure 119) includes a PDP 11/40 with one AUTOMAP digitizing station (an Altek table). (The two Summa-graphics digitizing tables and other equipment are used for census-boundary digitizing and other thematic mapping work.) The proposed additional digitizing stations and interactive graphics screens will need a more powerful computer, and a PDP 11/70 (500 kilobyte) minicomputer has been purchased and will replace the PDP 11/40 late in 1982.

A Kongsberg GT 5000 flat-bed plotter, together with its own controller, is also part of the Canberra system. It is used to plot digital map information automatically from data stored on specially formatted magnetic tapes, originating in either the Dandenong or the Canberra office. A photo-head is used for the preparation of repromat material, but ink pen, ball-point pen, scriber and cutting tool (for masks) are also available as plotting devices.

MAINTENANCE

Natmap uses contractors for some maintenance, but a large proportion of the equipment repairs and maintenance associated with the Dandenong system is done internally by specially trained and experienced electronics technicians, employed by Natmap. This system has resulted in a significant cost savings despite the need to acquire a stock of suitable spare parts.

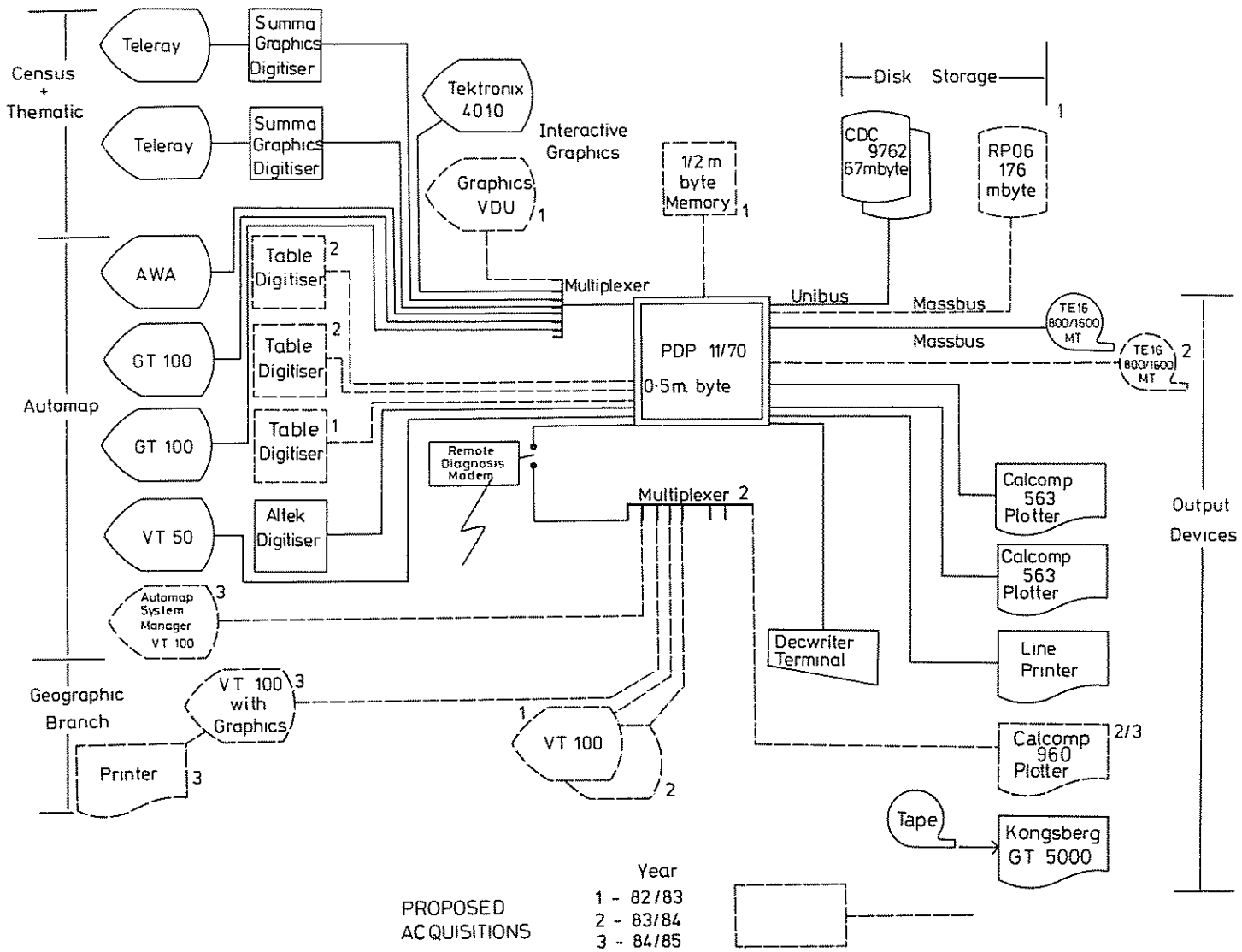
Figure 118. Australia: digital mapping system at Dandenong office of Division of National Mapping



Note: Interfaces are provided so that editing stations, data capture stations and terminals can be transferred from one host to the other.

PROPOSED ACQUISITIONS 1 - 82/83
2 - 83/84

Figure 119. Australia: digital mapping system at Canberra office of Division of National Mapping



SOFTWARE

AUTOMAP

AUTOMAP is a large suite of programs used to control the collection and editing of data acquired by the digital mapping systems. Particular tasks covered are: creation of digital files; assignment of files to digitizing stations; setting of digital-capture parameters; transformation of digital data into appropriate units; use of various commands to digitize or edit features; alteration of the way a feature may be represented or symbolized; setting up of verification plots of digital data and Kongsberg plot tapes.

CARDIT

CARDIT, obtained from the Department of Lands, South Australia, permits AUTOMAP data files to be viewed wholly, or in part, on a graphics screen for verification or editing purposes. In particular, it permits photogrammetric models or map data to be more accurately joined, since an individual feature, or a group of features, can be viewed at enlarged scales. Individual points on a feature can be identified and relocated as necessary.

PROGRAMMING

Further development of AUTOMAP and CARDIT is a continuing task. In general, suggestions for software modifications and developments come from the users of the systems and are carried out by fully qualified computer systems officers working together with surveyors, cartographers and technical staff.

OPERATING PROCEDURES AND TRAINING

Detailed operating procedures and instructions are prepared after system installation. At the Dandenong office, all staff who might become involved in digital mapping were given an introductory course on the use of the system, and detailed training is being integrated with productive work.

CURRENT PRODUCTION

Digital topographic map production at Natmap is still new. Two: 1:250,000 scale map areas--comprising 12 map-sheets at 1:100,000 scale--have been commenced, with both stereodigitizing and line-digitizing data-capture methods being used. Digital map production will gradually increase, with much of the work carried out under contract by private photogrammetric firms.

AUTOMATION IN COMPUTER-ASSISTED CARTOGRAPHY: AUTOMAP 2*

Paper submitted by Australia

RESUME

Au cours des dernières années, le Royal Australian Survey Corps a participé à un certain nombre de réalisations exceptionnelles et impressionnantes dans le domaine de la cartographie automatisée, dans un contexte où la production de cartes est limitée par les ressources disponibles. Parmi ces faits, on mentionnera le matériel et le logiciel conçus pour améliorer l'efficacité du cartographe dans un contexte militaire. Depuis l'introduction du système AUTOMAP 1 en 1976 (cartographie automatisée), le Royal Australian Survey Corps utilise largement l'automatisation pour rationaliser les activités de cartographie. Les techniques perfectionnées qui sont utilisées ont un caractère novateur et passionnant et promettent des défis tout aussi importants au cours des prochaines années.

Le présent document décrit ces faits nouveaux et contient une évaluation préliminaire de leurs incidences sur l'établissement de cartes et la production de données liées à la cartographie dans le cadre du Royal Australian Survey Corps, à l'aide de critères concernant le débit. Dans le cadre d'un bref aperçu du système AUTOMAP, on décrit le programme d'application prévu en trois étapes qui permettra à tous les services du Royal Australian Survey Corps d'utiliser largement les techniques numériques.

TOTAL AUTOMAP SYSTEM CONCEPT

AUTOMAP is a digital cartographic facility designed to replace some of the labour-intensive activities in mapping and so increase map production in the Royal Australian Survey Corps within existing manning levels. The total AUTOMAP project is being implemented in three phases:

(a) Phase 1. AUTOMAP 1 was designed in-house and a contract for its implementation was awarded to Systemhouse, a Canadian firm; it entered service at the Army Survey Regiment, Bendigo, in 1976. It consists of the following subsystems:

(i) An input subsystem for digital data acquisition and editing via stereoplotters and table digitizers;

(ii) A plot verification subsystem for quick, relatively accurate, verification plot production;

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* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.16.

(iii) An optical line-following subsystem for digitizing existing analogue map data with a computer-assisted technique;

(iv) A general-purpose subsystem to handle the bulk of the data manipulation and reformatting tasks and for software development;

(v) An output subsystem for very accurate output plotting by ink, scribe or photo exposure;

Each subsystem is capable of stand-alone operation, and all are based on 16-bit Hewlett Packard minicomputers. This system has been in production for six years and has produced a steady stream of digital map data;

(b) Phase 2. AUTOMAP 2, the second phase of the project, is currently being developed under contract with Intergraph Corporation Pty Ltd. and is due to be in service in mid-1983. This phase will provide the Army Survey Regiment with a second digital system, being similar in nature to the AUTOMAP 1 system but consisting of state-of-the-art technology. Interactive graphics will be employed for all manual digitizing and editing procedures, and raster scanning and plotting techniques will be introduced. The AUTOMAP 2 system will be based on Digital Equipment Corporation, VAX, 32-bit minicomputers and will consist of the following subsystems:

(i) An input subsystem for digital data acquisition and editing with stereoplotters and table digitizers. Each input station will include interactive graphics facilities;

(ii) A plot verification subsystem as for AUTOMAP 1 but able to run "on-line" from any subsystem;

(iii) A graphical editing subsystem for interactive data-base editing and preparation of files for final cartographic output;

(iv) A raster scanning subsystem for high-speed digital capture of existing maps and plotting of raster data;

(c) AUTOMAP 3. The final planned stage of the AUTOMAP project will follow AUTOMAP 2. The stereoplotting facilities of the Royal Australian Survey Corps, to be found in each of the four Field Survey Squadrons and the School of Military Survey, will be incorporated into the AUTOMAP system. Each unit will be equipped with an input subsystem and plot verification subsystem as described in AUTOMAP 2.

AUTOMAP 2

As mentionned earlier, the AUTOMAP facility was planned to be introduced in phases. AUTOMAP 1 has provided the Army with manual and computer-assisted digitizing, editing and output facilities which have increased production capacity and allowed the build-up of technical and production management expertise in a computer environment. AUTOMAP 2 will provide additional digitizing and interactive editing facilities to realize the full potential of the AUTOMAP concept. The following sections provide a brief description of the AUTOMAP 2 system components.

Input subsystem

The stand-alone input subsystem is designed to collect, store and permit changes to three dimensional co-ordinate data from eight stereoplotter stations. Two graphical editing work-stations will be employed to edit that data for inclusion in a digital data bank. Also included will be a system manager station to control and monitor all aspects of the system. Figure 120 is a configuration diagram of the input subsystem. More detailed descriptions of the components of the input subsystem are described below.

Stereoplotter station

Currently, Wild B8 stereoplotters, fitted with tri-axis locators, rotary encoders and air-bearing, are active components of the AUTOMAP 1 system. It is believed that an improved digital product is possible with more interactive operation, including the latest technology hardware to replace the alphanumerical terminal and keyboard now in use with AUTOMAP 1.

Voice recognition and response, plus a small command keyboard on the tracing-stand, are being designed to permit command entry and verification without requiring the operator to look away from the stereo model. A foot switch is being added to enable the operator to change digitizing modes rapidly.

Another enhancement will be the addition of a monochrome raster display device in place of the alphanumerical terminal. It will provide a graphical display of data as it is digitized, thus improving the operators data verification facilities, previously provided in analogue form.

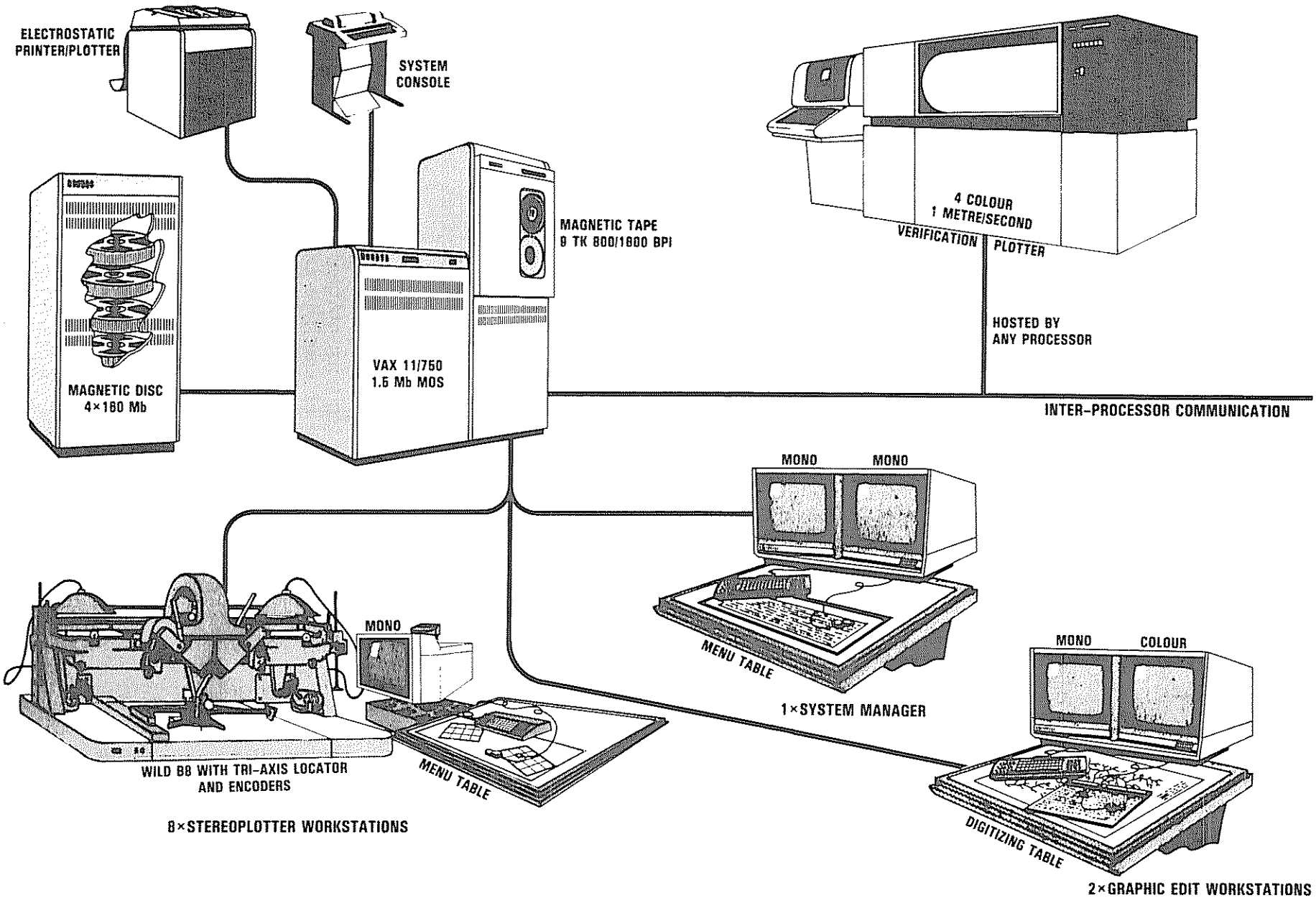
Lastly, a second monochrome raster graphics tube will be slaved from the first and will display the digitized data by optical superimposition, over the left picture image. Thus, the operator will get graphical feeback without looking away from the model. In this way, completeness and accuracy of digital data can be verified against the original analogue model during data capture. Verification text can also be displayed within the operator's field of view. The designed throughput of these eight stereoplotter stations (in combination) is two stereo models per eight-hour shift.

Graphical editing work-stations

Each of the two graphical editing work-stations will include two interactive raster graphics displays, one of which is in colour, and a high-precision table digitizer with floating command menu. The graphics displays will have the ability to display symbols, such as the Australian map and chart series symbols, lines of various weights and symbolology, area infills and alphanumerics with various founts at a resolution of 1,024 by 1,280 pixels on the 19-inch diagonal screens.

Highlights of the table-digitizer component include efficient command and data entry facilities that allow the interactive display and editing of all files on the system. In addition, rapid interaction between source graphics on the digitizing table, data displayed on graphics screens and the command and data entry system will be provided.

Figure 120. Australia: input and plot verification subsystems for AUTOMAP 2, Royal Australian Survey Corps



These stations will be employed to edit stereoplotter files that have been merged and clipped to form 1:25,000 standard map areas, which will then form the basis of the digital data bank. The ability to form all scale map compilations from the data bank is inherent but compilation on this subsystem will normally be limited to 1:25,000 and 1:50,000 scale products. The designed throughput of these two graphical editing work-stations (in combination) is one map compilation per two eight-hour shifts.

System manager station

This station will provide the system manager with a graphical display of digital data collected at any stereoplotter station and, if required, a fast hard-copy of that display. Additionally, the system manger will have control of files, work allocation, system status and operator records, and the quality assurance of key photogrammetric operations.

Plot verification subsystem

The plot verification subsystem will consist of a fast, accurate drum plotter which can be switched on-line to any of the three computers controlling each of the input, graphical editing and raster scanning subsystems.

The system will be used to produce four-colour, full-scale plots on paper or drafting film by wet ink or ball-point pen or to produce scribed output. Requests for plots will be accepted from any terminal on the network and a local visual display unit will be used to control the plotting operation.

Besides the full-scale vector plotting capability, each graphics screen in the system will be able to obtain a real-time hard copy of the raster displays on electrostatic plotters.

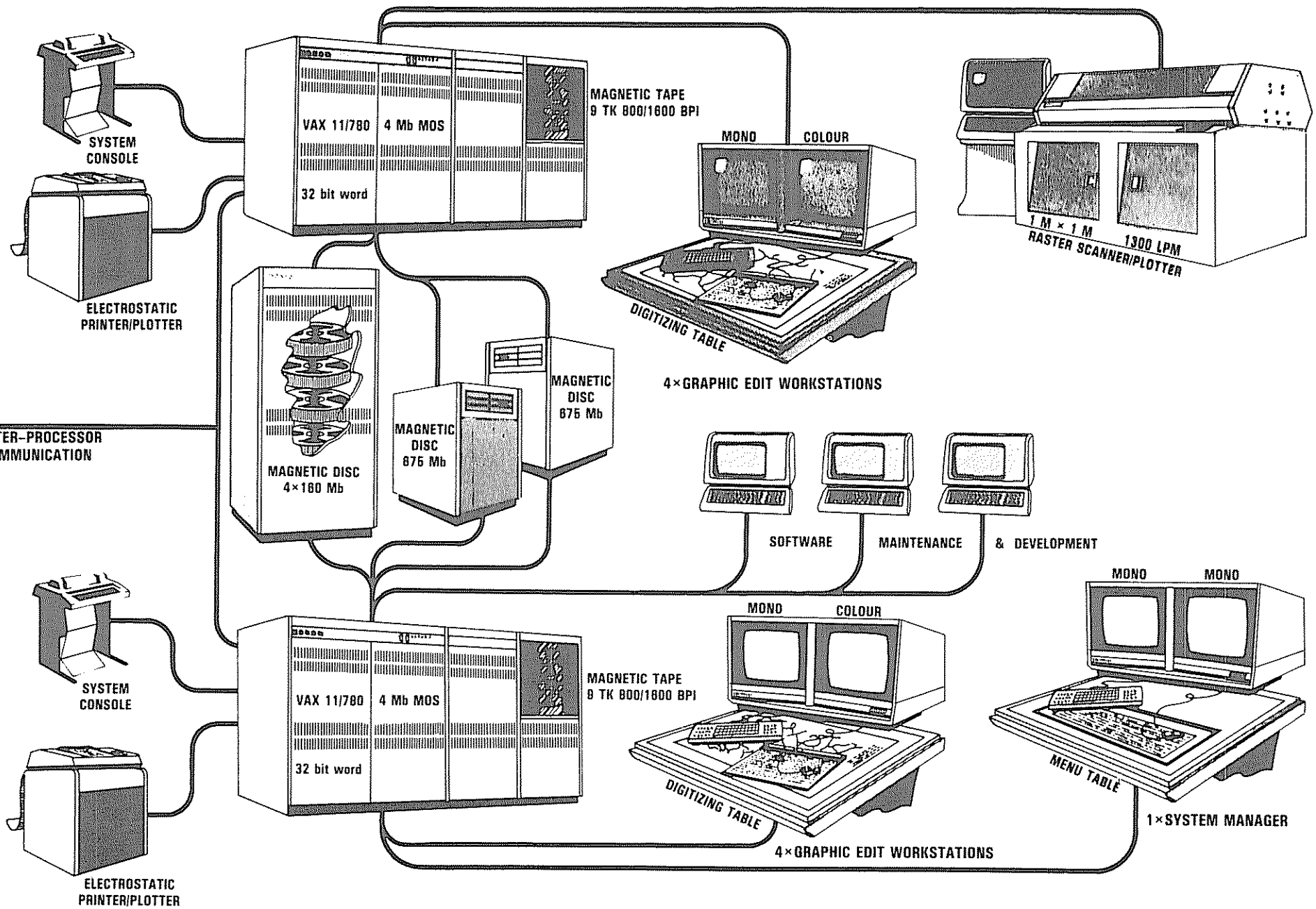
Graphical editing subsystem

The graphical editing subsystem, a stand-alone system, will be employed to create map compilations at standard mapping scales, the information being derived from the source data produced in the input subsystem and from existing maps through the raster scanning subsystem. The process will entail the efficient handling of text as well as the cultural, relief, drainage and vegetation features to be found on topographic maps.

Four graphical editing work-stations and one system manager station, identical in all respects to those of the input subsystem, will be included. This subsystem is designed to edit and compile two standard map compilations each working day.

The configuration of the graphical editing subsystem is shown diagrammatically in figure 121.

Figure 121. Australia: graphical editing and raster scanning subsystems for AUTOMAP 2, Royal Australian Survey Corps



Raster scanning subsystem

The stand-alone raster scanning subsystem is designed to scan and vectorize coloured maps and charts, colour-separated maps and chart reproduction material, and pencil and ink drawings. The raster data will be converted to vector format and feature coded so as to be compatible with all other AUTOMAP subsystems. It is designed to be capable of scanning and vectorizing a complet map-sheet of four separations in four hours.

The equipment will be capable of scanning or plotting documents up to a 100 x 100-cm format at various resolutions down to 0.025 mm. The scanning operation will be capable of discriminating by colour and line or point size down to 0.05 mm.

The raster-to-vector conversion process will be able to discriminate various line weights and use these to perform automatic labelling of data files, for example, index contours of a relief file. Il will be able to smooth or suppress unintelligible data from an imperfect data set and to produce vector output accurate to one-half line-width of the original.

Four graphical editing stations, identical to those of the input and graphical editing subsystems, will be employed to edit the vectorized data and to tag all features with relevant feature attributes. They are designed to handle two maps each working day.

SYSTEM COMMUNICATION

The two computers controlling the graphical editing and raster scanning subsystems will be identical in all respects, and each of their work-stations will be capable of on-line operation from either central processing unit (CPU). In addition, on-line storage will be accessible by both CPUs, thus providing a hardware back-up to CPU failure and the work-station configuration to be changed to meet production requirements.

The input subsystem computer will be software-compatible and hardware-upgradable to the previous computers. An interprocessor link will allow commucation and data transfer between each CPU. Input to and output from the AUTOMAP 2 system will be through magnetic tape recorded at 800 or 1,600 bytes per inch.

CONCLUSIONS

AUTOMAP 2 will give the Royal Australian Survey Corps greater digital cartographic production capacity through the introduction of state-of-the art technologies.

An enhanced stereoplotting station employing graphical superimposition and ergonomic improvements will provide a more efficient operation and is expected to improve significantly the quality and quantity of the digital data captured. The amount of away-from-source editing will be limited to product or area consideration rather than individual model corrections.

The introduction of interactive raster graphics, both monochrome and colour, along with a more efficient command-entry facility, will significantly improve the map compilation task. The ability to display and edit standard mapping symbolology and text will permit the full flexibility of the digital map-making technique to be used to eliminate many manpower-intensive procedures. As the system develops, the capability of producing line, screened and stipple map detail on one pass of the raster plotter will generate considerable film and photo-technician savings.

Raster scanning technology will provide the Royal Australian Survey Corps with a means to digitize, more quickly, the map compilations prepared by manual methods in years past.

The digital data bank of topographic information, necessary for rapid response mapping, efficient revision procedures and numerous non-mapping applications in resource and defence areas is becoming a reality.

ANALYTICAL HILL SHADING*

Paper submitted by Australia

RESUME

Le Royal Australian Survey Corps a mis au point une technique permettant d'établir des modelés à l'aide de données numériques sur l'altitude sous forme de vecteurs. Suivant cette technique, on extrait d'AUTOMAP les données concernant le relief, on produit un DTM, on calcule la valeur des éléments d'image et on établit le modelé en utilisant un enregistreur opto-électronique couleur. Le résultat est traité en simili suivant les techniques classiques avant l'impression.

The Royal Australian Survey Corps, with the assistance of the Division of Computing Research (DCR) of the Commonwealth Scientific Industrial Research Organisation (CSIRO) and the Aeronautical Research Laboratories (ARL), has been developing a procedure for producing a hill-shading component for topographic maps from digital elevation data in vector format. The procedure is still a research and development project, but a small image has been generated as a component of a recently published product and it is expected that the method will be developed to the stage of a regular production tool in the near future.

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* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.17.

BACKGROUND

For many years, the Royal Australian Survey Corps has used hill shading to enhance the relief on certain of its products. Originally, the shading was created manually using pencil-shading and airbrush techniques. This procedure was time-consuming and subjective, and it depended largely upon the artistic ability of the technician for its effectiveness.

In an attempt to simplify the task and introduce consistency of result, the technique of terrain embossing was developed and is the current production procedure. In this method, a model of the terrain is prepared by moulding a thin sheet of vinyl plastic (e.g., AK polygraphy), using hand tools such as those used in clay-modelling or leather work. A simple height gauge is used to monitor relative model heights during production. The finished model is photographed, with careful attention being paid to the arrangement of light sources, and the result is then screened to produce a half-tone image.

Terrain embossing has made it possible to obtain consistent results with a minimum of training. However, when AUTOMAP was implemented and a digital data base began to develop, the possibility of generating hill shading directly from the digital relief data became apparent. Although development was initiated as early as 1975 and some experimental images were produced, no real progress was made towards creating a practical package until 1980, when software was made available by ARL. ARL had been using AUTOMAP relief data to generate digital terrain models (DTM) for use in the development of navigation systems. One by-product of this research was a suite of programmes used to display a shaded image of DTMs on a television monitor. This package was extensively modified and rewritten by the Survey Corps to suit computers available to it, to output the image on a different device and to use Australian map grid (AMG) co-ordinates rather than geographical co-ordinates. These developments were completed in December 1981.

PROCEDURE

The procedure developed can be described in five stages: (a) preparation of input data; (b) production of DTM; (c) calculation of pixel values; (d) generation of the image; and (e) preparation of the reproduction material.

Preparation of input data

The AUTOMAP relief data include contours in vector format as well as spot heights. These data are extracted from the relief file and divided into sub-areas of a size suited for processing and manipulation.

Production of digital terrain model

The digital terrain model is generated on the DCR Cyber 76 through the CSIRONET connection to the Army Survey Regiment PDP 11/70. During this phase, the contour vector data are converted to a gridded network of terrain in elevations at 100-m intervals using a complex interpolation algorithm. Each of the

sub-areas processed represents a 10-km square and hence they are resolved into 10,000 terrain elevation values. This stage is the most costly of the entire procedure. In a test involving the YAMPI (SE 51-3) joint operation graphic, DTM production took 14 hours (elapsed time) and cost $500 in computing time; this represents 40 per cent of the total time expended and 80 per cent of total material costs incurred in producing the hill-shading reproduction material. At the conclusion of processing, the sub-areas are merged to create a single DTM.

Calculation of pixel values

From the terrain elevation values computed, a reflected-light value is calculated for each pixel and this is used to determine a grey scale value in the range from 0 to 255. A number of algorithms have been tested for this phase and evaluation is continuing.

Generation of image

Image generation is performed by the DCR staff. The image is generated on an Optronics Colorwrite C-4300 film recorder situated in the DCR Image Processing Laboratory. Prior to projection, the image is inspected on a COMTAL 8400 display system. Each pixel of the sub-area is exposed as 0.1-mm dot and so the scale of the resulting image is 1:1,000,000. It is produced on 25 x 25-cm monochrome film.

Preparation of reproduction material

The output from the Colorwrite is further processed by the Lithographic Squadron of the Army Survey Regiment. Each sub-area is enlarged to the required reproduction scale; a block-out is applied to ensure that no imagery shall occur in sea or lake areas; and the whole is screened to produce a half-tone image. Photographic processes can be applied to modify the image but the intention is to minimize the need for such modifications.

Results achieved

A number of experimental products have been produced but the most recent test was used to produce the recently published Christmas Island (SC 48-11) joint operation graphic. The results achieved were quite pleasing. Some stepping is apparent along diagonal image edges and it is intended to investigate this problem further; however, the hill shading is soft detail and the effect is not highly visible. Earlier tests included the generation of hill shading for a proof of the YAMPI (SE 51-3) joint operation graphic by both analytical means and terrain embossing. While the manual method was inexpensive in terms of material costs, the embossing stage required 25 man-hours out of a total of 41 hours for the complete task. In the analytical procedure, computing costs were high, but although the time required for processing was 32 hours (out of a total of 35 hours), the operator was not exclusively committed to this task and so it does not represent actual man-hours expanded.

FUTURE DEVELOPMENT

Future developments will be directed towards:

(a) Minimizing the stepping effect along image edges at reproduction scale;

(b) Reducing computing costs for DTM production;

(c) Evaluating the best algorithm for calculating reflectance and assigning grey scale values; and

(d) Improving the user interference so that it can be implemented as a production tool.

CONCLUSION

The availability of AUTOMAP digital elevation data has allowed hill-shading imagery to be produced consistently and with a minimum of skilled, technical involvement. It is expected that the technique will be advanced from the status of a research project to that of a production tool in the near future.

A SYSTEM FOR COMPUTER ASSISTANCE IN LARGE-SCALE MAP PRODUCTION*

Paper submitted by Australia

RESUME

On utilise les ordinateurs pour la saisie de données photogrammétriques, la vérification des données, l'ensemble des opérations d'élaboration et de rédaction cartographiques et la représentation graphique des séries de cartes topographiques et cadastrales au 1:10 000 de l'Etat d'Australie-Méridionale. On élargit à l'heure actuelle les utilisations de ce système de cartographie automatisée et l'on s'attend à une baisse du prix de revient.

DESCRIPTION OF THE COMPUTER-ASSISTED MAPPING SYSTEM

Computer-assisted mapping techniques are now used in the State of South Australia in the production of the large-scale (1:10,000) topographic/cadastral

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* The original text of this paper, prepared by the Survey and Mapping Division of the Department of Lands, South Australia, appeared as document E/CONF.75/L.33.

series. Four separate but interrelated subsystems make up the total system for computer assistance in map production in the state.

Photogrammetric data acquisition

Photogrammetric data acquisition of contours, drainage and some cultural detail is carried out by means of three Wild A10 stereoplotters, each interfaced to a separate Data General Nova 1220 minicomputer, with a Tektronix 4014 graphics display screen providing interactive editing facilities. The data are first written on discs. Data acquisition can also be carried out on the Zeiss C100 planicomp analytical stereoplotter. No hard-copy graphical output is prepared on the stereoplotters. All of the software for this subsystem was developed in-house. It is written in FORTRAN and is known as DIGMAP.

Data verification

Verification of the digitally acquired data is provided by a fast edit plot prepared on a Zeta 3620-C53 plotter controlled by a shared computer, a recently acquired data General MV8000. A second edit plot is prepared after the data are cartographically edited.

Cartographic editing

The photogrammetrically acquired data are cartographically edited by one of three editing systems, each consisting of a Data General minicomputer with a Tektronix 4014 graphics display screen and a GTCO digitizing tablet. The editing consists of joining to adjacent sheets; and amending, deleting, moving and joining features as required. Most of this is done on the Tektronix screen. All of the software for this subsystem was developed in-house. It is written in FORTRAN ans is known as CARDIT.

Graphical output

The digital data are output in positive transparency form by means of a Gerber 4432 cartographic plotting system equipped with a light projection head. The transparencies are used for the preparation of printing-plates or composite transparency, as required.

OTHER APPLICATIONS

Various components of the computer-assisted mapping system are also utilized from time to time to meet an increasing demand for the digital map data required for special projects. Development ot the system is also continuing in order to provide for its extension to large-scale (1:2,500 and 1:1,000) cadastral mapping and to the placement of map text.

Experience to date indicates that no cost savings are achieved in base map production through the use of digital techniques, but significant savings are expected in subsequent use of data, including the production of derived and revised maps.

AUTOMATED CARTOGRAPHY, COMPUTER MAPPING AND DIGITAL TERRAIN MODELS*

Paper submitted by Australia

RESUME

Le Bureau de cartographie utilise les techniques de cartographie automatisée depuis 1975 afin de contribuer à la production de divers plans. Plus récemment, les organismes spécialisés ont commencé à fournir les données numériques que les utilisateurs demandaient, élargissant ainsi le champ d'application des techniques automatisées.

L'évolution des techniques automatisées dans le cadre du Bureau de cartographie est décrite compte tenu du développement général des techniques informatiques. Plusieurs projets ont été identifiés, touchant en particulier la numérisation des délimitations cadastrales, la création d'une banque de données permettant de fournir des services par des enregistreurs de données sur le terrain et l'utilisation de modelés de relief numériques pour les études techniques.

The impact of computer graphics technology in the field of cartography has, in general, been less dramatic than in other traditional draughting-based industries. During the 1970s, computer graphics had significant effects in computer-aided design and manufacture (CAD/CAM), particularly in the electronics industry. It was during the mid 1970s that computer graphics were introduced into cartography. The main reasons for this were the availability of digital plotters and minicomputers at affordable costs and the availability of the high-resolution direct-view storage tube graphics screen. Of particular importance also was the availability of reliable real-time, multi-user operating systems for the minicomputer.

Implementation of computer mapping in the Australian Survey Office has reflected these developments in technology. In 1975, a digital plotter was put into production and plot files were generated on a small minicomputer with a single-queue batch operating system. Computer software was obtained to reduce the manual drafting load on the more laborious and repetitive areas of drafting:

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* The original text of this paper, prepared by The Australian Survey Office, Department of Administrative Services, appeared as document E/CONF.75/L.35.

(a) Contour string formation from regular or irregualr spot heights;

(b) Grids, graticules and title blocks;

(c) Base sheets for photogrammetric plotters;

(d) Engineering longitudinal and cross sections;

(e) Plotting of points of cultural detail as an aid to the drafting of large-scale engineering drawings.

In 1978, a minicomputer with a real-time operating system was obtained; and interactive systems were added, including a digitizing system, interfaced to a digitizing table and two stereoplotters. During 1981, additional computer resources, together with digitizing and plotting facilities, were put into production to support the growing demand for computer mapping.

Since these "blind" computer mapping systems fall short of producing a fully completed drawing, a single-station interactive graphics system is to be purchased in late 1982.

INPUT TO COMPUTER MAPPING SYSTEMS

Survey Office tasks cover a broad range of surveying and mapping activities, which is reflected in the types of data input to existing computer mapping systems: (a) survey field observations; (b) digitized data; (c) mathematical models; and (d) contract-supplied digital data.

Conventional survey field observations have consisted of level or stadia data observed for the automatic production of engineering sections and contour and detail plans. More recently, marine data have been observed for the control and production of plans in the Great Barrier Reef and other coastal waters. The problem with data of this type is the amount of data preparation needed to enter the data into the computer systems. This problem is avoided with automatic data-recording devices, and recently two total station instruments were put into production. Tu support the existing survey instruments, one hand-held data recorder was obtained for evaluation and several more are to be purchased.

Digitized data are obtained from existing plans on digitizing tables and from aerial and terrestrial photography on stereoplotters. The digitizing tables have been used for the production of cadastral and services (work-as-executed) plans as well as samller projects. One such small project was the Canberra road network, plotted in two 1:25,000 sheets showing 17 different road classifications by the use of different colours and line styles. The latter project was requested to form a basis for co-ordination of the annual maintenance cycle of roads in Canberra. The stereoplotters have been used to capture spot heights and digital elevation models (DEMs) as input to automatic contouring and sectioning software. As yet, full map-sheet production by digital means has not been attempted because an efficient editing system has not been available. In addition to producing plans, the digitizing system has been found to be a surprisingly versatile tool for ad hoc applications, including boundary/shoreline plots and length/perimeter calculations, areas and volumes, and photo-montaging. A recent project used terrestrial

photogrammetry to determine the changes in volume and shape of termite mounds in central Queensland.

A mathematical model of the cadastre at Canberra is being computed. The data base is 35 per cent complete, and there is access by both a plotting system and a digital data reporting system to supply client departments with their special plot requirements and any changes in the condition of parcels. The plotting system produces up to 15 different types of plots from the data base. While this system benefits from the speed of digital plotting, the creation of the data base itself is not interactive and could benefit in the future by the use of an interactive graphics system, provided the system supports the storage and computation of co-ordinates to sufficient precision and sufficient interactive response.

Digital data supplied by contractors have been in the form of DEMs and aerial triangulation control points. It is anticipated that, in the future, more digital data will be provided by contract.

In an attempt to minimize the costs of software maintenance and development and to allow users conveniently to combine data sets, a standard file structure has been designed. It prints the storage of both graphical and non-graphical data and can be used in both batch and interactive systems. It has so far been implemented in the stadia- and field-data recorder systems and also in the digitizer system.

DIGITIZATION OF CADASTRAL BOUNDARIES

The capture of cadastral boundaries in digital form from existing manuscripts is very topical in computer mapping because of the importance given by many authorities to knowing the location of boundaries. Because these authorities require the definition of the cadastre to different accuracies and need plans at different scales and with different symbolology, there is a strong argument for a single digital data base of the cadastre from which all requirements for plans and digital data can be met. This ideal has generally not yet been realized in most countries owing to the cost involved.

There two broad approaches to obtaining a digital cadastre. The first is only to capture and store the line-work of the cadastre and thus to form no more than boundary strings. If plots are all that is required, this method is suitable and benefits accrue if different plot scales and symbolology are required by different users. Also, plots at the scale of digitizing and larger are acceptable (i.e., no miscloses in joins) if, during digitizing, a lock-on facility is used to join to existing points and lines. This is the simplest and fastest method of capturing cadastral boundaries and avoids the overplotting problem. The clear disadvantage is that the land parcel is never an entity in the data file, and reference to a particular land parcel is not possible except by its position.

The second approach to the digital cadastre is to capture and store the boundaries of each land parcel and to form an aerial structure. The most accepted data structure is to define the land parcel by pointers to strings, each of which is linked to points. Since each point has a unique number,

each point in the cadastre has a unique co-ordinate. Thus, each parcel can be individually referenced and assigned attributes or integrated into a land parcel-oriented land information system. The disadvantages are that sophisticated computer software is needed (especially if overplotting is to be avoided), larger data files need to be supported and data capture is slower than in the string method.

The Survey Office is reponsible for the cadastral mapping of the Australian Capital Territory. In 1978, it was decided to revise the 1:2,500 cadastral series of the Territory. As part of the revision, it was decided to produce a part of the series by digitizing existing subdivision sheets which were on scales 1:500 and 40 feet to the inch. A total of forty-five 1:2,500 sheets were produced in this way, using one digital plotter and one digitizing table (each 1:2,500 sheet contained an average of about 2,000 parcels). The method used was the string approach, with parcel or block numbering held in the data file as annotation. In addition, strings were feature-coded and derived products obtained at various scales. The string codes were: block boundary; section (road) boundary; kerb line; division boundary; and district boundary. The identified advantages of the approach are:

(a) Accuracy and metrication. Plots at scales smaller than 1,500 are accurate and the imperial-to-metric conversion is implicit in the digitizer transformation;

(b) High throughput. Often, drawing office "bottle-necks" occur at the final-plot stage, which is where a digital plotter has an advantage;

(c) Derived mapping. Layering or the selective plotting of a subset of features, together with plotting at different scales or with different symbology, is available;

(d) Digital data. There is a growing demand by users for digital data, especially from the utility companies;

(e) Amendments. These can be readily plotted to produce a new product.

The identified problems encountered were:

(a) Editing. The software relied upon "blind" editing using the digitizing board, rather than a graphics screen, and was slow;

(b) User interface. The design of the user interface relied upon the user keeping account of a large number of computer files.

USE OF AUTOMATIC FIELD-DATA RECORDING ON THE BRISBANE INTERNATIONAL AIRPORT REDEVELOPMENT

The redevelopment of the Brisbane International Airport involves provision of new facilities on a site adjacent to the existing Eagle Farm Airport. Completion of the project is planned for 1986.

Field-work has recently begun to locate the services as they are constructed, using an extensive numerical feature coding system to identify uniquely each service. A standard file structure is being used to store both spatial and attribute data, such as type of material, pipe diameter, electrical capacity and invert height, and allowing input from total station recorders as well as conventional stadia, and theodolite and electronic distance measurement (EDM) observations. Also, data may be digitized from existing large-scale plans. To support the use of total stations, a serial communication line between the site office and the city computing centre is being provided. At the computing centre, the data are processed into the standard data file and a plot is immediately produced. Enhancement of the plot will be done at first using the digitizing system, ant it is hoped that interactive graphics can be used later in the project.

The three main plan products are:

(a) The work-as-executed plan series, on the scales 1:250, 1:1,000, 1:5,000 and 1:10,000;

(b) Separate plans for the individual utility companies, to their own plotting specifications;

(c) Quick, up-to-date plans at appropriate scales from the most recent data.

By 1986, it is expected that a data bank of all above and underground services will be available as a planning and construction base for future work at the airport.

DIGITAL TERRAIN MODELS

The term "digital terrain model" (DTM) has traditionally beeen the name applied to the data base used in computer-assisted terrain analysis. The term was generic in that it applied to all forms of data bases that were in use, irrespective of their method of capture, structure or application.

Inevitably, refinement of this broad term has occured as the discipline itself became more refined. Through this refinement process, another term has evolved--"digital elevation model". Both DTMs and DEMs are machine-readable (digital) representations of a topographic (elevation) surface. That is, both DTMs and DEMs hold, in some form, effective x, y, z co-ordinates which can be used to define a surface. The difference between the two terms in that, currently, DTM is generally interpreted as being an enhanced version of a DEM in that a DTM also contains digital planimetric data (which for example, may or may not be used in contour generation).

Survey Office involvement in the area of computer-assisted terrain analysis has been developing over recent years from initial testing and feasibility studies to the point where the techniques developed have now been used in production.

Application of digital terrain models: Australian National Railways project

The first large-scale project on which the Survey Office has employed digital terrain modelling techniques for terrain analysis is in the construction by the Australian National Railways (ANR) of 1,600 km of railway track through central Australia. The project has been subdivided into a number of stages of construction. The first stage is the construction of approximately 500 km of track from Alice Springs to Tennant Creek.

The Survey Office was asked to provide survey support for the construction task. This support included:

(a) Approximately 80 detail map-sheets at 1:10,000 scale (2-m contours) over the proposed route(s);

(b) Engineering longitudinal sections over possible trial alignments as identified on the detail sheets;

(c) Final engineering design longitudinal section plans over the adopted alignment.

DTM amd DEM techniques were used in the first two of these operations.

The Survey Office has experimented with all three of the commonly encountered forms of tabular DTMs and DEMs: regular square grids (RSGs); digitized contours; and triangulated irregular networks (TINs). Because the data manipulation technique is fixed by virtue of existing software, the overriding influence on choice has usually been the accuracy required. This choice may then have been tempered by resource limits and processing capabilities.

The technique generally adopted is to capture a grid of points over the area in question. The density of the grid is calculated to ensure sufficient general detail. This basic grid of "surface random" points may then be infilled with "surface specific" points by digitizing ridge and depression lines and peak spot heights. As a general rule, the higher the accuracy requirement, the denser the grid and infill.

The actual digitizing technique employed is to parallel-scan the model, with the base of the scans being the shortest side of the model. Points are captured automatically at fixed-distance intervals. Typically, over a model of 1:25,000 scale with a grid interval of 80 m, approximately 2,000 points would be captured. As stated, if particular detail is required, the operator would digitized terrain specific lines and points (at fixed distance or with operator-controlled sampling), generating a pencil plot simultaneously with monitor coverage.

In fact, for the ANR project, the majority of the work of data capture was performed by contract consultants. Having established the techniques detailed above were a viable solution to ANR requirements, specifications were developed which described for contractors full details of the data capture and data transfer operations. (These specifications have generated considerable interest by bodies working in this area.)

The manipulation technique employed varies, depending upon the final product required. For example, the initial requirement of ANR for contour plots resulted in the following processing stages:

(a) DEM is verified for any irregularities in the data, given that the capture was performed to certain specifications, and also taking into account the expected terrain limits;

(b) Captured data are filtered to remove points redundant for contouring;

(c) The data required to cover the map-sheet area are expected from DEMs captured. This results in a map-sheet based DEM (rather than a model-based DEM);

(d) The map-sheet DEM is triangulated (i.e., triangles formed over all points);

(e) Contour strings are generated and then plotted.

On the other hand, for the required longitudinal section drawings, processing stages were:

(a) DEM is verified;

(b) A corridor of interest corresponding to the proposed alignment is extracted from model DEMs to form a DEM to be analysed. This results in a DEM of minimum size;

(c) The corridor DEM is triangulated;

(d) The alignment intersects the triangles generating three dimensional co-ordinates along the alignment (and along cross-section lines if required);

(e) The resultant data are plotted.

At any stage along the processing chain, the data can be saved. Thus, raw DEMs may be stored; or, depending upon the intended future use, filtered, triangulated or contoured DEMs, may be saved.

With a long-term goal of generating a topographic data base, the raw DEMs are the most suitable source to be stored.

Benefits of digital terrain model technique

The use of digital elevation data supplied in computer-compatible form has several distinct advantages over traditional methods during the stages of data manipulation and plan production.

The time taken to produce final contour plans from the data submitted by the consultants is relatively short. The data come in a standard format and can be entered directly into the data manipulation, analysis and plot system which automatically produces the final product.

Large amounts of data can be processed in a short time. When the technique was in full production for the ANR project, five final 1:10,000 contour sheets per day were produced, on average.

Terrain data in computer-compatible format can be readily used for other applications besides contouring. In the ANR project, the same terrain data were used to produce longitudinal sections and are available for other uses requiring elevation data. Additional products can be derived from the data at ever-decreasing unit cost.

The Survey Office now has a comprehensive specification covering terrain data capture and data transfer which will ensure standardized observation techniques and data formats for data used un future projects.

OUTPUT FROM COMPUTER MAPPING SYSTEMS

As in most similar organizations, the majority of output from the computer mapping systems is digital plots, although more users are beginning to require also digital data. Recently, the boundaries of forest compartments of different classification were captured from 1:36,000 photography and the 1:10,000 map-sheet overlays and digital data sent as input to a forestry data base. In addition, DEM data are increasingly requested by engineers and town planners.

The major issues associated with digital plotters are well known and include issues of plotter size, accuracy, resolution, on-line versus off-line, raster versus vector, pen versus scribe versus photo-lighthead etc.; they are not discussed here. Instead, a number of perhaps less well understood issues are discussed below based on experience gained over the past few years with several different plotting systems.

An early system-design decision was taken whereby all application programs would produce a device-independent plot file, similar in concept to the SIGGRAPH core standard Metafile. 1/ This decision has produced great benefits; first, because the application programmer has a very simplified view of a plotter and can proceed with programming using a standard library of subprograms. Secondly, the introduction of new and different digital plotters has not affected any application programs at all. A further benefit in the Survey Office, where there are currently three different plotters, is that the plotter manager can decide which machine is to be used for a particular job, based on the type pf plot required and/or individual plotter work-loads.

A second design feature allows the plot data within a plot file to be logically grouped together, producing the equivalent of cartographic overlays; for example, a single plot file produced from the mathematical cadastral data base contains 20 layers and 15 different plans are produced for the various users from the one single-plot file.

Since large-scale plans are usually dominated by annotation, the throughput of a plotter is far more affected by the pen-up and pen-down delays than the maximum speed and acceleration. The ability to store user-defined character founts locally (i.e., in the plotter controller) is also particularly important, especially with on-line systems where the load on the host computer and communication interface is minimal.

The attainment of consistent high-quality work requires skilled draughtsmen as plotter operators. The acquisition of a new plotter should be followed by a lengthy period of experimentation with different drafting materials, tools, inks, pen force and speed, and acceleration settings for each different type of work.

Editing of graphical data by an interactive graphics system

The graphical output from automated mapping systems usually requires a small amount of editing by a cartographer unless a facility is available to edit the digital data directly. The Survey Office has had some success in editing using digitizing boards, but normally the philosophy has been to use the automated systems to achieve efficiently an almost complete product. With the use of an interactive graphics system (IGS), the final editing can be performed directly on the digital data and a final plan produced on the digital plotter. In addition, IGS allows annotation placement on the drawing and general enhancement prior to plotting.

An interactive graphics system normally consists of a minicomputer with a real-time operating system and sophisticated graphics software, interfaced to one or more graphics stations and digital plotters. The graphics stations used in cartography consist of a large graphics screen (minimum of 48 cm), keyboard or visual display terminal and cursor controller (joystick or data tablet). The graphics screen is usually a high-resolution direct-view storage tube, although high-resolution raster screens will become more common.

The Survey Office is about to begin a validation project with a small IGS. The main application is to be large-scale contour, detail and work-as-executed plans. A major consideration in the purchase of the particular IGS has been the requirement for good interactive response on heavily detailed plans. This problem is often overlooked in cartographic applications since it is not usually a problem in the more common CAD/CAM applications. The latter applications feature the very complex manipulation of two-dimensional and three-dimensional images, but involve only a moderate amount of line-work. On the other hand, cartographic applications feature simple geometrical manipulations on very detailed images which involve a great amount of line-work, especially on heavily annoted plans and contour overlays.

Other important issues to cartography are the need for user-definable character fonts, symbols and line-styles and the ability to feature code graphical elements. Very few CAD/CAM systems satisfactorily address any of these issues.

CONCLUSION

Automated mapping technology is used to assist the process of plan production. It has proved effective in many different applications. The advent of interactive graphics systems and digital data banks is viewed as an extension of mapping technology.

Note

1/ "GSPC metafile proposal", part IV SIGGRAPH, ACM Quarterly Report, vo. 13, No. 3 (August 1979).

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DIGITAL MAP DATA BASE AND APPLICATION PROGRAMS DEVELOPED AT THE NATIONAL BOARD OF SURVEY*

Paper submitted by Finland

The National Board of Survey in Finland has used computers since the beginning of the 1960s. The applications were at first purely scientific data processing, geodetic and photogrammetric computation. Since 1974, the National Board of Survey has used peripheral units, drafting machines and digitizing tables which are suited for graphical data processing.

Electronic data processing (EDP) devices are currently in use, for instance, for the following map applications: (a) geodetic and photogrammetric computation; (b) digital elevation model (DEM) applications, such as orthophotomaps and hill shading; (c) process of drawing basic maps (1:10,000-1:20,000) and large-scale maps; (d) thematic maps.

The processing programs for spatially oriented data have been mainly compiled at the National Board of Survey. Ready-made commercial software has not met the requirements for processing spatially oriented data. The software created for automatic drafting of maps at the National Board of Survey has not attained the level of sophistication required to produce "perfect" maps, owing primarily to the lack of areal data management.

The new system has to operate as widely as possible as a system of collection, processing, recording and output for all spatially oriented data. The capability of handling positional information makes it possible to link different registers together, if the information can be located with co-ordinates.

The position can be used as a link between different registers, which is the only invariable, and the most flexible identifying system between these registers. This application makes use of the integration of registers, which in other organizations is termed a "land information system".

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* The original text of this paper, prepared by T. Keisteri and T. Tuhkanen, National Board of Survey, appeared as document E/CONF.75/L.59.

INTRODUCTION OF COMPUTER-ASSISTED CARTOGRAPHY AT THE NATIONAL BOARD OF SURVEY

Mapping works traditionally include the collecting, handling and distribution of terrain information. The most usual method of transferring the terrain information to users has been a drawn map. From the users' point of view, the map has been either good or bad, depending upon how it is used. A map is supposed to supply information, which includes areas, distances, elevations of contours and numbers of features of the terrain. In these cases, for instance, there is justification for handling the data in numerical form using a computer.

As a rule, the source information in the digital mapping process is obtained from archives, registers, terrain measurements, stereo mapping, manual or automatic digitizing and remote sensing. The terrain information is stored in the digital map data base after processing. It is possible to draw different types of maps and to produce numerical output from the material in the data base to be used in other applications.

DIGITAL MAP DATA BASE

The units to be processed in the map data base are points, lines, areas connections and texts (see figure 122). A line goes from node (end-point) to node, and the nodes are linked to all their lines. Areal features also are linked to all surrounding lines. An attempt has been made to distribute the data to different files using property criteria, such as terrain lines and boundary lines.

Structure of data base

Logical structure

The logical structure is outlined below:

(a) Point: independent point (symbol, text, geodetic point etc.); line point (end-point or intermediate point); node (end-point of one or more lines);

(b) Line: independent, areal connective line (from node to node, from node to end, from end to node, from end to end);

(c) Area: lines around an areal feature in one plane;

(d) Connection: a combination of lines, which have a logical meaning.

Physical structure

The physical structure of the map data base (see figure 123) is outlined below:

(a) Point: (i) X, Y; graphical line point (record size 2 word at 16 bits); (ii) K, X, Y, X_2, Y_2, symbolic point (5 W); (iii) K, X, Y, Z; simple altitude

Figure 122. Finland: units processed
in a digital map data base

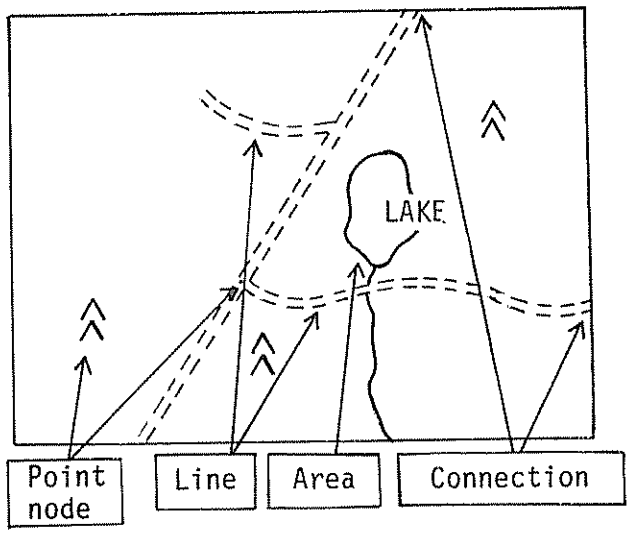
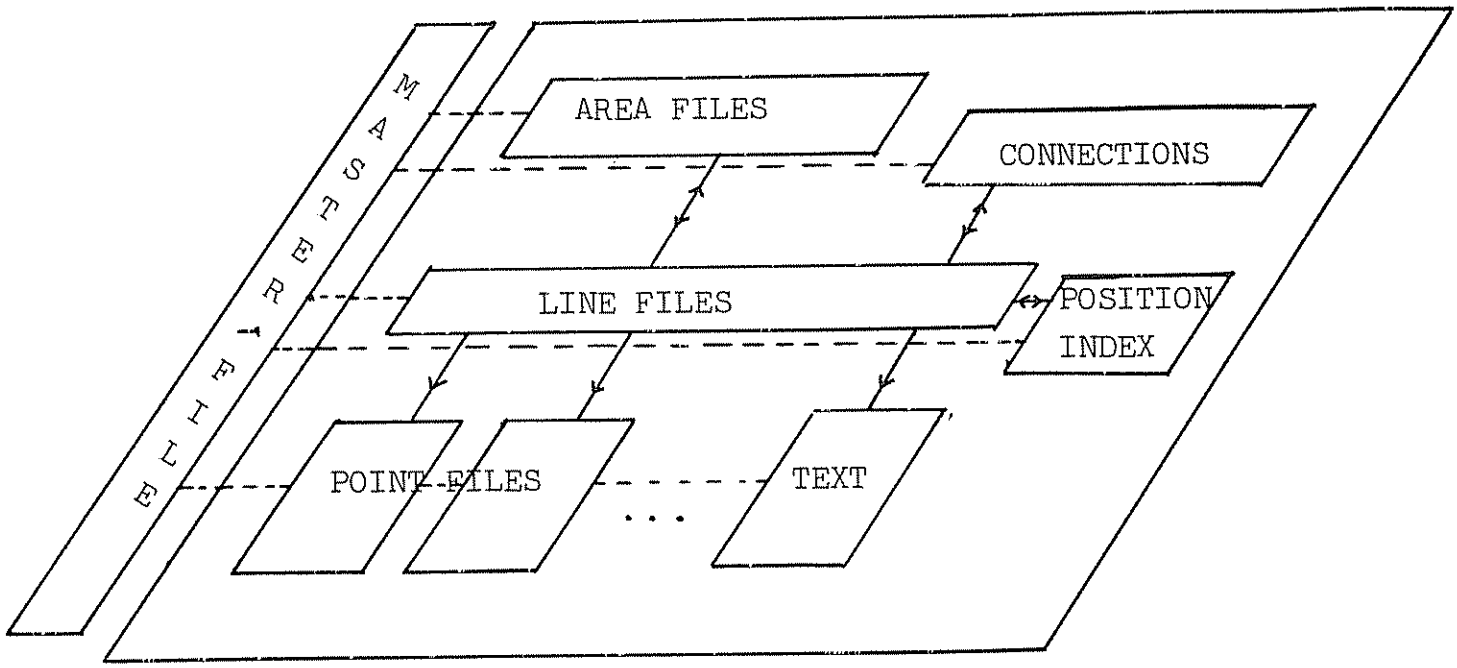


Figure 123. Finland: physical structure of a map data base



point (4 W); (iv) K, X, Y, Z; point number, position of the point number (10 W), photogrammetric and geodetic points; (v) text points (42 W);

(b) Line: quality code; point adresses (first point, first intermediate point, number of intermediate points, last point); line adresses (line pointers to the right and left at the end-points); area addresses on the right and left sides of the line; latest connection address, to which the line belongs; special information;

(c) Area: line address, which belongs to the area; "island pointers"; one reference point inside the area; areal code;

(d) Connection: line addresses and pointers to the earlier connection.

Position index system

Retrieval of a feature by pointing

Point P is pointed near the feature that is to be retrieved. The number of the square indicating the position index is computed by means of the co-ordinates of point P (see figure 124). Line addresses (L_1 ... L_{16}) are found int the square by means of the square number (6). Thereafter, the line nearest to point P is computed and the feature is found . If the areas have been created, area addresses on the right and left sides of the line can be found in the line record.

Computing intersection points (nodes) for lines

A line address, a number of a line point before intersection and the co-ordinates of a node are entered for the auxiliary file (figure 125) at every intersection.

After computing all intersections, the average values are computed for nodes that are near each other. Co-ordinates of nodes are written into the data base and addresses of nodes are written into the auxiliary file. The auxiliary file is then sorted in ascending order according to the line address and number of a line point (figure 126). Lines are cut from node to node by means of this auxiliary file.

Accuracy between 0.1 and 0.6 mm was required for a distance in the map, to accept the co-ordinates computed for the intersection point.

Creating areas

To create area A_1, for example, the procedure given here is to be followed: sort the lines going through the nodes; begin with line L_{11} (see figure 127). The address of area A_1 is written into line record L_{11}. Then go clockwise on line L_{22} to node N_4, which is found in line record L_{11}; write the address of

Figure 124. Finland: retrieval of a feature by pointing

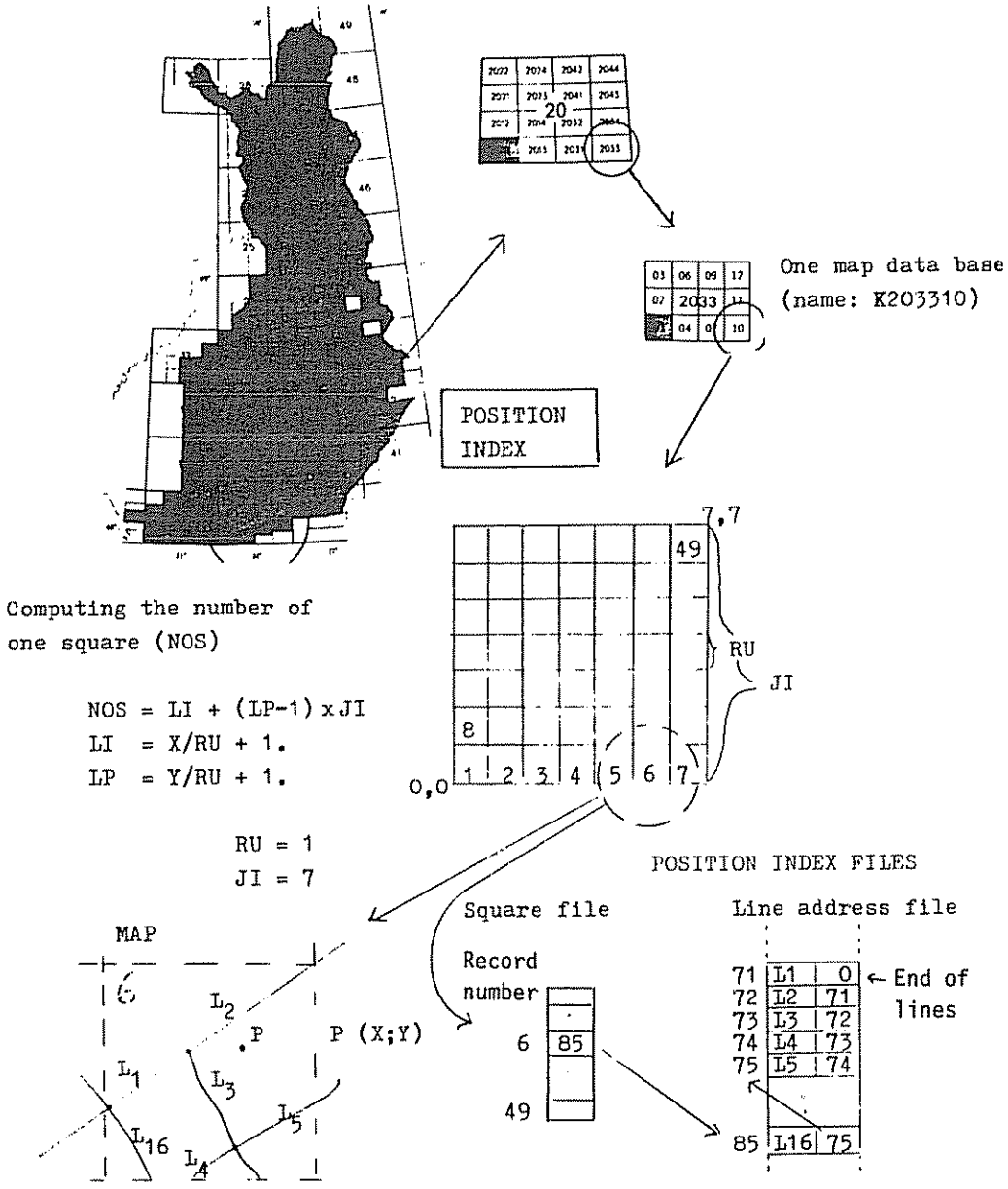
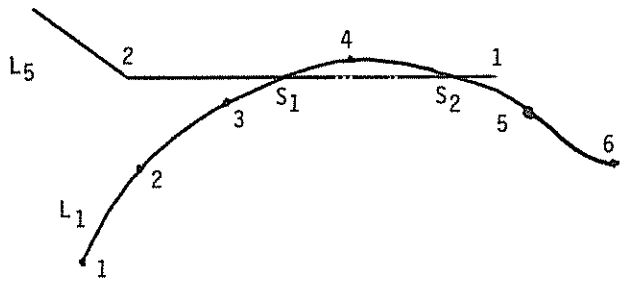
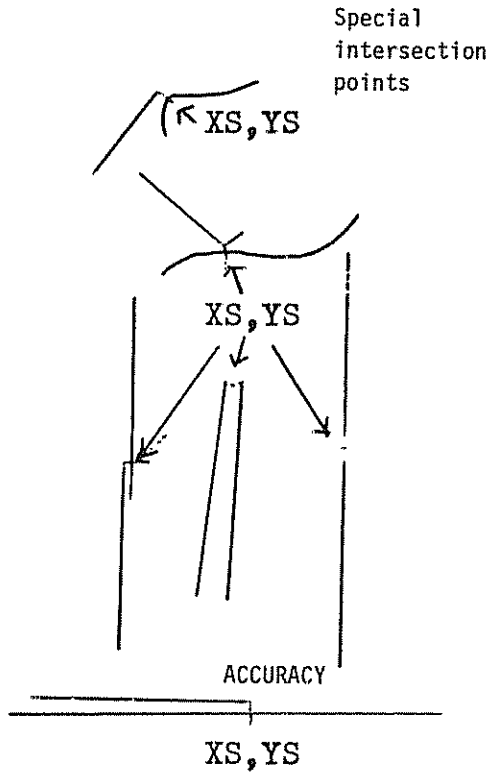


Figure 125. Finland: auxiliary file for intersection points



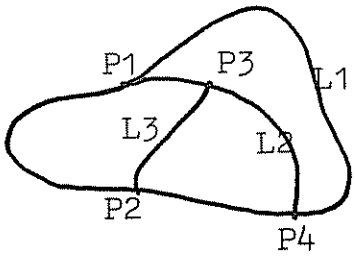
Note: L_1, 3, X_{S1}, Y_{S1}, L_5, 1, X_{S1}, Y_{S1}; L_1, 4, X_{S2}, Y_{S2}; L_5, 1, X_{S2}, Y_{S2}.

Figure 126. Finland: auxiliary file after sorting



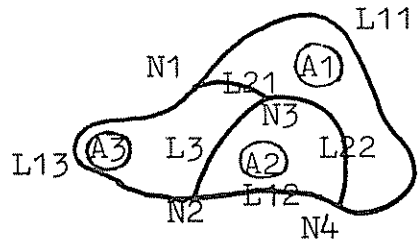
Note: L_1, 3, X_{S1}, address of node 1; L_1, 4, X_{S2}, Y_{S2}, address of node 2; L_1, 1, X_{S1}, Y_{S1}, address of node 1; L_5, 1, X_{S2}, Y_{S2}, address of node 2.

Figure 127. Finland: creating areas for the map



Digitizing:
L1 (P1 .. P1)
L2 (P1 .. P4)
L3 (P2 .. P3)

Computing nodes and cutting lines from node to node



Sorting the lines in the nodes

N3-node before sorting:
L21,
L22,
L3

N3-node after sorting:
L22,
L3,
L21

Creating areas

Area file before inputting areal codes:

A1 (L11, island pointers...)
A2 (L12, island pointers...)
A3 (L13, island pointers...)

An areal code is pointed by one point inside the area

Area file after that:

A1 (L11,island pointers,X,Y,code)
. . .

area $\underline{A}_1$ into line record $\underline{L}_{22}$. Next go clockwise on line $\underline{L}_{21}$ up to node $\underline{N}_3$, which is found in record $\underline{L}_{22}$. Lastly, when node $\underline{N}_1$ is found and the next line going clockwise is $\underline{L}_{11}$, the area feature is created.

Areal division management at several levels

Data for division A are taken out of division M: (a) areas of pieces out of division A + M; (b) areal codes for pieces out of division M. As an example, squares of the position index covering area $\underline{A}_5$ are computed (see figure 128). Line addresses in the combination are found by means of these squares, and area addresses are found in the line records. The reference point of those areas in the combination is compared with $\underline{A}_5$. If the reference point is inside area $\underline{A}_5$, the piece of the combination is inside that area. The aeral code in division M also is retrieved according to this reference point.

APPLICATION PROGRAMS

The main applications of the programs are: (a) maintenance and drafting; (b) aesthetic corrections; (c) logical checking; (d) management of elevations; (e) areal management; (f) conversion; (g) others (see figure 129).

Maintenance and drafting programs

Maintenance and drafting programs are used to update the map data base by means of new input and to convert digital data into drafting codes for various output machines.

Map data and stereo-photogrammetric data are digitized (figure 130) both in off-line work and in tests performed interactively in on-line work. The main activities are in the off-line work. After the initial digitizing, a proof plot is drawn and checked. Corrections are entered into the system by digitizing or by interactive work on the graphics screen.

Aesthetic corrections

Frequently, the same point has to be digitized several times, which results in observations errors. Other errors also may occur (see figure 131).

There is no need to make mass corrections on interactive work because most corrections can be made automatically in the batch mode. The number of corrections to be made is several hundred per sheet.

Logical checking

Digital data contain many logical errors, which are likely to remain unnoticed in manual checking. To correct those errors, programs are made

Figure 128. Finland: computation of reference points

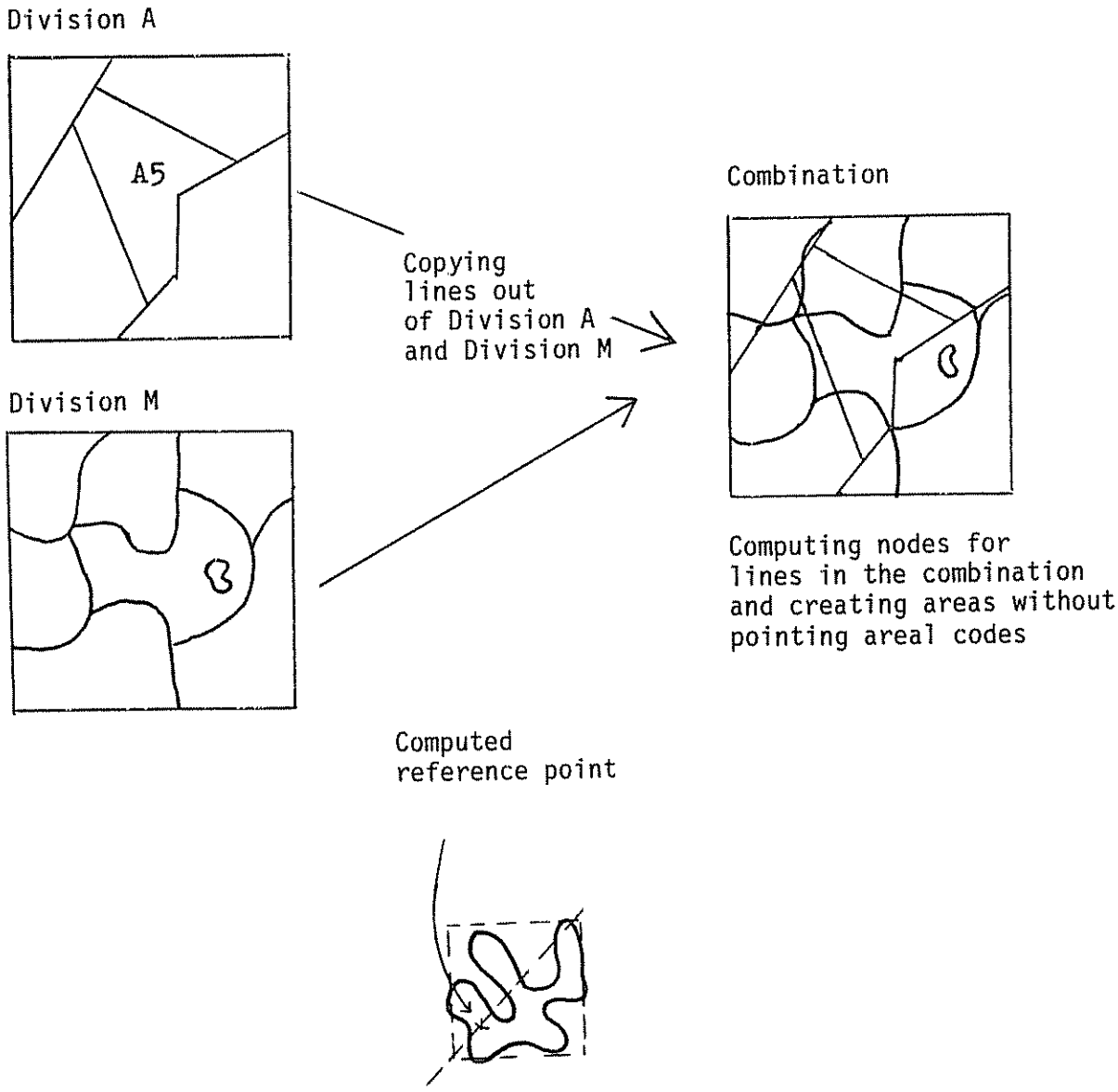


Figure 129. Finland: main applications of computer programs

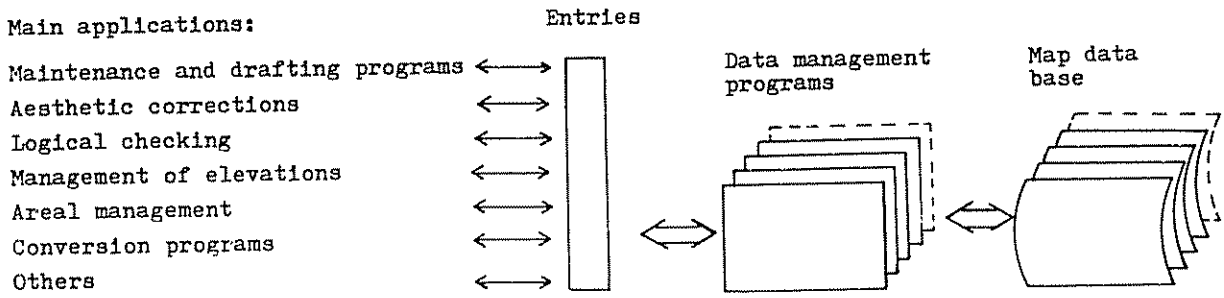


Figure 130. Finland: digitizing of map and stereo-photogrammetric data

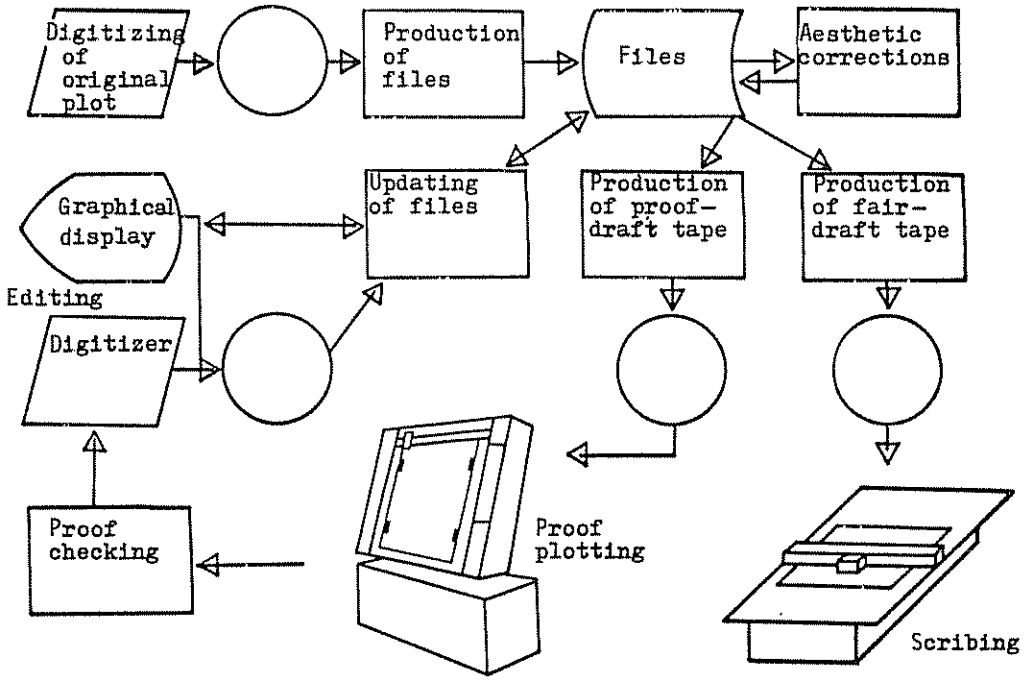
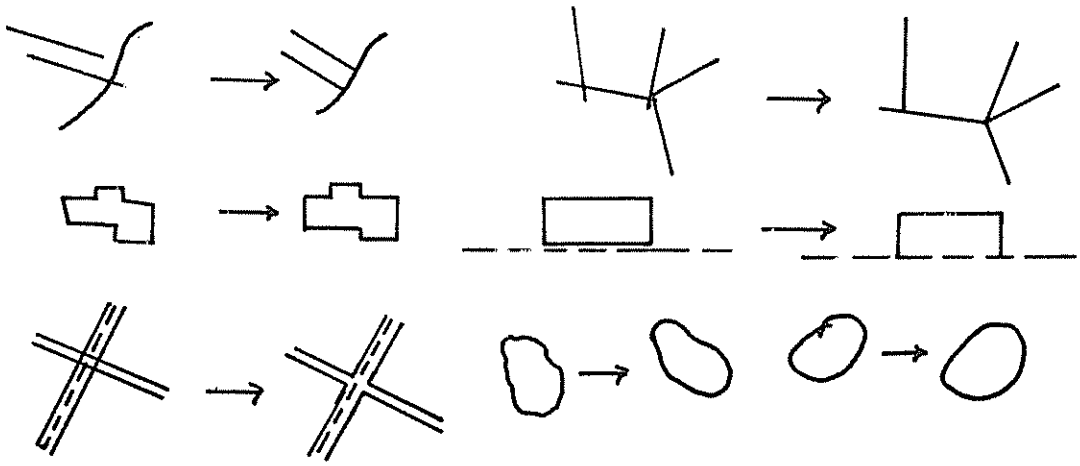


Figure 131. Finland: errors occurring in digitizing



to check the logical relationships of different features. For example, the altitude of each contour is checked against those of the neighbouring contours, and it is possible to find the breaks in the boundaries of an area.

FORESTRY TAX CLASSIFICATION IN KALANTI COMMUNITY

In the Kalanti project, 47 map-sheets for forestry tax classification and real estate elements (about 22,000 ha at 1:5,000 scale) were digitized in the old system. The digital data were converted into the new map data base (figure 132). Areal divisions were created for real estate, villages, tax classification features and a combination of these elements (see figures 133-136). Corrections of areal divisions were made by interactive updating programs on a graphical Tektronix VDU.

Statistical data

The processing time for the tax classification was:

(a) Digitizing, 1,500 hours;

(b) Run preparation, 70 hours;

(c) Batch mode runs, 1,390 hours (central processing unit, CPU);

(d) Interactive editing, 850 hours;

(e) Checking areal codes: 150 hours;

(f) Drafting, 72 hours with Calcomp 960 and 290 hours with Kongsberg DC 300/1216.

The digital data for one map-sheet are set forth below:

Element	Points	Lines	Areas	Thousand words
Real estate	1,000	250	80	54
Tax classification	22,000	3,000	1,000	320
Combination	26,000	4,500	1,500	256

The CPU times in the HP 3000, series II computer were:

(a) Computing nodes, 320 hours;

(b) Creating areas, 112 hours;

(c) Pointing areal codes, 62 hours;

(d) Output runs, 290 hours;

(e) Other (tests, conversions etc.), 586 hours.

The costs of the project were 480,000 markkaa (Fmk), or Fmk 22 per hectare.

Figure 132. Finland: flow chart of digitization process

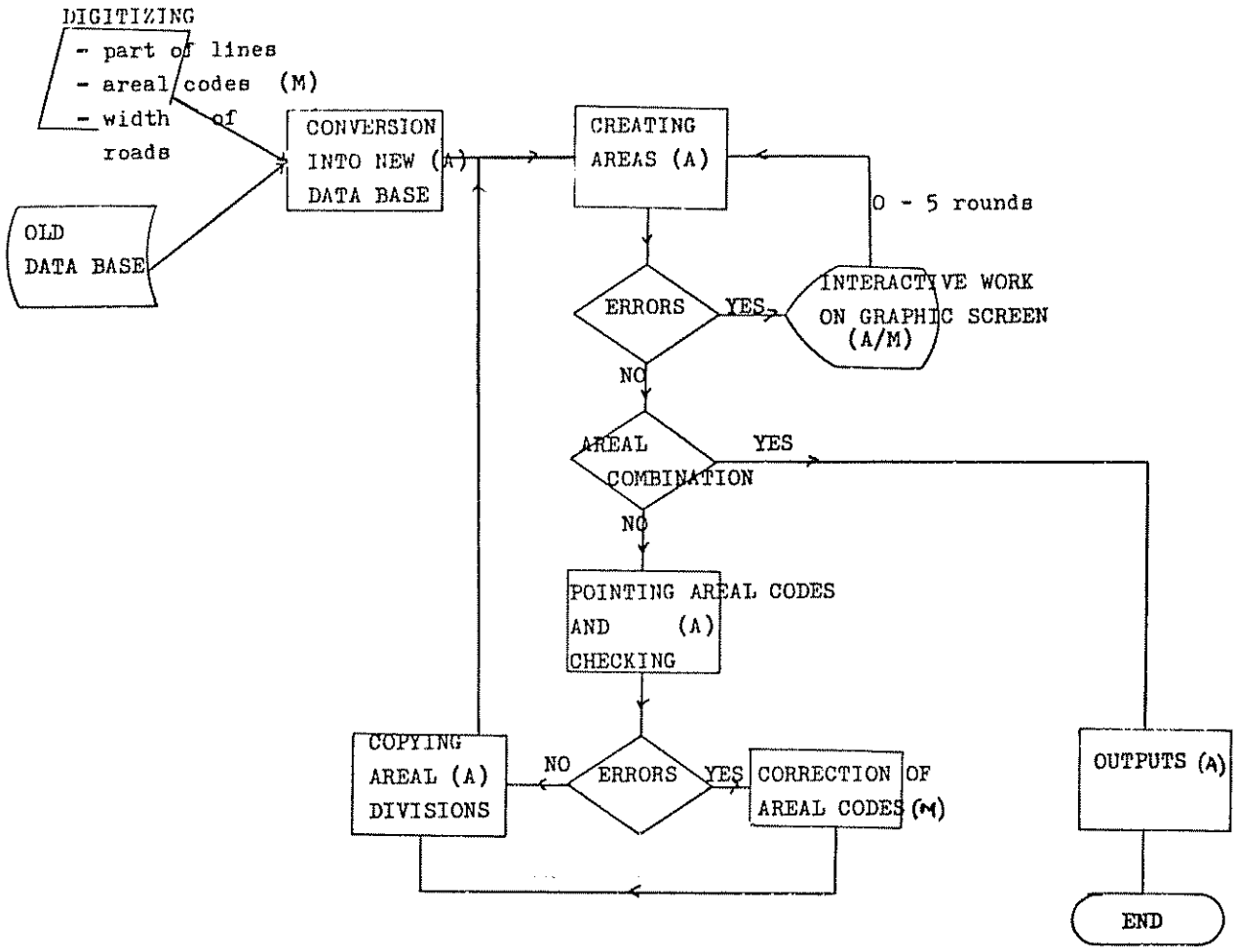
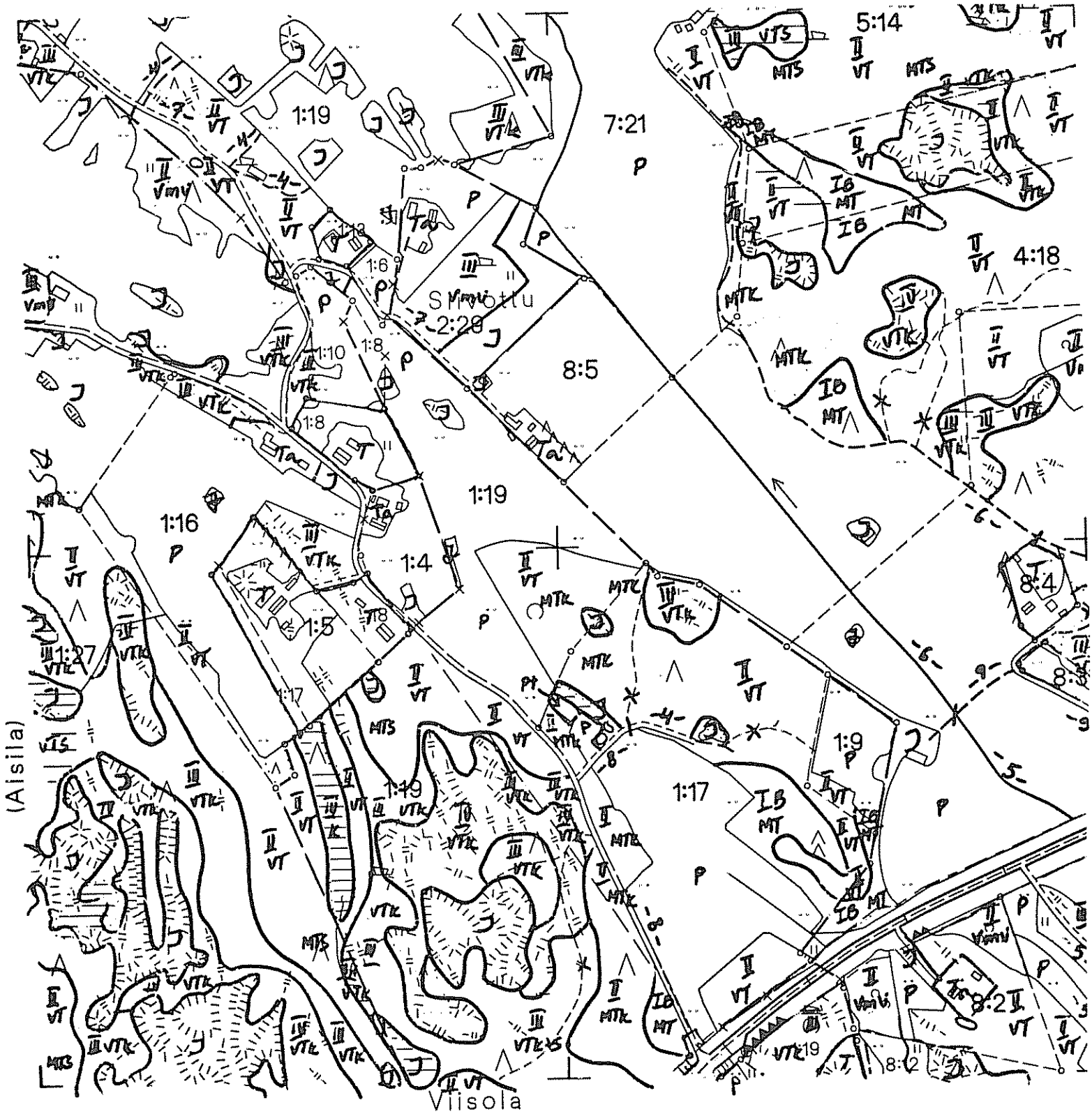
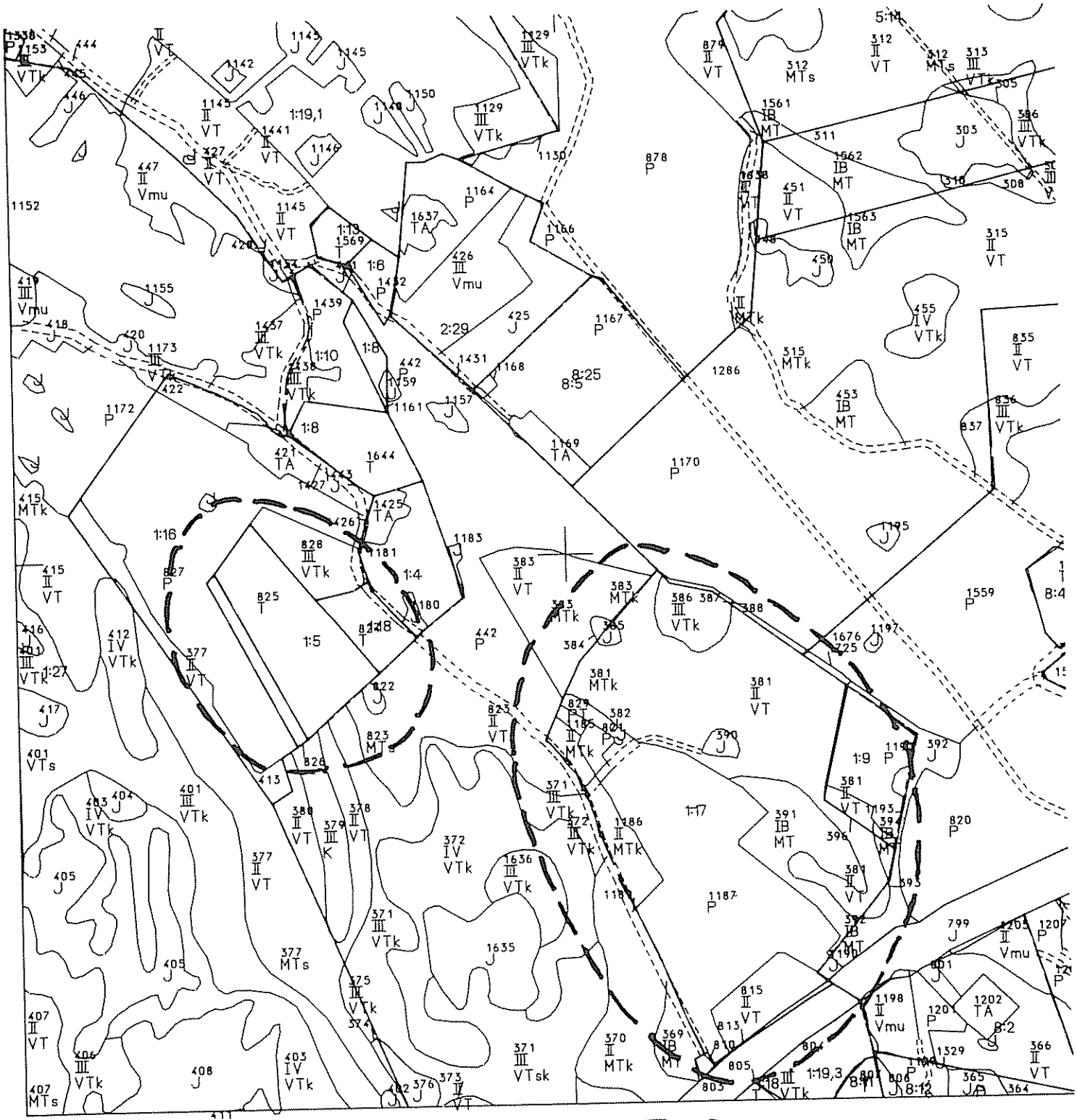


Figure 133. Finland: original of features of forestry tax classification



Note: Narrow lines indicate earlier digitizing.

Figure 134. Finland: proof plot of combination of real estate features and tax classification features



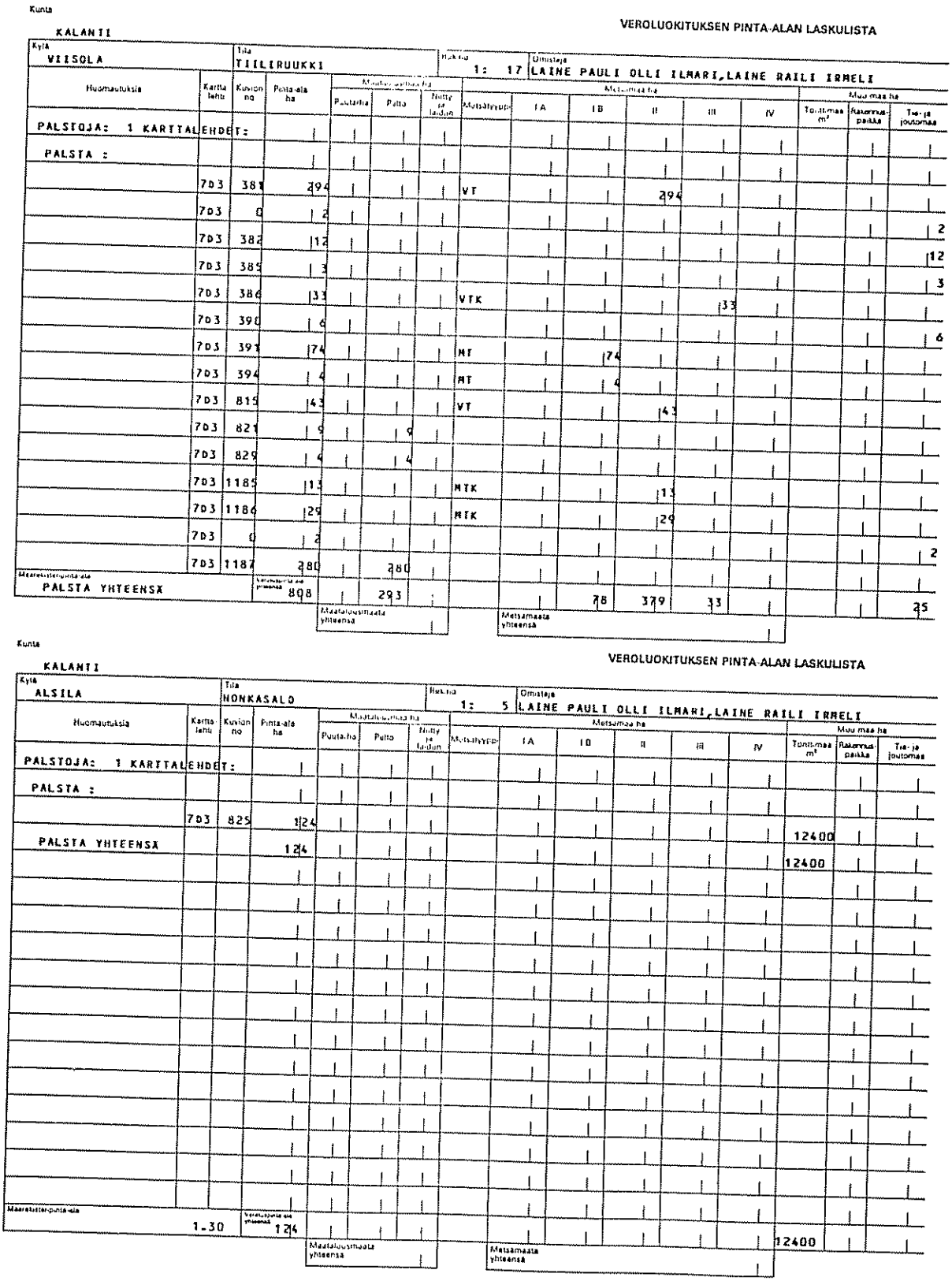
K113107 D 3

KALANNIN KUNTA: VEROLUOKITUSKARTTA

P	Pelto	N	Luonnonniitty	Ta	Tonttialue	Rp	Rakennuspaikka
Pt	Puutarha	L	Laidun	T	Tontti	J	Joutomaa

Note: For output of circled features, see figure 135.

Figure 135. Finland: areas of real estate and tax classification features



Kunta

KALANTI

VEROLUOKITUKSEN PINTA-ALAN LASKULISTA

Kylä: VEISOLA | Tila: TIILIRUUKKI | Rekrno: 1: 17 | Omistaja: LAINE PAULI OLLI ILMARI, LAINE RAILI IRMELI

Huomautuksia	Kartta-lehti	Kuvion no	Pinta-ala ha	Maatalousmaa ha: Puutarha	Pelto	Niitty ja laidun	Metsämaa ha: Metsätyyppi	I A	I B	II	III	IV	Muu maa ha: Tontti-maa m²	Rakennus-paikka	Tie- ja joutomaa
PALSTOJA: 1 KARTTALEHDET:			1	1	1	1		1	1	1	1	1		1	1
PALSTA :			1	1	1	1		1	1	1	1	1		1	1
	703	381	294	1	1	1	VT	1	1	294	1	1		1	1
	703	0	2	1	1	1		1	1	1	1	1		1	2
	703	382	12	1	1	1		1	1	1	1	1		1	12
	703	385	3	1	1	1		1	1	1	1	1		1	3
	703	386	33	1	1	1	VTK	1	1	1	33	1		1	1
	703	390	6	1	1	1		1	1	1	1	1		1	6
	703	391	74	1	1	1	MT	1	74	1	1	1		1	1
	703	394	4	1	1	1	MT	1	4	1	1	1		1	1
	703	815	43	1	1	1	VT	1	1	43	1	1		1	1
	703	821	9	1	9	1		1	1	1	1	1		1	1
	703	829	4	1	4	1		1	1	1	1	1		1	1
	703	1185	13	1	1	1	MTK	1	1	13	1	1		1	1
	703	1186	29	1	1	1	MTK	1	1	29	1	1		1	1
	703	0	2	1	1	1		1	1	1	1	1		1	2
	703	1187	280	1	280	1		1	1	1	1	1		1	1
Määrästetty pinta-ala: PALSTA YHTEENSÄ			Verotusarvoa ed. yhteensä 808	1	293	1	Maatalousmaata yhteensä	1	78	379	33	1		1	25
													Metsämaata yhteensä		

Kunta

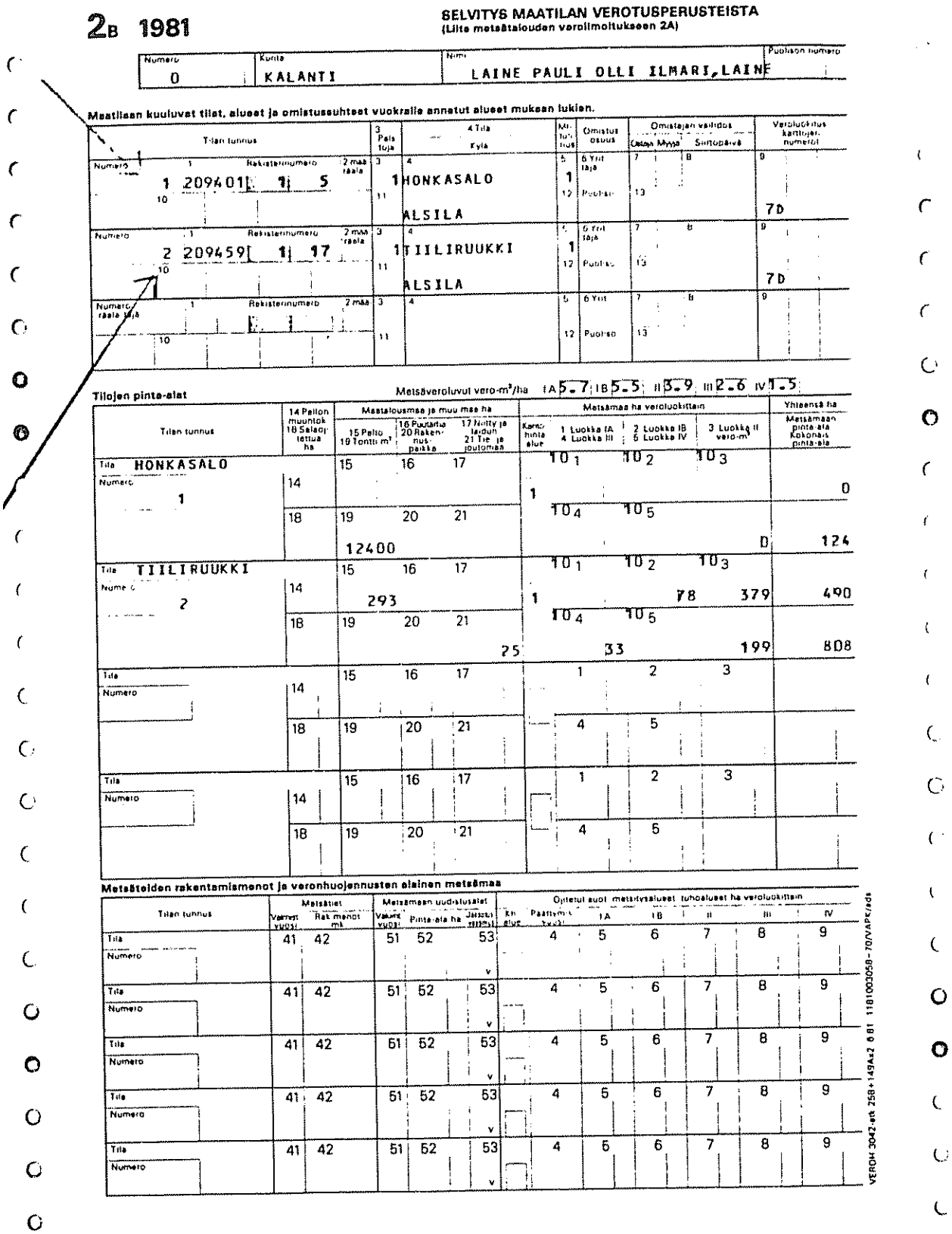
KALANTI

VEROLUOKITUKSEN PINTA-ALAN LASKULISTA

Kylä: ALSILA | Tila: HONKASALO | Rekrno: 1: 5 | Omistaja: LAINE PAULI OLLI ILMARI, LAINE RAILI IRMELI

Huomautuksia	Kartta-lehti	Kuvion no	Pinta-ala ha	Maatalousmaa ha: Puutarha	Pelto	Niitty ja laidun	Metsämaa ha: Metsätyyppi	I A	I B	II	III	IV	Muu maa ha: Tontti-maa m²	Rakennus-paikka	Tie- ja joutomaa
PALSTOJA: 1 KARTTALEHDET:			1	1	1	1		1	1	1	1	1		1	1
PALSTA :			1	1	1	1		1	1	1	1	1		1	1
	703	825	124	1	1	1		1	1	1	1	1		1	1
PALSTA YHTEENSÄ			124	1	1	1		1	1	1	1	1	12400	1	1
			1	1	1	1		1	1	1	1	1	12400	1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
			1	1	1	1		1	1	1	1	1		1	1
Määrästetty pinta-ala: 1.30			Verotusarvoa ed. yhteensä 124	1	1	1	Maatalousmaata yhteensä	1	1	1	1	1	12400	1	1
													Metsämaata yhteensä		

Figure 136. Finland: basis for taxation of property



2B 1981

SELVITYS MAATILAN VEROTUSPERUSTEISTA
(Liite metsätalouden verolimoitukseen 2A)

Numero	Kunta	Nimi	Puolison numero
0	KALANTI	LAINE PAULI OLLI ILMARI,LAINE	

Maatilaan kuuluvat tilat, alueet ja omistusuhteet vuokralle annetut alueet mukaan lukien.

Tilan tunnus	3 Pals toja	4 Tila / Kyla	Mi-tu-tus	Omistus osuus	Omistajan vaihdos: Ostaja Myyja	Siirtopäivä	Veroluokitus kanttojen numerot
Numero 1 209401 Rekisterinumero 1 5 2 maa räala	3 1	4 HONKASALO ALSILA	5 1	6 Yrit täjä / Puoliso	7	8	9 7D
Numero 2 209459 Rekisterinumero 1 17 2 maa räala	3 1	4 TIILIRUUKKI ALSILA	5 1	6 Yrit täjä / Puoliso	7	8	9 7D
Numero räala täjä Rekisterinumero 2 maa	3	4	5	6 Yrit / Puoliso	7	8	9

Tilojen pinta-alat

Metsäveroluvut vero-m³/ha IA 5.7 IB 5.5 II 3.9 III 2.6 IV 1.5

Tilan tunnus	14 Pellon muuntok 18 Salaojitettua ha	Maatalousmaa ja muu maa ha: 15 Pelto 19 Tontti m²	16 Puutarha 20 Rakennuspaikka	17 Niitty ja laidun 21 Tie ja joutomaa	Metsämaa ha veroluokittain: Kanto hinta alue	1 Luokka IA 4 Luokka III	2 Luokka IB 5 Luokka IV	3 Luokka II vero-m³	Yhteensä ha: Metsämaan pinta-ala Kokonais pinta-ala
Tila HONKASALO Numero 1	14	15	16	17	1	10 1	10 2	10 3	0
	18	19 12400	20	21		10 4	10 5	0	124
Tila TIILIRUUKKI Numero 2	14	15 293	16	17	1	10 1	10 2 78	10 3 379	490
	18	19	20	21 25		10 4 33	10 5	199	808
Tila Numero	14	15	16	17		1	2	3	
	18	19	20	21		4	5		
Tila Numero	14	15	16	17		1	2	3	
	18	19	20	21		4	5		

Metsäteiden rakentamismenot ja veronhuojennusten alainen metsämaa

Tilan tunnus	Metsätiet: Valmist vuosi	Rak menot mk	Metsämaan uudistusalat: Valmist vuosi	Pinta-ala ha	Jäljellä vuosi	Ojitetut suot metsitysalueet tuhoalueet ha veroluokittain: Kh alue	Päättymis vuosi	IA	IB	II	III	IV
Tila Numero	41	42	51	52	53 v		4	5	6	7	8	9
Tila Numero	41	42	51	52	53 v		4	5	6	7	8	9
Tila Numero	41	42	51	52	53 v		4	5	6	7	8	9
Tila Numero	41	42	51	52	53 v		4	5	6	7	8	9
Tila Numero	41	42	51	52	53 v		4	5	6	7	8	9

VERDH 3042-etk 258+149Ax2 6 81 1181003058-70/VAPK/eds

Difficulties encountered

Some difficulties encountered in the Kalanti project were: (a) lack of hardware resources: (b) lack of programs at the beginning of the work; (c) very complex original tax classification plot (many overlapping lines, breaks in the areal lines, two different digitizations); (d) varying width of lines in the original plot (figure 137).

CONCLUSION

The Kalanti project has shown that it is possible to create a powerful, three-dimensionally oriented map data base management system. Moreover, such a system is economically profitable. In pursuing follow-up development, particular attention will be given to the correctness of digitizing, a "user-friendly" error correction and updating of programs on the areal level.

In the near future, the National Board of Survey plans to apply the new map data base management system to the production of terrain maps and real estate surveys. These data will be stored so as to minimize data loss and thereby to maximize future use of the data. What these future uses will be, however, is still somewhat unclear; and for that reason, it is necessary to proceed slowly so as to prevent unfortunate consequences.

APPLICATION OF A SYSTEM OF CARTOGRAPHIC MODELS TO COMPUTER-ASSISTED THEMATIC MAPPING*

Paper submitted by the Federal Republic of Germany

RESUME

On constate actuellement, en cartographie assistée par ordinateur, une évolution de toutes les techniques de traitement des données par la trame vers la production de données graphiques. Il ressort de l'examen des avantages et des inconvénients des techniques de production que les appareils de restitution électrostatiques permettent d'établir des cartes thématiques rapidement et à peu de frais. On peut améliorer considérablement leur diversité et leur efficacité en utilisant un logiciel orienté vers l'image. Un programme de ce type est le BIZEPS qui a permis de mettre au point un système spécial de programmes cartographiques pour les appareils de restitution électrostatiques. Compte tenu de leur structure modulaire et de leur conception, il est facile de sélectionner les sous-programmes les plus utiles pour la production de cartes thématiques tant simples que complexes. On peut

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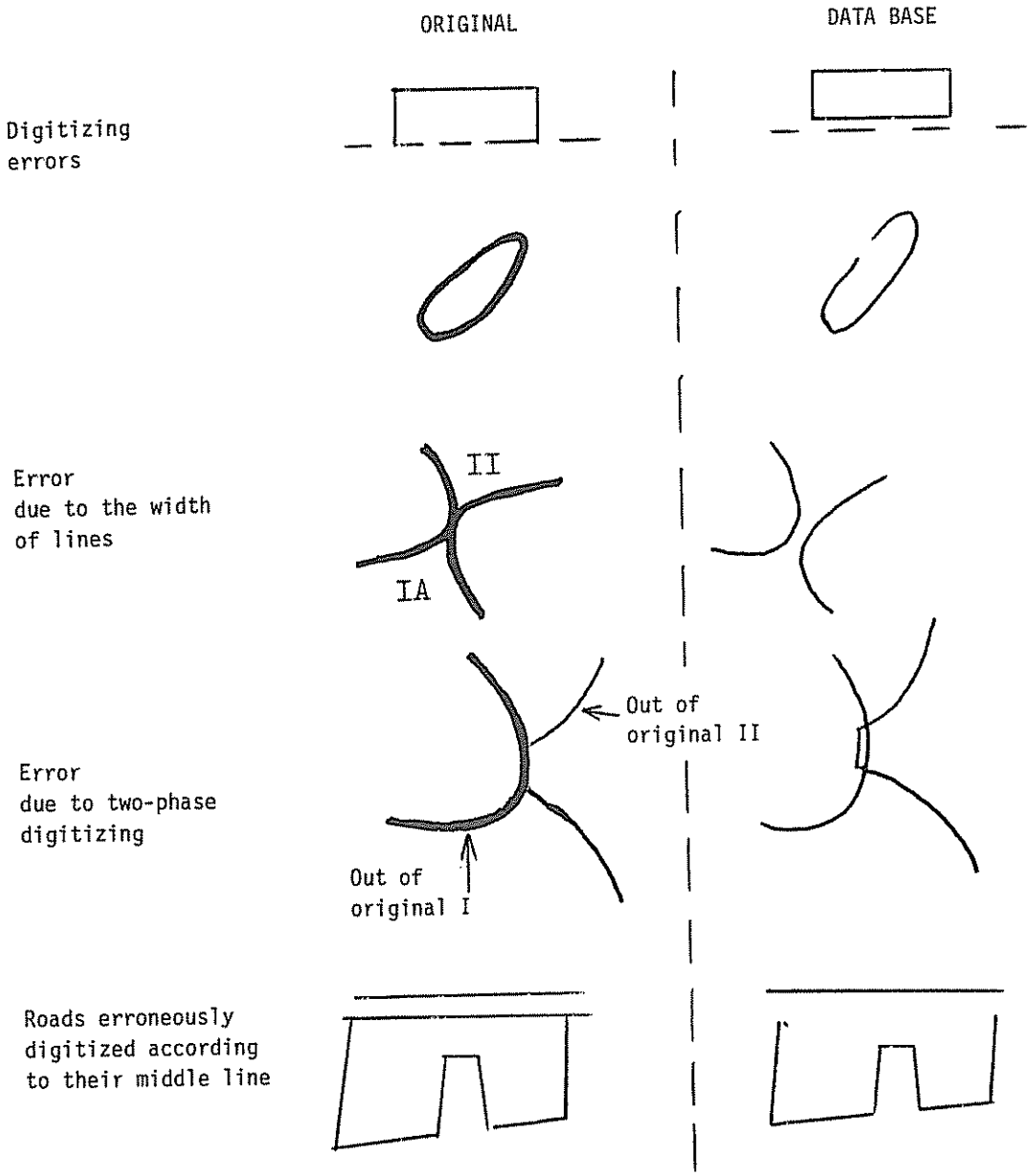
* The original text of this paper, prepared by U. Freitag, Institute für Anthropogeographie, Angewandte Geographie und Kartographie der Freien Universität Berlin, appeared as document E/CONF.75/L.45.

Figure 137. Finland: examples of difficulties encountered in Kalanti project



également produire des tracés qui peuvent être utilisés immédiatement comme originaux pour le procédé d'impression offset quatre couleurs. Ainsi l'appareil de restitution électrostatique peut devenir un instrument très efficace en ce qui concerne la production rapide de cartes pour l'information et la planification nationales et régionales.

USE OF RASTER TECHNIQUES IN CARTOGRAPHY

Recent textbooks on computer-assisted cartography clearly show the increasing importance in cartography of raster-mode thinking as compared with vector-mode thinking. 1/ One of the most decisive factors for this development was improvement of the hardware for digitizing and plotting in the raster mode.

The full range of raster-mode handling of cartographic data includes digitizing, storage of digitized data in a raster base, variation of the data by means of raster operation and output of the data by means of a raster plotter. 2/

Digitizing is the most effective means of generating raster data. It means the transformation of graphical analogue data (draft, photo and map) into digital raster form, and it is currently most accurately and rapidly achieved by laser beam scanners. A samll sensor moves along scan lines over the original plot; it virtually dissects the analogue data into very small cells (pixels) and transforms their reflected light (grey value) into electro-magnetic signals which can be recorded, stored and manipulated by means of computers. Similar systems of data recording are well known as remote-sensing techniques and telecommunication techniques.

The storage of raster data in digital raster data banks requires large storage capacities as the volume of raster data is often considerably higher than the volume of vector data of similar objects. Currently, magnetic discs are the best means for raster data storage. They also guarantee a high data-transfer rate to the computer and direct access to selected data selections.

The procedures of data variation have been developed primarily as operations of digital-image processing. 3/ Among the basic operations should be mentioned the radiometric transformation of the grey value of the pixels, the parallel motion of the entire data set and the arithmetic and logical combination of two data sets. More complex are macro operations, which include geometrical transformations, the thickening or thinning of pixels and the skeletonizing of features as a combination of basic operations, the filling of areas by assigning them feature codes, the filtering by reduction or supression of selected grey values or frequencies etc. The operations can be carried out by various types of computers.

The output of digital data can be produced on a graphics screen and an attached hard-copy unit, or by raster plotters. It consists of a pattern of cells (pixels), the constant size, the density and the arrangements of which define the visual impression of the output. Details are given below.

The major advantages of raster data handling as compared with vector data handling are the very rapid generation of raster data by means of scanners, the very rapid production of graphical output by means of raster plotters, the simpler and faster data processing and the simpler structure of the data banks. The major disadvantages are the requirements for large data-storage space and longer computer time, and the difficulty of definition of individual entities. Various efforts are being made to minimize these disadvantages by raster mode hardware and software improvements.

Other possibilities for utilizing the advantages of raster data handling are in the use of selected or specific processes only and their combination with processes of vector data handling or with other processes of cartographic production. Described below is the systematic development of software that allows rapidity of map production by raster plotters and its integration into well-known cartographic reproduction techniques for the fast production of various types of regional and national thematic maps.

USE OF RASTER PLOTTERS AS A MEANS OF MAP PRODUCTION

The output of digital raster data on a graphics screen and an attached hard-copy unit or a photographic device is normally used only to control and manipulate (interactively) the data. Various systems of graphics screens are in use and are described below.

The limitations in screen size, number of pixels, availability of colours and number and quality of the reproduced copies, as well as the costs of the installation and operation of the system, restrict the use of graphics screens for cartographic purposes.

Larger maps of better quality can be produced by raster plotters. Two major types of raster plotters can be distinguished: (a) photo-optical raster plotters; and (b) electrostatic raster plotters. 4/

Photo-optical or laser-beam plotters reverse the scanning process. A laser beam is projected pixel after pixel, scan-line after scan-line on photographic material of up to 1 m^2; its electronically controlled modulation produces square dots (pixels) of definite intensity. Advantages of this type of plotter are the high resolution of the laser beam which offers suitable pixels of 100, 50 or even 25 μm, and the use of rather stable films as drafting surfaces. They guarantee a very high standard of precision and registration for multicoloured reproduction. However, the very high price of installation and operation is a considerable obstacle to their wider application in cartography.

Electrostatic plotters used a prepared electrostatic paper of up to 2 m in width and 200 m in length as the draft surface. The paper moves over an array of styli; they can electrostatically charge on its round dots, which are made visible by a liquid toner. The resolution of the dots is coarser than that of the photo-optical scanner; it is currently 125 μm but will be improved soon to 85 or 65 μm. The use of paper as a drafting surface does not guarantee tonal homogeneity over the whole drafting area. The use of stable

transparent foils as drafting surfaces and of stabilized charging styli achieves visual homogeneity. In the near future, the higher resolution and the transparent drafting material will considerably improve the quality of the output of electrostatic plotters.

A great advantage is the fact that these plotters are relatively inexpensive and are available as standard peripherals in many computing centres. They are very often used as a substitute for line-printers only, while their capabilities as versatile tools of fine map production are not exploited. The use of a suitable software will turn these plotters into instruments for the much-requested rapid production of small-scale thematic maps for regional and national information and planning.

SOFTWARE FOR ELECTROSTATIC RASTER PLOTTERS

In general, electrostatic plotters are operated by software that is supplied by the plotter producers. This software is vector-oriented. As a first step, all graphical point, line and area data are transformed and stored as vectors, which have to be arranged in chorological order rather than chronological order for the second step, which is the transformation into pixels. In this method, the raster plotter is used as a substitute for a pen plotter only, and the advantages of the raster-mode data handling are lost.

To gain these advantages, a general plotter software had to be developed which transformed the data into pixels before they are stored for further operations. This preserves the chronological order of operations and allows the plotting of graphical layers one over another; it also allows a free choice of area pattern and drawing with a white pen. Software of this type, BIZEPS, has been developed and implemented by the Computing Centre of the Free University. 5/

The use of this general software was the necessary prerequisite of the development of a series of cartographic software in the Department of Cartography of the Free University. 6/ It has been named THEMAK, for "Thematische Karten" (thematic maps).

The theoretical base of the software package is that: (a) all maps are representative or demonstrative models of spatial pattern of reality; (b) the number of the models can be restricted to a few basic types; and (c) the correlation of the spatial pattern can be represented by the combination of their models. This concept can best be realized by a system of programs for the models and by the modular structure of the programs. Each type of graphical symbol can be selected and plotted individually; it can be combined and plotted together below or above other types of graphical symbols as well as by using various subroutines of the major programs.

The major programs of THEMAK are:

(a) LINIE, used to produced line maps (road maps, administrative boundary maps, river-system maps etc.);

(b) AREAL, used to produce choropleth maps or mosaic maps;

(c) QUADRA, used to produce square grid maps (with squares of graduated size or differences of grey value or dot maps) (see figure 138);

(d) AREDIA, used to produce choropleth or masaic maps with superimposition fo various diagrams (see figures 139 and 140);

(e) ISOLIN, used to produce isolin maps or layer-tint maps with the superimpostion of various diagrams;

(f) LDIA, used to produce choropleth or mosaic maps with the superimposition of flow-lines, isolines, layer tints or locational diagrams (see figure 141).

Even the basic subroutine LINIE shows the versability of the programs for electrostatic plotting. It contains the following operational possibilities:

(a) The plotting of lines in a variety of graphical structures (dotted, broken, straight; single, double, triple; positive and negative; and lines of different width);

(b) The plotting of selected lines in automatically generalized or rounded form;

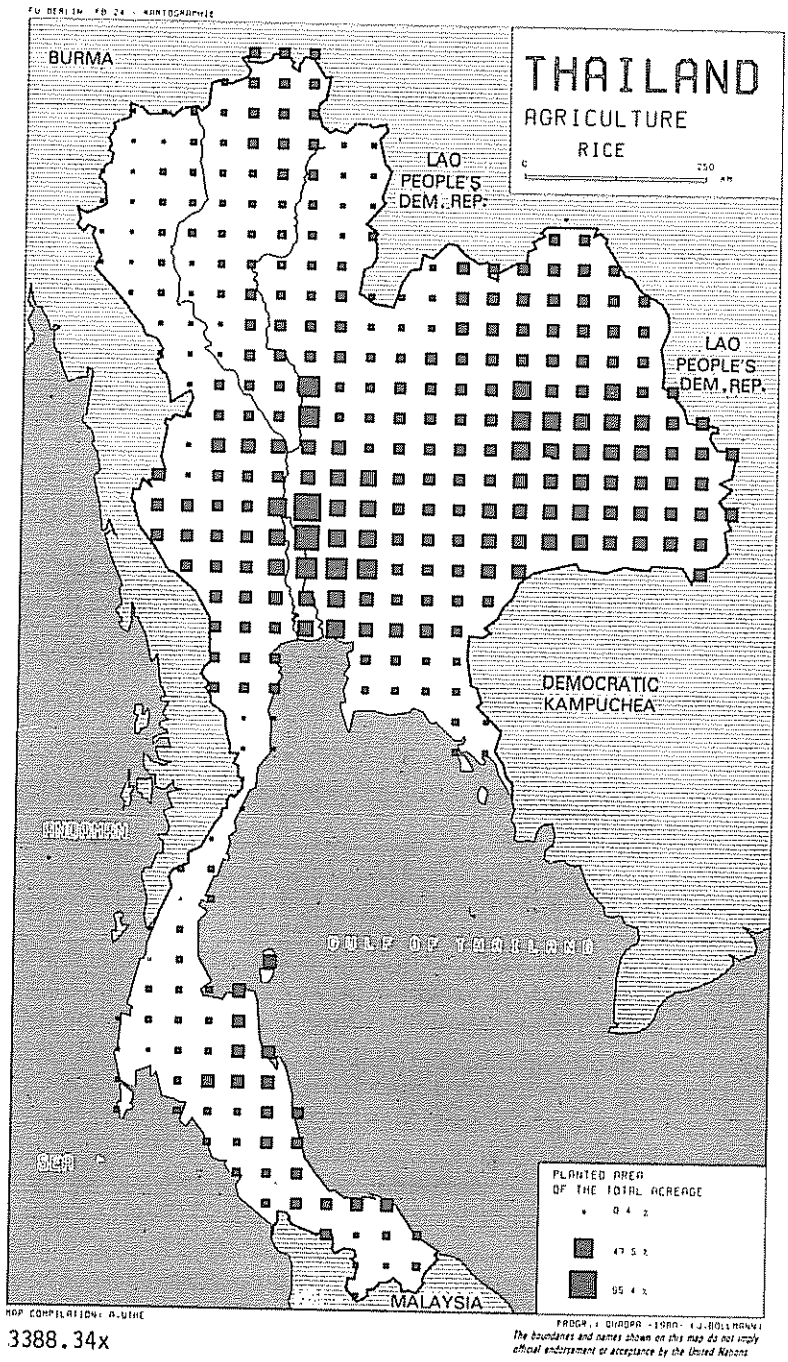
(c) The plotting of screens of 20 different structures and of two sets of different grey values;

(d) The plotting of letters and numbers of different size, width and form in any position within the map face and as marginal information.

In a similar way, subroutines are organized within each major program. The modular structure of the program system eases their application and permits their combination to create very complex maps with various layers of spatial information. The programs can easily be understood and used after only a short period of training. The statement is verified and the programs are illustrated by four maps made by students. The two maps of Thailand show simple maps, one (figure 138) using only one graphical variable (size of grid cell) on a topographic line and area base, the other (figure 139) using two variables (size of circle and scaled grey value of circle area). The map of Detmold (figure 140) is more complex, using a variety of lines, scaled grey values within area polygons and pie charts of different sizes and with different structural screens. The most complex map, of a river basin in Norway (see figure 141) contains several graphical layers, the pie-chart layer, the flow-line layer, the isoline layer and the line and area layer. All maps are in black and white and are reduced by 50 per cent for reproduction.

The capacity of the general solftware BIZEPS to create various area patterns and sets of graduated grey values inspired the development of area screens which could be used for muticoloured map production. The problem that had to be solved was the arrangement of the dots. 7/ The photographic screens used in map production achieve different grey intensities by screen dots of different

Figure 138. Federal Republic of Germany: map of Thailand with superimposition of squares of graduated sizes



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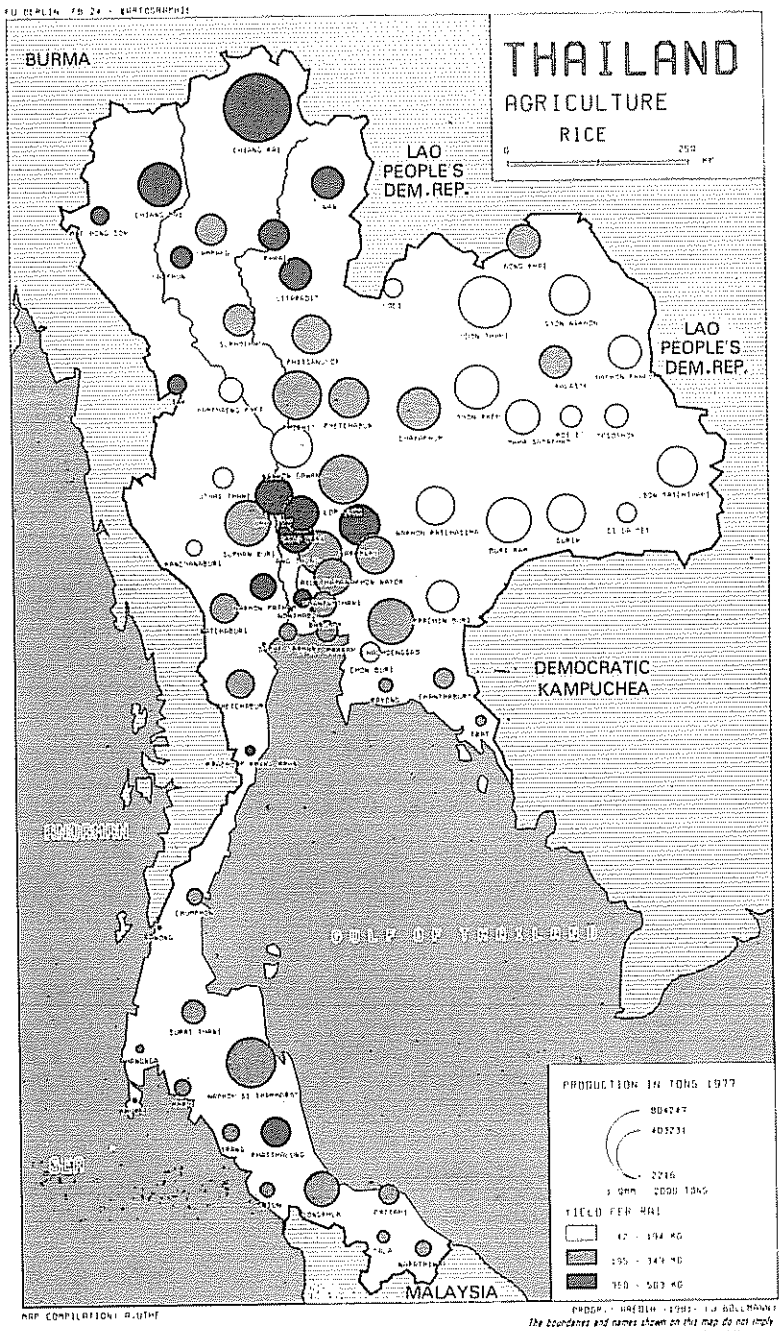
The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations

Figure 139. Federal Republic of Germany: map of Thailand with graduated symbols



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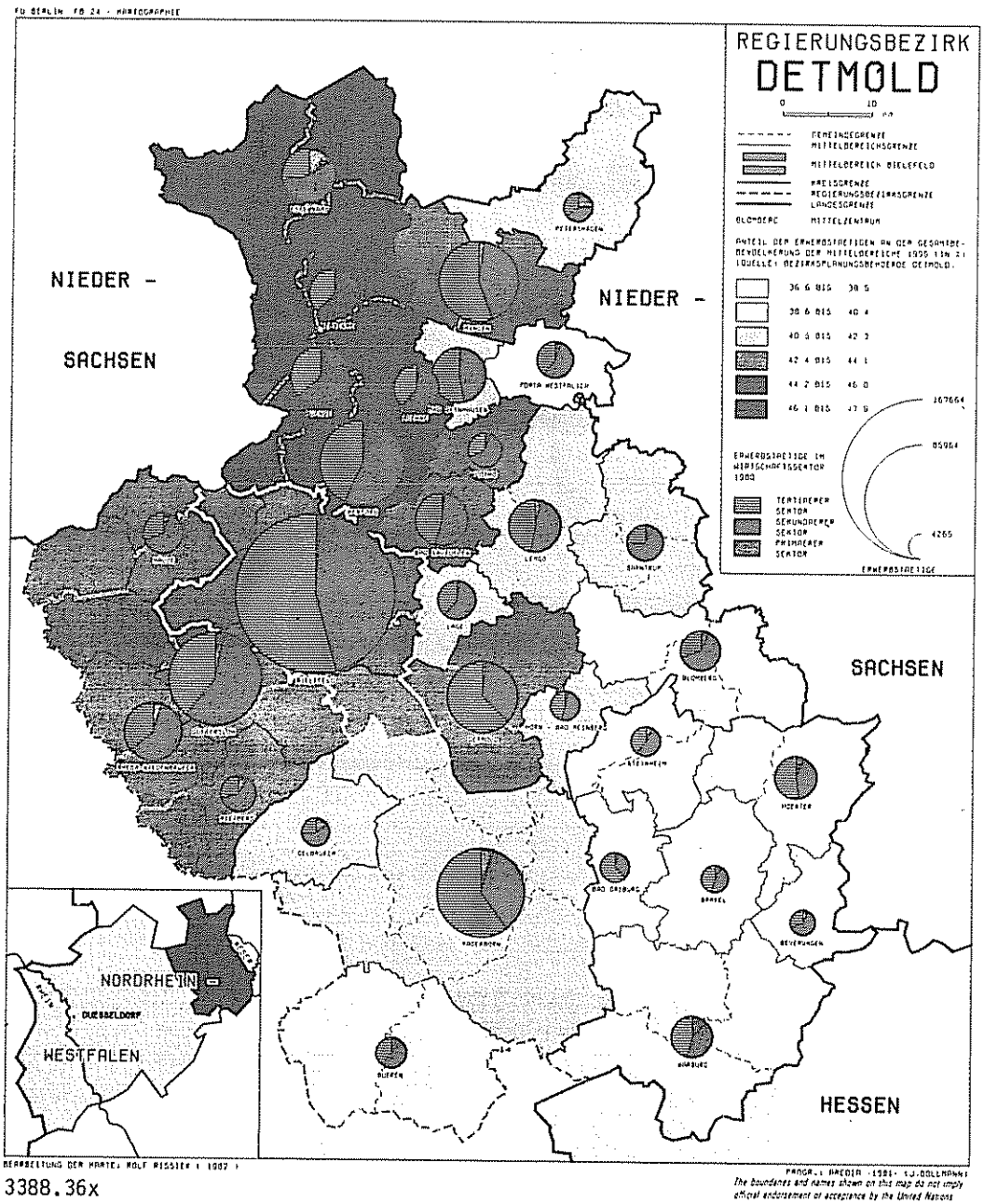
The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations.

Figure 140. Federal Republic of Germany: choropleth map of Detmold with graduated pie charts



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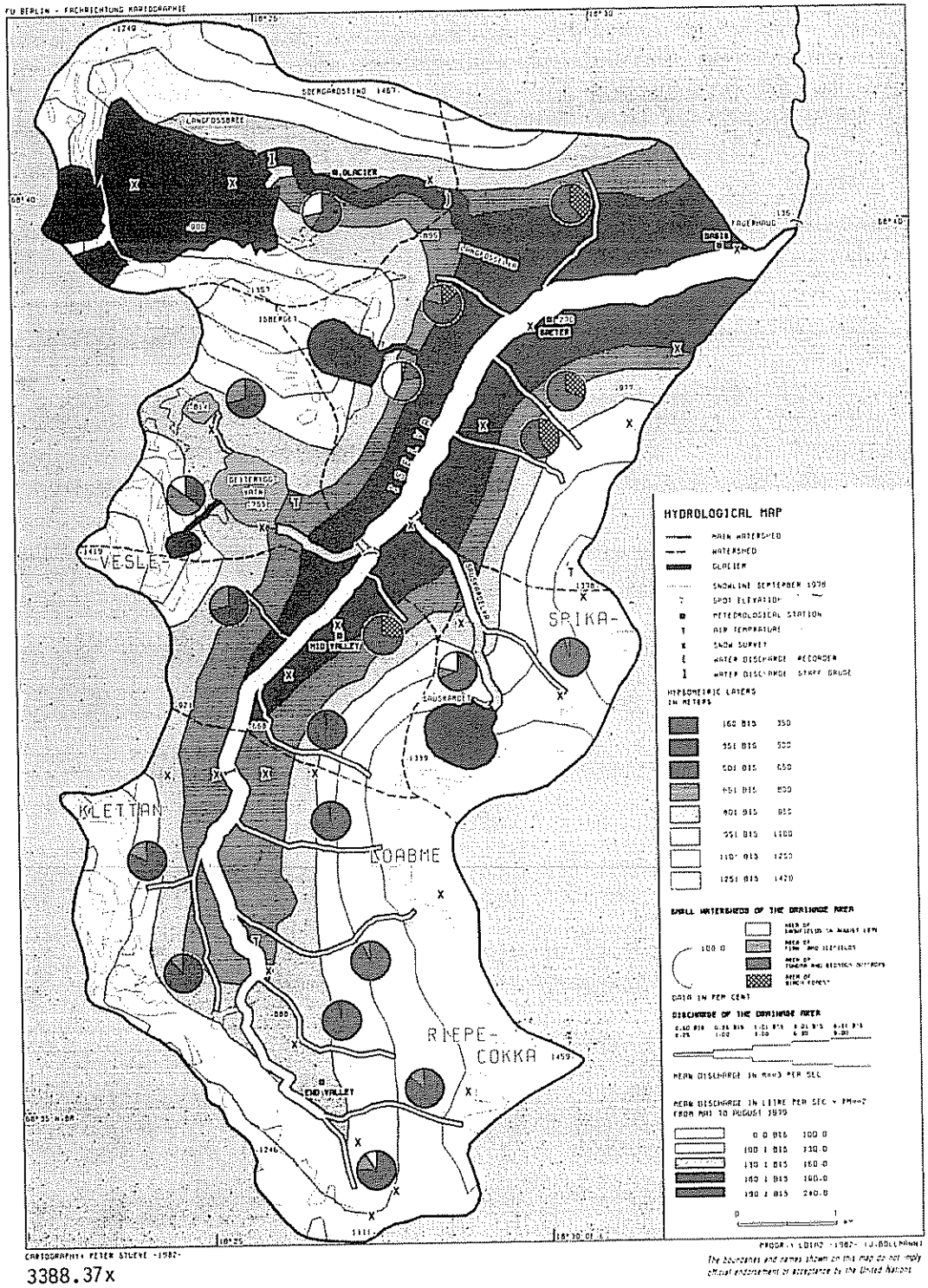
The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations

Figure 141. Federal Republic of Germany: map of Isdalen basin, Norway, with hypsometric layers and pie charts



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The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations.

size at equal distance; plotter screens achieve them by different distances of dots of equal size. For multicoloured map production, the dot lines of the photographic screens are turned mechanically to various particular angles in order to avoid a moiré effect, while the plotter screens have to be programmed and can be lined in very few angles only.

After some experiments in programming and perception, a set of plotter screens was accepted as being similar to the standard screens of the European standard four-colour offset-printing scale. It was included as a subroutine in all major programs of THEMAK as a means of colour separation. It permits the plotting of all graphical elements (dots, symbols, lines, areas and names) of one colour on one plot that can be used, without alteration, as the original for the four-colour printing process. In this way, the rapidity of map production by the electrostatic plotter can be used with great advantage to speed up map production by offset printing.

CONCLUDING REMARKS

The electrostatic raster plotter can be a very versatile tool in map production if it is operated by raster mode-oriented software. Plotters of this type are available at many computing centres where they can be employed as map-producing devices. National and regional statistical and planning offices should take advantage of the possibility of rapidly producing sets of maps as working-sheets or as originals for publication. In connection with printing offices, they could produce colourful informative and demonstrative maps of census results only a short time after the end of the census.

To achieve either immediate information by simple maps or the consideration of correlations by more complex maps, various elements of the system of cartographic models can be employed in all cases with great benefit as a means of thematic mapping.

Notes

1/ Mark S. Monmonnier, Computer-assisted Cartography: Principles and Prospects (Englewood Cliffs, NJ, Prentice-Hall, 1982).

2/ W. Weber, "Raster-Verarbeitung in der Kartographie", Nachrichten aus dem Karten- und Vermessungswesen, series I, vol. 88, pp. 111-190.

3/ A. Rosenfeld, ed., Digital Picture Analysis. Topics in Applied Physics, vol. 11 (New York, Springer-Verlag, 1976).

4/ P. Stefanovic, "Digital screening techniques", ITC Journal, No. 2 (1982), pp. 139-144.

5/ J. Bechlars, "BIZEPS and Rastergraphik", Nachrichten aus dem Karten- und Vermessungswesen, series I, vol. 89, pp. 7-9.

6/ J. Bollmann and U. Freitag, "THEMAK - a software package for automatic mapping by electrostatic scanplotters", paper submitted to the Eleventh

International Cartographic Conference of the International Cartographic Association, Warsaw, 1982, p. 9.

7/ J. Bollman, "Erzeugnung von Druckvorlagen für den Mehrfarbendruck mit Hilfen elektrostatisch arbeitender Plotter", Nachrichten aus dem Karten- und Vermessungswesen, series I, vol. 89, pp. 11-18.

COMPUTER-ASSISTED MAPPING*

Submitted by Kuwait

RESUME

La Municipalité de Koweït est sur le point de s'engager dans l'exécution d'un projet qui devrait l'aider à gérer efficacement et sans délai le cadastre et les services publics. Ce projet a fait l'objet d'une étude approfondie qui a duré près de deux ans. Une première phase a été consacrée à l'étude théorique des besoins et des possibilités et à la réalisation de petits projets pilotes. Ce travail a permis à la Municipalité de formuler un projet d'ensemble concernant trois de ses fonctions: établissement de cartes topographiques, tenue du cadastre et cartographie des réseaux de services publics. Le projet devrait démarrer en janvier-février 1983.

Durant les six ans prévus pour l'exécution du projet, le système sera mis au point et la responsabilité en sera confiée à des techniciens locaux formés à cet effet. On espère en outre le relier alors à l'ordinateur central du gouvernement pour assurer le transfert direct des données nécessaires.

Une fois le projet terminé, le Département de cartographie espère pouvoir disposer d'un système permanent de tenue du cadastre et d'établissement de cartes des réseaux de services publics, avec une banque de données à jour, et être en mesure d'informatiser ses opérations sur le terrain ainsi que ses activités cartographiques.

Ce système fournira également des données fiables aux ministères et départements qui s'occupent des services publics, de même qu'à tous les organismes qui participent aux divers aspects du développement du pays.

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* The original text of this paper, prepared by Jassem al Jassem, Deputy Director, Survey Department, Kuwait Municipality, appeared as document E/CONF.75/L.105.

Kuwait can be aptly described as a small and highly developed country with nearly all of its activities concentrated in the metropolitan agglomeration of the city of Kuwait.

During the past 25 years, the city has undergone fundamental and wide-ranging changes in its infrastructure. The old city area (Medina) has been progressively rebuilt to meet the demands of modern life while the outskirts of the old city have been systematically built up into an urban agglomeration. The inner city now consists mainly of business and commercial buildings, and the new urban areas house the former city-dwellers as well as the rapidly increasing expatriate population. Between 1957 and 1975, the population increased from 193,600 to 1,000,000. This increase has had a direct impact on the system of utilities, such as electricity, water-supply and telecommunications, all of which are necessary for modern life (see table 46).

CURRENT SITUATION OF MAPPING

Control network

The maps currently available and in use are from diverse sources, based on various geometrical systems and updated variously for different details. The evolution of the system of mapping in Kuwait Municipality is briefly reviewed here. In 1950, a fourth-order triangulation network for Kuwait City was based on one samll measured base; it is known as the "local system". This net was later extended to Jahra and on to the northern border. From the precision point of view, however, it was unacceptable because of intrinsic lacunae: it has originally been intended only for the city and subsequent profileration, rather than for a precise extension of control.

Table 46. Population and consumption of utilities, Kuwait City, 1965-2000

Year	Population	Electricity (megawatts)	Water-supply (litres per capita per day)	Sewage
1965	467 339	100	80	60
1970	738 662	110	120	85
1975	994 837	1 120	150	110
1980	1 355 827	2 200	200	150
2000	3 143 800	10 000	360	270

Notes: Utility figures are approximate. Figures for the year 2000 estimated assuming lower growth rate; the rate was 63 per 1,000 during 1975-1980.

Before this local system set-up, however, the Kuwait Oil Company (KOC) had made a first-order triangulation/traverse for the entire State of Kuwait, but this network is currently not available for use as such, although from time to time various survey firms have used certain points of the KOC net for supplementary control at some places.

Recently, the Kuwait Institute for Scientific Research established a first-order control net for the entire country. It comprises 43 monumented geodetic stations which can now be utilized for further surveys after due analysis of the net calculation.

Topography

The entire country is covered by line maps at 1:100,000, 1:50,000 and 1:25,000 scales as well as photomaps at 1:10,000 scale, of various times of survey. On a large scale, the settled areas of the country are covered by 1:2,000 scale topographic line maps, with each sheet covering an area of 1 x 1 km, while the major built-up areas are covered by line maps at 1:500 scale, with each sheet covering 250 x 250 m.

Cadastre

Kuwait Municipality makes and maintains the cadastral maps using the local system traverse points. This local survey is plotted on aluminium-backed 60 x 60-cm cardboard sheets. Earlier, some of these were mapped only at 1:2,000 or 1:1,000 scale, but all current mapping is at 1:500 scale, including revisions of previously mapped areas. Althogether, about 2,000 sheets exist, covering 32,000 cadastral plans (old plus new), of which about 7,000 plans are currently in use. Continuous updating of cadastral maps on the scales 1:1,000 and 1:2,000 is made as per the plotted cadastral sheets on the scale 1:500. But even large (2-m) discrepancies arising from updating are only graphically adjusted.

Utility mapping

Utility mapping is done on maps at 1:2,000 scale obtained simply by reduction of cadastral maps. The utility information is collected by contractors executing construction of utilities, streets and buildings. This utility mapping, however, suffers from certain basic flaws:

(a) Because 1:2,000 scale is small, the map is not positionally accurate but only serves as a conventional symbolic representation;

(b) The ground survey of utilities is not based on suitable control;

(c) Often utility mapping is done solely on planning information and no "as built" survey is done;

(d) Frequently, updating of utility information is not done simultaneously with works on the utilities;

(e) There is no central authority controlling utility mapping in terms of quality, timely updating, synthesis of information on diverse utilities, co-ordination of the various concerned ministries and contractors etc. An attempt to combine information on utilities from the various sources reveals large discrepancies, as is seen from figure 142.

SCOPE FOR IMPROVEMENT

The complete mapping system, as well as utility management in Kuwait, can be considerably improved by providing for the following criteria:

(a) An acceptable national geodetic network with necessary supplementary control in urban areas, on which all mapping will be commonly based;

(b) Standardization of utility mapping in terms of procedures, symbols, frequency of updating, larger scale, access to map information etc. Integration of all topographic, cadastral and utility information to ensure precision and avoid discrepancies.

National geodetic net

Utility mapping must be based on topographic and cadastral information, with reference to one homogeneous geodetic co-ordinate system, whose accuracy must be sufficient even for numerical cadastre. All topographic mapping will now be based on the new national geodetic network, which will be analysed and supplemented suitably to provide a precise homogeneous system of control points. The current 43 points are shown in figure 143. Their co-ordinates will be computed on the Kuwait Transverse Mercator (KTM) system with 48° East longitude as the central meridian.

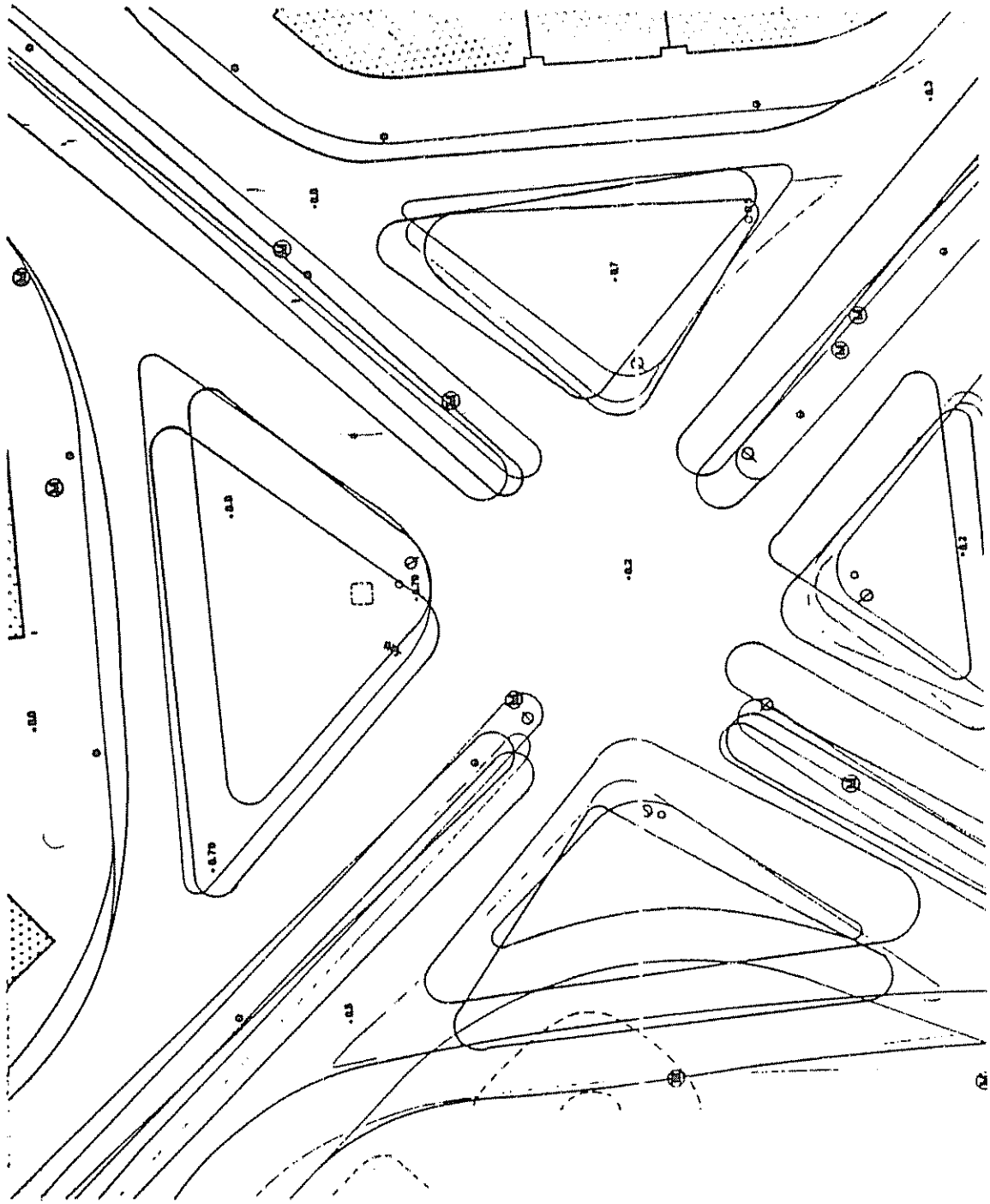
Cadastral documentation

The numerical cadastre currently in use in Kuwait is based on local traverse co-ordinates, which will have to be systematically transformed into KTM co-ordinates. Also, a suitable system of numbering of all cadastrally salient points (such as building corners, traverse points and boundary points) will be adopted so as to provide a unique address (number) for each point whose co-ordinate is needed. This will facilitate computerized calculation and automatic plotting with the necessary precision and speed.

Utility documentation

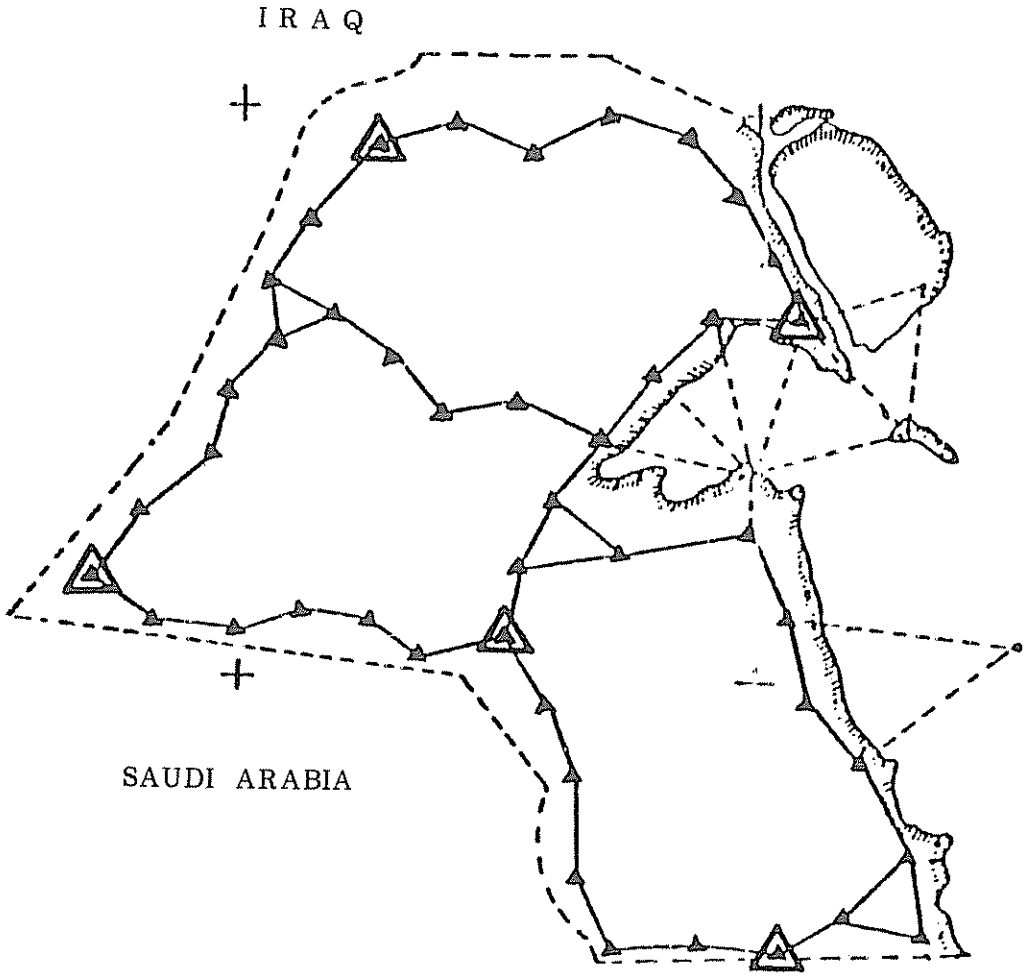
Basically, each type of utility information must form one transparent sheet overlay for the base map formed by combining topography and cadastre. Such multiple overlaying of utilities information can be done by conventional drafting manually or by interactive computer graphics. Collection of utility information for existing old utilities, however, will require skillful use of various procedures and sources. The existing utility maps and charts, regulations on land reserved for laying utilities, field-checks and location surveys,

Figure 142. Kuwait: geometrical reliability of utility maps at Abdul-Razzak Square, Medina



Note: For easier reading, utilities have not been shown.

Figure 143. Kuwait: current geodetic network



Approximate locations for doppler positioning

3388.38x

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including use of sensors and trenches, will all be used in proper priority order to obtain up-to-data and complete information.

CONCEPT OF KUDAMS PROJECT

It is very important that utility mapping be based on the combined updated topographic-cadastral map on scale 1:500, in order to serve its complete purpose. This leads to the basic need for all mapping to be based on one common precise geodetic co-ordinate system. The other important factor is of time needed to have the mapping system up to date and ongoing. This time factor leads to the use of automation, computerization and state-of-the-art technology in geodesy, topography, cartography and interactive graphics to establish the system, to bring it up to date and to keep information continuously updated.

Thus, the concept for the KUDAMS project was formed as an integrated system, shown in simplified form in figure 144.

Interactive graphics system

Utility documentation in a modern, fast-changing urban environment cannot be kept up to date by manual methods due to lack of speed as well as diversity of sources and authorities concerned. A computerized interactive graphics system, which will facilitate simultaneous overlaying of required utility information on precise base map and updating amendments through work stations at the concerned Ministries as well as Kuwait Municipality, is the answer to this problem.

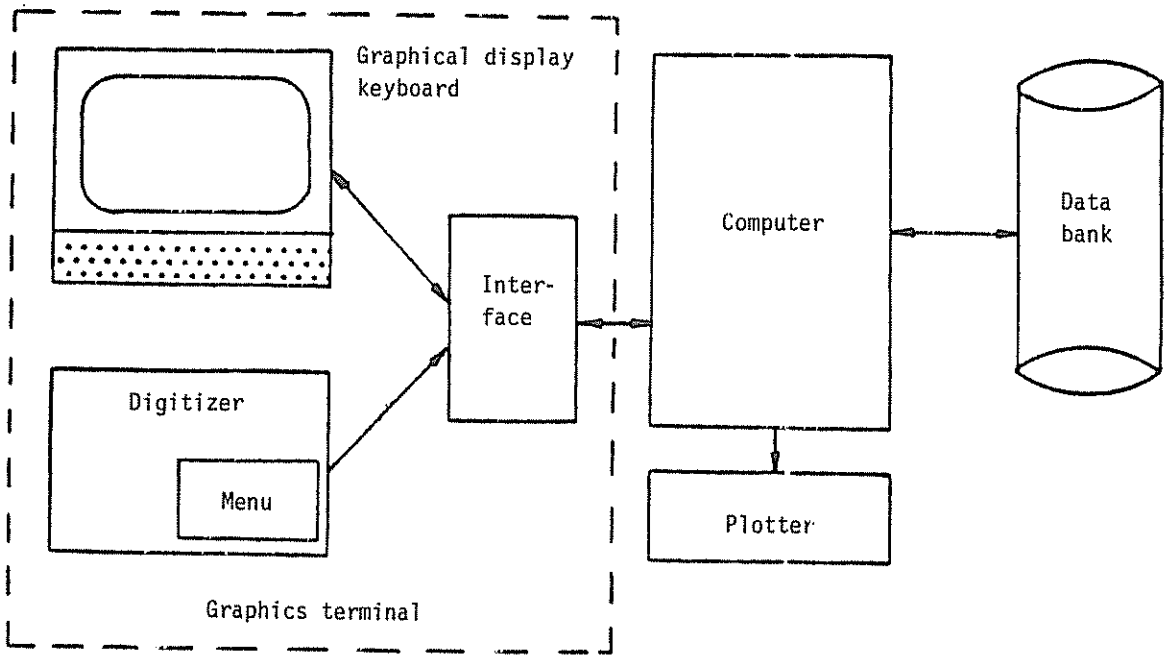
The data bank is to be established with graphical and non-graphical information on topography, cadastre and utilities all referred to one unique geodetic co-ordinate system and one unique point-numbering system. The computer controls input and output. Output can be plotted out graphically or as a digital terrain model. Amendments to information may be done interactively with good flexibility in working and data processing, such as: (a) uniform standards of mapping; (b) choice of scale for display and plotting; (c) quick amendments; (d) accurate overlaying as desired; (e) integrated information in data bank.

Proposed methods and equipment

Since this project is complex and involves technology not currently in use in Kuwait, it was decided to get the tasks executed by contract. Kuwait Municipality called for international firms of repute to pre-qualify for the tender; and from among those pre-qualified, six firms submitted tender proposals which were duly considered. The final decision on the firm to be awarded the contract is to be made during January 1983.

To facilitate the proper execution, the entire project is formulated into 14 phases of tasks, as listed below:

Figure 144. Kuwait: simplified principle of interactive graphics system; hardware components



(a) Completion and densification of the geodetic control network, including vertical control;

(b) Preparation of the property cadastre;

(c) Preparation for utility mapping;

(d) Hardware system;

(e) Software system;

(f) Digital photogrammetric mapping (including ground control and aerial photography);

(g) Computer works to restructure data tapes;

(h) Interactive input of utility data;

(i) Output of utility maps;

(j) Additional programming and demonstration of capability for other outputs;

(k) Demonstration of amendments execution;

(l) Training of Kuwait Municipality personnel in operating the system;

(m) Acquisition of a digital photogrammetric system;

(n) Acquisition of three total stations (for field surveys to maintain up-to-date information).

Detailed specifications for each phase, as well as for other adjuncts such as management software for the execution of project itself, have been made. There is provision to revise/update the specifications if found necessary so that the system will not become obsolete at an aerly date.

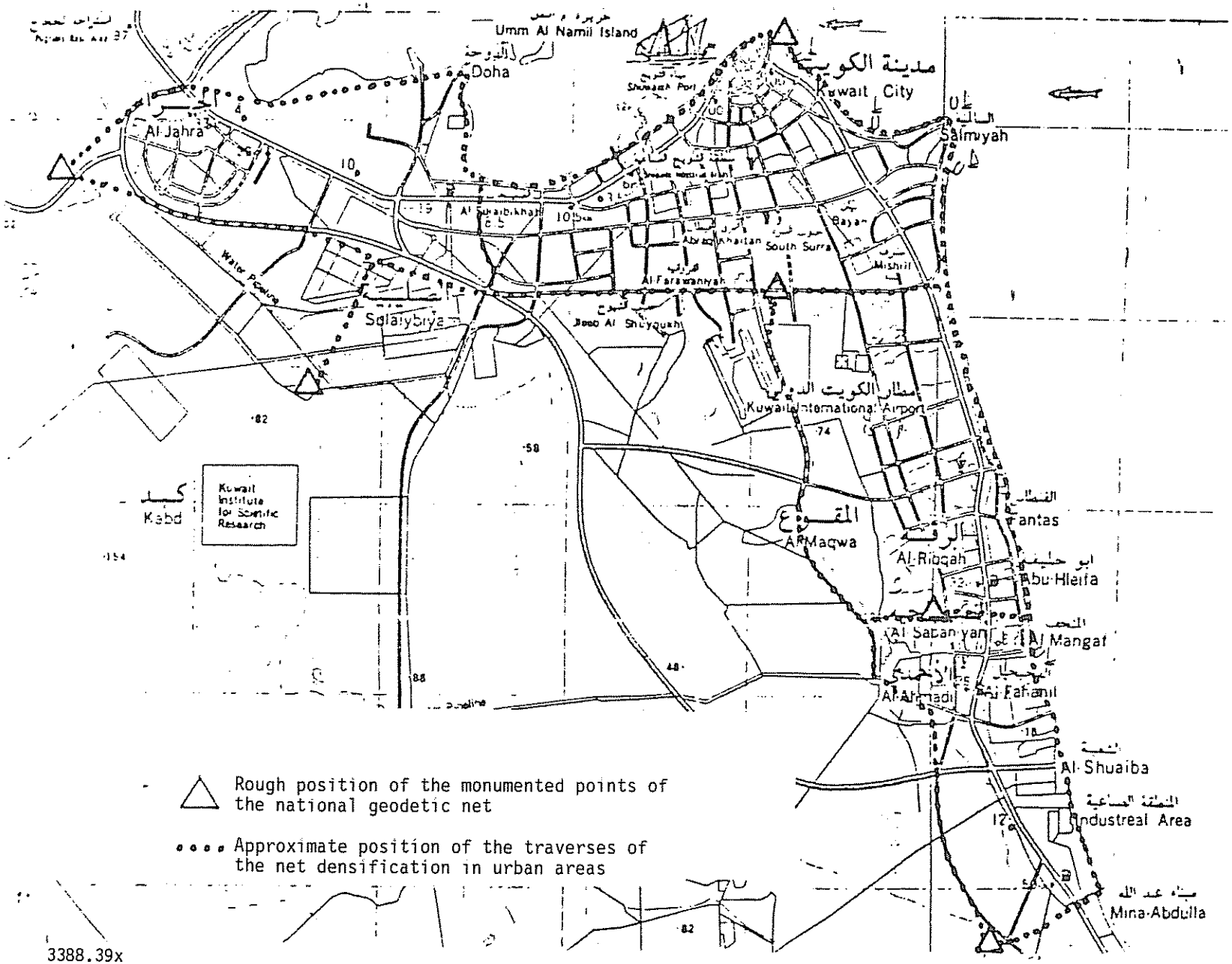
The overall area of the project is divided into four progress areas in terms of time-sequence priority so as to facilitate monitoring of the progress of project completion and scheduling.

Salient aspects of each phase

Control network

The national geodetic network comprising 43 first-order stations, is to be analysed and additional observations (60 new points) made to obtain the necessary geodetic horizontal control for the entire country. The location of the geodetic net is to be defined with satellite Doppler positioning of five stations, as shown in figure 143. The geodetic net is to be densified in urban areas by traverses of necessary precision, as indicated in figure 145.

Figure 145. Kuwait: densification of national geodetic network in urban areas



All co-ordinates of the network are to be in terms of the KTM projection, which is similar to the Universal Transverse Mercator (UTM) projection but has 48° East longitude as the central meridian. The reference ellipsoid is geodetic reference system 1980 of the International Union of Geodesy and Geophysics (Canberra). The adjustment will be the least-squares method, including all available observations with proper weights. The vertical control will be by precise spirit-levelling based on the existing bench-mark at Shuwaikh Port.

Preparation of property cadastre

The current numerical-graphical cadastre system is to be prepared for computerized processing. A suitable (11-digit) numbering system is to be made so as to provide a unique address for each point in a block and for each parcel in the cadastre. The co-ordinates of the points will be transformed from the present local system to KTM, blockwise.

Preparation for utility mapping

All available existing utility data, maps and charts are to be collected from the various authorities concerned and scrutinized for accuracy. All visible features, such as manholes, are to be identified and signalized for subsequent aerial photography (for aerial photographic coverage to date, see annex I). Sensors will be used to clarify ambiguous cases. Some of the proposals indicate use of sensors, such as SUN-55-1, CPR 404 and pile and cable locator.

Hardware

The hardware configuration must fulfill all software requirements and allow simultaneous operation of all components. The proposed configuration incorporates the latest colour raster tubes, 3,000-megabytes disc storage, five work-stations at the Municipality computer centre and five remote work-stations at the three concerned Ministries, a printer-plotter, a precision plotter etc. as shown in figure 146.

Software

The software must be compatible mutually with the hardware and the functions/tasks desired of the system. It is necessary to use menu tables and to reduce shift operations by hand. Suitable software to monitor the execution of the project and to show the extent of participation of each technical personnel is necessary.

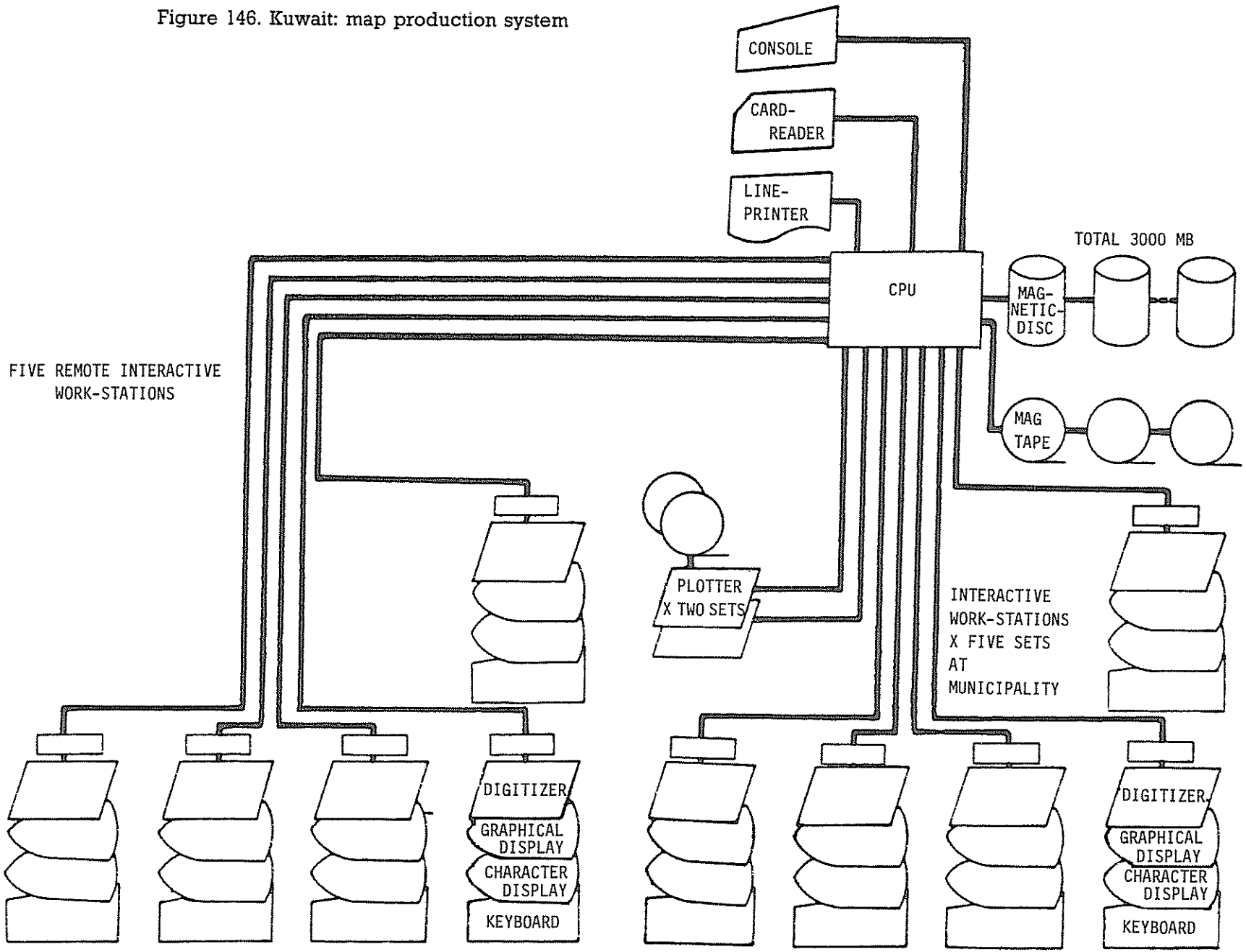
Digital photogrammetric mapping

The project area is to be progressively mapped for topography on the scale 1:500, and all relevant topographic details are to be digitally recorded on tape to facilitate subsequent utility mapping.

Restructuring of data tapes

The co-ordinates of the boundary points and house corners in the local system are to be transformed into the KTM system, blockwise, using the

Figure 146. Kuwait: map production system



co-ordinates of the traverse points in both systems. Cadastral map-sheets will be plotted digitally using the final KTM co-ordinates. Edges will be matched properly.

Input of utility data

All possible system supports with intercative graphics work-stations will be fully used. Where digital mapping of underground utilities cannot be completed with the information on topographic tapes and field-checks, the priority of using additional information will be: (a) additional measurements (sensor); (b) additional digital information; (c) information on utility reservations; (d) digitizing from existing utility maps.

Output of utility maps

When the information for a mesh area (map-sheet 250 x 250 m) is complete in the computer storage, a set of paper plots--one plot per type of utility--will be made using the topographic and cadastral base information. This set will then be ckecked and amended.

Additional programming

Ownership certificates, cadastral lists and mapping of the freely definable shares are all intended.

Amendments

The system should be capable of amending digitally and using the additional information listed in the section on input of utility data.

Training

During the project execution period, the personnel of Kuwait Municipality will be trained to be able to take over and run the complete system. Such training will include all tasks of the project, from control network observations to amendments to existing utility information and plotting out.

CONCLUDING REMARKS

The project is designed for completion in six years, during which time the up-to-date system will be established and will be taken over by trained Municipality staff. Furthermore, it is hoped that the system can then be suitably interacted with the central computer of the Government for direct transfer of requisite data.

At the completion of the project, the Survey Department hopes to have set up an ongoing system of cadastral and utility mapping with an up-to-date data bank and to have switched the topographic and geodetic survey aspects of the department on to electronic and automated methods of field survey as well as cartography. (For current personnel and equipment, see annex II.)

It will also provide safe and reliable data to the Ministries and departments concerned with utilities, as well as to all agencies involved with overall national development.

Annex I

AERIAL PHOTOGRAPHIC COVERAGE OF KUWAIT

Kuwait has been covered by aerial photography many times during the past 30 years. The sequence of such photography was carried out as follows:

(a) In 1951, Kuwait City was photographed to produce photo mosaics at 1:13,000 and 1:2,000 scales, covering an area of 8 km^2;

(b) In 1969, Kuwait City and the suburbs were photographed to produce the following scales: 1:40,000 scale photography; 1:2,000 scale line maps with 1-m contour intervals; 1:10,000 scale line maps with 5-m contour intervals; 1:2,000 scale of photography;

(c) In 1962, the neutral zone between Kuwait and Saudi Arabia was photographed to produce photo-mosaics at 1:50,000 scale;

(d) In 1964, Kuwait City and a part of the developing area were photographed as follows: 1:10,000 photographic scale; 1:10,000 photo mosaics for the area from Al-Jahra to south of Shuaiba; 1:20,000 photography scale; 1:20,000 scale of line maps; 1:2,000 scale of photo mosaics for different areas;

(e) In 1967, Kuwait City was photographed to produce: 1:10,000 scale for photo mosaics; 1:20,000 scale photo mosaics for part of the south-eastern seashore; 1:40,000 scale photo mosaics; 1:10,000 and 1:2,000 photography scales;

(f) In 1971, the neutral zone was photographed at 1:10,000 and 1:2,000 scales of photo mosaics covering 3,171 km^2;

(g) In 1974, aerial photography at scale 1:7,500 was carried out for some selected parts of the developing area, producing maps on the scale 1:2,000;

(h) In 1976, the State of Kuwait was photographed as follows: 1:3,000 scale aerial photography for Kuwait City to produce 1:500 line maps (figure 147), covering 53 km^2; 1:7,500 scale aerial photography for the developing area covering approximately 1,000 km^2 to produce 1:2,000 line maps (see figure 148); 1:32,000 scale aerial photography to produce 1:10,000 photomaps (figure 149) for the entire State;

(i) In April 1980, the developing areas of Kuwait were photographed at two different scales, 1:7,500 and 1:3,000 to revise the 1:500 and 1:2,000 scale maps and to produce new line maps for new areas (figure 150). All aerial photography and mapping were carried out by foreign firms.

Figure 147. Kuwait: line map at 1:500 scale of 1976 project for residential area of Kuwait City

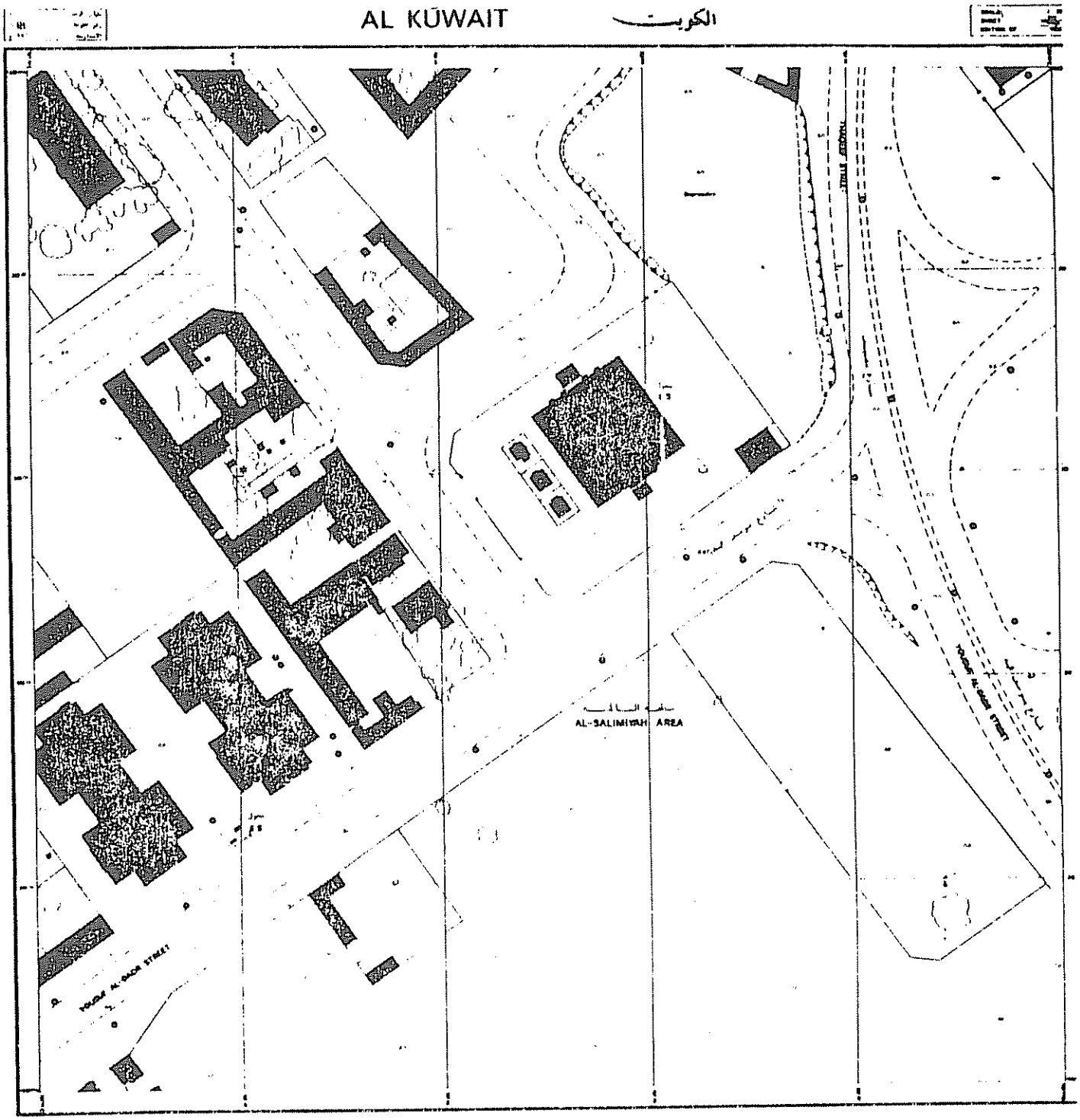
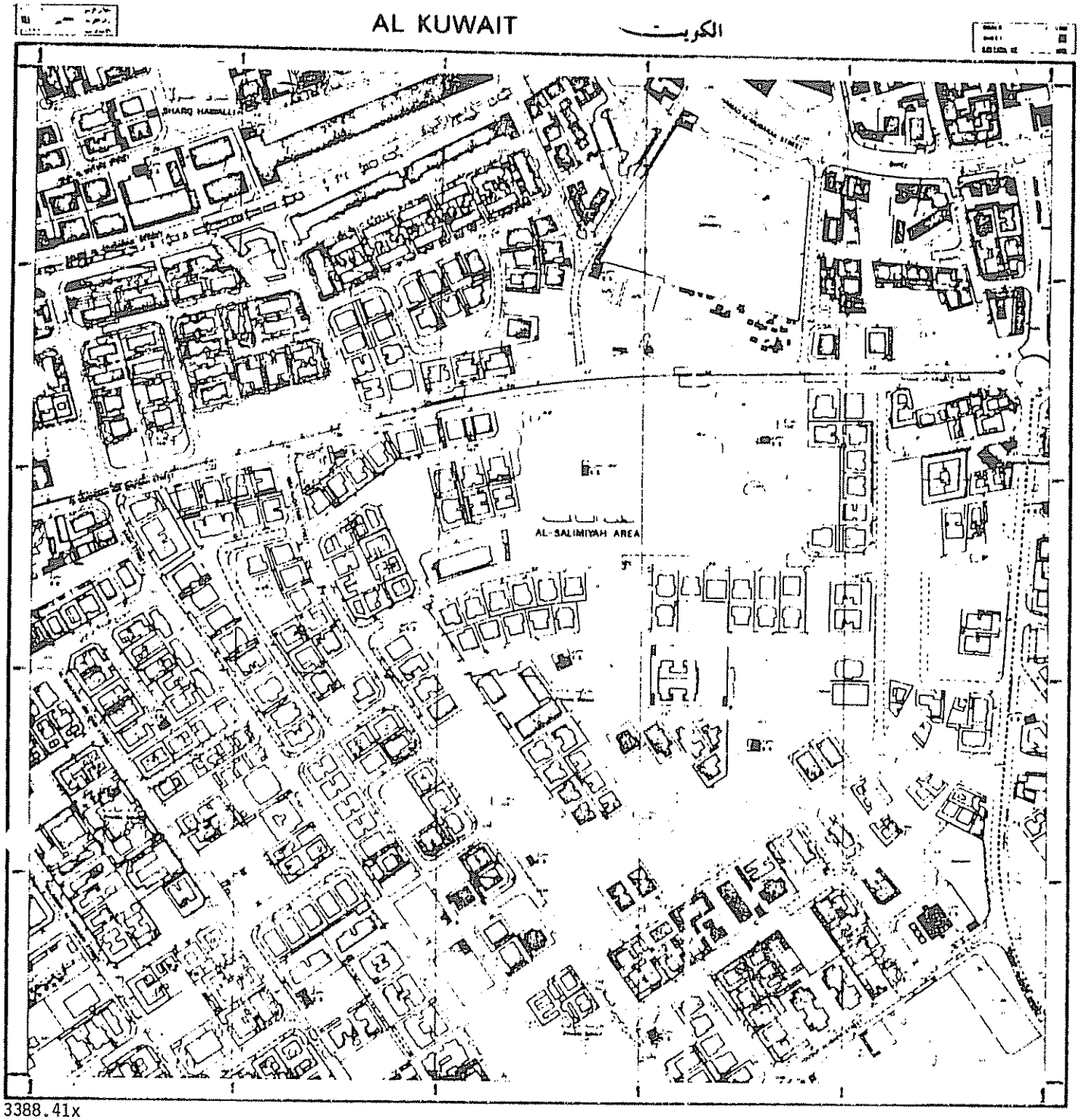
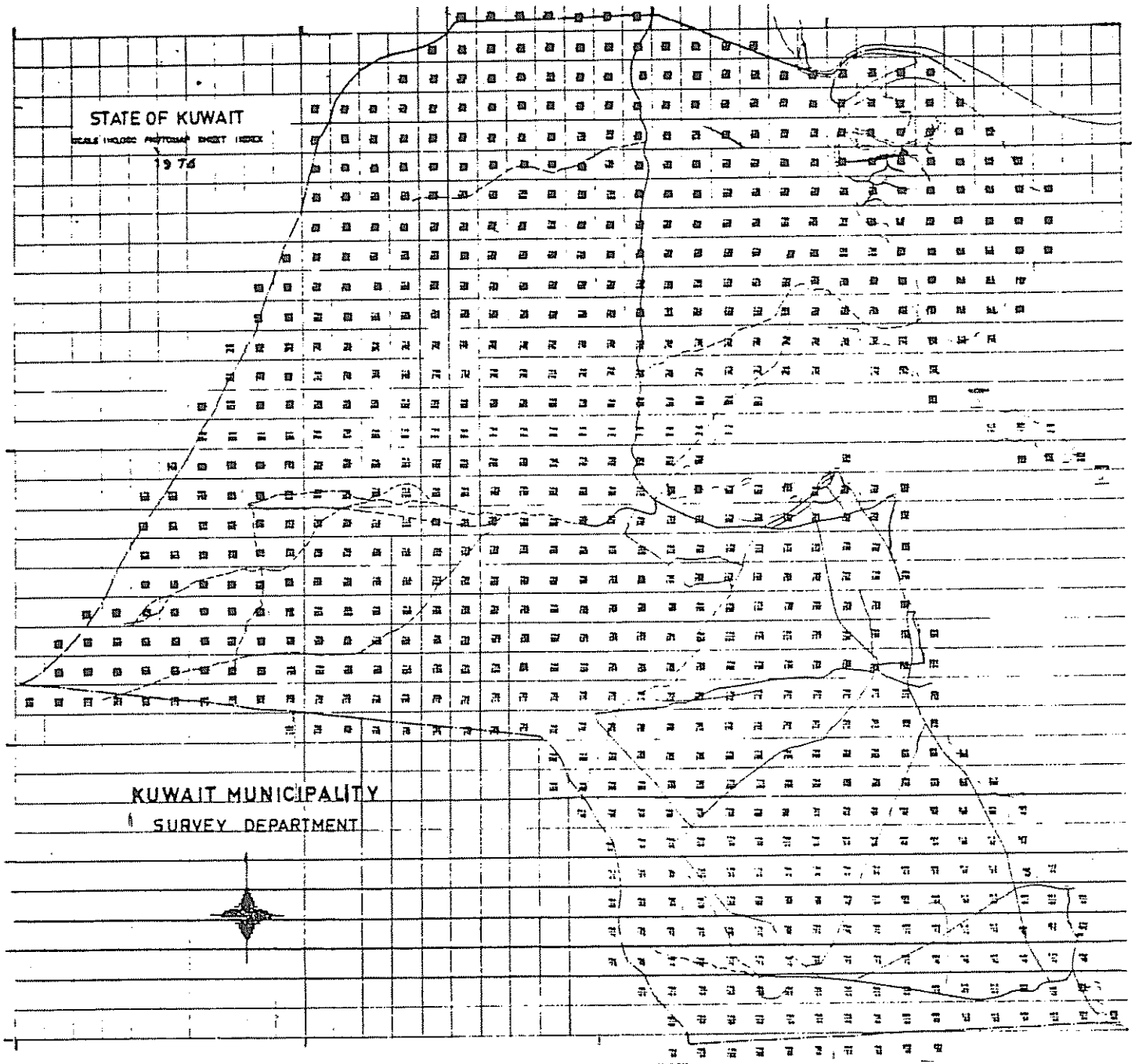


Figure 148. Kuwait: line map at 1:2,000 scale of 1976 project for residential area of Kuwait City



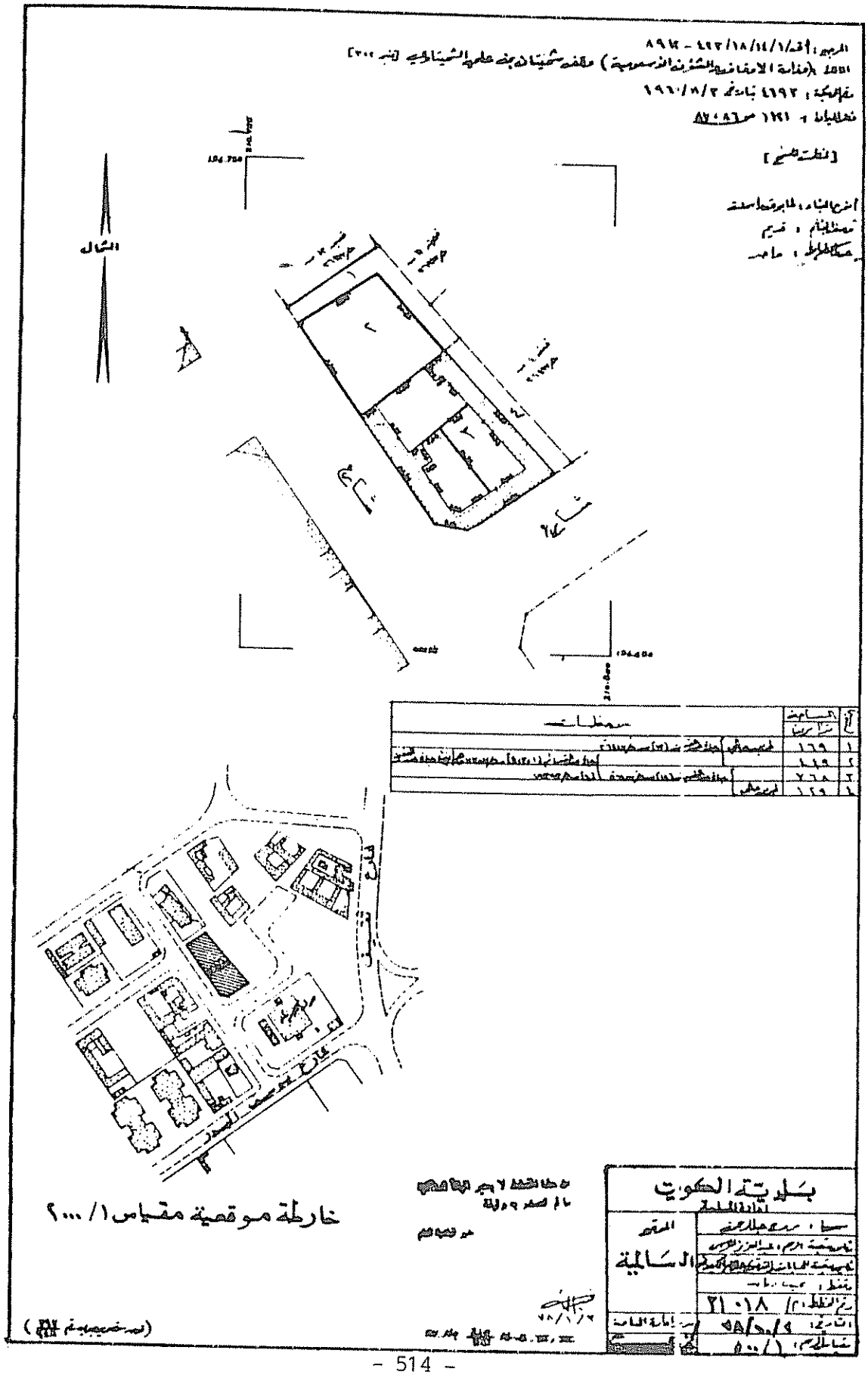
3388.41x

Figure 149. Kuwait: aerial photography of Kuwait City; photomap index at 1:10,000 scale, 1976



MUNICIPALITY OF KUWAIT

Figure 150. Kuwait: survey plot at 1:500 scale for land and building registration, with a location map at 1:2,000 scale



Annex II

PERSONNEL AND INSTRUMENTS OF SURVEY DEPARTMENT

The field surveying section consists of 45 surveyors and 150 labourers. The cartographic section has a staff of 25 draughtsmen, 10 technicians for computations and checking drawings and 6 clerks for map and sheet storage. The transactions section has a staff of 35 personnel for land-registration and filing. The photographic section has a staff of 12 technicians.

The field surveying section has the following instruments:

Theodolites

Make	Quantity
Wild T3	2
Wild T2	16
Wild T1	4
Wild T16	5
Wild RDII	4
Wild Distomat DI 3	1
Wild Distomat DI 35	1
Wild Distomat DI 20	1 (on order)
Wild Distomat DI 4	2
MD 60 siemens Albis	1
Watts 2	8
Gyrosscopic mom Gi-B1	1

Levels

Make	Quantity
Wild NA 1	3
Wild NA 2	15
Watts	4
Kern	3

Plane tables

Make	Quantity
Wild	3
Kern	2

The photographic section has th following instruments

1. Klimsh super Autorica 101 copy camera;
2. Pictorial contact printer 127 x 163 cm conventional;
3. Milligan electronic contact printer for aerial films;
4. Wild E-1 rectifier enlarger;
5. DR 70 Agfa film drier;
6. Pictorial film drier.

COMPUTER-AIDED MAPPING*

Paper submitted by New Zealand

RESUME

On trouvera dans le présent document un bref aperçu des progrès réalisés par le Département des levés topographiques de la Nouvelle Zélande dans le domaine des systèmes de cartographie assistée par ordinateur.

En 1978, le Département a créé un service de cartographie automatisée qui est à présent opérationnel en cartographie cadastrale et dans certains domaines de la cartographie aéronautique. Le service est doté de deux mini-ordinateurs, de trois convertisseurs analogique/numérique interactifs et de deux appareils de restitution à plat.

Dans le cadre du programme de cartographie cadastrale, on utilise un convertisseur analogique/numérique pour saisir les traits et les données descriptives figurant sur les cartes du Commonwealth, pour restituer un produit à des échelles métriques et selon une présentation adaptée aux besoins particuliers du Département, avec la possibilité supplémentaire de réaliser pour d'autres utilisateurs des cartes à toute échelle et de toute présentation. On applique des centroïdes visuels à l'ensemble des secteurs routiers, des parcelles de terrain et des détails hydrographiques. On associe les sommets de tous les polygones à ces centroïdes, qui sont eux-mêmes associés aux fichiers descriptifs de chaque polygone. On établit les minutes en extrayant les données pertinentes par l'intermédiaire des centroïdes et on peut établir la carte définitive en fusionnant les données saisies.

On est également en train d'élaborer une base de données aux fins de la cartographie aéronautique. On a déjà réalisé certaines cartes et l'on se propose, d'ici le début de 1983, d'automatiser entièrement l'ensemble des dessins au trait et des masques.

Le Service de cartographie automatisée assure également la mise à jour d'un répertoire de tous les lieux et rues de Nouvelle-Zélande qui fait autorité. Utilisé essentiellement à des fins électorales, ce répertorie sera incorporé dans le programme de cartographie cadastrale.

On met également au point des programmes permettant d'établir des cartes topographiques à partir de données recueillies sur le terrain. Les essais débuteront à la fin de 1982 et on mettra finalement

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* The original text of this paper, prepared by Graeme R. Crocker, Department of Lands and Survey, appeared as document E/CONF.75/L.40.

sur pied un service à l'intention des géomètres des secteurs public et privé.

On prévoit pour l'avenir de réaliser des études de faisabilité concernant une base de données topographiques numériques. La réalisation de cette base et sa fusion avec la série cadastrale initiale permettront au pays de se doter d'un réseau d'informations foncières universel.

The Department of Lands and Survey has been developing computer-aided mapping systems since 1978, when it established the Computer Mapping Unit to research and develop such mapping. The unit is now entering the production stage in cadastral mapping and some aspects of aeronautical charting. Currently, the Unit has two minicomputers (DEC PDP 11/34 and PDP 11/24) operating under RSX-11M, three interactive digitizing stations and two flat-bed plotters, the latest acquisition being a Calcomp 7000-series flat bed with pressure pen feed and tangential scribe and art and peel options.

BACKGROUND

The Surveyor-General, as head of the Survey and Mapping Division of the Department of Lands and Survey, is reponsible for civil and military surveying and mapping activities in New Zealand. In 1973, these activities were metricated, with the resultant requirement to convert all existing imperial mapping to metric. In terms of cadastral record maps, there was a need to convert some 20,000 manually drawn sheets in 12 separate Land District Offices. On these map-sheets are recorded the day-to-day changes in New Zealand's cadastral subdivisional pattern. The effort was calculated to take some 45 years, utilizing the then existing drafting resource, a resource which has continued to decrease under successive Governments' economic measures.

As a result, the Surveyor-General authorized the establishment of the experimental Computer Mapping Unit to develop programs for the generation of digital cadastral record maps from existing imperial sheets. An initial purchase of equipment, comprising a PDP 11/34 (64K) computer, digitizer, graphics screens and plotter, was made.

CADASTRAL MAPPING PROJECT

The New Zealand land title survey system is nationally controlled by a triangulation network to which all subdivisional surveys are tied. Parcel boundaries are monumented and all surveys are supported by survey plan, surveyors' field notes and traverse sheets. Each ground point is co-ordinated in terms of a local meridional circuit origin or geodetic datum.

As subdivision occurs and the survey is approved, the cadastral record maps are updated to show the most recent subdivisional pattern. Imperial scales of one and two chains to an inch for urban areas and 10 chains to an inch for rural areas were originally used; metric scales have now been established at 1:1,000 and 1:2,000 scales for urban and at 1:10,000 scale for rural areas,

based on a subdivision of the national 1:50,000 scale mapping series on the New Zealand map grid.

The objective of the cadastral mapping package is to capture the imperial record maps, which have been accurately plotted and maintained by digitizer and to provide output at specified scales and format for departmental use but also with the facility to produce at any scale or format to any user specification. Because of the ability to convert any parcel boundary point to ground truth, through the traverse sheet tabulations, the high-accuracy digitizing capability of some of the modern digitizers has not been considered a necessity in the New Zealand system, since it is more important to collect a concise relative association of data capable of being updated to ground accuracy in order to meet a specification.

In this way, the digitizing process has been somewhat simplified in order to obtain rapid capture of the geographical component of the cadastre (points, lines and streams) and then to associate those data with the descriptive or tabula data by use of a geographical visual centroid.

At the outset of the digitizing, the visual centroid is applied to all road sectors, land parcels and hydrographic features (rivers, lakes etc.). Bounding points of all polygons are then associated with the centroid, which is in turn associated with descriptive files for each polygon. Plot files are created by extracting the relevant geographical and descriptive data through the centroid.

Much of the effort made in the cadastral programs has been concerned with the design of a plotting procedure whereby the descriptive data for plots at any scale can be placed automatically at fount sizes appropriate to the specified scale. The manual or interactive placement of type is only used in extreme cases, when either the parcel is too small to contain the descriptive data, in which case data may be arrowed in, or where, because of scale, hydrographic names need to be relocated for better placement with the feature.

In brief, the significant attributes of the cadastral program are:

(a) Digitizing of data from a multiple set-up of drawn sheets simultaneously, to create a "window" on the new mapping format. Within the "window", sheets with different distortion factors can be captured as a composite sheet, whereby the gaps between the sheets are automatically eleminated;

(b) Standard line-editing procedures by graphics screens, with the included feature of being able to adjust digitized co-ordinates to ground truth by upgrading from tabulated field data;

(c) Plotting routines that automatically produce in excess of 95 per cent of the output of the completed map;

(d) Merging of data captured at varying scales to produce map output to any new specified scale and format.

RESEARCH AND DEVELOPMENT

The Unit is currently working on several research and development programmes with universities in order to improve the current system. The most significant of these projects are:

(a) The use of voice recognition modules (VRM) attached to digitizers to expedite the entry of descriptive data. The objective is to enter descriptive data at the time of centroid capture, with an estimated saving of some 40 per cent over current methods;

(b) Automatic association of parcel boundary points with the centroid. As not all parcels are rectangles, there has been some difficulty in associating all boundary points to the specific centroid. Currently, this is handled manually. The University of Waikato is to investigate the feasibility of facilitating this procedure automatically.

AERONAUTICAL CHARTING

Early in the development of the Computer Mapping Unit, some experimentation was undertaken in computer-assisted aeronautical charting. At first, a program was written to produce holding patterns. This program successfully produced atlases of holding patterns for all existing variables of altitude and air speed with the facility to subsequently produce one-off charts as new variables were required. In less than three weeks, 96 charts were completed, compared with normal production averaging six days per chart.

Grid and projection software was then developed and coupled with a digitized coastline of New Zealand on the scale 1:500,000. Final scribed continuations of graticules and coastline are now being produced on demand for all new mapping.

A data base of air space and navigational aids is now being compiled with the aim of producing automatically all line drawings plus masks for aeronautical charting. It is hoped that it will be in production in early 1983.

INDEX OF PLACES AND STREETS

The Computer Mapping Unit has compiled and currently maintains a computerized index of places and streets in New Zealand for electoral purposes. All places and streets have been authenticated and related, in terms of cadastre, to electoral and territorial local authority boundaries, and geographically to map-sheet references. Listings are obtainable by any key. This index is maintained on a day-to-day basis as changes occur and will eventually be incorporated in the cadastral mapping base to provide map output.

SURVEY PLAN DRAWING

Programs are being written to facilitate the drawing of survey plans from raw field data. This development is entended to provide a service to the survey profession in both the governmental and private sectors, on a bureau system. Trials are exepcted to begin in early 1983.

FUTURE DIRECTIONS

The initial move into cadastral mapping has proved to be both feasible and economic. It is intended that a move will be made from the developmental to the production stage over the next few years.

A second phase of development, now being entered, is to examine the feasibility of developing a digital topographic data base. Areas of concern are the initial capture of digital data from computer-enhanced stereoplotters, the methods of converting existing data to digital information and the development of a geographical data base that can be merged with the cadastral base.

If successful, this programme will enable the Department to provide a geographical data base suited to the production of thematics which will meet the demands of a wide range of users in the planning, socio-economic, scientific and administrative fields. Essentially, the concept is the development of a geographical land information system.

It is expected that this area of development will take many years to complete and it is not without significant cost and benefit implications. The Department has taken the view that, as New Zealand's mapping agency, it needs to be involved in the future changes in technology and techniques as they apply to the science of mapping, and that a gradual implementation scheme is the only way to ensure that both equipment and trained personnel shall be available to meet increasing demands.

STRUCTURING OF URBAN DATA WITH THE HYPERGRAPH-BASED DATA STRUCTURE MODEL*

Paper submitted by Thailand

RESUME

Les données cartographiques peuvent être structurées de différentes manières, suivant les divers modèles de structure des données: arbres enracinés, réseaux, etc. Toutefois, aucune d'elles, ni aucune de leurs combinaisons ne sont suffisantes.

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* The original text of this paper, prepared by V. Satharanond, Survey Division, Royal Irrigation Department, appeared as document E/CONF.75/L.26.

Le HBDS est un nouveau modèle fondé sur la théorie des ensembles et le concept d'hypergraphe. Il est composé de quatre types de données abstraites - à savoir: la classe, l'objet, l'attribut et le lien qui correspondent aux notions d'ensemble, d'élément, de propriété et de relation. Ces quatre types de données permettent de structurer tout phénomène, aussi complexe soit-il et aussi nombreuses que soient les données.

Bien aue le modèle HBDS puisse être appliqué dans tous les domaines, il est particulièrement approprié à la cartographie, étant donné que ce phénomène est très complexe et difficile à réaliser par tout autre modèle de structure des données existant. Le présent document indique la manière dont les données urbaines peuvent être structurées et mises sur ordinateur. Les données sont protégées, peuvent être partagées simultanément, sont transférables et peuvent être diffusées et résider en mémoire centrale, la mémoire étant complètement dissimulée à l'utilisateur. C'est pourquoi, en utilisant le système HBDS, l'utilisateur peut manipuler ses données sans restriction comme les autres systèmes d'exploitation de bases données.

Cartographic phenomena are represented according to different modes corresponding to grids, isolines, topological boundaries and localized symbols. These phenomena have their own structures wich must be recognized before their representative data can be introduced into the operative system. In most cases, however, the structure of a particular cartographic phenomenon is not recognized and data are structured according to the choice of a data structure model that is available on the computer. As a consequence, the application is incorrect for the real world that the cartographer is trying to represent.

The hypergraph-based data structure (HBDS) model, 1/ a new model based on the set theory 2/ and the hypergraph concept, 3/ is composed of four abstract data types: class; object; attribute; and link. These types, which correspond to set, element, property and relation concepts, permit the structuring of any phenomena, no matter how complex nor how numerous the data.

The HBDS model is the best model for structuring cartographic phenomena. It offers possibilities of structuring any type of relations between cartographic elements. These relations, both hierarchical and non-hierarchical, cannot be completely defined by any other existing models. For this reason, the cartographic data banks of many countries are still not properly organized.

The entire picture is too complex to be presented in this paper; therefore, only that part of it which concerns urban data structure is covered. The author would like to emphasize that this applciation has already been realized and implemented on the CDC CYBER 750. 4/

BRIEF DESCRIPTION OF GRAPH AND HYPERGRAPH CONCEPTS

According to the set theory, a set is composed of elements that have properties and may or may not present relations with other elements belonging to the same set or to another one. 5/ If one represents elements by points named "vertices" and relations by arcs, and considers an application $\underline{A}$ in $\underline{S}^2$ such that two vertices, $\underline{S}_i$ an $\underline{S}_j$, verifying a given relation by an arc carrying the indication of its direction noted by $\underline{A}_{ij}$, the directed graph $\underline{G}$ is then defined by:

$$\underline{G} = \langle \underline{S}, \underline{A} \rangle \ , \ \underline{S} = \left\{ \underline{S}_i \right\} , \ \underline{A} = \left\{ \underline{A}_{ij} \ / \ \underline{A}_{ij} = (\underline{A}_i , \underline{A}_j) \right\} \in \underline{S}^2 .$$

In an arc $\underline{A}_{ij}$ is always associated with another arc $\underline{A}_{ji}$, then the graph is a directed symmetrical graph (figure 151). Moreover, more than one arc may join two vertices; then such a graph is called a "multigraph". Then it is possible to associate a valuation with every vertex to produce a valued graph. If this graph is a multigraph, it is called a "value multigraph". One may also associate several valuations with each vertex, and thus have a multivalued graph.

The concept of a hypergraph 6/ (figure 152) is a generalisation of the graph concept. On the vertices $\underline{S}_i$ of the set of vertices $\underline{S}$, one builds parts $\underline{P}_k$; the subset $\underline{P}_k$ is represented by a line surrounding the vertices belonging to the part and is named an "edge". Now one considers the set $\underline{P}$ of parts $\underline{P}_k$ and the set $\underline{S}$ of vertices $\underline{S}_i$; the hypergraph $\underline{H}$ is defined by:

$$\underline{H} = \langle \underline{S}, \underline{P} \rangle \ , \text{ such that } \underline{P}_k \in \underline{S}^n .$$

The different parts may have common elements corresponding to the intersections of edges. This aspect is represented by the so-called "representative graph of edges of the hypergraph".

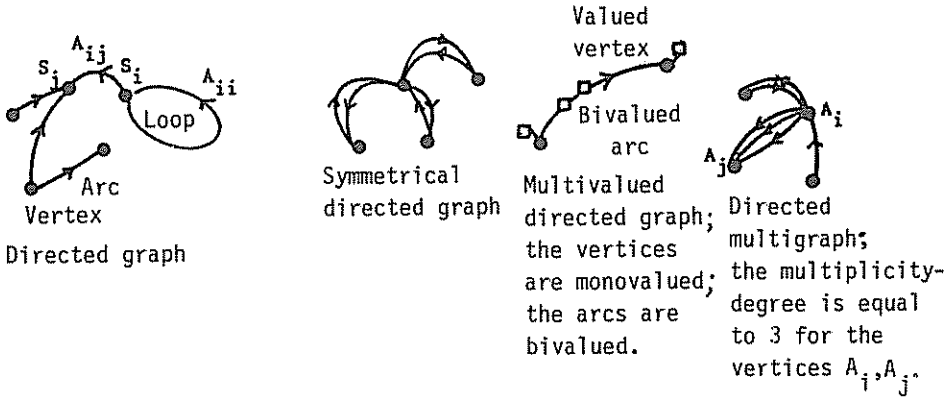
HYPERGRAPH-BASED DATA STRUCTURE MODEL

HBDS is made of two parts corresponding to two substructures, hierarchized and non-hierarchized.

Hierarchized part

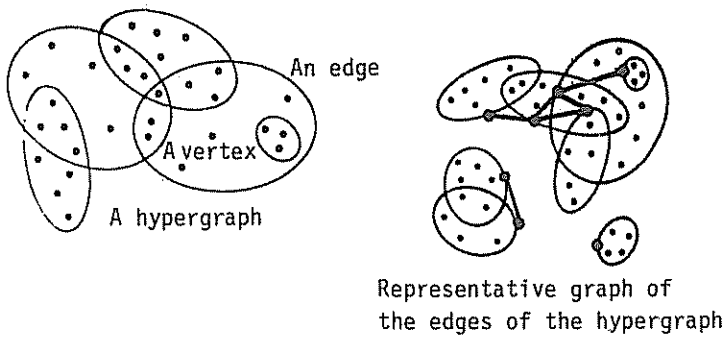
The hierarchy of $\underline{Ac}$ is composed of set $\underline{C}$ of vertices $\underline{C}_i$ and set $\underline{S}$ of arcs $\underline{C}_i \underline{S} \underline{C}_j$. This system is a directed graph, oriented from the root to the hanging nodes. Consequently, one associates another hierarchy $\overline{\underline{Ac}}$, oriented in the opposite direction. These graphs are thus defined. Now, each vertex $\underline{C}_i$ is associated with a set of valuations $\underline{A}_i$; the pth valuation is indicated by $\underline{A}_{ip}$, representing a property of the vertex $\underline{C}_i$. No hypothesis is given concerning the nature or the number of these properties. The vertex $\underline{C}_i$ also carries a second set of valuations, implicitly composed of all valuations of the preceding

Figure 151. Thailand: various types of directed graphs



Sources: Derived from F. Bouille, ''Un modèle universél de banque de données, simultanement partageable, portable et repartie'', unpublished doctoral dissertation, Université Pierre et Marie Curie, Paris, 1977; and F. Bouille, ''Hypergraphs and cartographic data structures: the HBDS system'', paper prepared for the Ninth International Conference of the International Cartographic Association, College, Park, Maryland, 1978.

Figure 152. Thailand: the hypergraph concept



Sources: See figure 151.

vertices and its own. This second set is indicated by $\underline{A_Z}$ and is defined by

$$\underline{A_I} \cdot \underset{j}{U} (\underline{A_j}/\underline{C_j} \in \overline{\underline{r}}_{\underline{A_C}} (\underline{C_i}))U\underline{A_i}$$

The first hypergraph, $\underline{H}$ (see figure 153), is now introduced. To each vertex $\underline{C_i}$, one assigns a part, $\underline{O_i}$, of the set of vertices $\underline{O}$, with the condition tha the parts $\underline{O_i}$ are disjoined. If $\underline{N_C} = |\underline{C_i}|$, then one has $\underline{N_C}$ parts like $\underline{O_i}$, and a set $\underline{Q}$ of parts $\underline{O_i}$ can be defined as

$$\underline{Q} = \left\{ \underline{O_i} \;/\; \underline{i} \in \left[1, \underline{N_C}\right] , \underline{O_i} \neq \emptyset \right\}.$$

The vertices of part $\underline{O_i}$ are indicated by $\underline{O_i^m}$, $\underline{m} \in \left[1, |\underline{O_i}|\right]$.

The simple hypergraph $\underline{H}$ is defined as $\underline{H} = \langle \underline{O}, \underline{Q} \rangle$.

In the graphical representaiton, an edge is drawn around vertex $\underline{C_i}$ and part $\underline{O_i}$, even though in fact, this edge should be drawn only around part $\underline{O_i}$.

Now, each vertex $\underline{O_i^m}$ also carries a set $\underline{a_i^m}$ of valuations $\underline{a_{ip}^m}$, the number of these valuations being equal to the number of valuations $\underline{A_{ip}}$ of set $\underline{C_i}$ (see figure 154).

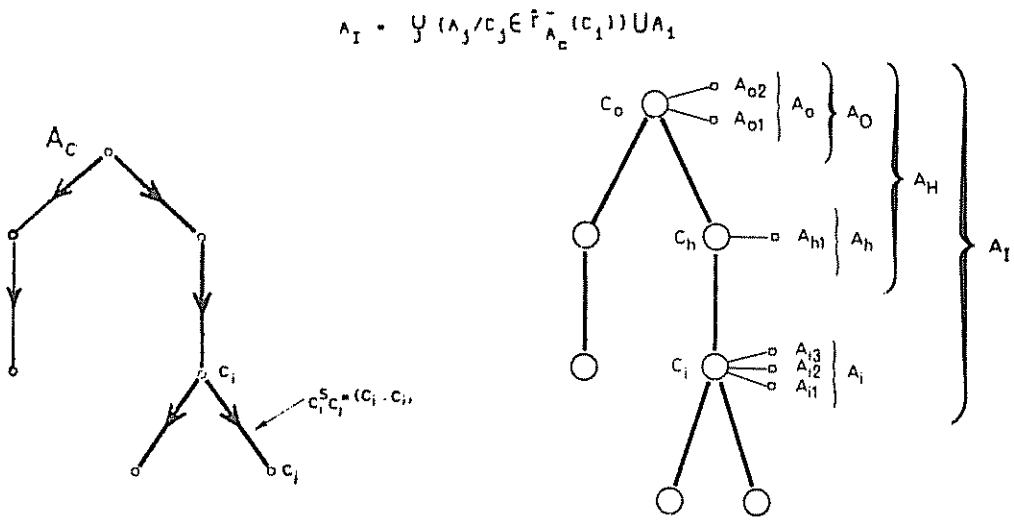
A set $\underline{C_i}$, vertices $\underline{O_i^m}$, properties $\underline{A_{ip}}$ and valuations $\underline{a_{ip}^m}$ are called, respectively, class; objects; attributes of class; attributes of object.

Non-hierarchized part

Each class like $\underline{C_i}$ may join another class, for instance, $\underline{C_j}$, by one or several arcs named "links" carrying a valuation which is a relation. The $\underline{k}$-th relation is thus indicated by $\underline{R_{ij}^k}$ and is carried by the link indicated by $\underline{C_j}\ \underline{L^k}\ \underline{C_i}$. Another arc is associated which is going from $\underline{C_j}$ to $\underline{C_i}$ and carries the reciprocal relation $\underline{R_{ji}^k}$; two classes may be linked by several links and a class may carry loops. These arcs compose the multigraph $\underline{G_{CC}}$, which is a symmetrical directed valued graph (figure 155).

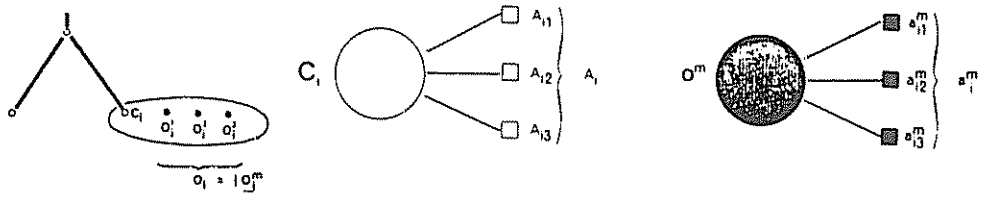
In HBDS terminology, the arcs between classes are called "links between classes"; the relation carried by a link concerns the objects of the classes which possibly may verify this relation, but is not obligatory. I f two objects $\underline{O_i^m}$ and $\underline{O_j^n}$ belonging respectively to classes $\underline{C_i}$ and $\underline{C_j}$ verify the relation $\underline{R_{ij}^k}$,

Figure 153. Thailand: hierarchized part of hypergraph-based data structure model



Sources: See figure 151.

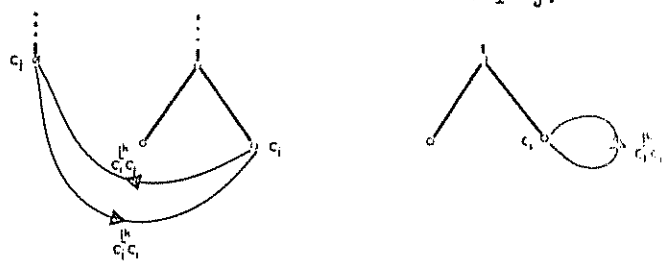
Figure 154. Thailand: hierarchized part of model; parts of set C_i



Sources: See figure 151.

Figure 155. Thailand: multigraph G_{CC}, a symmetrical directed value graph

$$G_{cc} = \langle C , L_{cc} \rangle \quad ; \quad C = \{ c_i \} \quad , L_{cc} = \{ c_i L^k c_j \} \in C^2$$



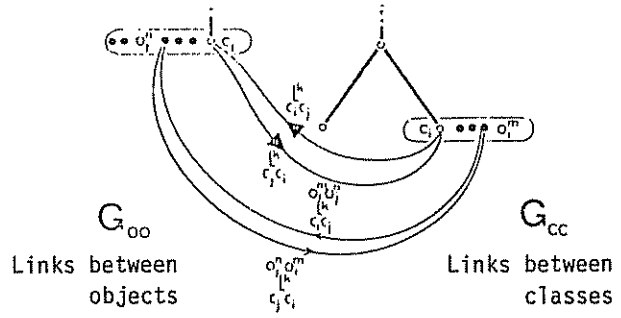
Sources: See figure 151.

Figure 156. Thailand: multigraph G_{OO}, a symmetrical directed graph

$$G_{oo} = \langle O , L_{oo} \rangle$$

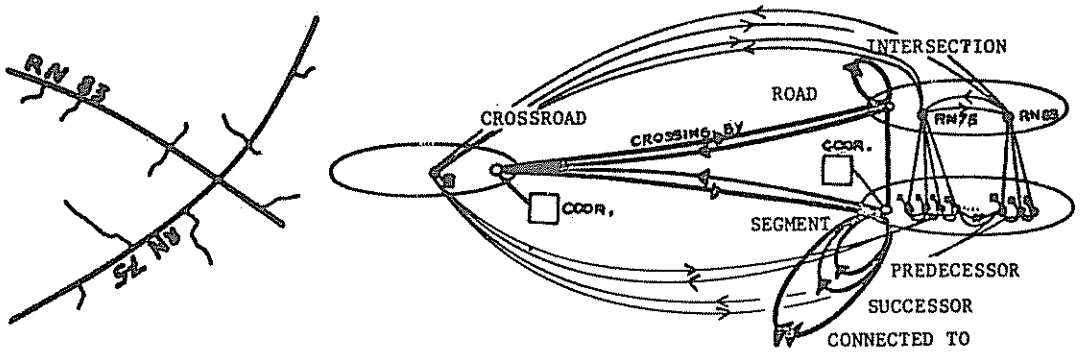
$$O = \{ O_i^m \}$$

$$L_{oo} = \left\{ \begin{matrix} o_i^m & & o_j^n \\ & L & \\ c_i & & c_j \end{matrix} \right\} \in O^2$$



Sources: See figure 151.

Figure 157. Thailand: hypergraph-based model applied to road structure



Sources: See figure 151.

the two objects are joined by another arc called "link between objects" and indicated by $\underline{O}_{\underline{C}_i}^{m} \; \underline{L} \; \underline{O}_{\underline{C}_j}^{m}$. These arcs belong to a second multigraph $\underline{G}_{\underline{oo}}$, which is a symmetrical directed graph (figure 156).

STRUCTURING URBAN DATA WITH HYPERGRAPH-BASED MODEL

To facilitate understanding of the HBDS concepts, one may turn first to the road structure example given in figure 157.

To define the structure of roads, a set or class named "road" was set up. The particular road, RN 75, is nothing but an element of this set or an "object" of this class. Further, a road is made of segments; therefore, another class, which is a subclass or road, is called "Segment". The objects of this subclass are segments of each corresponding road introduced in the upper class, road. Moreover, roads intersect each other. To materialize these intersections, a link, which is a loop on the class road, is inserted. This link carries the relation "intersect". If road RN 75 intersects RN 83, then both objects are joined by a link verifying this relation. At each intersection, it is then necessary to have another class, "crossroad". All the objects of this class are crossroads. These objects concern not only the roads, but more precisely some segments of these roads. These two links are required (in fact, four when the reciprocal links are included) in order to materialize the same relation "intersected", one for the classes crossroad and road, and a second for the classes crossroad and segment. On the other hand, if one considers carefully the road structure, one sees that it can be assimilated to a directed graph. In that case, a segment may be a predecessor or a successor of the other. This fact implies two new links carrying, respectively, the relations "predecessor" and "successor" on the class segment. Furthermore, segments of different roads may be directly connected via a crossroad; then there is a third loop carrying the relation "connected to" on this class. So far, only the topological characteristics of the road structure have been considered; one may be astonished by how the topometric can be represented. This is easily done by introducing two attributes called "co-ordinate".——the classes crossroad and segment, respectively. The first one defines the co-ordinates $\underline{x}$, $\underline{y}$ of each crossraod. The second defines the co-ordinates of accessory nodes of the segments (corresponding to an array in this case).

It is now proposed to discuss a more complicated structure dealing with the French Répertoire géographique urbain (Urban Geographical Repertory). This type of data base using the classical method has been built since 1974 but the applications that can be used from this data base are quite limited and costly, because the method used to structure these urban data was not efficient enough. The author has developed a new method based on the HBDS concept. The results obtained were very satisfactory and many times easier than those achieved by the above-mentioned method.

Due to the space limitation of this paper, it is impossible to give a detailed explanation of the urban data structure recognition; more details

may be found elsewhere. 7/ It is appropriate here, however, to provide an example in the form of a graphical representation of the urban data structure of Paris (figure 158). This structure was obtained by analysing the global urban structure of the Paris Metropolitan. In fact, France is divided into 99 départements (and likewise 200 urban units). The Paris département is again subdivided into 20 arrondissements and 80 quartiers. Each quartier contains several blocs, and each bloc is defined by an area surrounded by roads. Faces are common elements between a bloc and roads. In considering the limit of the above-divided administrative units, one sees from the figure that the limit of the larger unit is a sum of parts of smaller unit limits. For example, if Δ is one of the limits of the department X, then is a sum of limits θ , Σ , Ω of, respectively, arrondissements e, a, b (see figure 159). Therefore, the only metric needed to represent the limit of administrative units is the co-ordinates of the smallest unit limits, which is in this case the quartier. Moreover, there is another unit called "Zone dense", which specifies the area in which the corresponding data base had been created.

DATA BASE MANAGEMENT SYSTEM

The hypergraph-based data structure model has been used to build up a new type of data base managment system in two ways:

(a) As the data structure, which is the concentrical abstraction at the external part of the system seen by the users. The user employs this data structure to describe and manipulate data;

(b) As the basis of the management system, which only works with class, object, attribute and link concepts in order to process its own components and to solve its own problems.

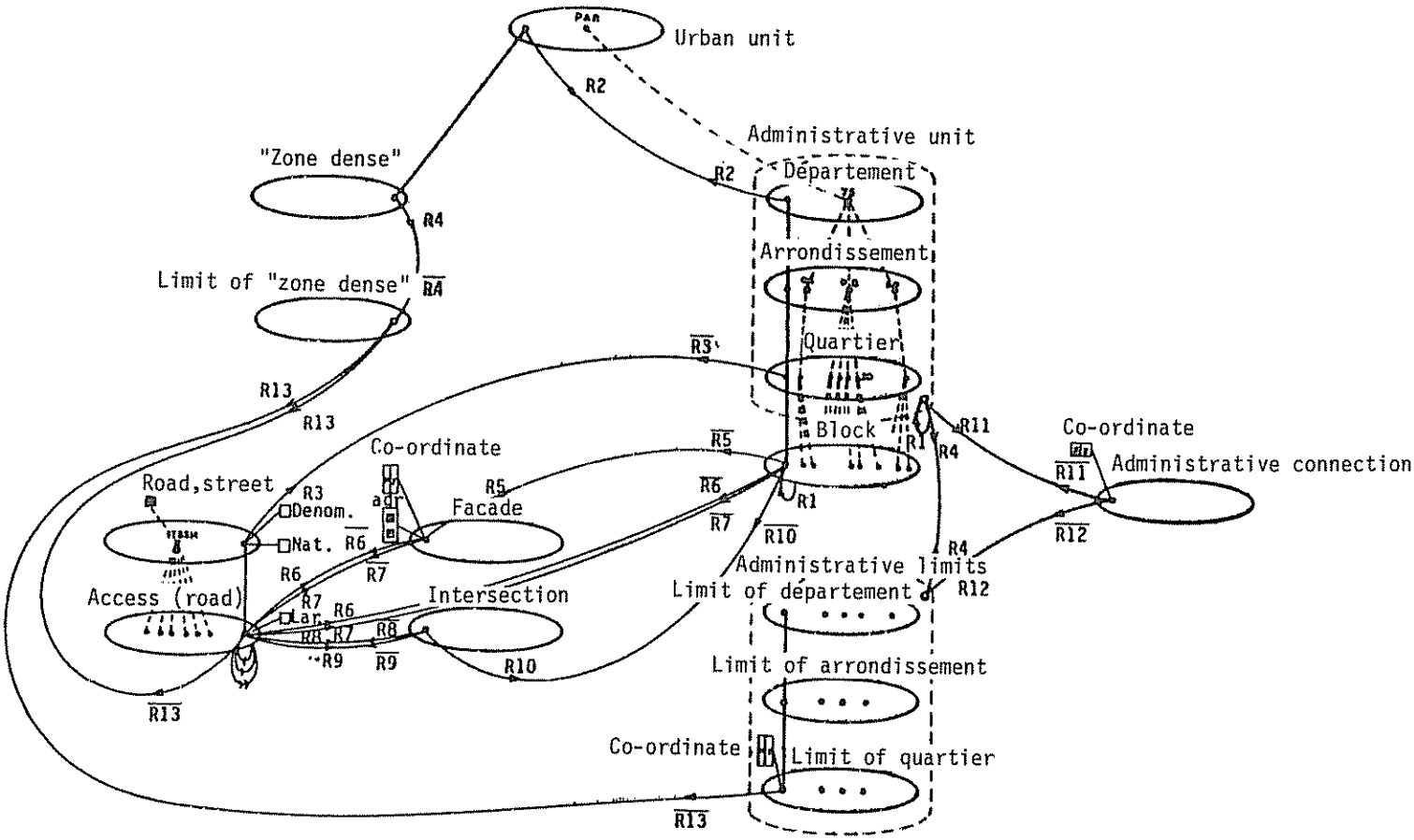
This data base may use all types of standard file systems, which are thus considered the storage structure. An interface is placed between the data structure and the storage structure performing the transfer of data. The author has implemented this system on the CYBER 750 using FORTRAN VI programming language.

CONCLUSION

The new method of urban data base modelling presented in this paper realizes a long-time hope of people concerned with cartography. It offers possibilities of manipulating any type of data and information without the limitations imposed by other existing operational urban data bases. The user can create, delete, update and purge data without any knowledge of storage structure; the system takes full responsability of these tasks with the file management system. Moreover, HBDS is an extendible data structure model. Whenever, there is new information, the user can add to the previous structure without any modification of the file structure.

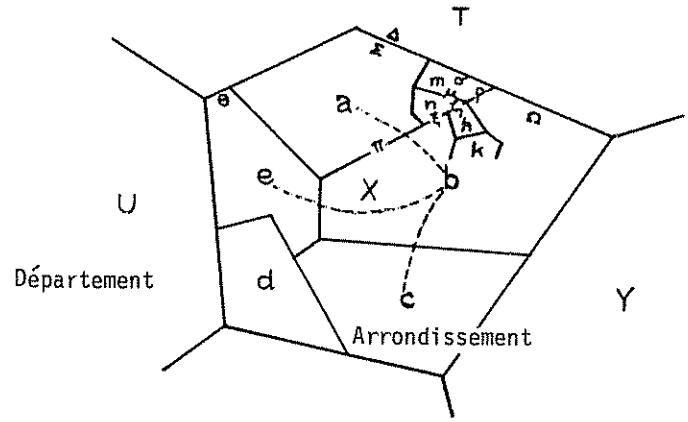
The results obtained from several experiments showed that this new urban data base conserves both topological and topometrical information. The precision of map-drawing is exactly the same as the original digitized map.

Figure 158. Thailand: example of urban data structure, Paris



Note: R1=neighbour; R2=related to; R3=inside of; $\overline{R3}$=contain; R4=limited by; $\overline{R4}$=limiting; R5=belonging to; $\overline{R5}$= constituted by; R6=having on its left; $\overline{R6}$=is at the left of; R7=having on its right; $\overline{R7}$=is at the right of; R8=having origin crossroad as; $\overline{R8}$=is the origin crossroad of; R9=having extreme crossroad as; $\overline{R9}$=is the extreme crossroad of; R10=surrounding; $\overline{R10}$=surrounded by; R11=defined by; $\overline{R11}$=defining; R12=having the vertex; $\overline{R12}$=is the vertex of; R13=coinciding; $\overline{R13}$=is coincided with.

Figure 159. Thailand: units and their limits



Sources: See figure 151.

Notes

1/ F. Bouille, "Un modèle universel de banques de données, simultanément partageable, portable et répartie", doctoral dissertation, Université Pierre et Marie Curie, Paris, 1977.

2/ N. Bourbaki, Théorie des ensembles, vol. I (Paris, Hermann, 1939).

3/ C. Berge, Graphes et hypergraphes, 2nd ed. (Paris, Dunod, 1970).

4/ V. Satharanond, "Méthodologie de structuration des connaissances et de saisie du Répertoire géographique urbain: implementation en mise en oeuvre", doctoral dissertation, Université Pierre et Marie Curie, Paris, 1982.

5/ Bourbaki, op. cit.

6/ Introduced by Berge, op. cit.

7/ Satharanond, op. cit.

Other references

Satharanond, V. Automatic searching of terrains for rice agriculture. Paper prepared for HBDS '81, Richmond, Virginia, 20 p.

_____. An application of the hypergraph-based data structure in an agricultural suitability study. Paper prepared for the ASP-ACSM Fall Technical Meeting, San Francisco, California/Honolulu, Hawaii, 1981, 10 p.

CURRENT RESEARCH DIRECTIONS IN THE NATIONAL MAPPING PROGRAMME*

Paper submitted by the United States of America

RESUME

En 1980, le Service géologique des Etats-unis a réorganisé les différents éléments de la Division des publications, du Programme de géographie du Bureau d'information et d'analyses pédologiques, et de la Division de topographie pour former ce qui est actuellement la Division nationale de cartographie. Les fonctions de recherche de la nouvelle Division ont été organisées de façon à poursuivre les analyses théoriques et les études d'application dans les domaines de la géographie et de la cartographie, à mener

* The original text of this paper, prepared by Lowell E. Starr and Robert B. McEwen, United States Geological Survey, appeared as document E/CONF.75/L.48.

un programme actif de développement de systèmes et à fournir un appui opérationnel et technique aux activités des centres locaux. Ces modifications d'organisation ont eu un effet important sur la formulation et la gestion des activités de recherche relevant du Programme national de cartographie. On a souligné la recherche géographique et cartographique liée à l'analyse des données spatiales pour appuyer la mise au point d'une base de données cartographiques numériques et la cartographie numérique en général. Après deux ans, les résultats positifs de cette réorganisation et l'accent technique mis sur la cartographie numérique apparaissent clairement. Ces résultats joueront un rôle important dans l'élargissement des fonctions de la Division, en partant de l'accent mis sur l'établissement de cartes topographiques de base pour aller vers la création, la gestion et l'analyse de diverses catégories de données produites par la Division nationale de cartographie et le Service géologique des Etats-Unis.

Until 1980, the Topographic Division of the United States Geological Survey was organized with two staff-level offices and four production-level mapping centres. The staff offices were: (a) Plans and Program Development; (b) Research and Technical Standards. The origins of the two offices go back to 1946, but since about 1958, a span of 22 years, the Research and Technical Standards Office was subdivided into five branches, three that paralleled the major technical operations in the mapping centres--field surveys, photogrammetry and cartography--with two additional branches, one responsible for acquiring all aerial photography by contract and another responsible for equipment design and acquisition in the Division.

The major objective of the Division was the production of the standard 1:24,000 scale topographic map series, and both staff offices were primarily organized to support and exercise control over the process as well as to conduct investigations for improving production. The organizational structure of the Research and Technical Standards Office served the Division well and provided a mechanism for technical staff to accomplish many developments and evaluations in orthophotography, analytical photogrammetry; inertial, Doppler and electro-optical field survey equipment; and mapping with satellite remote-sensing data. However, this structure had two principal deficiencies. First, it was difficult to address new multidisciplinary mapping problems that crossed existing production components; and, secondly, it was difficult to address longer range technical issues that could not be defined in terms of existing topographic mapping operations.

For example, when the Division decided to implement digital cartographic technology into its programme in the mid-1970s, a special project team was established to conduct the associated research and development. Personnel from the existing branches formed the team and operated independently under the auspices of the Office of the Chief of Research and Technical Standards. This arrangement overcame some of the deficiencies of the Office's organizational structure, and the effort was successful in defining and initiating a new technical direction for the Division. It was concluded, however, that the team approach to research management could not be used for all types of new technical developments and that special project teams often outlived their

usefulness in from three to four years. Also, neither the production-oriented branches of the Office nor the special project teams were conducive to long-term theoretical research where objectives were defined in general terms. In order to respond to new cartographic requirements in a changing environment, a new organization was needed.

In 1980, a major reorganization of the Division and other related components of the United States Geological Survey was accomplished after several years of planning.

The essential features of the reorganization, which formed the National Mapping Division (NMD), were as follows:

(a) Principal components of the Survey Publications Divsision became a part of NMD and its major components now appear as the Printing and Distribution Field Center;

(b) The Geography Program of the Survey Land Information and Analysis Office became a part of NMD, with most personnel transferring to an Office of Geographic Research;

(c) Three staff offices were established for NMD, each headed by an assistant division chief; these offices are Plans and Operations, Research, and Information and Data Services;

(d) The mission of NMD was broadened beyond the former topographic mapping activities to include production and distribution of many types of geographical and cartographic information of national interest and to conduct related research.

ORGANIZATION OF RESEARCH

The Office of the Assistant Division Chief for Research is responsible for NMD activities in basic and applied geographical and cartographic research, systems and techniques development, and technical management and product standardization. This conceptual framework for research and development is not discipline- or production-oriented, but rather allows for activities to be grouped into four phases that have one or more of the following characteristics:

(a) Basic research and investigations: abstract concepts, a need to improve understanding and a high degree of uncertainty of outcome;

(b) Applied research and investigations: specific concepts and alternatives, a need to test applicability or feasibility and some uncertainty of outcome;

(c) System and techniques development: specific objectives determined, applicability and feasibility reasonably well-known in advance and some uncertainty on optimum implementation technique;

(d) Technical management: specific objective and methodology determined in advance, a need to standardize and an emphasis on quality control.

One view of the four phases envisions an idea or concept evolving progressively from the abstract to production as it is passed from one organization unit to the next. In practice, it does not always work that way; and many ideas, concepts and investigations may require all four phases to operate more or less simultaneously. The principal managerial advantages of separating research and development activities into these particular four phases are:

(a) An ability to deal effectively with issues that cross several of the cartographic or geographical disciplines;

(b) An ability to employ effectively individual talents for abstract cocneptual thinking or systematic pragmatic development;

(c) An ability to consider multiple concepts in a basic or applied research environment before disturbing production or risking high development costs;

(d) An ability to devote a certain amount of resources to look further ahead without the constraints of current development or production;

(e) An improved ability to conduct relevant investigations in co-operation with related earth science disciplines.

With these concepts and objectives in mind, the research organization was at first formed in 1980 into three major offices - Cartographic Research, Geographic Research, and Systems and Techniques Development. The Cartographic Research and Geographic Research Offices contained separate branches for analysis and applications - the first two phases previously mentioned. Actions are now almost completed to consolidate the two offices into a single Office of Geographic and Cartographic Research with responsability for the two phases of basic analysis and applications. This will effectively complete the integration of similar research capabilities of the former research and technical standards organization and the Geography Program.

The Office of Systems and Techniques Development includes a Branch of Systems Development, a Branch of Applied Sciences and a Branch of Technical Management. As the titles imply, these branches effectively assume responsibility for the remaining two phases--systems and techniques development and technical management. In addition, during the reorganization, each field centre established a techniques office responsible for implementing new techniques into production in co-ordination with the Research Office. The new organizational structure effectively provides NMD with the capability to conduct research and development on a complete range from the abstract to the concrete.

RESEARCH PERSPECTIVES

The United States Geological Survey is the principal agency of the federal Government devoted to the earth sciences. The mission of the National Mapping

Division is to be a source of expertise and professional guidance in geography cartography and remote sensing; to produce and distribute maps and earth imagery; to provide geographical and cartographic information; and to conduct relevant research, investigations and development.

The Division's Research and Development programme is directed towards satisfying major responsibilities in support ot its mission. This includes increasing the knowledge and capability of personnel in the techniques and rational of geographical and cartographic data acquisition, analysis and presentation; investigating the theoretical concepts and instituting the design processes for advanced cartographic and geographical analysis and information systems; improving the productivity, flexibility and use of resources in the cartographic production system; and establishing the capability to provide an increased level of service and a multi-purpose series of products.

Like most national mapping organizations, NMD is undergoing a major transition from analogue to digital cartography. The transition may prove to be more profound than the transition fron plane-table methods to photogrammetry 40 years ago. During the earlier transition period, improvements in the science of photogrammetry and the application of its processes--analytical aerotriangulation, stereocompilation and orthophotography--greatly increased map production capability and capacity; and substantive cost benefits were realized. The advance in technology helped the Survey to increase United States map coverage at 1:24,000 scale from 4.8 per cent in 1947 to 77.2 per cent in 1982. In recent years, however, the technology has matured and the unit cost of preparing conventional maps has turned from a constant decrease to an increase, while fiscal and personnel resources committed to the process continue to shrink. Also, there is the challenge of a growing map revision programme.

The demand for special maps is increasing and the maps are often required within short time-frames. Many of the maps can be prepared from existing materials by conventional photomechanical techniques, but often the need for changing map projections, symbolization or content defies the capability of traditional methods to produce the needed product within the available budget or time-frame. Closely coupled with this demand is the growing use of electronic displays for maps and the desire to manipulate and analyse geospatial data on a computer in a user-oriented applications environment.

It is both difficult and risky to forecast the future in an area where unexpected events and technical developments have a habit of occuring. Nevertheless, in a research and development environment, it is necessary to have some perspective on probable future developments, especially in the next 5-10 years. This perspective provides focus and scope to profitable areas for research and helps to separate the revolutionary developments from those better described as "evolutionary". Some of the present views are described below.

It is believed that the need for paper maps will not diminish during the next 10 years, even with such developments as electronic displays. Moreover, the basic map-making processes of surveying, aerial photography, photogrammetry, cartography and lithography will not change in a revolutionary way, but will rather be subject to incremental improvements and modernization. Some changes may appear dramatic, such as the increased use of automated plotters, electro-

optical field instrumentation, satellite and intertial positioning systems, satellite imaging systems, minicomputers and microcomputers, and electro-optical photographic and lithographic equipment. Taken in perspective, these changes represent a natural evolution from current operations and can be accommodated and implemented with existing mapping concepts and a vigorous development programme. The goal is to adopt improvements and modernization whenever they will improve productivity and utilization of resources.

The basic mapping process, however, must be augmented with multiple capabilities to capture and use digital cartographic data. Some of these data may be useful for preparing certain standard Survey map separates, but other categories of digital cartographic data will be more suited to new types of map products and computer analysis of geospatial data. It is doubtful if all map categories will need to be digitized; and short-term emphasis will continue to be on elevations, boundaries and land use in digital form. Many new forms of cartographic information will come into common use where timeliness and relevant content will be more critical than accuracy or cartographic presentation. Many will serve short-term requirements and many will be produced outside NMD.

Image maps will constitute a larger share of the NMD product mix, both at scales larger than 1:24,000 and at smaller (regional) scales. Satellite capabilities to produce satellite images of adequate resolution at the samller scales will improve from the LANDSAT era, and image maps and classification derivatives from multispectral data will play a significant role in this new product mix. Capabilities to analyse, process and reproduce colour image maps and thematic maps will continue to be researched and developed.

Geographical information systems (GIS) will continue to be developed by many federal and non-federal agencies and should become moderately sophisticated by the end of the 1980s. In spite of the considerable fanfare that such systems currently receive, the highly sophisticated GIS will take several years to develop and be effectively used. However, it is anticipated that GIS applications (especially those involving more accurate and complex analysis) will constitute the more significant application of NMD digital data by the latter part of the present decade.

By the early 1990s, the capability quickly and accurately to determine geodetic positions anywhere on Earth will be well developed. While the scope and ramifications of this development are still not clear, it could be as revolutionary as the many applications of microprocessor technology today. Anyone may be able to determine positions more accurately than it is now possible to determine map features. Geodetic position accuracy is an area worthy of considerable additional research and study, for almost certainly the Division will have to respond with new products and will have to consider modifying certain procedures for data acquisition. It will also tend to reduce the distinctions that now prevail between surveying for cartographic or cadastral purposes.

RESEARCH ACTIVITIES

The research programme of NMD consists of several major activities and numerous subactivities that are managed within the organizational framework previously described. Approximately 105 permanent personnel work in research--about 60 in the Office of Systems and Techniques Development, 40 in the Office of Geographic and Cartographic Research and 5 in the Office of the Assistant Division Chief for Research. In the Office of Geographic and Cartographic Research, the career ladder for many of the professional personnel is governed by research grade-evaluation procedures that encourage and recognize individual competence, resourcefulness and original contributions. In addition, from 30 to 40 part-time personnel are employed in various components of research and development (e.g., college faculty, summer college students and secretarial positions). The technology offices in the four mapping centres collectively account for about 15-20 additional personnel who are also engaged in development and implementation activities.

It was mentioned above that the Research and Technical Standards staff office of the former Topographic Division was primarily involved with equipment, procedural developments and technical standardization associated with the map production mission of the Division. These tasks are still major responsibilities of the present Research staff office, and other activities have now been added that emphasize basic research and applications investigations in the geographical and cartographic sciences. The current division of functions (estimated percentage) within the Research staff office is as follows:

(a) About 20 per cent of the work involves analysis and applied research;

(b) About 20 per cent of the work involves staff support functions associated with NMD headquarters operations. This includes the preparation of budget justifications and policy documents, answering requests for technical information, and co-ordination functions with federal and state agencies;

(c) About 40 per cent of the work involves technical development, management and standardization of the Division's production mission. This includes equipment procurement and maintenance, development of technical standards and monitoring of quality control procedures; and the development, installation and testing of prototype equipment, software and procedures;

(d) About 20 per cent of the work involves service functions that support other research and development operations or that perform a unique Division function. Many of the functions in the instrument laboratory, the electronics laboratory and the camera calibration facility fall in this category.

Many staff members perform duties in support of several functions, and this breadth of individual capability and flexibility is considered one of the major assets of the NMD research organization. It is still too soon to determine if these percentages represent a correct balance.

A report entitled Research, Investigations, and Technical Developments, National Mapping Program, 1981 was recently published. Copies are available for sale to the public through the United States Geological Survey Open-File

Services Section, Western Distribution Branch, Box 25425, Federal Center, Denver, Colorado 80225 (request Open-File report 82-236).

The report reflects the major research activities within the National Mapping Division. The last report, published in 1977, covered cartographic research in the areas of field surveys, photogrammetry, orthophotomapping and remote sensing, with a minor emphasis on hardware for digital cartographic applications. Since 1977, additional research areas have gained in importance owing to organizational changes, technological developments and an increased emphasis on the mission of the Division to develop a digital cartographic data base. Therefore, the report includes digital cartography, with emphasis on several key areas of spatial data-handling relating to both cartographic and geographical digital data, geographical analyses of land use and changes in land use, assessment of potential environmental hazard areas and multidisciplinary studies.

Several special projects, undertaken in 1981, are highlighted. The eruption of Mount St. Helens in 1980 resulted in a series of special cartographic products. The System Alpha Study, which reports on a three-phase strategy for the development and maintenance of the digital cartographic data base, was completed. A 1:2,000,000 scale data base, developed using source materials from the National Atlas of the United States of America, will be completed in 1982. Standards for a new series of provisional edition topographic maps were prepared to meet the goal of completing nation-wide large-scale map coverage by the end of the 1980s. In the area of remote sensing, a concept was developed and validated for an operational earth resources mapping satellite--MAPSAT.

The section in the report in spatial data-handling reflects the current major research thrust in the Division and covers a wide range of activities in the areas of manipulation, retrieval and analysis of digital cartographic and geographical data. Included are such projects as the development of a prototype geographical information system for utilizing the digital products of the land-use and land-cover mapping programme, and activities relating to the development of the digital cartographic data base. The section on cartographic and geographical studies covers basic and applied research in both disciplines, including topics that range from changes in land use to the development of new cartographic techniques. Research discussed in the section on remote-sensing and space technology includes studies specifically related to LANDSAT, SEASAT and side-looking airborne radar. The treatment of digital data derived from space-sensor for image-mapping and geographical applications is also included. In the section on systems and techniques research and development, emphasis is on developments in digital applications hardware and techniques for handling raster-formatted data. The section also covers studies in screenless lithography and automation of cartographic lettering. Associated activities, such as the testing and calibration of aerial cameras, research in camera calibration and information on resolution targets and the distribution of computer software are described in the final section of the report.

CONCLUSION

The reorganization of MND research activities in 1980 represents a major change from the objectives and scope of research that had prevailed for the

preceding two decades. The geographical sciences, especially those relating to quantitative spatial data analysis, have been joined to the cartographic sciences of photogrammetry, geodesy and surveying which have always been a major endeavour. Increased emphasis is being placed on digital cartographic systems and image-processing. The research and development process is now operating on several levels--abstract concepts, investigative studies, systems and procedural developments, technical management--that have been melded in a multidisciplinary fashion. It is believed that considerable progress has been made in forming and implementing an effective organizational framework. Positive results are being shown in pursuing an advanced research programme for the changing requirements of the NMD mission and for advancing the professions of geography and cartography.

OVERVIEW OF AUTOMATED CARTOGRAPHY EFFORTS AT THE DEFENSE MAPPING AGENCY AEROSPACE CENTER*

Paper submitted by the United States of America

RESUME

Le Centre aérospatial de la Defense Mapping Agency passe de la méthode traditionnelle (manuelle) de séparation des couleurs dans les produits cartographiques à un procédé automatisé. On utilise essentiellement le système automatisé de numérisation graphique pour convertir les données graphiques en données numériques. Cet instrument permet également au cartographe de manipuler interactivement (éditer, transformer etc.) les données recueillies sur les détails cartographiques pour en faire des fichiers numériques référencés à couleurs séparées. Ces fichiers sont traités en différé en Graphic Line Symbolization Software pour faire des fichiers à reproduire pour la prochaine génération de positifs à couleurs séparées sur une table traçante.

On met à jour les spécifications des données d'analyse des détails numériques pour tenir compte de l'automatisation de la cartographie. Ces nouvelles spécifications constituent ce que l'on appelle la deuxième édition. On s'attache particulièrement au rassemblement des données sur les routes, les voies ferrées, les détails culturels, l'écoulement ainsi que des données sur les caractéristiques du terrain nécessaires pour la cartographie automatisée. Les spécifications de la deuxième édition s'appliquent à la collecte de toutes les données d'analyse des détails numériques. Les données ainsi obtenues seront incorporées à la base de données sur les applications de la cartographie numérique

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* The original text of this paper, prepared by Dennis P. Franklin and Garry L. Holmes, Cartographers, Techniques Office, Aerospace Cartography Department, Defense Mapping Agency Aerospace Center, appeared as document E/CONF.75/L.49.

et seront stockées dans un segment linéraire nodal pour économiser la mémoire et faciliter l'entretien.

On examine les besoins en matière de visualisation pour les années 80. Un système de visualisation entièrement numérique connecté à la base de données pour les applications de la cartographie numérique grâce à un système standard de permutation est décrit. Le logiciel final sera une version modifiée du GLSS. On consultera la base de données pour les applications de la cartographie numérique pour obtenir des données numériques pour la séparation de couleurs pour les contours, l'écoulement, les routes, les voies ferrées, etc. Le cartographe devrait pouvoir aussi bien séparer les couleurs pour un clicheur à laser pour la lithographie que réunir tous les clichés pour l'impression directe.

The Defense Mapping Agency Aerospace Center (DMAAC) has the responsibility of meeting an ever-increasing number of different mapping charting and geodesy requirements. The charting programme primarily consists of the series 200 (S/200) and the navigation and planning (NAV/PLAN) charts. Special charts are produced for the National Aeronautics and Space Administration (NASA), the Air Weather Service and many other users. Most of these charts and navigation products are produced using traditional cartographic methods. 1/ The traditional chart production process (i.e., feature selection, panelling, compilation, symbolization, negative engraving etc.) requires manual, labour-intensive skills. Therefore, a significant portion of DMAAC production resources are devoted to ensuring that these products shall be kept current with user needs. Obsolescence comes from either or both of the following: the charts no longer meet current accuracy requirements; the information provided is outdated. Thus, DMAAC has established a need for accurate up-to-date cartographic information in a digital format readily transformed to meet specific charting requirements. Specifically, DMAAC has the requirement for a digital colour-separation production process to include the collection, maintenance and exploitation of a data base of product-independent digital cartographic information. The data base must contain not only lineal features in a line segment noded digital format but sufficient textual information to support utilization requirements for a "family-of-charts" (FOC) production process. This paper discusses DMAAC current, proposed and future efforts for automating chart production processes to include the development and implementation of a digital cartographic applications data (DCAD) base for chart features in a standard linear format (SLF).

TRADITIONAL COLOUR SEPARATION

The traditional colour-separation techniques for chart production require manual panelling, compilation and negative engraving. These manual, labour-intensive processes are prime candidates for computer-assisted colour-separation techniques. The domestic series 200 programme was selected as the first candidate for automated colour-separation at DMAAC because of the large number of charts produced each year. The S/200 charts are produced at a scale of 1:200,000 and are used by air crews for general planning, in-flight navigation and training. After collecting the cartographic source package, the cartographer

begins highlighting, on United States Geological Survey 7.5 minute quadrangle sheets, the planimetric and hypsographic features selected for portrayal on the chart at 1:200,000 scale. The cartographer performs a sheet-to-sheet match and the highlighted cartographic source is then scaled against the projection and photographically reduced to 1:125,000 scale. The film positive photo-reductions are panelled to the 1:125,000 scale projection. This serves as a panel base from which final planimetric, hypsographic and special feature manuscripts (i.e., contour drainage, railroad, culture etc.) are drafted. The manuscripts are drafted on a 1:125,000 compilation scale, then photo-reduced to the final 1:200,000 chart scale and imaged on scribe cote. The negative engraver then colour separates and symbolizes the various chart features manually on the scribe cote. The engraved scribe cote (colour separate) is used for making the lithographic printing plate. 2/

Objectives for automating the traditional colour-separation processes

The objectives for automating the traditional colour-separation processes are: (a) improvement of existing production processes; (b) standardization; (c) quick response to users' needs; (d) cost savings (maintenance); and (e) movement towards an all-digital, soft-copy production system. The aim is to improve existing production processes through automation, to develop and implement a digital cartographic applications data base and to implement an all-digital soft-copy production system by the mid- to late 1980s.

CURRENT DIGITAL PROGRAMS

DMAAC is producing prototype charts from digital data. The digital data for these charts are collected, edited and colour-separated in-house by the automated graphic digitizing system (AGDS). The current digital colour-separation production scenario at DMAAC is shown in figure 160. AGDS collects line centre data and generates line segments which are tagged by the operator with an appropriate graphics line symbolization system (GLSS) code. The cartographic features from the digital data are symbolized according to chart specifications, and plotting instructions for them are generated off-line by GLSS software. Application of GLSS software can save 50 per cent of the man-hours normally used by the negative engraver for building lithographic colour-separation plates. Tagged digital data from AGDS is archived for subsequent chart revisions. 3/

Automated graphio digitizing system

AGDS is designed for data collection, interactive editing and colour separation of compilation overlays or selected feature lifts. The three main subsystems of AGDS are: the scanner; the vectorizer; and the edit/tag subsystem (see figure 160). The laser-scanning subsystem is used to scan compilation overlays outputting the data in raster format. The vectoriizng subsystem converts the raster data to vector format. Once the scanned overlays are in vector format, the data are input to the edit/tag subsystem. The cartographer at the edit/tag subsystem has the capability to edit the data

Figure 160. United States of America: digital colour separation

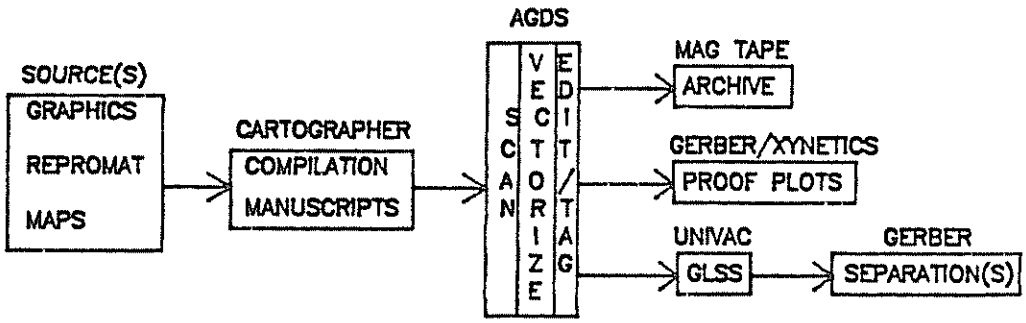


Figure 161. United States of America: composite of separations



interactively, to create subfiles from the data (i.e., select feature lifts, compilation overlays etc.) and to transform mathematically the seaprate overlays to the compilation projection base (digital panelling). Common points between the individual overlays and projection base are used for controlling the overlays to the projection, and the cartographer can digitally transform the overlays to the projection. He then interactively inserts unique feature-identification codes (FIC) to features according to their unique colour separation. For example, drainage would be displayed on the blue colour separation whereas cultural features would be displayed on the black separation. The colour separations correspond to the colours for the lithographic printing-plate. The FIC or tag number corresponds to a specific set of previously defined instructions for feature symbolization. Table 47 gives an example of the procedures and symbol pieces required to symbolize a non-perennial drain. 4/

After the data has been colour-separated at the edit/tag subsystem, an output tape is generated for off-line chart symbolization by GLSS software.

Graphio line symbolization system

The GLSS software is to provide the cartographer with a chart that shows cartographic features so that one feature can be easily distinguished from the other. The GLSS software converts line-centred data to a specific product format which depends upon the chart specifications being used for the final chart compilation. The product format is generated by a graphical film (photo) plotter.

Film positive separates

Thus far, the collection and processing of digital cartographic data through the AGDS and GLSS systems have been discussed. Next to the viewed is a composited subplot taken from a full-scale production chart. Figure 161 presents a symbolized plot for the following colour separations: contours; drainage; roads; railways; and radar significant analysis code (RSAC). Each separation encompasses the same geographical area. The cartographic features for each separation are plotted according to chart specifications. Figure 161 shows a composite registration of the film positives.

The symbolized film positives from GLSS eliminate the need for the negative engraver to extensively hand-engrave symbolology on scribe cote. The engraved scribe cote is used for making photo negatives for creating a lithographic press-plate. 5/

Savings for the negative engraver

By eliminating the need for manual engraving of most chart symbolology, the negative engraver can save 60 per cent of the man-hours he would need to engrave the chart. For a particular prototype production chart, the engraver time required to scribe symbolology and prepare the chart for printing was 430 man-hours. To colour-separate the same prototype chart using digital data

Table 47. Symbol specification file

Feature identification code	Conformal/ non-conformal	Type of symbol	Lineal (blank) falsh (F)	Symbol size (inches)	Symbol line weight (inches)
4347	CON	DASH	-	0.193	0.007
	CON	SPACE	-	0.029	0.000
	CON	DOT	F	0.007	0.007
	CON	SPACE	-	0.025	0.000
	CON	DOT	F	0.007	0.007
	CON	SPACE	-	0.025	0.000
	CON	DOT	F	0.007	0.007
	CON	SPACE	-	0.029	0.000

and GLSS software for symbolization required only 170 man-hours from the negative engraver. Additional savings would be made for smaller scale, larger format charts. 6/

Digital landmass system

DMAAC is currently producing digital files of feature analysis data (DFAD) and digital terrain elevation data (DTED). These digital files are combined to form the digital landmass system (DLMS) and are used to support advanced aircraft simulators and navigation systems. The DLMS data base contains two major types of data: elevation data; and physical feature data.

Digital terrain elevation data

Elevation data are collected either by automatically scanning profiles from a photogrammetric model on an analytical stereoplotter or by digitizing contours from an existing map. 7/ Photogrammetric methods are used to collect the majority of DTED compiled for DLMS in DMA. Interpolation of collected elevation data yields a uniformly spaced grid of elevations in accordance with DLMS specifications for DTED. 8/

Cartometric methods for DTED production are based on AGDS collection of map/chart contour manuscripts. Similar to photgrammetric methods, interpolation algorithms for converting vectorized raster contour data to final DTED matrix form are based on weighted radial averaging methods for points surrounding

matrix posts. Contour data are likewise enhanced with geomorphic information (e.g., stream-beds and ridges) to preserve the integrity of terrain forms. 9/ Collected data are then transformed by post-processing on the UNIVAC 1100 Series computer to the DTED matrix format.

The role of digital cartography is increasing at DMAAC. In areas where a suitable data base exists, contours are generated from DTED. Cartographers use a computer program which constructs contours from a rectangular array of elevation points at specified increments of latitude and longitude. A smoothing algorithm automatically eliminates noise and bias errors that enter in the collection process. Generalizing selectively retains the geomorphic character of the surface while thinning the elevation data for compilations at smaller scales. Lastly, the contouring algorithm converts the elevation matrix data to linear contours. The advantages of computer-drawn contours are threefold: (a) man-hours and machine-hours are reduced; (b) advantage can be taken of the digital terrain elevation data base; and (c) there is less need for cartographer interpretation of topography.

Digital feature analysis data

The associated feature data file holds digitally encoded descriptions of culture and landscape features within the terrain region. Most feature types are represented by polygonal boundaries and descriptor tables. The table includes coded information such as surface type (e.g., forest), predominant makeup (e.g., deciduous trees) and average height. Some features, such as bridges, dams, walls and pipelines, are specified by line segments, while others, such as towers and certain buildings, are specified as point locations with feature heights included. Header records containing index and reference information are used to relate descriptive information to corresponding geographical locations of features. Detailed DLMS data content is described in a Defense Mapping Agency publication. 10/

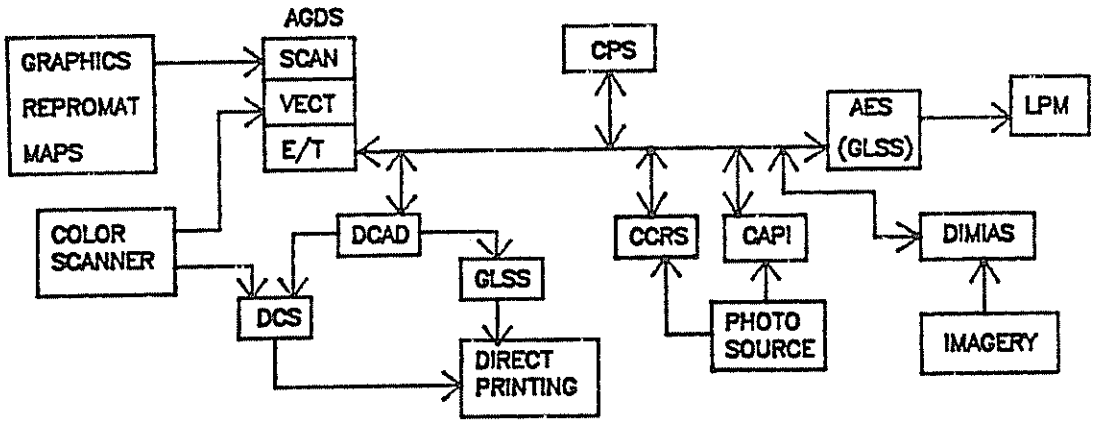
Specification upgrade for charting requirements

The DFAD specifications are being updated to support charting requirements. The scale at which these data are collected must be sufficiently large so that it will support all charting products. Special emphasis must be placed on the collection of roads, railroads, cultural features and drainage. Attribute data for features of the DFAD base must be of such detail as to ensure successfull retrieval for charting.

Advanced edit system

The advanced edit system, shown in figure 162, was developed as an interactive editing system for editing symbolized colour-separation data in final plotter format prior to final plotting. It can also be used for editing digital features from various other formats. It is anticipated that DCAD will be edited on AES for revision and for recompilation of the 1:200,000 scale aeronautical charts.

Figure 162. United States of America: proposed production scenario for advanced edit system



PROPOSED AND FUTURE DIGITAL PROGRAMS

Soft-copy production

DMAAC is escalating the automation of the charting process and expects to achieve an all-digital soft-copy production capability by 1988 (see figure 162), which will include the establishment, as appropriate, of uniform procedures relating to the collection, screening, evaluation, editing , symbolization, retrieving and exchange of digital source and production data. It is anticipated that the concept of digital colour-separation and data-base development will necessitate some minor changes in product specifications and compilation procedures. Existing charting specifications for DMA products were developed in an era devoid of automation. These specifications need to be re-evaluated for redefinition of certain cartographic rules in order to maximize the savings that are possible through automation while maintaining effective communication to the users. 11/

Listed below are currently identified developmental efforts to support the proposed soft-copy production system.

System capabilities include:

(a) Advanced edit system to support the preparation, editing and plotting of symbolized digital map colour-separation data;

(b) Cartographic compilation/revision system (CCRS), to provide a capability to work simultaneously with graphical, photographic and digital data;

(c) Computer-assisted photographic interpretation system (CAPI) for integrated photo-interpretation/mensuration/compilation, to supprt DTED, DFAD, digital vertical obstruction data (DVOD) and automated charting;

(d) Digital interactive multi-image analysis system (DIMIAS), used primarily to analyse and extract landscape features from digital imagery in a semi-automated mode;

(e) Clustered carto-processing system (CPS), to provide a set of interrelated automatic and interactive functions to accept digital data from AGDS, CAPI and DIMIAS and to perform various transformations on the data;

(f) Digital chart system (DCS), to be a new generation of auto-carto hardware/software to accomplish maximum exploitation of the planned digital cartographic applications data base.

Support hardware includes:

(a) Colour scanner, for rapid digitization and separation (by colour) of symbolized cartographic feature data protrayed in DMA chart and source materials in multicoloured lithographic format;

(b) Digital laser plate-maker, to provide a capability to go directly from digital data to press-plate;

(c) Direct printing, to combine text and digital colour-separation data and directly print in a variety of colours in a single press run with no reproduction copy or plate preparation.

The data base is described below:

(a) Digital terrain elevation data constitute a digital file that is a subset of the digital landmass system, DTED is composed of terrain data with elevations stored in a matrix referenced to mean seal-level, with horizontal positioning referenced to the World Geodetic System 1972 (WGS 72);

(b) Digital feature analysis data are a digital file that is a subset of the DLMS system. It described the physical characteristics of the three-dimensional surface described by DTED;

(c) Digital vertical obstruction data form a digital file consisting of vertical obstructions referenced to WGS 72;

(d) Digital cartographic applications data base is a data base of chart features in a standard lineal or segment-noded format. DCAD is a combined product specification which will satisfy DFAD, DTED, DVOD and automated charting requirements.

Support software includes:

(a) Software for auto-carto to provide advanced contours to matrix;

(b) Matrix to contour and line-data thinning;

(c) Auto-carto feature identification data to support product compilation (i.e., automatic tagging of cartographic features);

(d) Line generalization for automatic adjustment of chart detail for product scale changes;

(e) Universal transformations and adjustments.

Data base requirement

Regardless of the complexity of the above-mentioned production processes, the creation of an off-line digital cartographic applications data base remains one of the largest hurdles to be overcome prior to implementation of an effective automated charting production process. The many systems within the proposed production process shown in figure 162 would currently be limited in their effectiveness for lack of a common standard format that would allow data exchange between those systems not directly interfaced. DMA is developing a standard linear format for the efficient interchange of digital data. Such a format could be the logical basis for DCAD, and for the purpose of the present paper, DCAD and SLF will be synonymous. 12/

In the past, the charting, DTED, DFAD and DVOD programs have been separate and legitimate programs because each had its own requirement and production schedule. Typically, DMAAC requirements for charting, DFAD, DTED and DVOD could all be derived from the same basic control and source materials. The CAPI system is expected to provide this capability to achieve all four requirements in a single pass. It would produce common data elements, to the extent practical, in terms of cost and time available, when digital data are required to support multiple products over the same geographical area. Such a production process would capitalize on redundant production requirements, provide source and product commonality and subsequently minimize profileration of production and maintenance software. DCAD has two basic design objectives: (a) to store a string of data only once, no matter how many features it may be a part of (segment/node format); and (b) to accommodate multi-product and multi-series charting requirements. 13/

The segment node format of DCAD will have inherent advantages over the polygon format currently used for DFAD data storage. The polygon format does not identify nodes of feature segments. The whole feature (see figure 163) can be identified only as a segment. Thus, DFAD features sharing a common boundary were overlapped to ensure coverage. This procedure was developed because, at that time, only manual digitizers were available for data collection and the capability to digitize a single common boundary for adjacent features was impractical. Manual overlap could have been eliminated in off-line post-processing of the digital data but often resulted in the subsequent computer generation of overlap slivers or fictitious gaps in the digital data; and additional processing was required to eliminate them, where possible. The line segment-noded format would eliminate this problem, avoid double storage or common boundaries, simplify update and correction, and be responsive to thinning and generalization algorithms.

It is feasible to develop a storage format designed to accommodate these requirements. Such a design would include the following items:

(a) Header information to contain descriptive information or attributes of the data set;

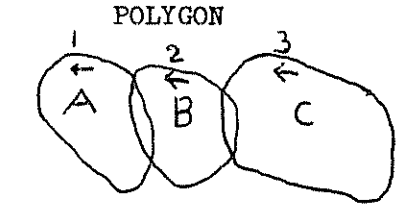
(b) Data sets to accommodate feature and line segment information:

(i) Feature information (see figure 164) to identify the unique features which make up the data set. Specifics on feature data content would depend upon the product specification;

(ii) Line segment information (see figure 164) to contain the actual coordinate strings for the segments which make up each unique feature. All features that include a segment would be so identified;

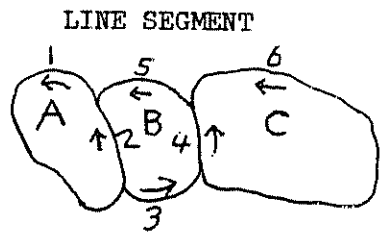
(c) Free text information to further define or uniquely to qualify data as required. 14/

Figure 163. United States of America: data base formats



FEATURE A: SEGMENT 1
FEATURE B: SEGMENT 2
FEATURE C: SEGMENT 3

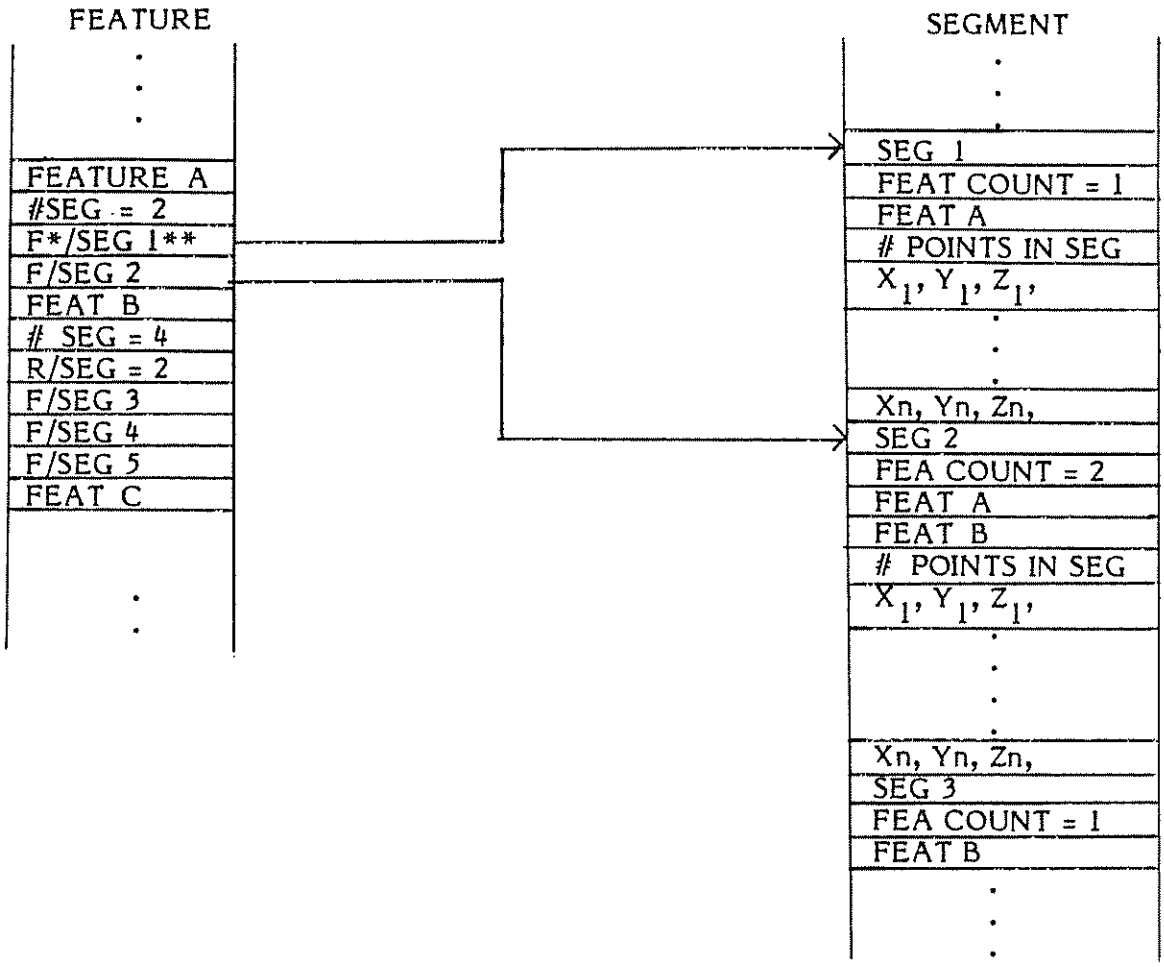
A



FEATURE A: SEGMENTS 1, 2
FEATURE B: SEGMENTS 2, 3, 4, 5
FEATURE C: SEGMENTS 4, 6

B

Figure 164. United States of America: line segments data base



Note: * indicates direction of segment (forward (F) on reverse (R));
** signifies that segment list is ordered to track the feature boundary.

CONCLUSION

Automated charing at DMAAC is approaching production levels. Equipment and systems projected to support future auto-carto production requirements, through the decade of the 1980s, have been defined and are in development. To support these future requirements, DMAAC is developing for implementation a digital cartographic applications data base to support charting requirements where digital data is available. Relief information would be generated from DTED source and chart feature data would be derived from DCAD.

To satisfy charting requirements using DCAD as a source, additional software development is needed. Algorithms are being investigated and will be developed to support the filtering, generalization, displacement and symbolization requirements of multi-series, multi-scale charting. The cartographer should also have the option to output the final colour separations to a laser plate-maker for lithographic printing or to exercise a computer algorithm which will composite all separations for the direct printing process (raster colour-printing technique). For the immediate time-frame, digital cartographic data for input to DCAD must be collected using various collection equipment and sources. Computer systems, software and procedures such as digital panelling, AGDS, GLSS, Gerber/Xynetic proof-plotting and Gerber photo-plotting will be the current mainstays for automated charting.

Notes

1/ Dennis P. Franklin, "Charting utilization requirements for a digital cartographic data base", in Proceedings of Auto-Carto 5/ISPRS IV, Crystal City, Virginia, 1982.

2/ Charles A. Erphenbach, "The development of small scale map control via digital paneling of large scale map source", in Proceedings of the ACSM-ASP Convention, Denver, Colorado, 1982.

3/ Garry L. Holmes, "Computer assisted chart symbolization at the Defense Mapping Agency Aerospace Center", in Proceedings of Auto-Carto 5/ISPRS IV.

4/ Ibid.

5/ Ibid.

6/ Ibid.

7/ Philip K. Alderman, "Experiences with digital terrain elevation data contouring programs", paper presented at the ACSM-ASP Convention, Denver, Colorado, 1982.

8/ Darryl L. Rue, "Computer assisted feature analysis for digital landmass system (DLMS) production at DMA", in Proceedings of Auto-Carto 5/ISPRS IV.

9/ Ibid.

10/ Defense Mapping Agency, Product Specifications for Digital Landmass System (DIMS) Data base (1977).

11/ Franklin, op. cit.

12/ Ibid.

13/ Ibid.

14/ Ibid.

(e) Topographic and large-scale mapping

MAP-ACCURACY SURVEYS BY THE DIVISION OF NATIONAL MAPPING*

Paper submitted by Australia

RESUME

La Division de cartographie effectue régulièrement des levés de terrain afin de tester l'exactitude des cartes topographiques au 1:100 000 par rapport aux normes du Conseil national de cartographie. Des méthodes ont été mises au point et améliorées lors de récents levés et, à l'avenir, il sera fait davantage appel aux techniques photogrammétriques pour les évaluations d'exactitude.

Since 1970, the Division of National Mapping (Natmap) has undertaken map-accuracy surveys in order to test the quality of the 1:100,000 scale national topographic map series against the standards of map accuracy set by the National Mapping Council (NMC).

Those standards are:

(a) Horizontal accuracy. The horizontal accuracy of sandard published maps shall be consistent with the criterion that "not more than 10 per cent of points tested shall be in error by more than 0.5 mm". This limit of accuracy applies to the positions of well-defined points only. Well-defined points are those which are easily visible or recoverable on the ground;

(b) Vertical accuracy. Vertical accuracy, as applied to the contours of standard published maps, shall be consistent with the criterion that "not more than 10 per cent of the elevations tested shall be in error by more than one half the contour interval". In checking elevations taken from the map, the

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, appeared as document E/CONF.75/L.5.

apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

Currently, Natmap carries out accuracy surveys for two 1:100,000 map-sheets each year--about 1 per cent of the annual compilation production at 1:100,000 scale.

The sheets selected for field evaluation are those representative of a group of sheets within a photogrammetric block with common compilation methods and ground control distribution. A variety of ground control and compilation methods have been used in original compilations, and the accuracy surveys influence decisions on whether to upgrade control or compilation in areas where maps are due for revision.

METHODS

The current methods evolved during the three most recent accuracy projects, undertaken since October 1981.

The first of these three surveys established ground co-ordinates of points of well-defined identifiable map detail directly, by measuring a closed electronic distance measurement (EDM) traverse within the area of the map-sheet, supplemented by local survey radiations.

This technique suited the topography and road access, but a party of six was still unable to fix enough map-detail points in the three-week period to draw a sound conclusion as to the accuracy of the map. However, the new ground control established was used in an analytical aerotriangulation adjustment, which in turn was used to assess the accuracy of the original analogue planimetric model control (which came from an assembly of slotted photo-templates).

The second survey used JMR Doppler positioning equipment in order to establish photo-identified horizontal control points, with an accuracy better than +3 m at 15-minute intervals on the perimeter of the map area. This control, together with four existing ground control points, was used in an analytical adjustment to:

(a) Determine the standard errors in the original analogue model control points;

(b) Compare the analytical values of map-detail points with the surveyed values.

Further points of well-defined map detail within the map area were identified and fixed by Doppler point-positioning and local traversing. A total of 37 detail points were fixed and comparisons made between: ground survey and analytical; ground survey and compilation (digitized values); compilation and printed map; and ground survey and printed map.

The ground survey and printed-map comparison showed that the map-sheet was well within the NMC horizontal accuracy standard. The aim of the other comparisons was to find out how much accuracy was lost in mapping.

The latest survey, carried out in June 1982, has further developed the procedures, particularly those for vertical accuracy evaluation. Level connections wre made to the original vertical model control points, fixed by laser terrain profiler, in order to check the accuracy of this technique.

THE FUTURE

The next accuracy project will establish ground control--on the perimeter of a map-sheet--for a new analytical adjustment which will include observations of a large number of well-defined map detail points. The derived analytical co-ordinates for the field-identified detail points will then provide a comprehensive comparison with the scaled map-sheet values. Apart from a few vertical check-points to strengthen the analytical adjustment, no further field survey of map detail will be required. Previous accurate surveys indicate that the horizontal analytical co-ordinates produced for the well-defined points will be within +5 m of the true values. This difference is considered negligible for the purpose of assessing 1:100,000 map accuracy.

The check of vertical accuracy will be supplemented by independently controlling selected models of undulating terrain, by trigometrical heighting or spirit-levelling of the model control points and by replotting of the contours for comparison with the published map in order to determine likely error components.

SELECTION OF TOPOGRAPHIC NAMES FOR THE NATIONAL MAP SERIES*

Paper submitted by Australia

RESUME

Les noms de lieux sont recueillis par la Division de cartographie à partir des anciennes cartes au 1:250 000 et de la nomenclature toponymique, de mêne qu'auprès de sources officielles et par précomplètement.

Lorsque le nom officiel et le nom local découvert au cours du précomplètement ne concordent pas, il faut prendre une décision quant au nom à retenir. On retient le nom officiel d'un lieu à moins que des preuves suffisantes n'indiquent que le nom utilisé communément est largement accepté et serait le plus utile pour l'utilisateur d'une carte.

Une note est ajoutée aux cartes, indiquant que des noms officieux peuvent y figurer.

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, appeared as document E/CONF.75/L.4.

COLLECTION OF NAMES

Names of features are collected by the Division of National Mapping (Natmap) for its mapping programme covering all states and territories of the Commonwealth of Australia. The programme, commenced in 1965, is to produce national series of topographic maps at 1:100,000 and 1:250,000 scales.

The R502 series of 1:250,000 scale maps, completed in 1968, is the basic source of names. Tese maps and the gazetteer derived from them provide a comprehensive, although not necessarily official or complete, listing of topographic names in Australia.

The original material is updated and corrected with information obtained from the relevant official state names authority, other authorities and field inspection.

A problem occurs if the official name of a feature differs from the locally accepted name. The surveyor checking the map-sheet in the field has to make a decision on which name is to be used by considering the origin, source and value to the map user of each alternative.

OFFICIAL NAMES

Official names are those approved by the relevant state names authority. They usually originate from official government records, including maps, and have a strong historical background.

The state names authority is the primarily source of official names within a particular state, but names can also be obtained from national parks, lands, pastoral, forestry and water authorities.

Reliability of the position and spelling of official names is assured by the practice of their approval and notification in the states' government gazettes.

LOCAL USAGE

Locally known names become established from long-term usage by the community. Occasionally they are corruptions of official names or have alternative spellings.

These names come from a variety of sources, including:

(a) Local authorities (e.g., post office, police, local government and tourist authorities);

(b) Signposts;

(c) Landholders, particularly in the more remote areas;

(d) Existing maps.

DECISION TO SHOW OFFICIAL OR UNOFFICIAL NAMES

The official name of a feature is shown, unless strong evidence indicates that the commonly used name is firmly entrenched and would be the one most beneficial to the map user. In such cases, the official name will often eventually be changed to the one commonly used.

It is the policy of Natmap to encourage the use of official names. In some cases, however, where the official name is largely unknown locally, it may be necessary to show both the official and unofficial names on a map.

In order to avoid the impression that all names have an official status, Natmap now adds the following disclaimer to its maps: "Inclusion of a name on this map does not imply its approval by the relevant nomenclature authority".

MAP PRODUCTION AND MAP REVISION IN NEW SOUTH WALES*

Paper submitted by Australia

RESUME

Le présent document contient une description des méthodes pratiques et économiques appliquées en Nouvelle-Galles du Sud en ce qui concerne la production initiale et la révision de cartes rurales et urbaines.

Le Service central de cartographie de Nouvelle-Galles du Sud publie chaque semestre un catalogue des cartes de cet Etat décrivant les progrès réalisés dans le domaine de l'établissement de cartes à moyenne échelle et à grande échelle et de la photographie aérienne dans ledit Etat. La mise à jour périodique du catalogue est extrêmement utile dans la mesure où elle tient les utilisateurs au courant des progrès réalisés.

Australia has a three-tiered system of government, including the federal Government, seven state governments and several hundred local government authorities.

The National Mapping Council assures that there shall be no duplication between the federal Government and the state governments--broadly by allocating small-scale mapping to the Commonwealth and medium-scale and large-scale mapping to the states--while State Mapping Advisory Committees ensure that there shall be no duplication between state governments and local authorities and recommend priorities.

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* The original text of this paper, prepared by the Central Mapping Authority of New South Wales, appeared as document E/CONF.75/L.36.

In New South Wales, the Central Mapping Authority is reponsible for medium-scale and large-scale mapping over an area that has 5.2 million population, 2.4 million land parcels and 803,000 km^2 of terrain.

RURAL TOPOGRAPHIC MAPPING

Because of the vast change that occurs between the high-rainfall, densely settled, eastern coastal belt and the semi-arid pastoral leases of its western division, West South Wales has been divided into three medium-scale mapping zones: 1:25,000 covering the coast and the Great Dividing Range; 1:50,000 covering the broad acre cropping areas; and 1:100,000 covering the sheep-grazing areas in the "dead heart".

This rationalization of map scales to match terrain detail, land parcel size and land use has been the single most important factor in enabling New South Wales--a state larger than the famous State of Texas--to achieve initial map coverage within a reasonable period of time.

The following basic production methods are applied to initial rural mapping coverage:

(a) The geodetic framework is used to establish ground control at intervals of about 20 km;

(b) A Cessna 421 Golden Eagle, equipped with a Wild RC10 camera, is used to undertake aerial photography on scales of about 1:50,000. The film is processed on a Bako automatic processor, and aerial triangulation is done on a Zeiss stecometer connected interactively with a PDP 11/150 computer in order to obtain immediate feedback as to the accuracy of y-parallaxes and model joins;

(c) Compilation is undertaken in three layers on Kern PG2 stereoplotting machines applying Earth curvature correction. The layers are: (i) contours and watercourses; (ii) man-made detail, including roads, buildings and fences; (iii) vegetation;

(d) All cartography, including a cadastral overlay derived from the fence pattern and survey plans, is undertaken on scribe coat in negative and the maps are always printed in the four process colours. They include an integral cover and are folded for ease of marketing;

(e) The maps are distributed by the Crown Lands Office and by some 530 agents, as well as by the Central Mapping Authority itself.

RURAL MAP REVISION

The Authority revises about 100 rural topographic maps each year. The revision process includes:

(a) New aerial photography;

(b) Updating on Kern PG2 stereo machines by adding and deleting detail to a standard topographic composite of the four original negatives;

(c) Revision of the cadastral overlay from the new compilation and from new subdivision plans supplied by the Registrar General's Office;

(d) Rapid field completion to determine that road surfaces are correct, new features are named and that no significant information has been missed.

Altogether, the resources needed for revision are approximately two thirds of the resources needed for the initial compilation.

URBAN ORTHOPHOTOMAPPING

In 1970, no comprehensive series of large-scale mapping existed over the urban areas of New South Wales, which include Sydney (population of 3 million) and more than 100 towns with a population over 1,000.

It was decided that the only practical economic way of mapping these towns was the orthophotomapping; and the scale 1:4,000 was selected because this scale clearly depicts every house, street and tree.

The maximum enlargement possible on the Zeiss topocart used for orthophoto production is four times, which leads to the photo scale 1:16,000, a 2-m contour interval and a map format conveniently covered by one aerial photo (3 x 2.5 km):

(a) Ground control comprises points around the perimeter of each town, together with six height control points for every map;

(b) Thr 2-m contours are plotted independently on Wild B8 stereoplotting machines, and in most cases the contours are digitized directly into a PDP 11/10 computer for subsequent automatic scribing on a Calcomp 7000 flat-bed plotter;

(c) Cadastral information is scribed directly on to a print-down of the orthophotomap on stabilene. This enables the cartographer to trace directly about 50 per cent of the land parcels by identifying fences shown on the orthophoto and comparing these with survey plans while the balance of the cadastral is plotted from survey data. This process has doubled the speed of cadastral map production;

(d) After field completion, the orthophoto, the names and the contours are assembled as one product while the cadastral is produced as a second product.

The maps are used extensively by planners, by local government and by state law and emergency agencies.

An average production rate of 200 new maps per annum has been achieved.

In the inner-city areas, the land parcels are smaller than in the outer suburbs, and the maps will therefore be revised on the scale 1:2,000 x 2 m for the second edition.

REVISION OF LARGE-SCALE MAPS

The revision procedure for the urban map series is given below:

(a) New aerial photography is undertaken together with new aerial triangulation;

(b) The orthophotos are produced on a Wild OR1 off-line orthophoto machine, either from the digital contour data converted to profiles or from digital profiles run on a topocart or Wild B8;

(c) Contours in quarries, in road-cuttings and on new playing-fields are revised on a Wild B8 stereoplotting machine;

(d) Field completion and assembly are undertaken as for the original map.

Experience of production times for revision is limited to about 100 urban map-sheets, but indications are that total production effort will be about two thirds of the initial production effort.

The map production and map revision described above are at the core of the Authority's functions, which also include such important work as aerial photography, geodesy and thematic mapping, as well as service mapping for all three tiers of government.

MARKETING

All of the effort put into map production would be to no avail unless the maps reached the users. The Authority therefore makes a continuing effort to ensure that map users shall be aware of their availability by revising and reprinting the "Catalogue of NSW Maps" every six months; by advertising in the press, in suburban trains and even on milk cartons; and by keeping its 530 sales outlets well stocked. As a result, annual map sales have risen from 78,000 Australian dollars ($A) to $A 528,000 in the past six years.

TOPOGRAPHIC SURVEY TECHNIQUES AND ACTIVITIES*

Paper submitted by Bangladesh

Au Bangladesh, le Service topographique est chargé de préparer et de mettre à jour les cartes topographiques à petite échelle (aux 1:250 000, 1:500 000 et 1:1 000 000) et à grande échelle (au 1:50 000 et 1:25 000) ainsi que des cartes à diverses échelles, du 1:16 000 au 1 200, utilisées pour des projets de développement.

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* The original text of this paper, prepared by Abdul Matin, Assistant Superintendent of Survey, Survey of Bangladesh, appeared as document E/CONF.75/L.117.

Le pays a une superficie de l'ordre de 144 000 km^2 cartographiée de la manière suivante: a) 266 feuilles (15' x 15') au 1:50 000; b) 27 feuilles (10' x 10') au 1:25 000; c) 6 feuilles au 1:500 000; d) 4 feuilles au 1:1 000 000.

Le Bangladesh procède à l'heure actuelle à la révision des cartes au 1:50 000 établies à partir de photographies aériennes au 1:30 000 prises en 1975 avec l'aide du Canada. Les photographies au 1:30 000 redressées en SEG-5 à l'aide des points de contrôle planimétriques obtenus par polygonation au théodolite puis réduites au 1:50 000. En même temps, le quadrillage est aussi imprimé en surcharge. Les détails sont tracés directement à partir de la photographie redressée et quadrillée, un bleu est établi et les détails sont vérifiés sur le terrain. Après cette vérification, les cartes sont dessinées puis imprimées en six couleurs.

Les cartes au 1:250 000 sont établies à partir des cartes vérifiées au 1:50 000.

Les progrès sont lents car les cartes sont dessinées à la main mais nous espérons que la série complète des cartes au 1:50 000 et au 1:250 000 sera achevée en huit ans.

Le Bangladesh a également établi des cartes en courbes de niveau équidistantes de 1,5 m au 1:16 000 pour des projets d'irrigation; des levés ont également été effectués au 1:4 000 et au 1:1 200 pour certains projets.

On commence à réaliser des levés urbains. Dix villes sur vingt ont été cartographiées.

Le Bangladesh a fini de démarquer ses 200 km de frontière terrestre avec la Birmanie qui traverse des zones montagneuses, rudes et boisées et de ses 62 km de frontière fluviale avec ce pays. A l'heure actuelle il procède à la démarcation de ses 300 km de frontière avec l'Inde, en terrain, tout aussi difficile.

Le Bangladesh a entrerpis de dresser une nouvelle série de cartes au 1:25 000 pour l'ensemble du pays. Le sud-est du pays est très rude, montagneux et boisé et il est donc très difficile d'établir des levés planimétriques et altimétriques. Le Bangladesh serait très reconnaissant à tout pays développé qui se proposerait de l'aider techniquement et financièrement pour cartographier cette région au 1:50 000 et au 1:25 000.

Les noms figurent en anglais sur les cartes. On s'efforce de passer au bengali.

The survey of Banglasdesh is responsible for preparation and updating of topographic maps on small scales such as 1:250,000, 1:500,000 and 1:1,000,000 scale, and large scales, such as 1:50,000 and 1:25,000; and project maps for development works on various scales ranging from 1:16,000 to 1:1,200.

Its area is about 55,200 square miles and is covered by: (a) 266 sheets (15' x 15') at 1:50,000 scale; (b) 27 sheets (10' x 10') at 1:25,000 scale; (c) 6 sheets at 1:500,000 scale; (d) 4 sheets at 1:1,000,000 scale.

Bangladesh is currently revising the 1:50,000 scale maps from aerial photographs at 1:30,000 scale taken in 1975 with Canadian assistance. The 1:30,000 scale photographs are rectified in SEG-5 with the help of planimetric control points provided by theodolite traversing and are then reduced to 1:50,000 scale. The grid is also superimposed during rectification. The details are traced out directly from the gridded rectified photograph, obtained blue points and verified on the ground. After verification, the sheets are fair-drawn and printed in six colours.

The maps at 1:250,000 scale are compiled from the verified 1:50,000 scale maps.

Progress is slow as the maps are drawn by hand; still, it is hoped that the mapping at 1:50,000 and 1:250,000 scale will be completed in eight years.

Bangladesh has also completed mapping of the country at 1:16,000 scale with 5-ft vertical contour intervals for irrigation projects. Some areas are also surveyed at 1:4,000 and 1:1,200 for particular projects.

The town survey is under way. Out of 20 cities, 10 have been completed.

Banglasdesh has also completed demarcation of 123 miles of very difficult high, forested land boundary and 39 miles of river boundary with Burma, and is now demarcating 188 miles of similar terrain on the boundary with India.

A new series of 1:25,000 maps of the entire country has been undertaken. The south-eastern part is very hilly and forested, and it is very difficult to provide both planimetric and vertical contours by the ground method. Bangladesh would greatly appreciate both technical and financial assistance from a developed country for mapping that area on the scales 1:50,000 and 1:25,000.

Names on the maps are given in English. An effort is being made to change the names to Bengali.

APPLICATION OF SCRIBING OF ALL MAP ELEMENTS IN PHOTOGRAMMETRIC MAPPING*

Paper submitted by China

RESUME

Le procédé de tracé sur couche de tous les éléments est largement utilisé dans la restitution photogrammétrique en Chine. L'article en décrit la technologie et l'application. L'expérience a demontré les avantages de ce procédé: amélioration de qualité

* The original text of this paper appeared as document E/CONF.75/L.62.

des cartes topographiques, simplification des procédures et accroissement de la productivité de 50 pour cent environ.

The surveying and mapping departments in China began their research and experiments on scribing materials, tools and technology in the early 1960s, and the scribing method was introduced into map production in the mid-1960s. At the beginning of the 1970s, experiments were made on direct scribing in photogrammetric mapping. At first, the scribing method was used only for contours. Subsequently, scribing of all the map elements in photogrammetric mapping succeeded through experiments, and the method is now extensively used.

In the scribing method described here, all the elements on photogrammetric originals are directly compiled into printing originals. A trichromatic map, for example, is produced through the technological process shown in figure 165.

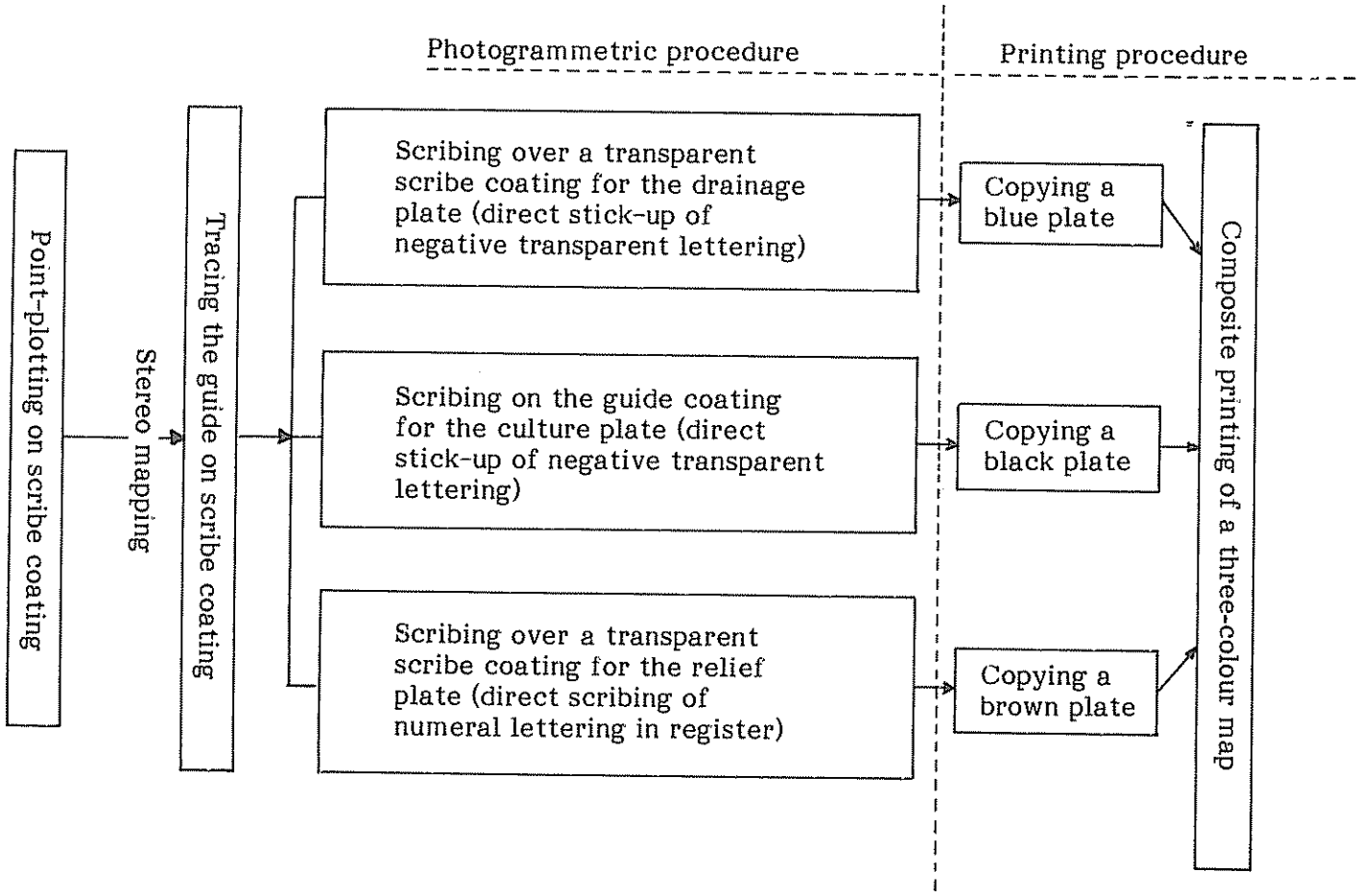
Mechanical scribing is mainly used, except for some special symbols (for example, point symbols), which are done by the electric-pen type of scribing.

Two types of scribing tools are mainly used: a floating-arm scriber; and a ring-type scriber. The floating-arm scriber is fitted with ruling pens, swivel pens and multi-purpose scribing heads. Its advantages include holding well and stable movement of the pens. There is less rubbing on the map surface and it is easy to keep the map surface clean, but the tools require strict manufacturing. The ring-type scriber is convenient to use and easy to maintain vertical if it is mounted with stable and swivel pens. These tools are manufactured easily, but the ring feet cannot prevent more rubbing on the map surface, which can easily be soiled and damaged. Experience in China has shown that desirable results can be obtained with both scribers provided they are used properly. In addition to a set of scribing pens for scribing different lines and symbols, a set of coating sheets of symbols is also needed for scribing map symbols of various shapes and sizes, including arabic numerals in register.

All types of script lettering on maps are completed with stick-up transparent lettering. As for the part of the map required for tinting, the printing-plate is made by making a negative separation using the stripping method, with an addition of ruling films.

In the course of scribing and compiling all the map elements on colour separations, there occasionally is a problem of poor registration, due to distortion of base of the scribe-coat film and to scribing and compiling differences on separations. Therefore, the film base used for making scribe-coat film must be pre-processed for setting. The problem of poor registration of relief, drainage and culture plates caused by scribing and compiling differences may be solved by revising the technological process, modifying the examination method and improving scribing and compiling quality. In revising the operation method, some agencies use a "dyeing" method to replace the scribing and compiling on separations with that on one plate. In a trichromatic map, for example, cultures are first scribed and compiled on the scribe-coating guide for all the elements and a wrong-reading positive plate for culture is copied after the examination. The guide is dyed in order to make the scribed culture elements opaque; drainages are scribed and compiled and a wrong-reading positive plate

Figure 165. China: technological process for scribing trichromatic maps at 1:10,000 scale in photogrammetric mapping



for drainage is copied. Then, the guide is dyed again and the relief plate is made in the same way. Therefore, the printing-plate may be prepared directly with the wrong-reading positive plates and the guide is taken as a model for examining registration.

In some agencies in China, experiments were made on directly scribing and compiling relief with photogrammetric mapping instruments, with good results. Their experience shows that for relief that is complete and not too broken, when the stereoscopic image is distinct, skilled operators can directly scribe and compile contours with mapping instruments. In addition, production efficiency and mapping accuracy may be raised and improved with it. For broken-relief areas, however, it might be difficult to scribe and compile relief directly with mapping instruments.

From the experience gained in China, use of the method for scribing all the map elements, as compared with that of fair-drawing with pens and ink, has the following advantages:

(a) Scribing lines are precise, exquisite and unbroken, with the symbols better standardized and a clean printed-plate surface; thus, map quality is improved by simplifying the working process and reducing operation errors;

(b) New operators may be easily trained, because mastering the scribing technique is easier than learning the fair-drawing technique;

(c) Working efficiency is increased by 20-30 per cent, as compared with that of fair-drawing;

(d) Printing originals may be provided directly so that the process of reproduction and duplicate copying can be eliminated. According to the statistics in some agencies, working efficiency might be raised by 50 per cent in the whole course of mapping;

AN OUTLINE OF NATIONAL CARTOGRAPHIC DEVELOPMENT*

Paper submitted by Malaysia

BACKGROUND

Although no definite data can possibly be set for the beginning of cartography in Malaysia, a map of Peninsular Malyasia, which was called Malacca, dates back to the sixteenth century. Systematic cartographic activities in Peninsular Malaysia, however, began as late as the middle of the nineteenth century. In 1832, a triangulation system was set up in Penang. Subsequently, survey departments were established in the Straits Settlements (Penang and

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* The original text of this paper, prepared by Shuib bin Fadzil, Chief Cartographer, Directorate of National Mapping, appeared as document E/CONF.75/L.88.

Malacca), the Federated Malay States (Perak, Selangor, Pahang and Negeri Sembilan) and the unfederated Malay states (Kedah, Perlis, Kelantan, Johore and Trengganu).

The first cartographic work was begun in the 1880s; and a series of 16-chain scale lithographed sheets of Kurau and Krian was produced and printed at Dehra Dun, India, in 1885.

Encik Md. Salleh bin Prang claimed to have made a map of the State of Johore between 1868 and 1877 and to have sent it to England for certification but no copy is known to be extant. The first known cadastral plan, dated 1885, is of land in the Gunung Pulai area. A further edition of the state map was prepared in 1907.

In September 1908, the first Survey-General of the Federated Malay States was appointed; and on 1 January 1909, the Revenue Survey Departments in Perak, Selangor, Negeri Sembilan and Pahang and the Trigonometrical Survey were formally amalgamated into the Federated Malay State Survey Department. The Federated Malay States and Straits Settlements Survey Departments were then amalgamated in 1920. In 1909, the Topographic Branch of the Federated Malay States Survey Department was set up to concentrate entirely on the mapping work. In its first year, 24 square miles of detail on the 1-inch scale were completed in Perak. In 1910, the survey of the standard sheets at 1 inch to a mile was begun in Perak; and at the same time, the Map Production Section was created under the supervision of a chief draughtsman solely for the purpose of producing Survey Department maps as required for civil administration, public use or military operations. The general work by the Map Production Section for the Revenue Branch was the printing of lithographs or copies of standard sheets. Photolithographic apparatus and machinery were installed in 1911 in the Java Street (now Jalan Tun Perak) Survey Headquarters building, which had been completed earlier in the same year.

Among the first maps produced were coloured editions of Selangor and Kinta. Thus, the Department established itself step by step and became independent of both India and the United Kingdom, where much of the earlier specialist work had to be carried out.

Malayan maps produced by the Map Reproduction Section included:

(a) Maps of the country ranging from the political and physical map of Malaya at 6 miles to an inch to the map at 45 miles to an inch used for a report map;

(b) State and settlement maps on scales ranging from 1 mile to 4 miles to an inch. These maps, wich later were termed "land-utilization maps", showed the purpose of land alienation together with as much topographic information (other than contours) as was required to make them useful as general-purpose maps;

(c) Topographic maps at 1:63,360 and 1:25,000 scales;

(d) Town maps of majors towns at various scales;

(e) Special maps designed to meet the needs of certain departments, e.g., geological and forestry maps.

The Map Production Section produced maps not only for Malaya but for Singapore, Sarawak, Brunei and British North Borneo on behalf of their governments.

The Topographic Survey Division continued to prepare maps showing the physical features of the country. These maps were immensely valuable for development purposes, especially in a country like Malaya. The Map Reproduction Section was responsible for drawing map originals, and its main function was to reproduce the first topographic map series, designated as the L707 series, covering all of Malaya.

The slump of the early 1903s affected every department in the country and drastic retrenchment took place, but a gradual trend of improvement set in by 1933 and the establishment had recovered and expanded when the Second World War broke out in the Pacific in 1941.

The Map Reproduction Section survived during the Second World War. Several ot its personnel served in the first Field Survey, Company set up after the withdrawal of United Kingdom Forces. The Surveyor-General had issued instruction for the dispersal and protection of records; copies of all maps were sent to India. The Map Reproduction Section at Kuala Lumpur continued operations until January 1942, in spite of air raids; and a second section continued in Singapore until it fell. Maps and equipment left behind were destroyed. During the period 1942-1943, Malayan maps were reproduced by outside mapping agencies, such as the Army Map Service or India.

The defeat and the Japanese occupation in 1942 halted cartographic activities in Malaya. Most of the mapping data, compilation sheets and negative plates considered important and classified by the British were either destroyed or shipped out. Offices were opened but many of the staff had fled or hab been retrenched, and no maps of Malaya were produced during that period.

The early post-war years were devoted to re-establishment--sorting out the problems created by the war and building up staff strenght to deal with the large areas awaiting development. The demand for topographic maps was great. The Map Reproduction Section was reorganized and set up into a highly specialized branch, the Central Drawing Office. The post of Chief Draughtsman was upgraded to that of Chief Cartographer; and the posts of Cartographer, Head Draughtsman and Head Artist were created.

In 1946, the topographic records that were being held in India and Australia were returned to Malaya, and map reproduction was resumed with a good deal of makeshift repairs.

It had been the original intention after the war to transfer complete responsibility for topographic mapping to the Directorate of Colonial Surveys in the United Kingdom. In 1947, it was agreed that the Topographic Branch should provide ground control, and the Directorate of Colonial Surveys did the compilation and contouring from aerial photography. The work has begun in 1947; and by 1949, ground controls for four sheets in the Endau area had

been forwarded to the United Kingdom. Because of the communication problems, the difficulties of co-ordination over such a long distance became increasingly apparent. In 1949, the Topographic Branch took over the aerial compilation, leaving only the contouring to be done by the Directorate. That plan proved generally unworkable, and the Topographic Branch eventually took complete responsibility for contouring as well.

In 1941, as much as 60 per cent of Malaya was covered with 1 inch to a mile topographic maps. The need to complete the mapping of the remaining 40 per cent as quickly as possible became apparent after the war. It was then decided to complete the 40 per cent in a period of 10 years. At the outbreak of the emergency in 1948, the Survey Department undertook to complete a 1-inch aerial reconnaissance map over the whole of the unmapped portion of Malaya in the shortest possible time; these were known as "emergency series" or "E" maps. The maps were prepared from aerial photographs utilizing all available existing survey data, including positions from panorama observations at a trig station and any other information collected from the Revenue Division, District Offices, Forest Offices and other authorities. The work was completed in 1953.

In 1947, it was decided that a new projection should be used for the military grid; and after taking into consideration both the condition of the existing triangulation and the possible future needs of revenue division, the rectified skew orthomorphic projection was adopted. At that time, topographic maps carried one or two reference 1,000-yard grids: (a) the Johore Grid or Southern Grid for areas in Johore; and (b) the Malay Grid or Northern Grid for the rest of the country, Malaya.

The projection is orthomorphic, the central meridian being skewed to 324° to conform to the general geographical axis of the country. Advantage of this change has been taken to redesign the topographic sheet layout. The existing sheets cover one quarter of a degree of latitude and one quarter of a degree longitude, each sheet being approximately 17 inches square and covering about 300 square miles. In the new series, sheets are not bounded by lines of latitude and longitude but by convenient grid lines. Each sheet will be roughly 50 per cent larger than the old series covering about 470 square miles. Each new sheet in the series at 1 inch to a mile will be accompanied by six sheets at 1:25,000 scale covering the same area for the benefit of those users who prefer or need a large scale. Tables for the projection were prepared by the Directorate of Colonial Surveys in 1948.

In 1950, it was decided to adopt a new series of grid edge 1-inch topographic sheets and to proceed with the completion of the 1-inch standard mapping. The grid was based on the rectified skew orthomorphic projection. The new series, L7010, which is known as the "new standard mapping", accompanied by L8010 at a larger scale (1:25,000), was introduced to replace the old L707 series.

With the introduction of the new series and other cartographic work, it became evident that the work-load borne by the Central Drawing Office (Map Reproduction Section) necessitated expansion and reorganization. A recruiting exercise was launched; and in 1955, the Branch established its own Training Section under the supervision of a full-time instructor. The section was the

first of its type in the country; it was able to produce highly trained cartographic technicians not only for its own purpose but for other agencies in need of such skilled personnel.

In 1956, Multiplex equipment and a Wild A8 stereoplotter were purchased, followed by an RC8 camera in 1958, to help the Topographic Branch to produce cheaper and more accurate maps and become independent of aid from the Directorate of Colonial Surveys.

In 1961, the Central Drawing Office moved to new air-conditioned premises at Jalan Gurvey, occupying two floors of the eight-storey Survey Department Headquarters Building.

In September 1963, a new country, Malaysia, was established by joining together the Federation of Malaya, the British colonies of Singapore, Sarawak and British North Borneo (Sabah). Cadastral surveys remained a federal responsibility for the states comprising the Federation of Malaya and the State of Singapore, but for Sarawak and Sabah, cadastral surveys remained a state responsibility. The federal Government was responsible for geodetic surveys and for topographic mapping for the whole of Malaysia.

In March 1965, the federal Government approved the establishment of the Directorate of National Mapping, Malaysia, with the following terms of reference:

(a) That the Surveyor-General, State of Malaya, be appointed as Director of National Mapping, Malaysia;

(b) To advise the Government of Malaysia on mapping and to implement such policy as the Government shall direct;

(c) To carry out topographic and geodetic surveys and produce and maintain topographic and town maps of Malaysian territories at scales to be determined by the National Mapping Committee.

After the formation of the Directorate of National Mapping, the Central Drawing Office acquired its present name--the Cartographic Division--which is more appropriate to the activities done.

CARTOGRAPHIC ACTIVITIES OF DIRECTORATE OF NATIONAL MAPPING

The Directorate of National Mapping is responsible for the production and publication of the topographic maps for Malaysia (Peninsular Malyasia, Sabah and Sarawak). The mapping of 135 sheets in the L7010 series on the scale 1:63,360 covering the whole of Peninsualr Malaysia was completed in 1974. In addition to the normal reprints or with few revision, 65 sheets were reproduced under the standard revision mapping programme. The revision was stopped in 1977 because of the work-load in the Directorate caused by its direct involvement in national projects and development. Furthermore, the new L7030 series on the scale 1:50,000 in metric, is being considered to supersede the old L7010 series.

Recently the preparation of the specifications for the publication of the new L7030 series was completed, and 10 sheets out of 177 sheets in this series that covers the whole of Peninsular Malaysia were cartographically prepared and are expected to be published by the end of 1983.

In series L8010, topographic maps at 1:25,000 scale, 377 sheets were published. The work has been halted as this series is to be published together with the new L7030 series on the scale 1:50,000, in which each sheet will be accompanied by four 1:25,000 sheets covering the same area.

Town maps are produced at various scales varying from 1:10,000 to 1:15,000 or even larger, depending upon the size of the town. Planimetric "non-restricted" town maps of the state capitals are cartographically prepared; and the first of this type, Kuala Lumpur, was published in 1982. Three more maps are expected to be published within this year.

Special-purpose maps, such as road maps, wall maps, political and physical maps and other small-scale maps, are derived from the topographic map series. Topographic maps also serve as base maps for the thematic series, such as soil, vegetation, forestry, water resources and geological maps. Some government departments do have a small cartographic section to produce special-purpose topical maps. The Geological Survey, Soil Survey and Forestry Departments prepare their cartographic works for the Directorate to reproduce.

The State Revenue Survey or the Cadastral Survey Department is responsible for the reproduction of its large-scale cadastral mapping. The Directors of Land and Surveying in Sabah and Sarawak, who produced the mapping of their respective territories before the formation of Malaysia, were asked to continue their mapping work as agents of the Directorate of National Mapping.

The topographic mapping of Sabah and Sarawak for the T735 series on the scale 1:50,000 are revised and produced by the Directorate of National Mapping, and 59 sheets were published during the period 1976-1982.

At the first meeting of the Asia, South-East Division of the United Nations Group of Experts on Geographical Names, held at Kuala Lumpur in 1975, it was agreed that the Directorate of National Mapping, Malaysia would produce the political and physical maps of the Division. It was also agreed that the Directorate of National Mapping would compile and print the regional and concise gazetteer based on the list of place names contributed by the member countries.

The Division has recently been expanded to include the Pacific South-West region, and it is now known as the Asia South-East and Pacific South-West Division. A new map of South-East Asia on the scale 1:7,000,000 was compiled with insets of Brunei and Singapore at 1:750,000 and 1:300,000, respectively.

NATIONAL CARTOGRAPHIC ACTIVITIES*

Paper submitted by Nepal

RESUME

Le Népal a grand besoin de cartes et de levés pour divers projets de développement socio-économique. Le Service géographique du Gouvernement du Népal est l'organisation centrale sous l'autorité de laquelle fonctionnent tous les services cartographiques du pays. Il doit satisfaire les demandes sans cesse croissantes en ce qui concerne l'établissement de cartes dans le pays, notamment exécuter des levés géodésiques, cadastraux et topographiques et assurer la formation de géomètres à divers niveaux.

Au Népal, on dispose de sept stations Laplace, de 14 stations azimutales et de 14 points Doppler. Des activités de triangulation de divers ordres sont en cours et, depuis 1976, on procède à des mesures précises à nivelle-niveau le long des grandes routes existantes.

Les levés cadastraux sont effectués par une méthode graphique avec planchette et alidade télescopique. Les levés cadastraux sont terminés dans 45 districts au Népal et on estime qu'ils seront terminés dans les 30 autres d'ici 1990 au plus tard. Le plupart des plans cadastraux sont rattachés au canevas trigonométrique national.

Un projet de levés topographiques a été lancé avec l'assistance du Programme des Nations Unies pour le Développement. Ce projet, pour lequel on dispose maintenant de matériel scientifique moderne, consiste à prendre des photographies aériennes du pays pour divers projets et à dresser diverses cartes, telles que des cartes topographiques ou des cartes des ressources du sol.

On améliore actuellement le centre de formation aux levés afin de former au Népal des techniciens de haut niveau. Néanmoins, comme la formation à l'étranger reste également nécessaire, on estime que des bourses multilatérales et bilatérales seraient trés utiles.

Because Nepal is a developing country, various economic and social development projects are under way in different areas. There is great demand for surveys and maps in order to execute these projects scientifically. Nepal is also an agricultural country; therefore, each arable-land parcel must be clearly mapped, identify the owners and tenants and classify the land.

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* The original text of this paper, prepared by A. B. Basnyat, Director-General, Survey Department, appeared as document E/CONF.75/L.98.

To fulfil these tasks, the Government of Nepal established the Survey Department in the Land Reform Ministry to conduct all cadastral, geodetic and topographic surveys. The Department also conducts training programmes for survey technicians at different levels. To perform the above-mentioned duties, the Survey Department has three survey branches: (a) the Geodetic Survey Branch; (b) the Cadastral Survey Branch; (c) the Topographic Survey Branch. It also has a training institute, the Survey Training Centre.

GEODETIC SURVEYS

During the 1960s, second-order triangulation points were established in Nepal with the co-operation of the Survey of India under the Colombo plan, to prepare maps at the scale of 1 inch to a mile. Further extension of this triangulation network was carried out during the 1970s.

In Nepal, 7 Laplace stations, 14 azimuth stations and baselines were established during 1976. First-order triangulation is being carried out and at the same time the existing second-order triangulation points are being broken down to provide lower order ground controls for different types of large-scale mapping. There is also a plan to apply necessary corrections, if any, in second-order control points if the point is found shaky after completion of the first-order triangulation. The first-order triangulation network, including 7 Laplace stations and 14 azimuth stations, is shown in figure 166.

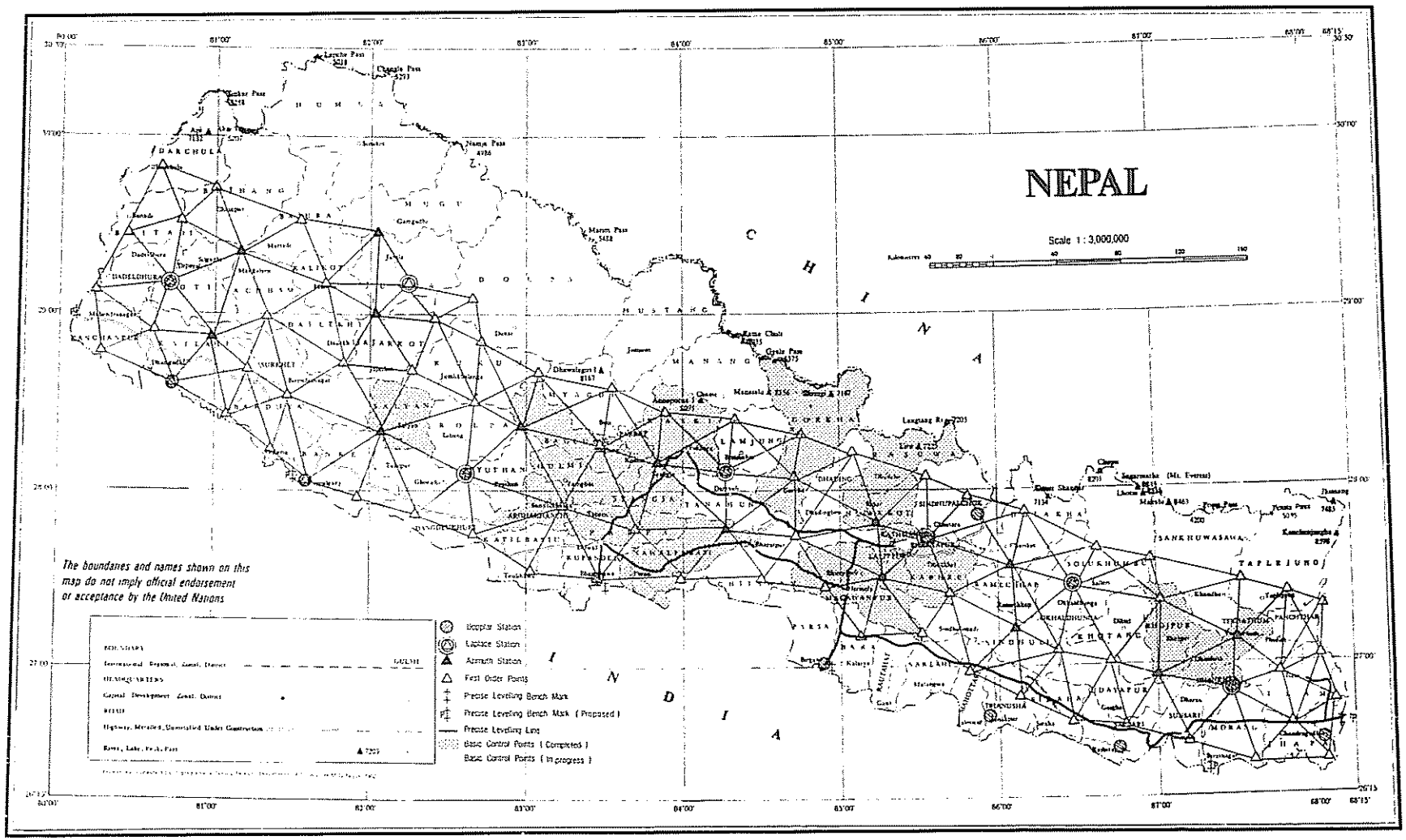
The lower order control points, that is the fourth-order trigonometrical survey, has been compelted in 18 districts and is continuing in 11 districts, out of the 75 districts in Nepal. The progress of lower order control work also is shown in figure 166. On addition to this progress, 14 Doppler stations have also been established in different parts of the country with the co-operation of a Doppler team from the United Kingdom of Great Britain and Northern Ireland; the locations are shown in figure 166.

Furthermore, the Survey Department has a geodetic observatory, which is situated at Nagarkot in the Katmandu Valley; and a circumzenithal instrument (made in Czekoslovakia) has been installed there. The observatory is mostly engaged in observation of stars for azimuth and time, and it also has a plan to make observations of a group of stars for latitude, longitude and time.

For various engineering projects, bench-marks with elevation above sea-level of different orders are in great demand. As Nepal is land-locked, establishing sea-level is obviously difficult. With the co-operation of the Survey of India, however, two first-order bench-marks were established at two places, one at Birgunj in 1975 and the other at Bhairahawa. Furthermore, in order to establish four more precise bench-marks, a request has been made to the Survey of India. The locations of these proposed bench-marks are also shown in figure 166. Precise levelling from the existing two bench-marks along the highways of Nepal has been conducted since 1976. In future, the lower order bench-marks will be provided and situated according to user requirements.

It also is planned to provide gravity stations at various places in Nepal; and one of these points situated at Tribhuvan International Airport, Kathmandu, has already been connected with the gravity station at Bangkok (Thailand). It

Figure 166. Nepal: first-order triangulation network



3388.42x

is planned to connect it also to that of Delhi (India). A first-order triangulation is taking gravity readings on most of the high trigonometrical stations.

CADASTRAL SURVEY

The cadastral survey has adopted a graphical method in which plane-table and telescopic alidade are used. From three to four trigonometrical control points are plotted in each map-sheet and thus tied with national framework. Before 1970, the control points were obtained by resection and intersection methods from local baselines, and these control points have no connection with the points in adjacent districts. During field-work, landowners and tenant farmers are identified, land is classified and correct area of parcels are determined. Then ownership certificates are issued to the owners as a security to their right of property. There are nine field survey parties, each consisting of about 140 persons, who perform the above-mentioned tasks.

Photogrammetric compilation for producing a cadastral plan is not feasible in Nepal, because the average size of ownership parcels is so small (less than a hectare) even in the plain areas. In many cases, also dual ownership of landowner and tenant farmers still exists. In the hilly and mountainous parts of Nepal, the valleys are narrow and the slopes are steep and full of vegetation. The traditional ground survey method is continuing there.

The scale of the cadastral plan varies between 1:500 and 1:2,500, depending upon the size of the parcel and the value of the land. For example, the scale selected at Kathmandu, the capital of Nepal, is 1:500 because of its highland values.

There are 75 districts as administrative units in Nepal, and the cadastral survey has been completed in 45 districts and is in progress in 11 districts. It is planned to complete the cadastral survey of remaining districts on or before 1990. As concerns built-up areas, of the 29 towns in Nepal, four have been surveyed and plans also have been prepared.

TOPOGRAPHIC SURVEY

The topographic survey project was begun with the assistance of United Nations Development Programme (UNDP), which has provided major equipment, fellowships for training and the services of experts since January 1976.

Currently, it is almost fully equipped with modern and scientific equipment, and a number of Nepalese have been trained in different subjects, such as cartography and photogrammetry. This UNDP assistance programme was terminated in June 1982, and the activities of the survey are being executed by Nepalese personnel.

Equipment

The following types of equipment are available in the topographic survey project:

Type of equipment	Quantity
Wild RC10 aerial camera	4
Contact printers	
Zeiss KG-30	1
Milligan	1
Log E-Etronics	1
Dia Nippon screen	1
Wild E4 rectifier	1
Kern PG3 precision plotter with ER2	1
Stereoplotters	
Kern PG2	3
Wild BOS	6
Nippon process camera	1
Automatic processors	
Carn Feldt APS	1
Kodak	1
Berthold diatype machine	1
PUG 4 point marker	1
Heidelberg two-colour offset press	1

Many other types of equipment, such as theodolites, levels, telescopic alidades, electronic distance measure (EDM) instruments, co-ordinatographs, diazo copy machine, whirler, paper cutter and programmable desk claculator, are also in the project.

Programmes

The following programmes have been launched under the Topographic Survey project:

(a) Updating of the existing 1 inch to a mile map-sheets;

(b) Carrying-out of large-scale survey works;

(c) Preparation of maps on scales ranging from 1:10,000 to 1:50,000;

(d) Preparation of maps of development regions, administrative zones, and districts;

(e) Preparation of small-scale maps;

(f) Preparation of special maps, such as land resources maps.

The topographic survey project has four main working sections--the Field Survey Section, the Photogrammetry Section, the Cartography Section and the Map Reproduction Section--in order to gear the machinery to the tasks it has to execute.

The Field Survey Section carries out the following works:

(a) Provision of required ground control points for the Photogrammetry and Cartography Sections;

(b) Marking of details on maps or photomaps as per map specifications;

(c) Verification of maps in field, prepared under the project;

(d) Field survey works for large-scale maps requested by different agencies for their project works.

The Photogrammetry Section has the capability to carry out the following works:

(a) Aerial photography and processing;

(b) Triangulation with planimetry strip adjustment;

(c) Map compilation in stereoplotter;

(d) Production of rectified photos;

(e) Production of photo mosaics.

In the near future, it will try to perform aerial triangulation with independent model block adjustment using the ICL computer of the National Computer Centre of Nepal. The Photogrammetric Section also has a photo library where anyone can see the aerial photos, and the photo indexes are displayed for their reference.

Currently, all the manuscripts of base maps are scribed and maps are prepared by the traditional method. Automated cartography is not yet applied in the Survey Department, due to lack of instrumentation, specialists and technical know-how in this field.

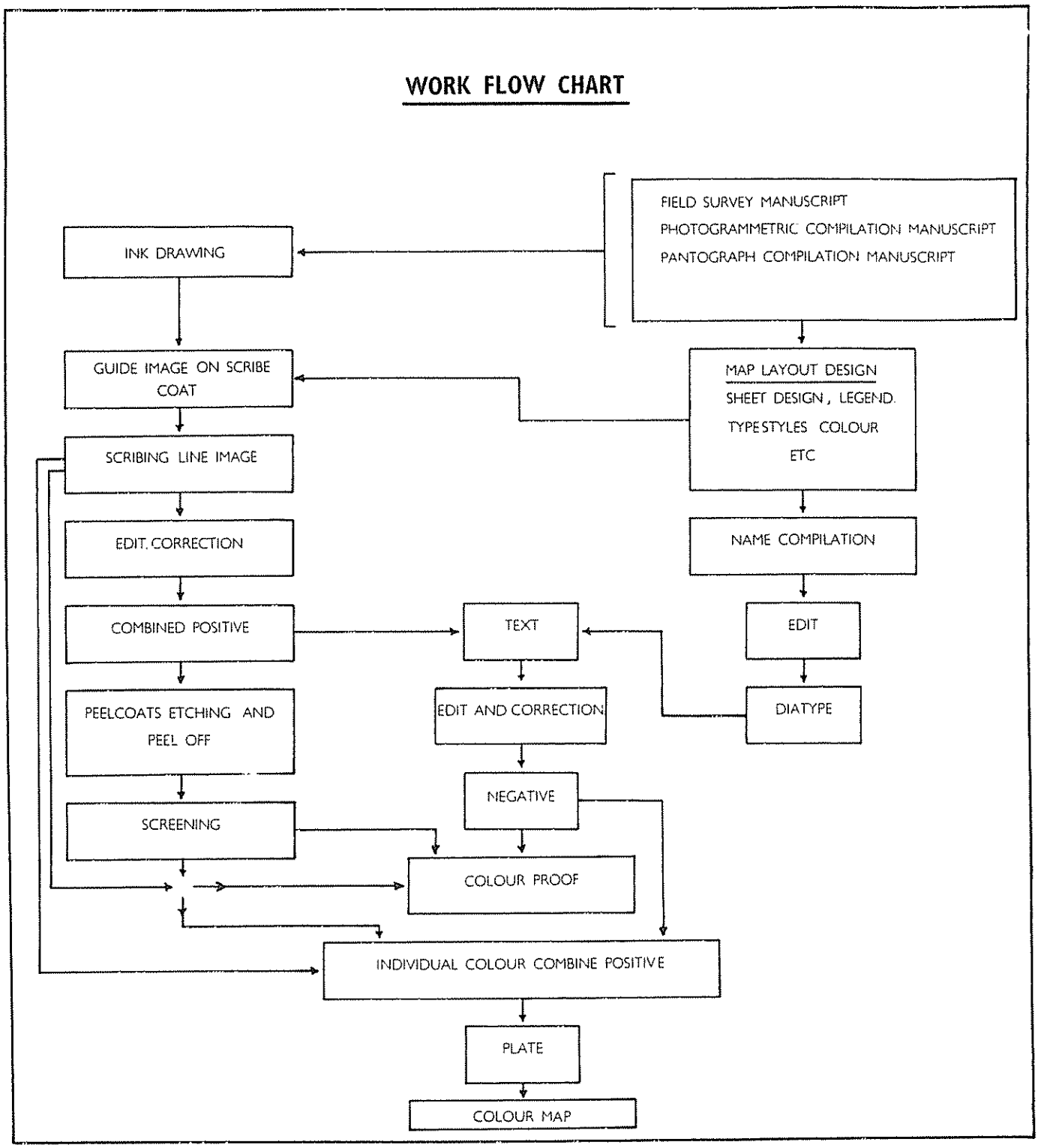
Mapping procedure

The pencil map manuscripts are obtained from three units of the project. The Field Survey Section provides large-scale manuscripts, the Photogrammetry Section provides large-scale and medium-scale map manuscripts and the pantograph unit of the Cartography Section provides small-scale map manuscripts.

These pencil manuscripts are treated cartographically till a coloured proof of the map is obtained; the steps in this process are shown in figure 167.

The plate-making system is by positive process. Thus, a combined positive is prepared for each colour by combining the scribe sheet, the text sheet and the pell-coat sheet of the colour. Then the printing plates are prepared, and the printing starts in the press for each colour, one after another until multi-coloured maps are obtained.

Figure 167. Nepal: work flow chart for map production



Achievements

Thus far, the topographic survey project has undertaken the aerial photography of Nepal listed in table 48. This aerial photographic coverage is shown in figure 168. In addition, photographs of the Tarai area were taken in 1966 at 1:12,000 scale as part of the forest resources survey.

During the past six years, the following maps were prepared:

(a) Maps of Nepal on the scale 1:2,000,000: administrative; physiography; relief;

(b) Maps of five development regions on the scale 1:500,000;

(c) Maps of 14 zones on the scale 1:250,000;

(d) Ozalid prints of 75 districts on the scale 1:125,000;

(e) Quite a number of large-scale maps ranging from 1:500 to 1:20,000, of different town areas and development project areas, such as:

(i) Map of Nepalgunj area, 55,000 ha at 1:5,000 scale with 1-m contour for Sikta irrigation project;

(ii) Map of Surkhet Valley at 1:7,500 scale with 10-m contour interval for town-planning etc.;

(f) Number of photomaps;

(g) Under the land resources mapping project:

(i) Land-utilization maps, 126 sheets on the scale 1:50,000;

(ii) Land-system maps, 126 sheets on the scale 1:50,000;

(iii) Land-capability maps, 126 sheets on the scale 1:50,000;

(iv) Geological maps, 43 sheets on the scale 1:25,000;

(v) Climatological maps, 7 sheets on the scale 1:250,000

SURVEY TRAINING

The Survey Training Centre was established in 1968 with the main objective of producing skilled medium- and technician-level personnel. The Centre currently conducts the following training courses:

(a) Amin (Recruit) Course;

(b) Junior Surveyors Course;

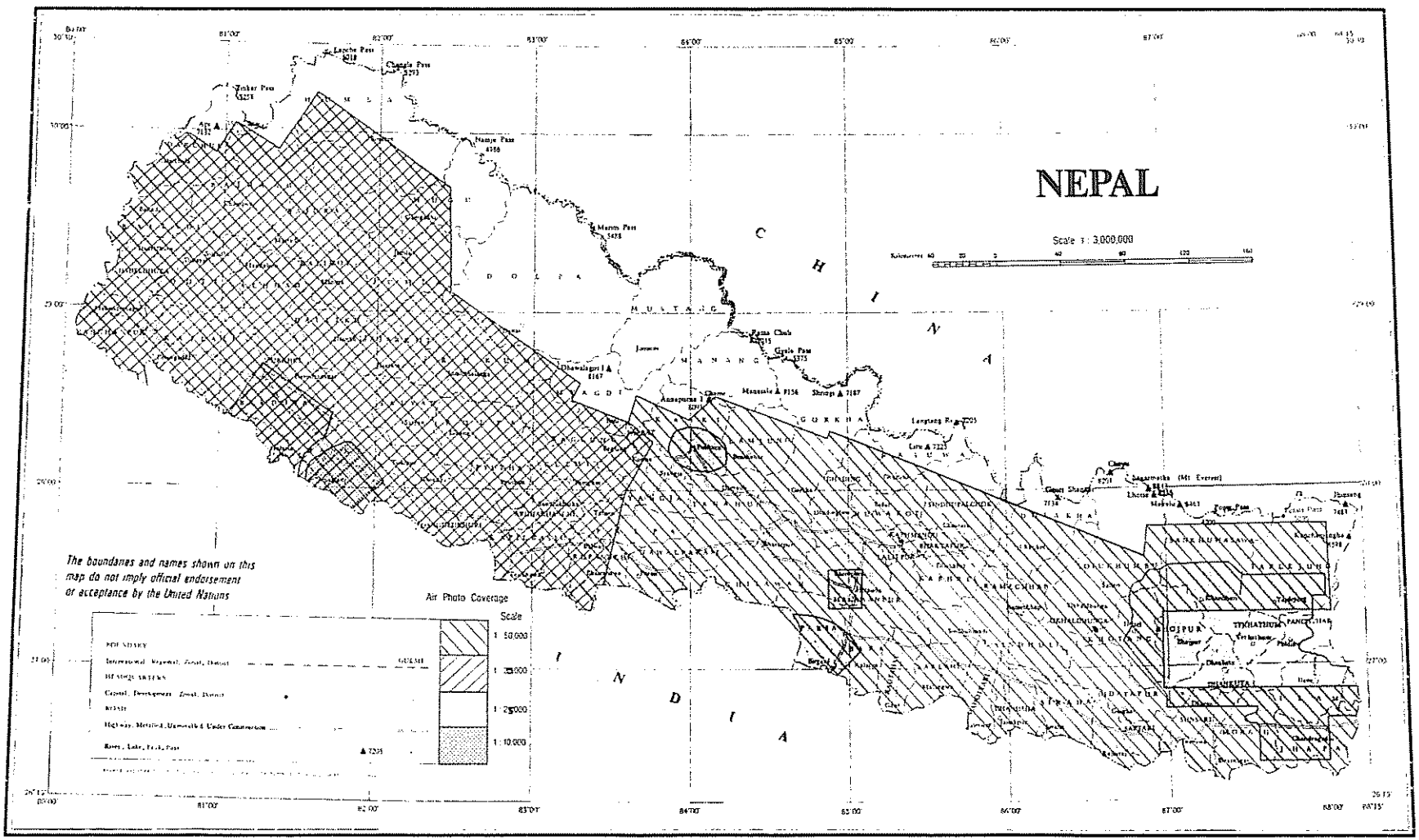
(c) Senior Surveyors Course;

(d) Special course on photogrammetry, cartography, geodetic observer and map reproduction.

Durations of the courses and the minimum qualification required to take them are listed below:

(a) Amin (Recruit): 12 months; school-leaving certificate with mathematics required;

Figure 168. Nepal: aerial photographic coverage



3388.43x

Table 48. Aerial photography of Nepal

Scale	Lens used	Date	Purpose
1:50 000	Super-wide-angle	1978/79	Land resources mapping project
1:25 000	Narrow-angle	1978	Hill area development project
1:20 000	Wide-angle	1978/79	Land resources mapping project
1:10 000	Wide-angle	1978	Sikta irrigation project

(b) Junior Surveyor: 12 months; Intermediate Science with mathematics or completed Amin Course with five years' experience in survey organization required;

(c) Senior Surveyor: 16 months; Bachelor of Science with mathematics or Master of Arts (Geography) or completed Junior Surveyor Course with 10 years' experience in survey organization required;

(d) Special course: 3 months; school-leaving certificate with mathematics required.

REMOTE SENSING

The Nepal Remote Sensing Centre is set up in the Soil and Watershed Management Department. The aim of this centre is to present remote-sensing technology to the user agencies. This centre also conducts training programmes on the application of the remote-sensing technique in agencies of the Government of Nepal, such as the Survey Department, Agriculture Department and Forest Department.

The Remote Sensing Centre published a technical report on the Marsyangdi watershed area in which various geographical information was compiled using remote-sensing technology. This was a pilot project and there will be one such pilot project each year depending upon the priority of Nepal Remote Sensing Centre activities.

CONCLUSION

The Survey Department is the central organization for all mapping services within Nepal. Thus, map users contact the Survey Department for their map requirements. In order to meet the demand for surveys and maps, the above-mentioned cartographic activities are undertaken and are being further developed.

The Survey Department is well equipped, but there are not sufficient numbers of high-level technicians, stereo operators and lithographers. In order to alleviate the shortage at these levels of personnel, both multilateral and bilateral fellowships are considered desirable. There is also a plan to upgrade the existing Survey Training Centre, but it may take time to produce the level of technicians needed.

UNITED STATES GEOLOGICAL SURVEY PROVISIONAL EDITION MAPS*

Paper submitted by the United States of America

RESUME

Dans le cadre du programme national de cartographie, le Service géologique des Etats-Unis a commencé à établir une série de cartes topographiques provisoires afin d'accélérer considérablement l'établissement de cartes pour les quelque 12 000 carrés de 7,5 minutes de côté du territoire contigu des Etats-Unis pour lesquels il n'existe pas de carte au 1:24 000. D'après le programme accéléré, il est prévu que ces cartes provisoires seront établies d'ici 1988. Ces cartes répondent aux normes de précision des cartes nationales, contiennent essentiellement le même niveau d'information que les cartes topographiques standard, sont présentées de façon provisoire, reproduites lithographiquement en quatre ou cinq couleurs et distribuées slon les procédures standard. Une simplification importante des opérations de finition et des modifications de détail des procédures de travail sur le terrain et de compilation permettent au Département de réduire de 25 pour cent environ le temps de production et le coût.

The United States Geological Survey (USGS) provisional edition map programme is a dynamic programme that should be of great interest to map-makers and map users throughout the world. Although the programme is new, it addresses an old problem--the need for complete nation-wide map coverage at 1:24,000 scale, as soon as possible.

DEFINITION OF PROVISIONAL MAPS

Simply defined, the term "provisional" means "prepared beforehand or temporary, to be followed by something permanent". That precisely describes the new USGS product, for what the survey is doing is bypassing some of the conventional production steps (primarily in map-finishing) and going to press

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* The original text of this paper, prepared by John I. Roney, United States Geological Survey, appeared as document E/CONF.75/L.50.

with compilation copy in order to reduce costs and hasten map availability. After complete United States coverage is achieved, it is planned to produce a completely finished map product.

When the term "provisional" was selected, it was noted that in the dictionary the word fell between the words providential (opportune) and provocative (stimulus)--an apropos coincidence. The programme is indeed opportune in that during the current and projected period of increasing demands and decreasing resources, it provides an appropriate means to complete United States map coverage on a timely schedule. And the programme does have a stimulus--that is, incentive--which shortens the timetable for complete map coverage.

RATIONALE FOR PROVISIONAL MAPS

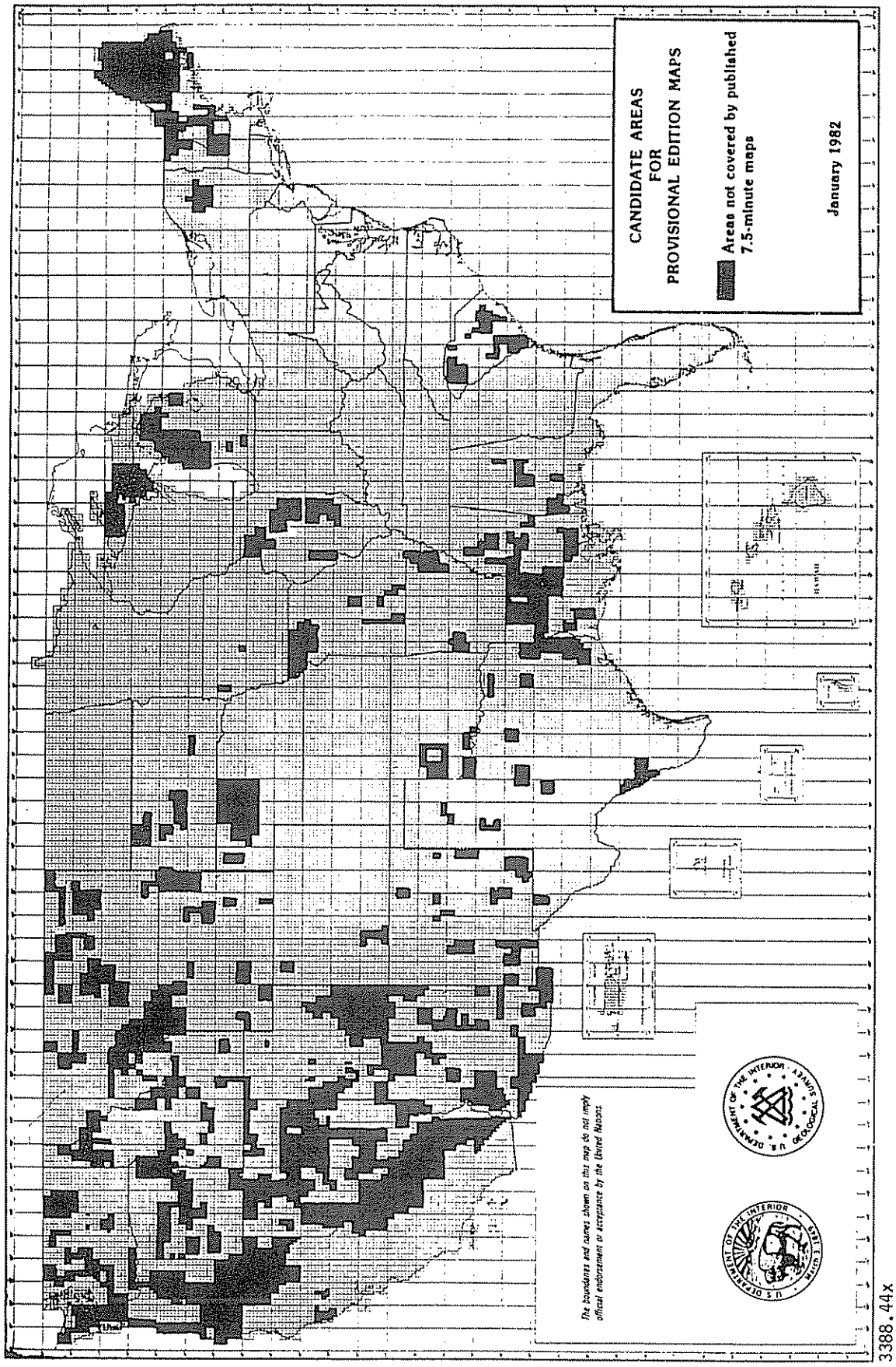
Before discussing the provisional map programme in general terms and describing the technical aspects of provisional map production in some detail, it may be helpful to review briefly the circumstances that prompted the establishment of the programme and the rationale for the technical approach that is being taken.

In 1973, the Office of Management and Budget (OMB) report of the federal mapping task force on mapping, charting, geodesy and surveying emphasized the federal Government's need to initiate meaningful long-range plans that would accommodate changing budgets, technologies and requirements. To accomplish this, OMB specified that new production techniques should be instituted, that more flexibility in programmes and products should be exercised and that cartographic products and by-products should be more diversified. OMB identified the Geological Survey as the lead civilian mapping agency and entrusted the Survey with the primary responsibility for implementing programmes and procedures that would best serve the interests of the map-user community in a responsive and timely manner.

Since the publication of the OMB report, the Survey has accomplished a number of significant actions in support of the task force findings and recommendations. The USGS Topographic Division, Publications Division and Geography Program have been reorganized into a new, more effective National Mapping Division. Within the new division, plans and operations activities have been redefined to better address user needs. Cartographic and geographical developmental and applied research efforts have been intensified to better respond to conventional and digital cartographic data base requirements. Lastly, a new Office of Information and Data Services has been created to better inform and serve the map user.

In addition to these steps, the standing National Mapping Division Long-Range Planning Committee was established in 1980 to provide long-range, real-time plans that address what needs to be done in the context of what can be done in the face of increasing demands and diminishing resources. One of the realities that the Long-Range Planning Committee addressed is that there is a growing need for nation-wide 7.5-minute map coverage; and of the approximately 54,000 quadrangle areas in the conterminous United States, some 12,000 quadrangles remain unmapped in 7.5-minute format (see figure 169). Another realty is that because of the emphasis on other programmes--photo-revision, orthophotoquads, county maps, the intermediate-scale series and the digital data base

Figure 169. United States of America: candidate areas for provisional edition maps by the Unites States Geological Survey



effort--the completion of 7.5-minute map coverage might not, at the current rate of progress, be accomplished until well after the year 2000. It was this set of circumstances that led to the decision to initiate the provisional map programme.

ESTABLISHING THE CRITERIA

Once the concept of provisional maps was approved by USGS, a working committee was established to set programme goals and prepare specifications. The five-member group consisted of professionals representing expertise in all major phases of map-making; planning; field surveys; photogrammetry; map-finishing; and publication. The criteria for provisional maps, the basis on which the planning and technical guidelines are built, were established as follows:

(a) Provisional maps will be prepared for all remaining unmapped 7.5-minute areas, including unmapped 7.5-minute areas currently covered by 15-minute maps. Unmapped 15-minute areas of Alaska will be produced in 15-minute provisional map format;

(b) The primary objective of the provisional map approach is to provide a realistic means for completing nation-wide large-scale map coverage by 1988 (assuming continued funding at the level of the 1981 financial year);

(c) Provisional maps will be prepared to national map-accuracy standards;

(d) Conventional techniques will be modified whereby provisional maps can be produced at significant cost savings without adversely affecting the utility of the map;

(e) Map content will generally reflect standard map content and will be appropriate for derived maps;

(f) Provisional map appearance will be legible and readily distinguishable from standard maps.

GENERAL MAP APPEARANCE

Once criteria were established, the working committee determined the general appearance of the new product. The maps will be produced in a 7.5 x 7.5-minute format at 1:24,000 scale for maps prepared in customary units and at 1:25,000 scale for maps prepared in metric units. It should be pointed out that the choice of customary units as opposed to metric units is a decision co-operatively reached between the Survey and each individual state. The maps will be printed in four colours (black, brown, blue and green) for non-public land states. A fifth colour (red) will be used to depict the land net in public land states which, incidentally, comprise over 80 per cent of the provisional map programme. In order that provisional maps shall meet the criteria of being readily distinguishable from standard maps, all of the marginal data will be shown in brown.

The published map colours and features of the provisional maps are given below:

(a) Black: graticule and grid (full, fine-line Universal Transverse Mercator grid; geographical and state plane co-ordinate ticks; culture; stick-up and hand-lettering; urban tint (13 per cent screened black); and boundaries;

(b) Brown: contours; contour numbers; provisional map note; selected collar information;

(c) Blue: drainage; water tint (8 per cent screened blue);

(d) Green: vegetation tint and patterns;

(e) Red: public land net and labels. The red plate is applicable only in public land survey states.

MODIFIED MAPPING PROCEDURES

Keeping in mind the objective of significant savings (perhaps from 20 to 25 per cent) over standard map production, the working committee analysed, step by step, each procedure used in the mapping process. Procedures were reviewed for each major function: pre-field; field; compilation, final scribing; and map-editing. Each detailed procedure and major item of map content was listed, and a determination made as to whether the item would be accorded standard treatment or modified treatment; or would be omitted (see figure 170). Nearly 200 procedural and map content items were reviewed for provisional map treatment. In each instance, decisions were based on the stated goal of realizing significant savings without adversely affecting the utility of the map. Where changes were determined to be appropriate, the percentage of change from standard mapping procedures was recorded and the estimated man-hour savings of provisional treatment over standard treatments were determined.

SUMMARY OF MODIFICATIONS

Provisional map modifications to standard map procedures and the percentage of differences in man-hours per square mile are summarized below.

Pre-field procedures

In pre-field procedures, man-hours are increased 500 per cent by performing boundary, land net, roads, drainage and woodland classification and names research in the office. The breakdown of the percentage change from standard mapping is:

	Percentage man-hour change
Basic control planning	0
Supplemental control planning	0
Pre-editing of names and information	+ 10
Boundary investigation	+100
Preliminary land net	+100

Figure 170. United States of America: sample committee worksheet; guidelines for preparation of provisional maps

	Item	Treatment - Content			Remarks
		Standard	Omit	Modify	
B. PRE-FIELD	B. PRE-FIELD				
	1. Basic control planning	X			
	2. Sup. vert. control planning	X			
	3. Pre-edit name and information sheet			X	Prepare on orthophotoquad. Search all office sources for names and special information (mines, wells, utility lines). Make calls for field on controversial names, missing names, hidden roads, etc.
	4. Boundary investigation			X	Do complete boundary investigation and plot in office (O-quad base). Make calls for field to resolve problems.
	5. Outline house omission			X	Reduce minimum area to ¼ sq. mile. Increase building density requirement (can be prepared anytime before compilation)
	6. Prepare red road guide		X		Substitute shields for red road classification
	7. Prepare edge information	X			

The majority of boundary investigation and all land net compilation normally done in the field that are to be done at the pre-field phase are included above. Standard mapping requires 0.08 man-hour per square mile; provisional mapping requires 0.40 man-hour. Thus, the modifications represent an increase of about 0.3 hour per square mile.

Field procedures

Man-hours are decreased 25 per cent by excluding the classification of buildings, drainage and woodland, and by substantially reducing control monument identification and boundary and names investigation. Standard mapping requires 4.4 man-hours per square mile; provisional mapping requires 3.3 man-hours. The modifications thus represent a decrease of 1.1 man-hours per square mile. The breakdown of the percentage change from standard mapping is given below:

	Percentage man-hour change
Basic control surveys	0
Identification of control monuments	- 70
Supplemental control	0
Classification of roads	- 95
Classification of buildings	-100
Classification of drainage	-100
Classification of woodland	-100
Location of boundaries	- 75
Location of land net	0
Investigation of names	- 75
Identification of features	- 75

It should be noted that roads, drainage and woodland are to be classified during compilation, and buildings are not to be classified.

Office compilation procedures

In office compilation, man-hours are increased 5 per cent by including classification of drainage, woodland and boundaries, by improving scribing quality and by hand-lettering descriptive labels and contour numbers. The percentage breakdown of the change from standard mapping is given below:

	Percentage man-hour change
Control editing	-30
Aerotriangulation	0
Plotting and classification of roads	+10
Selection and plotting of buildings	0
Plotting of fences	-10
Plotting and classification of drains	0
Plotting of vegetation	0
Plotting contours and numbers	+ 2
Labels and elevations	+ 5
Plotting land net	+10
Plotting boundaries	+10

Standard mapping requires 5.5 man-hours per square mile, while provisional mapping requires 5.8--an increase of 0.3 man-hour per square mile. It should be noted that extra care is required in compilation symbolology. Compilation copy will serve as the reproduction (printing) copy.

Final scribing

In final scribing, the man-hours are reduced 90 per cent by excluding the scribing of all final colour separates except open-window separates and by substantially reducing the use of phototype (stick-up) lettering. The percentage change from standard mapping is itemized below:

	Percentage man-hour change
Graticule and grids (to be Gerber-plotted along with values)	-100
Culture	-100
Contours	-100
Red roads (to be omitted)	-100
Fences	-100
Land net	-100
Drainage	-100
Water tint	+ 10
Vegetation	0
House omission	0
Other open windows	-100

It should be noted that for culture, contours, fences, land net and drainage, the compilation manuscript copy will serve as the reproduction copy. Furthermore, for contours, an additional "clean" contour separate is to be prepared for digitizing. These modifications represent a man-hour decrease of almost 1.6 man-hours per square mile: 1.74 man-hours for standard mapping less 0.17 for provisional mapping.

Editing procedures

In editing procedures, man-hours are reduced 70 per cent by minimizing standard checking and review functions and by making optimum use of automated lettering and lettering placement procedures. The breakdown of change for editing procedures is:

	Percentage man-hour change
General	
Line quality check (to be done during compilation)	-100
Name placement guide	- 70
Type order	- 70
Type stick-up	- 70

	Percentage man-hour change
First colour composite	0
Second colour composite	-100
Geographical names processing	0
Interior	
Place, regional area names	0
Hydro, hypso names	0
Political and reservation names	0
Churches, schools, Post Offices	-100
Railways, streets	-100
Descriptive labels	-100
Bench-marks, spot elevations, contour numbers	-100
TWP, range, section numbers	-100
Margin	
Geographical co-ordinates, grid labels (automated plot)	-100
Quad range name	0
Road legend (shown on master collar)	-100
Bar scale (on master collar)	-100
Declination diagram (on master collar)	-100
Accuracy/scale note	0
Credit notes (on master collar)	- 50
Road destinations (not shown)	-100
Adjoining quadrangle names	0
Provisional map note	+100
Map number	+100

It should be noted that the reduction in man-hours needed for name placement guide, type order and type stick-up is due to use of automated and hand-lettered type. Furthermore, reductions result from showing churches, schools, Post Offices, railways and streets by symbol or generic label only; and because the descriptive labels, bench-marks etc., and TWP etc. are hand-lettered on compilation separately.

These modifications represent a decrease of 0.9 man-hour per square mile. Standard mapping requires about 1.3 hours; and provisional mapping calls for 0.4 hour.

COST COMPARISON

The procedures and techniques prescribed for the preparation of provisional maps represent a 23 per cent decrease in overall costs compared with standard mapping. The majority of the cost savings occur in the final scribing phase (90 per cent) and the editing phase (70 per cent). Comparison of hours per square mile for provisional maps as opposed to standard maps and the percentage of change are given in table 49 (for direct hour comparisons, see figure 171).

Figure 171. United States of America: comparison of direct hours required for standard maps and provisional maps

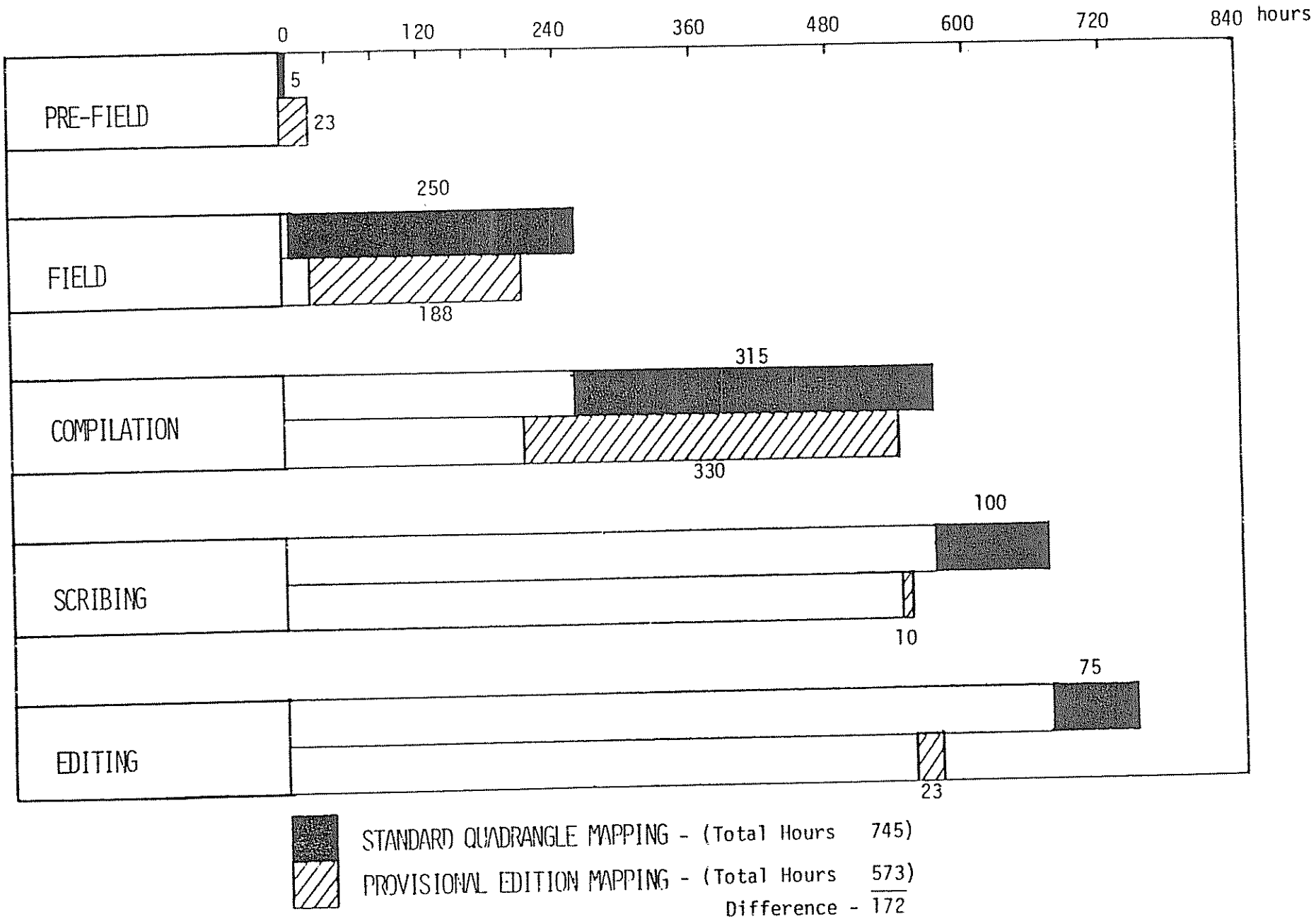


Table 49. Comparison of labour costs for standard maps and provisional maps

(man-hours)

Major function	Standard map	Provisional map	Percentage of change
Pre-field	0.08	0.40	+500
Field	4.41	3.30	- 25
Compilation	5.50	5.78	+ 5
Final scribing	1.74	0.17	- 90
Editing	1.34	0.40	- 70
Hours per square mile (total)	13.07	10.05	-3.02
Hours per 7.5 minute quadrangle[a/]	745	573	-172

a/ Direct hours comparisons are shown in figure 171).

TYPES OF PROVISIONAL MAPS

Because several thousand maps are in production at any given time, the treatment and general appearance of provisional maps will vary. There are three categories of provisional maps, depending upon the status of the individual maps or projects in the mapping cycle at the time of implementation of the provisional map programme. Content, symbolization and map-finishing procedures differ for each category of provisional map:

(a) Category 1 maps. Maps that have not yet been initiated through the field phases. Modified content, symbolization and map-finishing procedures are applicable to the preparation of category 1 maps (in general, the technical specifications discussed in the present paper apply to category 1 maps);

(b) Category 2 maps. Maps that have received advance field interpretation but have not been compiled. Standard content, modified symbolization and map-finishing procedures are applicable to the preparation of category 2 maps;

(c) Category 3 maps. Maps that have been through the field phases and have been compiled but have not been through the map-finishing (coulour-separation) phases. Content and symbolization as compiled and modified map-finishing are applicable to the preparation of category 3 maps (the example included in the present paper, figure 169, is a category 3 map).

Provisional map content and symbolology

Essentially, the same level of information is shown on provisional maps as is shown on standard maps. One exception is that buildings (houses as opposed to barns) are not classified on category 1 provisional maps and considerably less field verification is performed. There are, however, some significant differences in symbolology and in the general map appearance (see table 50).

Table 50. Symbolology for standard maps and provisional maps produced by the United States Geological Survey

Item	Standard map treatment	Provisional map treatment
Houses	Solid symbol	Solid symbol
Barns	Open symbol	Solid symbol
Roads, class 1, 2	Red road fill	No red fill
Drainage, perennial	Solid, 0.005"	Solid, 0.007"
Drainage, intermittent	Dash-dot line, 0,005"	Solid, 0.003"
Contour values, elevations	Photoset type	Hand-lettered
Descriptive labels	Photoset type	Hand-lettered
Margin data	Black	Brown
Published form	Final scribe copy	Manuscript copy
Overall appearance	Refined	Unrefined

IMPACT OF PROVISIONAL MAPS

Impact on operations

The change-over from standard mapping to provisional mapping for completion of the remaining unmapped areas will affect mapping operations and personnel to the extent that there will be:

(a) Increases in aerial photography procurement to accommodate the accelerated map-production process;

(b) Reductions in field classification and investigation functions performed by field personnel;

(c) Increases in field travel owing to shorter field cycles and the increased number of project assignments;

(d) Reassignments of scribing and editing personnel to pre-field and office compilation functions;

(e) Increased office functions relating to names, boundary and public land survey investigations and research;

(f) Retraining personnel reassigned to other mapping functions.

Impact on programmes

As was stated at the outset, the purpose of the provisional map programme is to complete the 7.5-minute mapping of the conterminous United States sooner than conventional procedures will allow. The programme will reduce the map cycle and the considerable cartographic backlog--a backlog created largely because most derivative products, such as intermediate-scale maps, essentially involve map-finishing operations. By reducing the map-finishing operations by as much as 90 per cent, the timetable for complete coverage will be moved forward by as much as 12-15 years. Also, the Survey will have modern 7.5-minute coverage for use as a base for preparing 1:50,000 and 1:100,000 maps in either standard quadrangle format or county, regional or national park format. The modern 7.5-minute data base is also urgently needed for use in the digital cartography programme.

As was also stated, the general policy is to prepare provisional-edition maps for the remaining unmapped areas; however, there may be some minor exceptions to this policy. Specifically, a few states are over 95 per cent covered by 7.5-minute standard quadrangle maps. In such instances, where it is the expressed preference of the state co-operator, or where joint federal and state funding is involved, exceptions to the provisional map programme may be made. The quadrangles identified as possible exceptions are less than 4 per cent of the total number of quadrangles affected by the programme. Such exceptions will be considered on a case-by-case basis. The Survey takes the position that such exceptions must be held to a minimum in order to preserve the time-reduction and cost-saving benefits of the overall provisional map programme.

Impact on map users

What the VSGS provisional map programme means to map users, stated simply, is that more 7.5-minute maps will be available much sooner than they would be under the standard mapping programme. The user will get a map that is produced to national map-accuracy standards and one that contains essentially the same information as a standard map. The information shown will be clear and legible, but some of the line-work and descriptive labels will not be of the highly refined cartographic quality traditionally associated with Survey topographic maps. Provisional map coverage will be included on the state sales indexes, and the maps will be sold and distributed under the same procedures that apply to standard maps. At some future point, provisional maps will be updated, fully map-finished and reissued as standard topographic maps.

CONCLUSION

The Geological Survey has the responsibility for the administration of the national mapping programme. The 7.5-minute quadrangle map series is a critical element of the programme because the series not only provides essential large-scale coverage but serves as the base for the production of much needed intermediate-scale (1:50,000, 1:100,000) maps. The conterminous United States is about 80 per cent covered by 7.5-minute maps. At the current rate of standard mapping, complete coverage would not be attained until after the year 2000.

The critical need for complete large-scale coverage and increasing requirements for intermediate-scale maps coupled with decreasing mapping resources has led the Geological Survey to initiate the provisional map programme. The maps are provisional in that some of the technical procedures are modified and most of the tradional, final map-finishing operations are omitted. Otherwise, provisonal maps are as accurate and contain essentially the same information as standard maps.

From the national mapping programme standpoint, completion of the 7.5-minute map series is advanced some 12-15 years. From the map-production standpoint, some technical procedures and map treatments are modified. From the map user's standpoint, the aesthetic appearance of the map is slightly diminished but the accuracy, content and utility of the map remain essentially intact. Most important of all, the chances are greatly increased that the large-scale maps will be available to the user much sooner than would be possible if the maps were produced using standard mapping procedures.

(f) Small-scale and thematic mapping, national and regional altlases, International Map of the World on the Millionth Scale and other international map series

MAPPING OF PRESENT VEGETATION*

Paper submitted by Australia

RESUME

La couverture végétale de l'Australie s'est considérablement modifiée au cours des deux derniers siècles; c'est pourquoi on a entrepris un nouveau projet en vue d'établir une carte de la situation actuelle. Une carte au 1:1 000 000 sera établie à partir de toutes les sources disponibles et complétée par des travaux limités sur le terrain; elle servira principalement pour la publication d'un atlas mais doit également être utilisée à un grand nombre d'aures fins.

Work has recently begun on a project to complete and consolidate the mapping of the present vegetation of Australia. The primary aim is to produce a map at 1:5,000,000 scale and a brief commentary text to form part of a volume for the Atlas of Australian Resources, third series (published by the Division of National Mapping), giving the general reader a map that more nearly reflects present reality than did the map of natural vegetation of the second series of the Atlas.

VEGETATION CHARACTERISTICS

Although the structure of the vegetation has not changed over much of Australia, significant changes have occurred in its floristic composition through grazing by introduced sheep and cattle or even, in some agriculturally unused areas, by exotic pests such as rabbits. In the agriculturally more productive regions of eastern, southern and western Australia, two countries of clearing, cropping and sown pasture establishment, to say nothing of urban growth, have created some much more marked changes.

Not much change is required in the structural classification used for the earlier map, "Natural vegetation" (1976, scale 1:6,000,000). This classification was based on growth form (tree, shrub etc.) and density of projective foliage cover. An additional growth form category may be needed to embrace sward-forming introduced pasture plants; and an additional foliage cover

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, appeared as document E/CONF.75/L.6.

class, of less than 1 per cent foliage cover, will not only better describe some areas of essentially native vegetation where trees are very sparse but none the less conspicuous but typify the common practice in many cleared areas of leaving a few shade trees along fences, ridge tops or streams.

The main changes in the classification will be additions to the typical genera or families to be recorded; for example, to distinguish wheat and other cereal grains from native tussock grasses, or forest plantations of exotic pines from native cypress pines.

MAPPING AND APPLICATIONS

At first, a series of overlays at 1:1,000,000 scale will be prepared, on which a coded description of every stratum of the vegetation present in an area will be recorded. As much use as possible will be made of recent LANDSAT satellite images at this scale, supplemented by all the relevant maps, aerial photos and field knowledge that can be gathered in the course of six two-week trips to 11 centres around the continent. These trips will usually include limited field traverses as well as office discussions.

Information on all strata in an area is being recorded for several reasons. One is that these overlays may thus be built up to form a reservoir of information useful in itself and from which data for other projects may be selectively tapped, for instance, mapping of forest resources or pasture types. Another reason is to avoid prescribing what selection of the information will be represented on the final atlas map at 1:5,000,000 scale, as well as to aid in the writing of its accompanying commentary test.

A subsequent possibility is the digitizing of these overlays so that selected data can be rapidly plotted. For instance, in conjunction with a similar digitized set of overlays showing land tenure, the natural vegetation in nature conservation reserves could be mapped at short notice, or regional area estimates of various kinds of forest in forestry reserves could be prepared.

Hence, although the primary purpose of this project concerns part of one of the 10 planned volumes of the new edition of the Australian national atlas, a little additional work on or reinterpretation of the data recorded may efficiently meet a variety of other needs and avoid future duplication of effort.

INNOVATIONS IN THE NATIONAL ATLAS*

Paper submitted by Australia

RESUME

Parmi les diverses nouveautés que présente la troisième édition de l'Atlas des ressources australiennes, en cours d'établissement, on mentionnera une présentation plus pratique sous forme de volumes reliés; une carte interprétative des sols; des renseignements plus détaillés sur l'agriculture; l'utilisation d'images-satellite pour la compilation de levés d'occupation des sols et de cartes de la végétation; l'utilisation de techniques de représentation graphique automatisée pour l'établissement de cartes statistiques et la mise sur pied d'une base de données polyvalente lors de la collecte des données.

The more obvious innovations in the third series (1980-), or third edition, of the Atlas of Australian Resources are those in presentation; the more important innovations are those in content, some of which have been made possible or practicable by innovations in technique.

INNOVATIONS IN PRESENTATION

The first series of the Atlas (1953-1960), and the second series (1963-1977) which gradually replaced it, consisted of 30 large coloured map-sheets (724 x 749 mm), each accompanied by a small black-and-white booklet commentary. The map-sheets were offered unfolded, folded once down the middle and with a linen strip mounting to fit in a heavy loose-leaf binder, or folded to commentary size (241 x 176 mm) for presentation in a boxed set.

The third series is also being published serially, but as thin bound volumes (433 x 305 mm) similar in format to many general and thematic atlases. Maps of Australia on the scale 1:10,000,000, which govern the depth of these volumes, need only be folded once; the small number of maps on the scale 1:5,000,000 are folded in both directions. Smaller maps are printed in four colours on text pages and interspersed with the commentaries that continue to be part of each topic. The commentaries themselves have been enhanced by the use of coloured photographs and other diagrams.

Ten volumes are planned, so each volume contains the maps and commentaries that previously were spread over two or more map-sheets and accompanying booklets. An important gain is that the maps of a topic can now exceed or be less than what would have fitted a map-sheet of the earlier series. The Atlas may still be purchased in sections, but in a much handier, more attractive and more

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, appeared as document E/CONF.75/L.18.

conveniently stored form. The brightly coloured, thin board covers differ from volume to volume in basic colour but conform to the same general design.

The greater time taken to produce a volume as compared with a single map-sheet and the commentary of the earlier series is partially offset by publishing the major maps separately, as soon as they can be printed, in either the Australia 1:5,000,000 map series or the Australia small-scale thematic map series. This practice also means that still, to a degree, readers need not buy what they do not want.

INNOVATIONS IN CONTENT AND TECHNIQUE

Some notable advances have been made by interpreting information in a way better suited to the general reader. The first was in the map, "Australia: soil resources" (1978) on the scale 1:5,000,000, which was prepared for volume 1, Soils and Land Use (1980). Described as an interpretative map of soils, it reduces the 102 mapping units of its parent pedological map (1975) of the same scale to 28 mapping units, which are further grouped into 12 broad categories of inherent soil properties that affect land management--for example, deep, highly structured soils with high initial fertility or soils with periodic subsurface waterlogging.

The other major map in volume 1, "Australia: land use" (1979), also on the scale 1:5,000,000, is more quantitative than the 1970 second series map on the scale 1:6,000,000. Surprisingly, however, is easier to read and graphically truer to reality. It shows grazing land in five numerical classes of livestock density and, secondarily, the main type of livestock; the earlier map primarily showed the main type of grazing livestock with a qualitative distinction between intensive and extensive production. Furthermore, the earlier map used a complicated method of calculation to show by colours those areas in which crop growing was economically predominant or co-dominant. The new map shows grazing virtually everywhere that agriculture is practised, as is the case in Australia, and has superimposed point symbols indicating the area under crop in four groupings ranging from cereal grains (one symbol to 5,000 ha) to fruit and vegetables (one symbol to 500 ha). For agriculture, both maps were based on detailed statistics for small areas, but the refinements of interpretation showing on the new map were made possible by the advent of LANDSAT satellite imagery. Indeed, this is the first major thematic map for which satellite imagery has been used Australia-wide.

The nine maps on the scale 1:10,000,000 and numerous maps on the scale 1:20,000,000 prepared for volume 3, Agriculture (1982, in press) display another type of innovation. Nearly all of them are largely based on agricultural statistics for 1975/76, the same year as the statistics used in preparing the above-mentioned map of land use; and all in one way or another reflect aspects of that map, such as the LANDSAT-based inland limit of wheat-growing, differences in livestock density within statistical areas, or areas of non-agricultural land, such as national parks. Hence, volume 3 presents a "snapshot" of Australian agriculture in the mid-1970s, with remarks in the commentary on subsequent changes; and there were significant savings in the time taken to prepare the maps.

In volume 2, Population (1980), the first use for the Atlas of graphical computer technique in statistical mapping was both possible and developed in time to enhance accuracy and reduce production time. For the topic "Population in major cities", three sets of maps of the 11 cities, on the scale 1:500,000, on facing pages, show population distribution within them, rate of population change in 1971-1976 and ethnic concentrations. The mapping was done at first on the scale 1:100,000, using computer-drawn plots of hundreds of statistical areas derived from census boundaries already digitized for other purposes and statistics from magnetic tapes available for the census. The statistics were processed by the computer, and aggregates were printed out at automatically determined central positions for the areas to which they applied. The presentation of this topic was an innovation prompted by the fact that, in 1976, 65 per cent of Australia's people were clustered in its 11 cities of more than 100,000 population.

FUTURE DEVELOPMENTS

Maps in progress, and being planned will, wherever possible, reflect the types of innovations already described. For example, "Australia: geology" (1982, in press; 1:5,000,000 scale), shows by a stipple overprint the large and widespread areas that are deeply mantled by more or less unconsolidated Cainozoic deposits such as sand dunes or laterite; and the vegetation map of the third series, just begun, will deal with present vegetation rather than natural vegetation at the time of European settlement and will owe much to the use of recent satellite imagery. The latter project also involves another potentially most important innovation in technique--that of establishing a multi-purpose data base of use in a variety of mapping projects. For more detail, see "Mapping of present vegetation" in this volume.

DEVELOPMENT OF DATA BASES FOR SMALL-SCALE AND THEMATIC MAPPING IN THE DIVISION OF NATIONAL MAPPING*

Paper submitted by Australia

RESUME

On a reconnu l'importance de bases de données fiables - graphiques ou numériques - à la fois pour la cartographie thématique et la cartographie topographique à des échelles égales ou inférieures au millionième. En fonction des fins auxquelles elles sont destinées, on a élaboré à des degrés différents de précision des bases de données relatives aux routes, aux terres domaniales, à la végétation, aux ressources hydrologiques, aux cartes de base et aux cartothèques. Les progrès des techniques dans le

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* The original text of this paper, prepared by the Division of National Mapping, Canberra, appeared as document E/CONF.75/L.38.

domaine de la cartographie assistée par ordinateur permettront encore d'améliorer un grand nombre de ces bases de données. Il sera peut-être possible dans l'avenir de grouper et d'analyser différents ensembles de données selon les besoins des utilisateurs.

Small-scale data bases are used by the Division of National Mapping (Natmap) primarily for thematic mapping on the scale 1:1,000,000 or smaller. However, they are also proving to be an important source of information for topographic mapping on scales from 1:100,000 to 1:1,000,000.

Much of the data have been provided by authorities in the various States of Australia and, once analysed, manipulated and brought together, form unique nation-wide data bases used not only by Natmap but other organizations engaged in mapping and research.

Some of the data bases originally developed to provide information for specific one-off mapping projects were not subsequently updated. Other data bases developed to provide data for ongoing projects have been systematically updated.

Increasing demands for new and regularly revised thematic maps have led to a review of all thematic data bases, with a view to bringing them up to date where necessary and implementing a programme of regular maintenance and gradual automation. The main advantages of automation are seen as the ability to handle larger amounts of data, greater flexibility in using the information and a substantial reduction in the resources needed to manipulate and analyse data.

CURRENT STATE OF DEVELOPMENT

Depending upon the type of data involved, the requirement of the mapping project for which the information was originally collected and the current state of development, the small-scale data bases range from marked-up maps and overlays to data sheets, punched cards, magnetic tape and discs. The various national data bases and their current status are set out below.

Roads

The national functional road classification (principal and secondary roads) is annotated on the 1:1,000,000 scale sheets of the International Map of the World (IMW), but larger scale maps are used for congested areas in and around the major cities. The information is kept up-to-date by regular input from state and territory road authorities.

This information is then available for use in the 1:100,000 and 1:250,000 scale National Topographic Map Series, the IMW series, general reference maps on scales 1:2,500,000 and smaller, national base maps and thematic maps.

Public lands

Information about various types of public land is used extensively by Natmap in its topographic and thematic mapping programmes. The names and boundaries of nature conservation and forestry reserves, Aboriginal land, water-catchment areas, prohibited areas etc. are shown on topographic maps. For thematic mapping, more information is often needed for classifying public lands, for example, area, controlling authority or a more detailed classification by type of reserve.

To satisfy these various needs the following data bases have been created:

(a) Nature conservation reserves. Regularly updated IMW overlays show the boundaries and names of all reserves of about 400 ha or more. Management of the other information has so far progressed from a manual card-index system to an in-house computerized system which permits easier manipulation and updating of data. From notices and plans supplied by the controlling authorities, relevant information on approximately 3,000 nature conservation reserves has been entered into a computer under the Hewlett Packard IMAGE/1000 data base management system. The data can then be processed to suit topographic or thematic mapping applications, for example, a listing of all reserves on a given 1:100,000 scale map of summary tables giving the total area of each type of reserve in Australia. It is proposed to develop this computerized system further by compiling and merging a file of digital boundary descriptions to replace the overlays;

(b) Forestry reserves. Regularly updated overlays like those for nature conservation reserves are maintained. Currently, a manual card-index system is used to store the other information about forestry reserves but these data will soon be computerized in a system similar to that used for nature conservation reserves;

(c) Aboriginal land. A manual card-index system is used to store relevant details. A computerized system, like those for nature conservation and forestry reserves, is planned;

(d) Land tenure. Maps at 1:1,000,000 scale showing all areas of over 400 ha of public land are being prepared, as part of the Australia 1:1,000,000 land-use series, for the more intensively settled areas of the continent. It is planned to extend gradually the land tenure mapping in this series over the whole of Australia.

Vegetation and forest resources

Work has commenced on collecting present vegetation and forest resource data for use in the third edition of the Australian national atlas, the Atlas of Australian Resources. The data are being assembled on IMW overlays at 1:1,000,000 scale. These overlays will form two more important small-scale data bases for use in other mapping projects, including the land cover and land use maps in the Australia 1:1,000,000 land-use series.

Water resources

The water resources data bases contain variously the boundaries of natural or administrative areas; line data, such as streams, point data, monthly and annual stream discharge and rainfall statistics; water-use statistics and some hydrogeological information. The data bases were created primarily to facilitate the collection, interpretation and cartographic presentation of water resources data by both Natmap and client organizations.

The water resources data bases can be grouped according to the nature of information stored:

(a) Area information data bases. This group includes drainage division boundaries, water conservation catchments, irrigation areas and rainfall districts. Each set of boundaries is currently kept on IMW overlays. Only the drainage basin and division data base has so far been developed further: after optical reduction to 1:5,000,000 scale, it was digitized and programmes were developed to produce small-scale choropleth maps using the basin boundaries in conjunction with classed statistical information relating to the river basins;

(b) Point information data bases. There are three data bases in this group, showing the locations of stream-gauging stations, pluviographs and water storages, respectively. All are on IMW overlays but only the overlays showing water storages were produced manually. Stream gauging-stations and the pluviograph network were plotted by computer from digital information: latitudes; longitudes; index numbers for identification; and additional information necessary for classification. The plotting programmes provide for symbolizing and plotting data at various scales and projections;

(c) Statistical information data bases. These are data bases of various water resources statistics, such as monthly and annual discharge and rainfall, or water-use and ground-water statistics. The storage medium is data sheets, punched cards, magnetic tape or disc, according to the degree of development. The computer-compatible data can be linked by appropriate index numbers to centroids of drainage basins or to individual stream-gauging stations. It is planned to merge this data base with the area, line and point information to form a single integrated system.

Base maps

Good topographic base maps are an essential component of any mapping data bank. Australia is fully covered by regularly updated 1:1,000,000 scale maps in the IMW series, and these maps are the basis of the Natmap small-scale data bases. Experiments with digitizing and digital updating of the IMW series, in order to create a digital topographic data base, are being conducted.

Map library

An important adjunct to the small-scale data bases is a map library data base, now at an advanced stage of computerization. It also makes use of the

IMAGE/1000 system. The system enables users to identify all maps that might be of particular interest, either by subject or for particular areas, such as 1:250,000 scale map. Individual maps are accessible directly by name, number or area covered, and accession lists or records of borrowings can be readily obtained. This system, when fully operational, will greatly increase the ease and flexibility of access to the Division's various map collections.

FUTURE DEVELOPMENTS

Most of the data bases outlined above are currently either manually maintained overlays or annoted maps at 1:1,000,000 scale, or digital information that can be plotted by computer as 1:1,000,000 scale overlays. The remainder will gradually be converted into one of these formats, depending upon the likely uses of the data.

Data are continually accumulating and the data bases need to be maintained; therefore, analysing and manipulating the data will be a continually growing task. This need has led to the introduction of some automation in order to help reduce the time and human resources necessary to perform routine work. Computerization allows not only faster updating but the manipulation of larger amounts of data and greater flexibility in output. Plans are currently being formulated for computerization of more of the data held, by digitizing existing overlays.

A major advantage of computerization is the greater ease of combining and manipulating several data sets to produce maps of new themes or resampled statistics. This should prove particularly useful for merging cadastral and administrative boundary data with different types of resource information, in order to produce national and regional thematic maps and associated reports. Examples include combinations of such data as forest types and forest reserve boundaries, ecological communities and nature conservation reserve boundaries, and rain forest on different types of conserved land. Not only can the desired information be mapped but such statistics as the proportion of rain forest within forestry or nature conservation reserves, for example, can be derived.

With the data bases and base maps in digital form, computerized revision using digital satellite imagery should be possible, and this step is now being considered.

ATLAS OF FINLAND*

Paper submitted by Finland

RESUME

La publication du cinquième Atlas de la Finlande a commencé en 1977, avec un premier volume. Une fois terminé, l'Atlas constituera un ouvrage de référence comprenant plus de 3 000 cartes thématiques et graphiques accompagnées d'un texte, et donnant une vue d'ensemble de la géographie physique et humaine du pays, de la population, de la vie économique, de la société et de la culture.

L'Atlas est publié conjointement par la Société géographique de Finlande et le Service cartographique national. La supervision de l'ensemble des travaux, qui est confiée au Comité scientifique de l'édition de l'Atlas, est assurée au sein du Service cartographique national. Des spécialistes de chaque branche aident à la conception des cartes et rédigent les articles.

A NATIONAL ATLAS OF FINLAND

Four earlier editions of the Atlas of Finland have been published by the Geographical Society of Finland--in 1899, 1910, 1925 and 1960. As these publications presented a broad description of a single country and people, the term "national atlas" came to be applied. In many countries today, the production of an atlas describing the land and society is considered a means of raising national consciouness. In this sense, the 1899 edition of the Atlas of Finland was indeed the first national atlas in the world. At that time, when there was political oppression, the first task of the atlas was political--to reveal to the rest of the world the existence of a distinctively Finnish society.

After Finland became independent, the political aspect faded; and distribution abroad is no longer the primary aim, even though the current Atlas is published in three languages. Priority is given to describing, as vividly as possible, the natural features and human activities in various parts of Finland. The maps 1/ may also help to pin-point regional problems and thereby provide a point of departure for social and regional planning.

A COLLECTION OF THEMATIC MAPS

Cartographers customarily divide maps into two main types--topographic maps and thematic maps. Topographic maps, such as the road maps and the 1:20,000

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* The original text of this paper, prepared by the National Board of Survey, Helsinki, appeared as document E/CONF.75/L.107.

base map of the National Board of Survey, describe the terrain or visible features of the surface of Earth. Thus, they can be used for locational orientation.

Thematic maps, on the other hand, represent a theme or something other than the terrain, perhaps in relation to municipal divisions or population size. They do not assist orientation. Most of the maps presented in the Atlas of Finland are thematic in nature.

FIFTH EDITION OF THE ATLAS

The fifth edition of the Atlas of Finland, although still a national atlas with the objective of describing comprehensively the land and people of Finland, differs from the preceding editions in the following respects:

(a) The scope is broader;

(b) It is being presented as separate subject folios, which are published immediately after completion;

(c) The text is central to each folio; it links the maps of each subject area into a unified whole;

(d) Each folio has a list of references and an index; the latter also provides the essential terminology of the field.

Legends and explanations for maps and diagrams are given in Finish, Swedish and English. Although the folio articles appear in Finnish, the Swedish and English translations are available as appendices to the folio. These appendices include translations of the index; figures and the list of references, however, are given only in th folio proper.

Forestry, the first folio of the fifth edition, appeared in 1977; plans call for the entire Atlas to be completed by 1986.

NATURE AND MAN

Although both nature and human activity are described in the Atlas, the emphasis is on human activity, that is, exploitation of the land and its resources to human advantage and the intensity of such activities.

The first division of the Atlas concerns the physical environment, in the broadest sense. The second and third divisions concern man--the population and the economy, society and culture of the country.

An example of a relief map depicting the physicla environment is given in "Production of thematic maps in Finland". 2/ It was prepared by reducing the contour lines of the road map of Finland from 1:200,000 scale to 1:2,500,000.

POPULATION AND LIVING CONDITIONS

Population density

The earliest population density maps of Finland date from the nineteenth century. Today, with the aid of a computer, it is possible to produce highly accurate maps directly from statistical registers.

For example, to prepare a computer-drawn map of population density in Finland on the scale 1:1,000,000, 3/ a square grid was first superimposed over the base map, with each side representing 2.5 km. For each square, population density figures were calculated on the basis of the 1970 census. The squares were graded by density, and a separate colour tone was assigned to each density class. This method produced a highly accurate map of population density, with sharp local variations.

A more general view of variations in population density is provided by a smaller scale map, also produced by computer and based on the 1970 census. Partially overlapping circles (about 9-km radius) were used as the calculation areas for populaiton density. Isolines for specific population densities were drawn on the map on the basis of the figures calculated for the circles and located at their centres. The density zones between the isolines were then assigned a distinctive colour tone.

Population structure

In maps showing the structure of the economically active population by sex and by county, the surface colouring of the counties indicates the percentage of the working-age population that is economically active. This is an example of the choropleth technique, where each area is coloured in accordance with intensity classes established for a particular phenomenon.

Column diagrams are superimposed on and at the side of the choroplethic presentation, to show the distribution of the economically active population by industry. For the country as a whole, manufacturing is the largest industrial sector in terms of supplying work, although in the eastern counties, more people work in agriculture and forestry. The industry distributions are clearly different for males and females.

Such maps raise questions about the causes of regional differences, to which firm answers cannot be provided merely by comparing the maps. The real value of these maps is that they present much information in a concise and highly visual form. They disclose problems and provoke questions, which complex data like statistics, not structured into maps, cannot do.

Living conditions

Living conditions in Finland as a whole and in individual areas are expressed in various maps. Choroplethic colouring on one map shows the degree of increase of unemployment from the south-west to the north-east. 4/ The

colum diagram in this map frame shows that the highest degree of unemployment is found in age group 20-24. Circular diagrams display the age composition of the unemployed population by county.

The floor space of dwelling units per person is shown on a pair of maps. 5/ Between 1970 and 1975, housing conditions improved throughout Finland, because the amount of dwelling space increased in all counties. Regional differences, however, have persisted. It seems that the lower the population density in a municipality, the smaller, and more crowded, the living-quarters.

The average life expectancy of Finns at birth, an important indicator of living conditions, is shown in figure 172. Life expectancy has grown appreciably during the twentieth century; females in Finland now live, on average, 75.2 years; and males, 66.7 years. Regional differences exist, however; life expectancy is greater in the south-west than in the north-east.

As concerns the average life expectancy for Finns of different ages, males aged 30 years, for example, can expect to live another 40 years, while males aged 80 years can expect only another 5 years. 6/

AGRICULTURE

Agriculture is practised in Finland under harsh climatic conditions. The long adaptation of agriculture to these conditions is shown by the diversity of production. Often on the same farm the land is cultivated, livestock are raised and forestry is undertaken. If the cereal crops fail, the meadows and grassland may still be capable of supporting livestock; and if livestock numbers must be reduced, it is possible to fall back on the forest.

Even crop production itself is diversified. Some 40 different crops are cultivated, although only about half of these are of significance in the national economy. This diversity also constitutes an excellent precautionary measure against climatic risks. In fact, the specialization recently introduced to increase agricultural production has increased the susceptibility to loss.

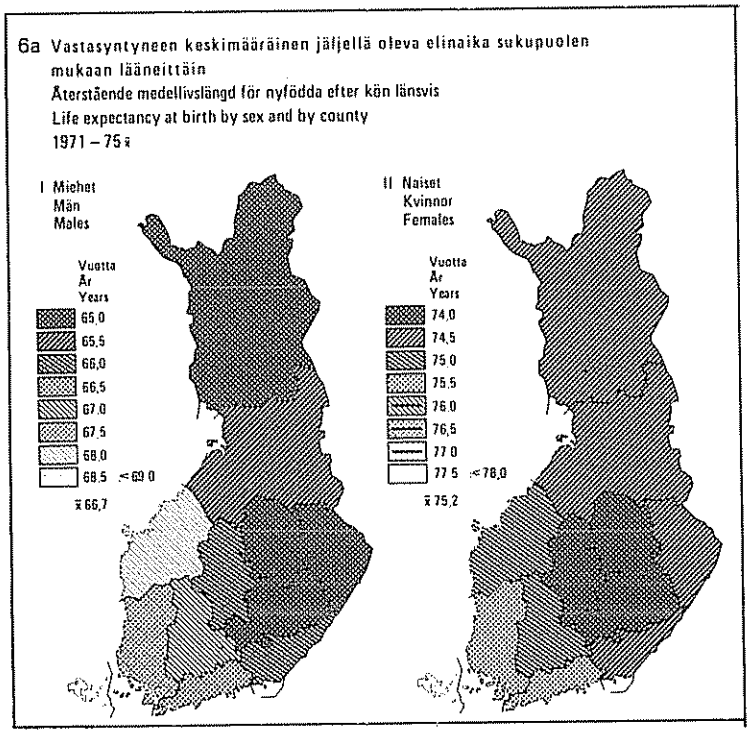
Arable land

A general view of the proportion of arable land to total farm area is presented in the Atlas. While the average arable area on farms in the country as a whole is 23.4 per cent, it is well over 35 per cent in the most fertile areas of southern and western Finland and under 5 per cent in the barren north-eastern and northern parts. Similarly, the proportion of forest and wasteland on farms increases as one moves from the south-west to the north-east.

Grain yields

About half the arable land in Finland is devoted to grain crops. A map in the Atlas includes a graph showing the increase in yields in the entire country and the relative importance of the various grains. In the map itself, the intensity of the regional colouring shows the average grain yield per

Figure 172. Finland: life expectancy at birth by sex and by county, 1971-1975



3388.45x

hectare in the different parts of the country. Sectoral diagrams depict the total grain yields in each area.

Finnish grains

Of all the grains grown in Finland, winter wheat is the most demanding to cultivate; its cultivation is limited to the clayey soils in the south and south-west. Spring wheat is grown over a somewhat wider area and is the most important food grain in the south. Rye succeeds well in less fertile soils, but the area devoted to it has decreased with the increase in the cultivation of wheat. Barley is an important grain for feeding and malting, and to some extent is used as a food grain. Planting of oats, the youngest of the Finnish grains, extended rapidly during the nineteenth century. In the twentieth century, oats have given ground to barley but continue as an important feed grain, especially in south-western and western Finland. Mixed grain is used chiefly for fodder and the total crop is small throughout the country.

Until rye replaced it in importance in the eighteenth century, barley was the most important food grain in Finland. Today, it is a common and high-yield feed grain. Hardy in the Finnish climate and quick to ripen, it is cultivated even in northern Lapland. Indeed, it is the only grain to be grown so far north. With the decrease in Finland's self-sufficiency in agricultural production, the cultivation of barley for food purposes has been decreasing in the north ever since the 1930s; at the same time, the cultivation of barley for feed has increased in the south. In the country as a whole, the area under barley has almost doubled since 1950.

The regional variation in the size of the circles in figure 173 shows production to be most extensive in southern Finland, except along the coast, and in southern Ostrobothnia. The column diagram shows that the barley yield per hectare has significantly improved since the mid-1960s, though there are annual variations, attribuable mostly to the weather.

The regional differences in yields per hectare are readily apparent from the isolines added to the map (figure 173). The highest yields are in the Turku area; and from there, the yields decrease towards the north-east. The adverse conditions prevailing in the barren strip of land along the Suomenselkä water divide stand out clearly, as in many other maps displaying human activity.

Milk production

Grassland crops occupy a good third of the arable land in Finland, in Lapland as much as 60 per cent. The harvest is used for animal fodder, and yields per hectare are about the same in the south and in the north. Dairying, which is essentially based on forages, thus differs from grain production in being almost equally advantageous in the north and south. The one great difficulty is that milk consumption is concentrated in the south, where the majority of the population live.

The number of milk producers in Finland decreased sharply in the late 1960s and in the 1970s. The decrease has been most rapid in the south-west

Figure 173. Finland: area planted in barley, by municipality, 1975

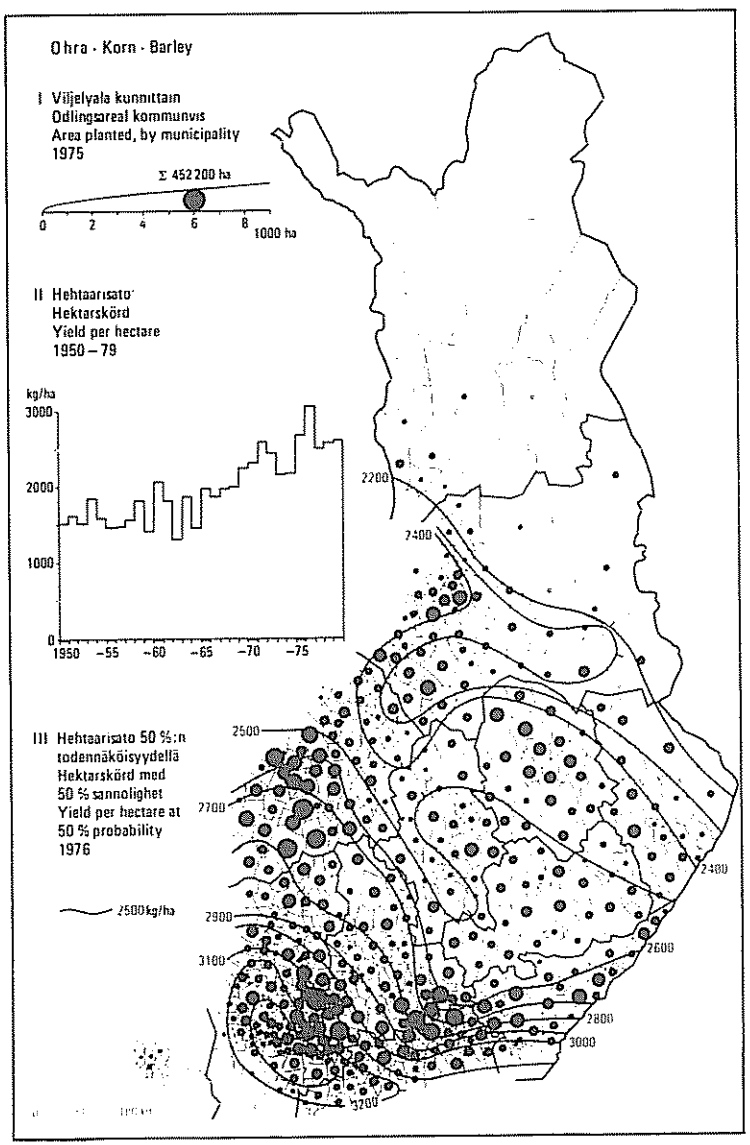


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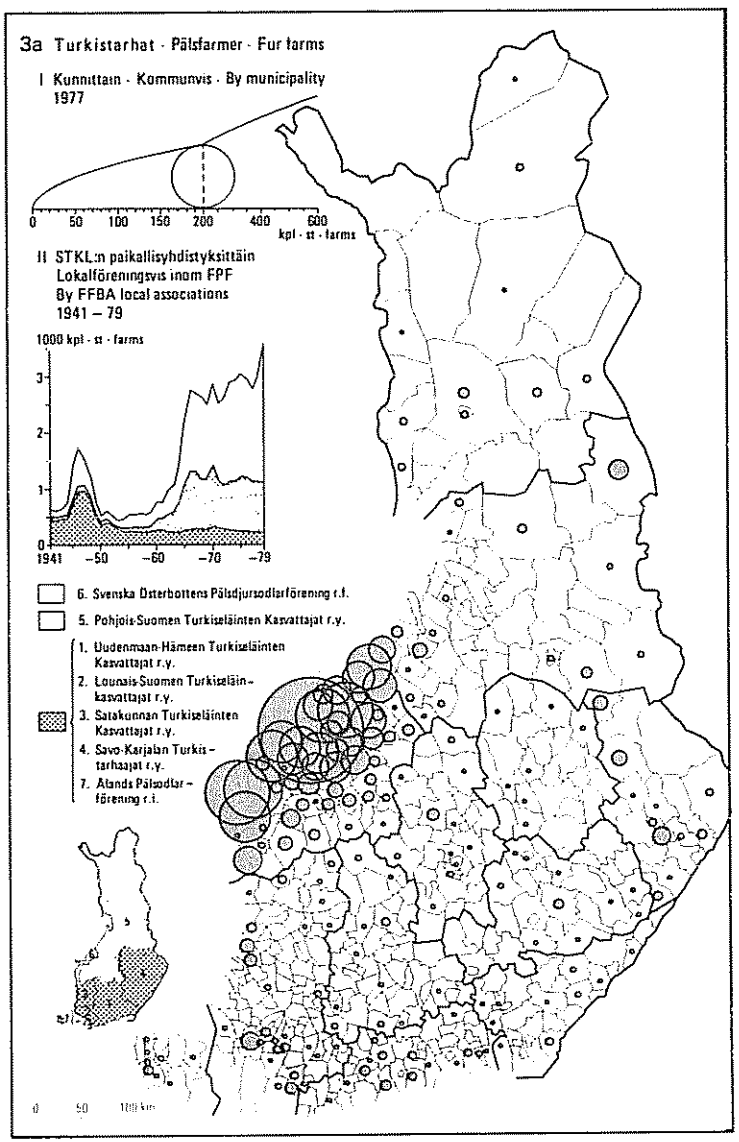
Figure 174. Finland: fur farms, by municipality, 1977



3388.47x

and south. In spite of the decline in the number of producers, however, the amounts of milk received by dairies have remained the same and even increased a little except in the counties of the south-west. The amount of milk received per supplier has thus increased. The regional colouring on the map presented in the Atlas shows the average amount of milk received by dairies per supplier in the different counties.

Dairying is an industry whose productivity does not diminish towards the north. This reflects the high grassland yields in the north as well as a purposeful direction of agricultural policy.

SPECIAL BRANCHES AGRICULTURE

Fur farming

Economically at least, fur farming is the most important of those special branches of agriculture ancillary to main production in Finland. The typical fur-bearing animals are several breeds of fox, and mink, finnraccoon, and fitch. The graph in figure 174 records a dramatic increase in the number of fur farms in the 1960s, during which time Finland rose to become one of the world's leading producers of furs. The circular diagram map shows the concentration of fur farming in Ostrobothnia. About 98 per cent of the production is sold abroad, with the Federal Republic of Germany the most important export market in recent years.

Reindeer husbandry

An older industry than fur farming is reindeer husbandry. The Lapp village, or siida, was traditionally the basic unit of reindeer husbandry as practised by the Lapps, but reindeer husbandry in northern Finland is currently based on the larger unit of the reindeer owners' association. The associations in turn make up the more extensive "marking district". The numbers of reindeer by marking district and the average number of counted reindeer (reindeer over one year) are presented graphically in the Atlas.

Figure 175 shows the marked fluctuations in the number of reindeer from year to year. This is an indication that the maximum capability of the winter fedding-grounds to support stock has now been reached.

Beekeeping

The first scattered attempts to introduce beekeeping into Finland were in the 1760s, when bees were imported from Estonia and Sweden. Beekeeping gained a foothold, however, only at the beginning of the nineteenth century, when the Finnish Economic Society imported a large number of colonies from Sweden. The twentieth century has been one of rapid growth. There were about 4,000 colonies of bees in Finland in 1910; and, in the keep of affiliated keepers alone, some 32,500 colonies in 1975. Most of the bee-yards are located in the southern and south-western parts of the country and in southern Ostrobothnia.

Figure 175. Finland: number of reindeer in the reindeer husbandry area, 1958/59-1977/78

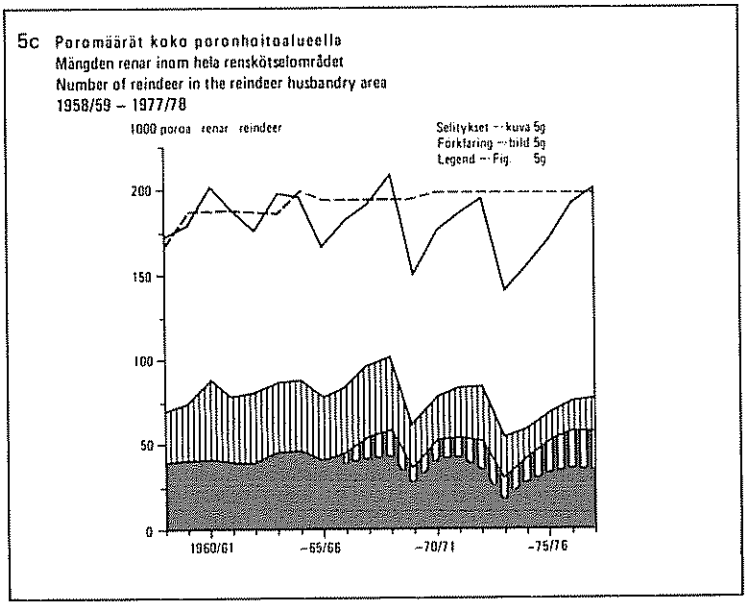
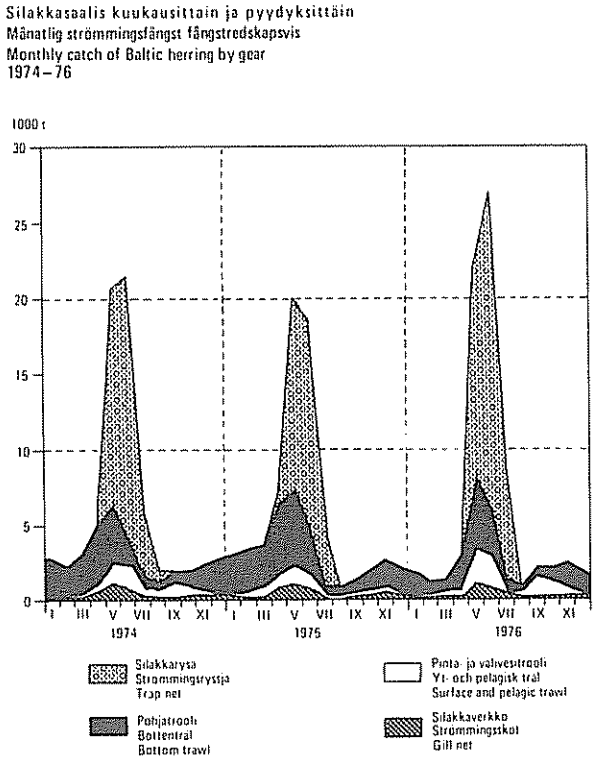


Figure 176. Finland: monthly catch of Baltic herring, by gear used, 1974-1976



The Atlas presents a map showing that most beekeepers operate on a small scale, managing fewer than 10 colonies. In 1976, only 0.5 per cent of the approximately 3,000 keepers considered beekeeping their main activity.

Honey production in Finland is, on average, 27 kg per colony. The production is higher than in many more southerly countries because of the comparatively low bee density and reduced competition for the honey plants. Moreover, the maximum amount of honey possible is collected from the hives, and the honey replaced with sugar for winter feeding. Bees are also significant in the national economy as pollinators of plants. It has been estimated that the harvest of forest berries can be multiplied two or three times with the help of bees.

Gathering of berries

By what is known as "everyman's right" any Finn may collect wild berries, mushrooms, and other useful wild plants from land owned by another, provided the owner has not clearly indicated an intention of collecting them himself. Everyman's right does not apply in the immediate vicinity of dwellings.

Berry plants growing wild in forests, bogs and meadows, and at the edge of cultivated fields are classified as wild berries. Widely found throughout Finland are the cowberry (red whortleberry, lingonberry), blueberry (whortelberry, bilberry), crowberry, cloudberry, rowan berry and juniper berry. The map presented in the Atlas had to be prepared on the basis of fairly limited information; it shows the areas of strong distribution of berry plants that are found only in specific parts of the country. The cranberry and the arctic bramble are found in abundance only in the central part of Finland, while the wild strawberry and raspberry are more southern in distribution. The sea buckthorn flourishes in a narrow belt along the coast of Ostrobothnia and in the south-western archipelago.

Only rough estimates are available on the yields of wild berries. For example, the yield of cloudberry in good growing sites may be from 30 to 300 kg per hectare, and the total harvest in a good year may surpass 25 million kg. The harvest of cranberries falls in the same class. From the best treeless bogs as much as 500 kg of cranberries per hectare may be collected. Most of the berries are used in private households.

HUNTING AND FISHING

Hunting

The Game Act currently in force in Finland dates from 1962. The Department for Fishing and Game, within the Ministry of Agriculture and Forestry, is responsible for enforcing the act and also sets the hunting seasons and the regulations to protect endangered species. Hunters are responsible for game management, which is supported by game fees. About 250,000 hunters paid the game fee in 1977.

Moose and deer, hares, waterfowl, grouse, farm-land birds and fur-bearing animals are the most important game. The value of the take of the most important game species is depicted by circular diagrams, and the return from hunting by square kilometre of land is shown by regional colouring. 7/ In all counties, the moose is the most important game animal. The return from hunting per unit surface area is seen to decrease from south to north.

The Atlas also shows the distribution of wild reindeer and some newly introduced species of deer, as well as the rapid increase in the killing of white-tailed deer. Also depicted are the decreasing distribution of the bear and the wolf--the traditional predators--and the decrease in the numbers killed. 8/ It should be mentioned, however, that neither predator has disappeared from Finland.

Fishing

With the long coastline along the Baltic Sea and the Gulfs of Finland and Bothnia, and myriad lakes and rivers, Finland is geographically favoured for the development of fisheries. Firm limitaitons are imposed, however, by the short growing season and low nutrient content of Finnish waters.

Of the 77 species of fish reported in Finnish waters, 36 are fresh-water species. Some fresh-water fishes are also found in the low salinity waters fo the archipelago. The largest fish catches, however, are marine species. 9/ In maps prepared to show the size of catch of four important marine species in different sections of the Baltic, the Finnish share of the total catch is represented by the shaded sectors of the circles.

The Baltic herring is by far the most important commercial species. Figure 176 shows that it is caught primarily by trap net and bottom trawl. Surface and pelagic trawling in the open sea became common in Finnish waters in the early 1960s, at which time total catches of Baltic herring began to increase, even while the number of commercial fishermen was decreasing. The Baltic herring is fished mostly in May and June.

Despite the increase in domestic production, fish must still be imported, particularly as feed for fur-bearers.

FORESTRY

Finland is one of the most richly forested countries in the world and forests are the most important natural resource. According to the Fifth National Forest Inventory, carried out during the period 1964-1970, land yielding an annual increment of at least 1 m^3 of stemwood with bark covers 61.2 per cent of the land area. In addition, 26.1 per cent of the land area is "other forestry land", mostly poorly productive land where growth is slow or waste land that is almost non-productive. The average annual increment on poorly productive land is 0.1-0.9 m^3 per hectare, and on waste land, under 0.1 m^3 per hectare. The poorly productive and waste land are predominantly bog.

Prevalence of forest land

A map presented in the Atlas shows the prevalence of forest land in the different parts of Finland. It was prepared at the Forest Research Institute with the aid of a sampling point net covering the whole country. The proportion of forest land of the total land area is slightly greater in southern than northern Finland. Forest land is especially extensive in Järvi-Suomi, or the Finnish Lake Region, while in northern Lapland, except for the area around Lake Inari, there is hardly any.

Peatlands

Finland is also one of the marshiest countries in the world. About 34 per cent of the land area of Finland and 37 per cent of the forestry land are peatland. The peatlands cover a particularly extensive area in the central and northern parts of Ostrobothnia.

Drainage

Finland has such a damp climate that if the bogs were not drained they would gradually encroach on the dry land. Particularly since the 1950s, the incremental growth of forests has been successfully augmented by the mechanical ditching of peatlands. The diagrams given in an Atlas illustration show the degree of drainage by owner group and in different regions. About half of the forestry land in southern Finland has been drained; in northern Finland, less has been done.

Since drainage converts poorly productive and waste land to forest land, the area of forest land in Finland is continually increasing. Thanks to drainage measures, the production from forest and poorly productive land, which between 1964 and 1979 averaged 55.5 mullion m^3 of stemwood with bark annually, increased by, from 4 million to 5 million m^3 in the early 1970s. Unfortunately, drainage has at the same time been responsible for the destruction of much of the wildlife and vegetation of the Finnish marshlands.

Tree species

In the early part of the twentieth century, there were still extensive areas of deciduous forest as a result of earlier slash- and-burn agricultural practices. Some of these areas still remain, as shown by the abundance of birch-dominated forests in southern Savo. 10/ With the end of this type of farming and the marked decrease in the number of forest fires, spruce increasingly took over as the dominant species on the best growing sites. In recent years, there has been a move to replant poorly fertile soils bearing spruce with pine.

Pine is the dominant species on 55 per cent of the forest land in Finland, spruce on 32 per cent and deciduous species on 8 per cent. Spruce is more important than pine in the more fertile areas of southern Finland.

Wood prices

The stumpage price of coniferous saw timber, or the price paid for standing timber, is highest in the south-west and lowest in northern Finland. 11/ The value of wood increases, of course, with harvesting, transportation and processing into various products. 12/

MANUFACTURING

The most important branch of manufacturing in Finland is the forest industry. Of the raw material needs only 7-8 per cent is obtained from company forests. The rest is purchased from the more than 300,000 private forest owners, from the State and municipalities, and to some extend from abroad. Each year the forest industry concludes over 150,000 purchase agreements with private forest owners.

The commercial cuttings mostly go to fill the timber needs of industry. Cutting is heaviest in the south-east and in the interior of Finland where the forest industry is concentrated. Between 1950 and 1974, there was a gradual increase in cuttings as well as marked business fluctuations.

Growth of Finnish manufacturing

Figures 178 and 179 record the rapidity of the industrialization process in Finland in the twentieth century, displaying the strength and the regional location of the clothing industry at two different time periods, 1915 and 1977. The revolutionary quality of the change emerges dramatically.

TRADE

The Atlas contains maps showing the distribution of wholesaling by municipality or group of municipalities. If there are fewer than three establisments in an area, the information is generalized in accordance with current regulations covering privacy of information. The same applies to the maps depicting the clothing industry. The inaccuracy introduced to the total map as a result of this method is small.

Regional distribution of wholesale trade

The wholesaling of textiles, clothing and leather articles accounted for 1.3 per cent of total turnover in the wholesale business in 1976. A comparison with the map of the clothing industry given in the Atlas shows the wholesale trade to be distributed over a similar geographical area but more highly centralized. The three counties in the south-west account for about 90 per cent of total turnover in the wholesaling of textiles, clothing and leather articles.

Figure 177. Finland: manufacture of wearing apparel, excluding footwear, measured by value added in 1977 money, by municipality, 1915

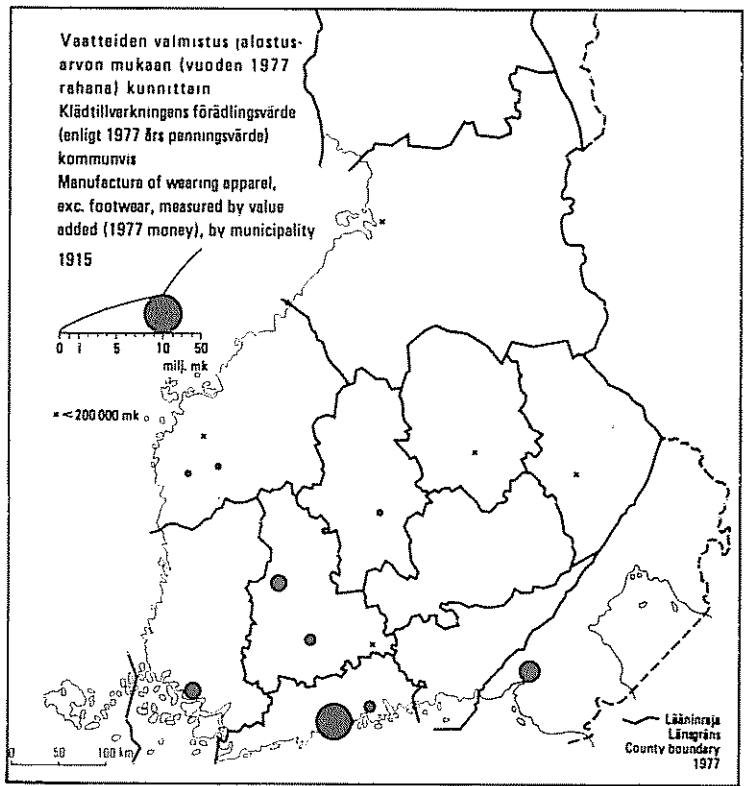


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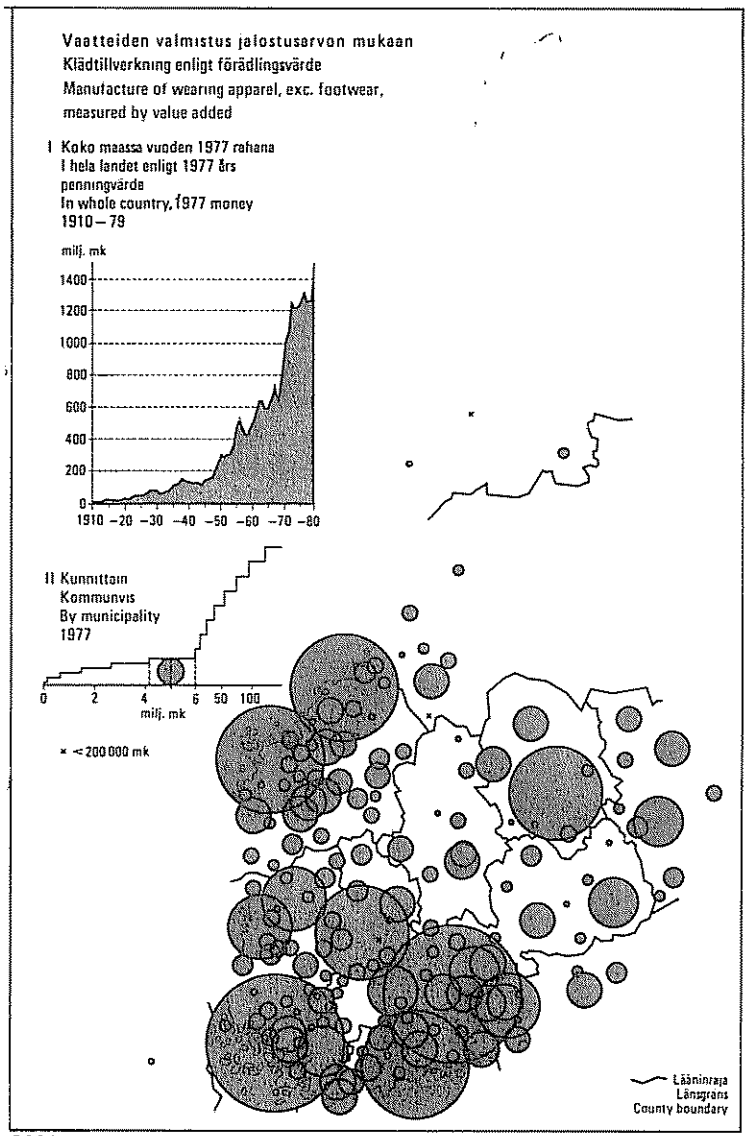
Figure 178. Finland: manufacture of wearing apparel, excluding footwear, measured by value added, 1977



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Total wholesale trade

The total turnover of the wholesale trade was 58 million markkan (Fmk) in 1976, or a good Fmk 1,000 per inhabitant per month. Like wholesaling in the clothing industry, the total wholesale trade is highly centralized. Thus, the area around Helsinki accounts for about half of the total turnover in wholesaling in Finland while only accounting for about one fifth of the population. The central warehouses and head offices of many of the wholesale firms are located in the Helsinki area. After Helsinki come Turku, Tampere and Oulu in importance. Also significant as wholesaling centres are Kuopio, Pori, Jyväskylä and Vaasa.

Sectors of wholesaling

In the Atlas presentation, circle sectors display for each locality the shares in total turnover of different sectors of the wholesale trade. Specialized wholesaling tends to be concentraded in large city centres, while general wholesaling tends to be more important the smaller the locality.

REALIZATION AND SCOPE OF THE ATLAS

The Atlas of Finland is being published jointly by the Geographical Society of Finland and the National Board of Survey. The Scientific Editorial Committee of the Atlas of Finland, appointed by the Council of State is supervising the work. The Chairman of the Committee is Professor Stig Jaatinen of the University of Helsinki. Specialists from each field participate in conceptualizing and designing the maps ans write the accompanying text for the Atlas. Editorial responsibility rests with the editorial staff of the Atlas within the National Board of Survey: Jussi Keinänen (Editorial Chief); Pentti Alalammi; Erkki Helin; and Risto Talman. The Atlas is being printed and marketed by the Publishing Division of the National Board of Survey, represented on the Editorial Committee by Osmo Niemelä.

The complete Atlas will comprise 26 separate folios averaging 25 pages each and will cover 54 subjects. Over 3,000 maps and diagrams will be published. The folios measure 32.5 x 49 cm. The largest scale used on maps of the whole of Finland is 1:1,000,000, and the usual scale is 1:8,000,000. The three divisions of the Atlas and the subjects treated in each folio are listed in "Production of thematic maps in Finland" (see pocket at end of this volume).

Notes

1/ For technical reasons, it was not possible de reproduce all the illustrations submitted with this paper. Some of the multicoloured figures, however, have been reproduced in black and white and are presented here. Others appear elsewhere in this publication.

2/ In pocket at the end of this volume; see figure 9.

3/ See "Production of thematic maps in Finland", in pocket at the end of this volume; figure 1 shows a section of this map.

4/ Ibid., figure 11.

5/ Ibid., figure 12.

6/ Ibid., figure 10.

7/ Ibid., figure 13.

8/ Ibid., figure 15.

9/ Ibid., figure 14.

10/ Ibid., figure 16.

11/ Ibid., figure 17.

12/ Ibid., figure 18.

PRODUCTION OF THEMATIC MAPS IN FINLAND

Paper submitted by Finland

This paper, which is in the pocket at the end of this volume, was prepared by Osmo Miemelä, Director of the Publication Division of the National Board of Survey of Finland. Portions of the original text appeared as document E/CONF. 75/L.108, under the title "Thematic maps--important cartographic products".

CARTOGRAPHY AT THE GEOLOGICAL RESEARCH AND DEVELOPMENT CENTRE*

Paper submitted by Indonesia

RESUME

Le document traite de la préparation et de l'établissement de cartes géologiques au Centre de recherche-développement géologique du Ministère indonésien des mines et de l'énergie.

* The original text of this paper, prepared by the Geological Research and Development Centre, Ministry of Mines and Energy, appeared as document E/CONF.75/L.103.

La préparation et l'établissement de cartes géologiques constituent l'une des fonctions principales du Centre, alors que le travail préparatoire incombe aux divisions de géologie régionale et de la documentation et des publications.

Les travaux de cartographie portent notamment sur la préparation de cartes de base, la sélection chromatique, les épreuves d'essai en couleurs et l'établissement des positifs définitifs. L'impression est confiée à des façonniers.

Les produits définitifs, comme les cartes géologiques, comprennent des coupures géologiques au 1:250 000 pour certaines régions au large de Java et au 1:100 000 pour Java et Madura, ainsi que des cartes préparées à des échelles plus petites - 1:1 000 000 et même 1:2 500 000 ou encore moins.

This paper deals with the preparation and production of geological maps by the Geological Research and Development Centre of the Ministry of Mines and Energy in Indonesia. This task is one of the primary functions of the Centre; map preparation is the responsibility of the Division of Regional Geology and the Division of Documentation and Publications.

The cartographic work includes base-map preparation, colour separation, colour proofing and final positive-film preparation. Printing is done by private printers.

The final products are geological map quadrangles on the scale 1:250,000 for areas off Java, 1:100,000 for Java and Madura, and compilations on smaller scales--1:1,000,000 and eventually 1:2,500,000 or smaller.

GEOLOGICAL MAP PRODUCTION PROCEDURES

Geological mapping has always been the main task and function of the former Geological Survey of Indonesia and Development Centre. Prior to the first five-year development plan (1969), this function could scarcely be implemented because of the shortage of qualified geologists as well as budgetary constraints. The United States Agency for International Development (USAID) provided technical assistance through the United States Geological Survey, commencing in 1970. This assistance provided training in geological field-mapping, remote sensing and cartography. The assistance terminated in 1975, but the cartographic personnel were already thoroughly reorganized and upgraded. As a result of this technical assistance, geological map production has been activated.

Geological field-mapping and base-map preparation

Within the Geological Research and Development Centre, geological field-mapping is done by geologists of the Regional Geology Division.

In order to produce accurate geological maps, reliable topographic maps are needed to serve as field orientation and data plotting. There is a relative scarcity, however, of reliable topographic base maps for areas off Java. This constraint may be overcome somewhat by using aerial photographs in the field, but aerial photographic coverage is limited either in area or in number.

The base-map preparation is done by the Publications Section of the Documentation and Publications Division. The Publications Section consists of four groups--cartography, typesetting, reprography, and map archives and distribution. The cartography group is divided into four teams of four technicians, each headed by a foreman. The supervisor of the cartography group distributes the jobs to the team foreman and supervises the progress of the teams. The base maps currently used are AMS series T503 on the Transverse Mercator projection scale 1:250,000 and AMS series T752 on the scale 1:100,000. Each sheet is separated into three parts: contour (brown plate); hydrology (open water, blue plate); and geographical names and man-made structures (black plate). The negative films for the three parts are then again united by contact printing on stable-base Mylar. The Mylar base map is called "green-line", because of the green colour of the print. Two green-lines are made, one to be given to the field geologist and the other to remain in the office for future geological data-plotting.

Layout and colour separation

The geologocial data are plotted on the green-line base map by the field geologist. Diazo copies are then made for the geologist in order to prepare a hand-coloured geological map manuscript. After the geological map manuscript has been reviewed and edited, the chief editor forwards the manuscript to the Director of the Centre for publication permission. The Publications Section supervisor then considers, together with the editor, the layout of the map. The flow of manuscript material for publication is shown in figure 179.

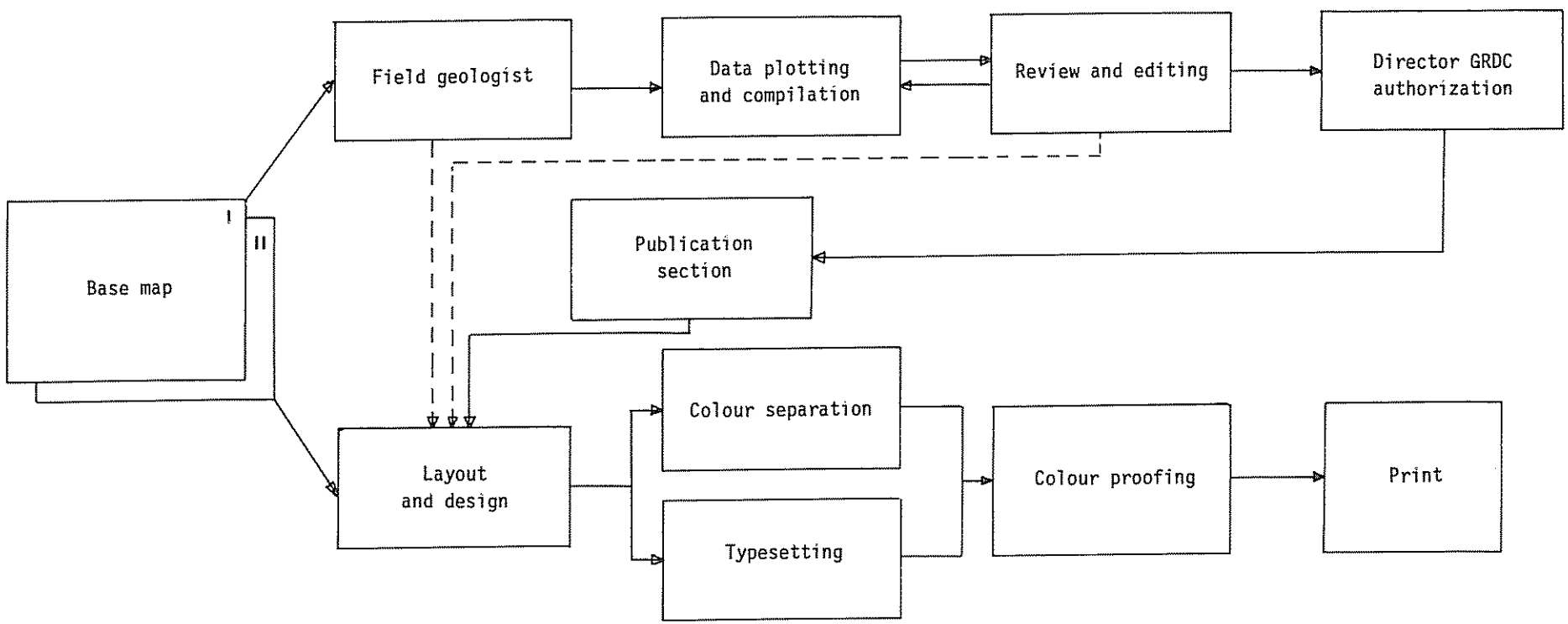
A geological map-sheeet contains the map proper and marginal information.

In the right-hand margin, the standard marginal information comprises geological unit classification, correlation diagram, geological symbols and a geographical glossary. The bottom margin shows th title of the sheet, the names of the authors, the map scale in bar and numerical scales, the map projection, aerial photographic coverage, graphical reference of previous geological investigations and geological cross-sections.

Colour separation

After the layout of the map has been designed, colour separation may be made. During the early years of the present cartographic method, colour separation was done on ortho film by blacking out the film except for the intended printed area. The result was termed "open-window negatives". Scribe and peel-coat films were subsequently applied.

Figure 179. Indonesia: simulated flow chart of geological map production



The colours are programmed on the basis of the United States Geological Survey Colortrol system, which applies a dot screen with densities of 15, 30, 50 and 70 per cent dots per unit area. This system provides more than 200 possible colour tones and hues. The printed colours were subdued cyan, magenta and yellow. The resultant geological maps did not appear bright, and dark or deep colours were normally avoided.

Lettering of geological symbols and geographical names is done with paste-up film. In addition to colours, patterns are used to show lithology or characteristic rock types. Colours and patterns are used to show lithological types and geological structure. Contours are shown in brown, while railways and other man-made structures are shown in grey.

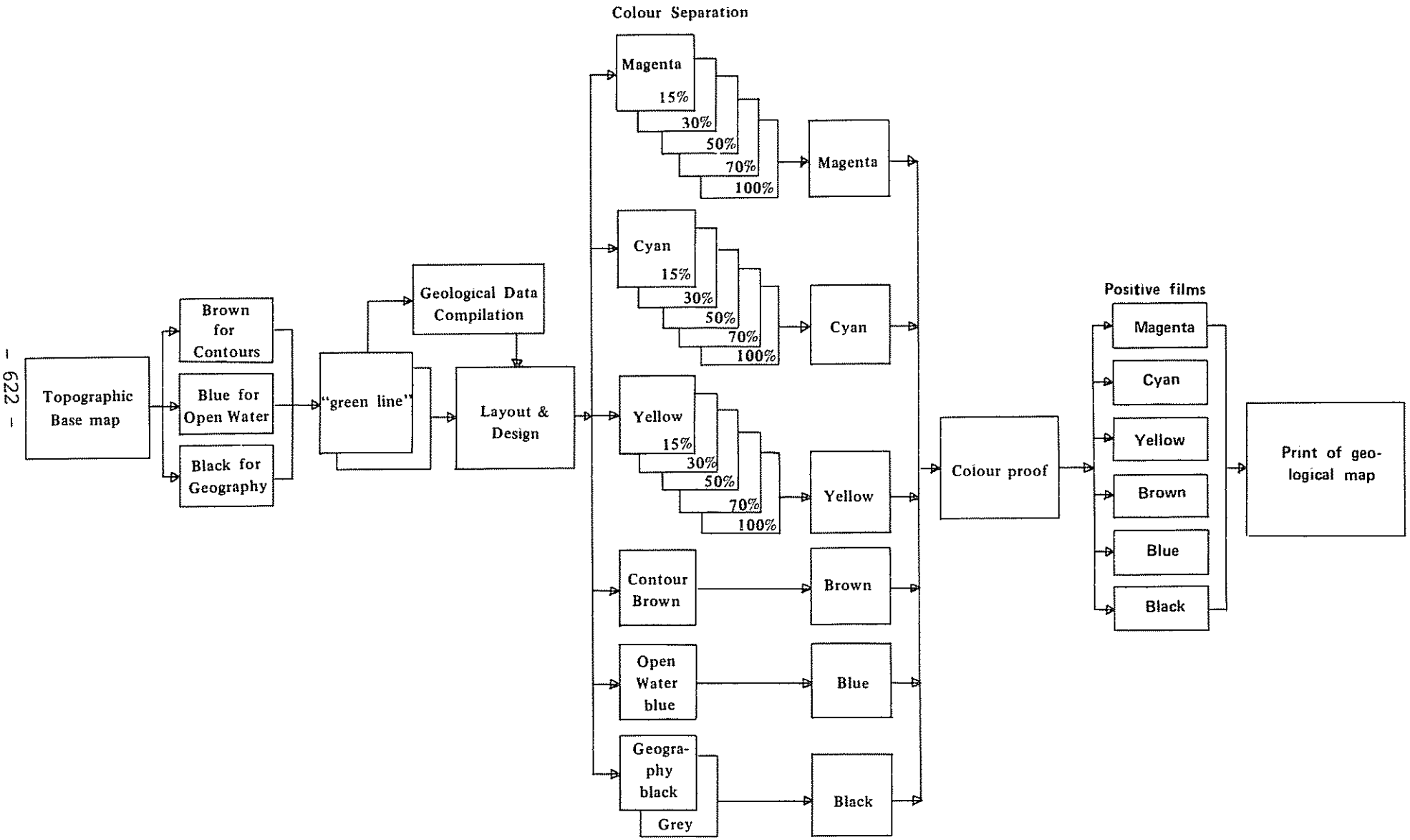
A colour proof is made on a white colour-proof plastic base by the photographic method. This proof is used by the supervisor, author(s) and editor(s) to check the colours, geological boundaries (registration) and text spelling. A second colour proof may be needed to eliminate all possible errors. After all the errors have been corrected, the negative films may be contact-photographed into the final positives, completing the cartographic process of geological map production. The entire cartographic procedure is represented graphically in figure 180.

PERSONNEL PLANNING AND UPGRADING

The cartographic work is carried out by personnel of the Publications Section of the Documentation and Publications Division. When modern cartographic processing was introduced, the Publications Section consisted of a leader and 18 staff members. Seven draughtsmen experienced only in drawing on tracing-paper formed the basis of all cartographic work. Because of their low educational level, it was decided that they could not handle such jobs as base-map calculations and precision photographic processing.

During the early 1970s many secondary-school graduates were recruited. Experts from the United States of America trained the new personnel in base-map compilation, scribing, colour separation and reprography. To date, there are no professionally educated cartographers in the Publications Section. The heads of the section have always been professional geologists. One junior geologist and two geographers are now supervising the cartographic procedure. Four technicians received professional training in camera processing and two technicians in book production. The current section head received on-the-job training in the Federal Republic of Germany and in the United States. The current staff of 16 draughtsmen, 5 photo-reproduction technicians, 3 typesetters and 2 offset-printing technicians are young people for whom more advanced training in modern cartographic and graphical art techniques is planned.

Figure 180. Indonesia: cartographic process in geological map production



(g) Cadastral surveying and urban mapping (including land information systems)

DEVELOPMENT OF A CADASTRAL DIGITAL CAPTURE FOR THE WESTERN AUSTRALIA LAND INFORMATION SYSTEM, COVERING THE PERIOD FROM JANUARY 1981 TO SEPTEMBER 1982*

Paper submitted by Australia

RESUME

Après avoir examiné les besoins de l'Australie occidentale en matière de système de documentation foncière, il a été décidé de numériser les plans cadastraux existants afin d'établir un système de référence cadastral reflétant la répartition de la propriété foncière dans cet Etat.

La première priorité porte sur les parcelles actuelles de terrain dans la région métropolitaine de Perth. Après avoir évalué leur exactitute, on numérisera les cartes au 1:500, au 1:2 000 ou au 1:10 000, compte tenu de la densité de l'urbanisation. On recueillera des données sur les "secteurs" délimités par des routes et il ne sera pas tenu compte des bords des feuilles.

Des techniques ont été mises au point, la numérisation est bien avancée et le Bureau des titres de Perth informatise parallèlement ses archives. Une deuxième étape, la fusion de ces deux bases de données, a commencé; dans une troisième étape, les anomalies seront corrigées et les données mises à jour.

BACKGROUND

Land information systems are essentially concerned with the exchange of information between organizations, both private and public, and the general public. Since the information involved in effect describes the fabric of the natural and cultural landscape it is, in the main, best presented in graphical form. Consequently, an essential prerequisite is some form of geographical referencing system.

In Western Australia, it was decided that a cadastral referencing system depicting land ownership would be used. Consequently, during the period from January to March 1981 an investigation was carried out by officers of the Surveyors General's Division, to determine the most appropriate method of raising the cadastral data base.

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* The original text of this paper, prepared by the Department of Lands and Surveys, Western Australia, appeared as document E/CONF.75/L.19.

Two capture methods were considered: (a) a numerical capture; and (b) a manual digitizing capture. In a numerical capture, the co-ordinates are calculated directly from the surveyor's field observations. In a manual digitizing capture, the co-ordinates are obtained by digitizing existing cadastral maps.

From this investigation, it was concluded that the more accurate results obtainable using a numerical capture would be outweighed by the far greater speed of digitized capture. In fact, it was estimated, that a numerical capture of the state could take about 137 man-years, compared with approximately 18 man-years by digitizing. Additionally, it was established that the majority of users of the system would be satisfied with digital-capture accuracies.

In the light of these findings, it was decided to digitize manually the existing cadastral maps. It was further suggested that a numerical capture of new transactions should be implemented as soon as possible after commencement of the digital capture.

A cost-benefit analysis for a manual digitizing capture was subsequently carried out. This analysis indicated that such a capture programme would be cost-effective.

In April 1981, the Surveyor General agreed to implement a manual digitizing-capture programme. A submission for equipment purchases was prepared and software development and project planning commenced.

A report on staffing requirements was completed in May 1981; and by June 1981, a work area had been set aside and the first four staff members allocated to perform the task.

SOME INITIAL CONSIDERATIONS

It is anticipated that eventually the cadastral subsystem data bank will contain Australian map grid (AMG) co-ordinate values delimiting the boundaries of all land parcels and administrative areas in Western Australia. Additionally, it will contain associated topographic data, such as the coastline and river banks.

In terms of land parcels alone, this involves the capture of approximately 1 million polygons, that is, some 640,000 current and 360,000 superseded land parcels.

It was decided that capture would begin in that area which would benefit the greatest number of potential users of the data in the shortest possible time. Ideally, it would begin in an area of high activity with good map coverage.

Based on these considerations, three areas were determined. These areas were, in order of importance: (a) the Perth Metropolitan Region; (b) the South-west land division; (c) the remainder of the state.

It was further decided, in the first instance, to concentrate on capturing current land parcels.

PERTH METROPOLITAN REGION

Within the Perth Metropolitan Region, there are approximately 350,000 current land parcels. The area has the densest survey control network and the most comprehensive cover of large-scale maps in the state. It has the added advantage that within this area a range of settlement patterns from dense inner-city to scattered rural holdings can be found. This range is particularly useful for testing capture software and digitizing techniques.

Cadastral mapping of the region ranges in scale from 1:500 in the Perth and Fremantle central city areas to 1:10,000 in the outer rural areas.

The extent of the Perth Metropolitan Region, for purposes of this project, was set to approximate as closely as possible the boundary established by the Town Planning Department (see figure 181).

Determination of capture scales

As a general rule of thumb, it was decided that capture would be carried out on the largest available map scale. The final selection of scales is given below:

(a) 1:500 scale: 53 sheets covering Perth and Fremantle central city areas;

(b) 1:2,000 scale: 1,021 sheets covering the mainly residential areas surrounding the two central city areas. Also included in this total were several isolated residential pockets in the outer rural areas;

(c) 1:5,000 scale: 44 sheets covering the transition zone between the 1:2,000 and 1:10,000 areas;

(d) 1:10,000 scale: 100 sheets covering the outer rural areas.

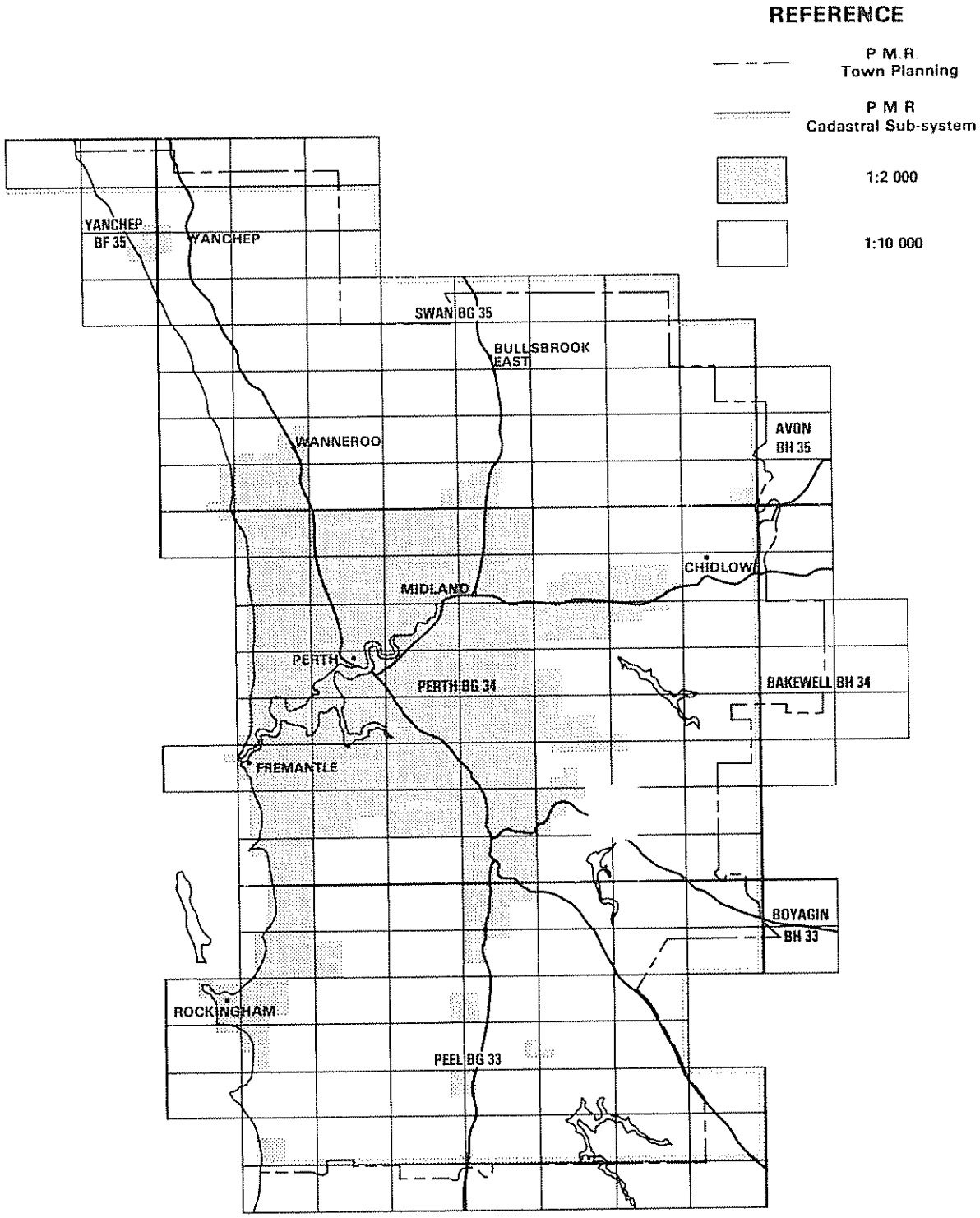
Consequently, to complete the primary capture of the Perth Metropolitan Region, a total of 1,218 map-sheets will have to be digitized.

Before finalization of capture scales could be achieved, it was first necessary to decide between the use of 1:1,000 or 1:2,000 bases. That is, the area covered at 1:2,000 is also mapped at 1:1,000. Essentially, the problem was one of weighing the possible advantage of a more accurate capture against a clearly definable saving in time and materials.

To resolve this dilemma, an area equivalent to a 1:2,000 map-sheet was digitized from both 1:1,000 and 1:2,000 map-sheets. Both the 1:2,000 and the 1:1,000 capture were plotted out at 1:1,000 and the results compared for accuracy with the original 1:1,000 base-map master. There was no appreciable degradation in accuracy using the 1:2,000 data.

In addition to this procedure, another 1:2,000 map-sheet was selected, containing 20 co-ordinated points of known AMG value. These points were located

Figure 181. Australia: index of digital cadastral capture; Stage 1, Perth Metropolitan Region



so that five lay in each 1:1,000 quadrant. Each point was digitized first on the 1:2,000 sheet then on each of the 1:1,000 sheets. The results were then transformed into AMG values and each compared with its known AMG value. A "mean square error" of the residual values for each scale was computed. They were: (a) 0.44 m for the 1:1,000 scale; and (b) 0.46 m for the 1:2,000 scale. These results indicate that digitizing at 1:1,000 scale would not produce an appreciable increase in accuracy over a 1:2,000 capture. Therefore, the 1:2,000 scale was selected.

Initial preparation

Capture scales having been determined, the next priority was seen to be the preparation of a set of master plans from which the data would be digitized. Furthermore, it was recognized that unimpeded access to up-to-date plans would be an essential prerequisite of success. Consequently, a set of master plans was assembled and stored in the production work area. These plans were drawn from Lands Department and Metropolitan Water Board sources. The plans so collected were grouped for storage into 1:10,000 blocks (5 x 5 sheets at 1:2,000).

One early consideration was how to resolve the problem of maintaining the integrity of data that crosses from one sheet to another. To resolve this problem, the idea of capturing individual map-sheets was replaced by the concept of capture by "control blocks".

Basically, in this concept, the State of Western Australia is viewed as being covered by a single continuous map. This map is divided up into a series of uniquely identified "control blocks". Each control block is, wherever possible, contained within road casements, and as such totally ignores individual sheet edges. Consequently, the problem of sheet-edge joins does not arise. Minor variations between control blocks are absorbed into the road casement areas.

An essential prerequisite of this control block approach is the availability of a control survey network. The Lands Department Cadmap system satisfies this requirement.

Developments to date

Between July and September 1981, site preparation was completed, project planning continued, a complete set of master plans was collected and control block booklets were made up. On 3 September 1981, detail enhancement commenced.

On 2 February 1982, staff training in software familiarization and digitizing procedures was initiated. Owing to tight time-schedules, it was decided to run staff training and software testing concurrently. Consequently, on 8 March 1982, one of the software development team moved to the production work area to be on hand to affect program changes and assist in staff training. This particular exercise proved invaluable in speeding up both the staff training and software testing processes. More important, it created a genuine bond between the production and software development teams by providing each with a greater appreciation of the other's problems.

On 12 February 1982, all outstanding items of computer equipment were received.

On 15 March, control enhancement commenced.

On 5 April, digital capture of the Perth Metropolitan Region commenced.

In a parallel development, Office of Titles staff have been transferring their records on to computer files. An essential prerequisite to maximizing the possible uses of this information is to provide it with a geographical position reference, that is, to attach to it the AMG co-ordinate values contained in the digitized data base.

Consequently, in May 1982, investigations into the requirements for merging the Office of Titles and Cadastral Digital Capture computer files commenced. This merging process is known as the "cadastral overlay project".

It was recognized that the merging of the two sets of information would reveal many anomalies. Furthermore, it was also clear that some mechanism for recording all new transactions to keep the data up to date would be required. Consequently, the total project was restructured into three logical phases, namely: (a) cadastral digital capture; (b) cadastral overlay; (c) revision.

By this means, initial digital capture could proceed unimpeded. All anomaly correction and updating of the data would be carried out by the "revision" group, with the actual merging of the two sets of information being carried out by the "overlay" group.

By 3 September 1982, initial staff training for cadastral overlay had been completed and the necessary software to support the task had been written and tested. On 6 September 1982, the cadastral overlay group commenced operations in production mode.

As at 13 September 1982, a total of 90 map-sheets at 1:2,000 scale had been digitized and prepared for overlay. This represents approximately 25 per cent of the Perth Metropolitan Region.

It is anticipated that primary capture of the Perth Metropolitan Region will be completed during the last quarter of 1983.

HERMANNSBURG ABORIGINAL LAND GRANTS IN THE NORTHERN TERRITORY*

Paper submitted by Australia

RESUME

Le Gouvernement australien a accordé des droits de pleine propriété sur 3 797 km^2 de ses terres traditionnelles à cinq tribus aborigènes à Hermannsburg dans le Territoire du nord.

Ces transferts ont un caractère historique, dans la mesure où ils permettent à certaines populations aborigènes de devenir propriétaires de leurs terres tribales et, pour la première fois en Australie, les terres des tribus aborigènes ont été délimitées par des levés de terrain et des titres de propriété ont ensuite été établis.

Le document contient un résumé de la conception de propriété foncière par les aborigènes australiens, décrit succinctement le rôle de la Mission d'Hermannsburg et expose les exigences en matière juridique et de levés. Les techniques photogrammétriques ont été adoptées car elles fournissent la solution la plus économique aux opérations de levés. Le document décrit les méthodes utilisées pour l'établissement des levés et les techniques photogrammétriques qui ont permis d'établir des plans pour la délivrance de titres de propriété.

On 2 June 1982, the Minister for Aboriginal Affairs in the Australian Government made grants of freehold title to their traditional lands to five Aboriginal Land Trusts at Hermannsburg in the Northern Territory. Their location is shown in figure 182.

The grants covered 3,797 km^2 of Crown Land formerly leased to a Lutheran Church Mission--the first church mission in the Northern Territory, commenced in 1877.

These grants were by no means the first Aboriginal land grants made in the Northern Territory. Their historic nature refers to the long process which finally enabled the Aboriginal clans to have ownership of their own homelands; and, for the first time in Australia, Aboriginal clan boundaries had been delineated by surveying procedures and translated into registered titles.

The present paper describes the procedures leading up to the making of the grants and the role of the Australian Survey Office.

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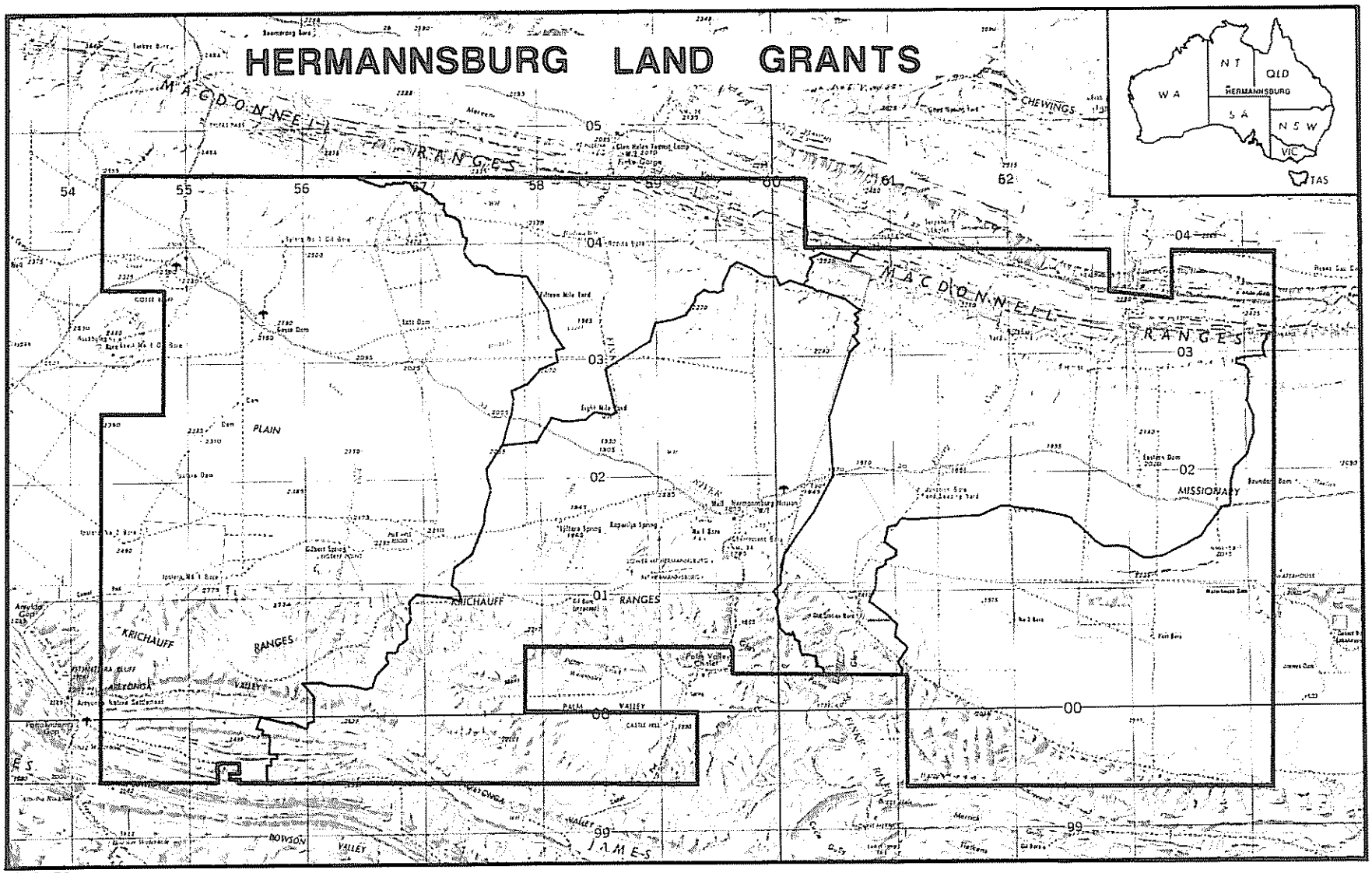
* The original text of this paper, prepared by the Australian Survey Office, Department of Administrative Services, appeared as document E/CONF.75/L.20.

Figure 182. Australia: Hermannsburg land grants, Northern Territory



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HERMANNSBURG MISSION

In 1875, the Lutheran Church decided to establish a mission among the Aranda tribe in Central Australia. This remote part ot the continent was still being explored. As the centre of the driest continent in the world, its landscape was in contrast to the more fertile coastal fringes.

In October of that same year, three missionaries began a journey from Adelaide for the newly explored Finke River area of Central Australia. Their epic journey took 20 months and ended at the present site of Hermannsburg in June 1877.

The settlement was named Hermannsburg after the village in Hanover where they had recieved their theological training.

ABORIGINAL LAND OWNERSHIP

Anthropologists and others have for up to 80 years focused attention on the relationship existing between Australian Aborigines, their concepts and beliefs, and the way in which they delineate, utilize and "own" land.

It has been found that before British settlement, different groups of Aboriginals claimed identifiable areas of land as their own. There was no part of the continent unaffected, although higher mountainous regions may have been seldom visited.

The social organization of the Aboriginal people is highly complex. For example, it is common to speak of Aboriginal "tribes" and this is a useful description of such people as the Aranda at Hermannsburg. The distinguishing marks of such a group are a common language, a commonly used name for that language and thus for the people speaking it, and an identifiable tract of country where those people live or used to live. In no sense, however, can the tribe be regarded as the basis of social organization. Smaller groupings have to be identified for this purpose. The clan or local descent group based on family links through a common ancestry--even if back beyond living memory--is commonly the key unit. The link between an Aboriginal's spirit and his land is regarded as timeless. The land-owning clan is a group of people who share links with the same land.

The spiritual connection between a clan and its land involves both right and duties. The rights are to the use of its natural products, while the duties are of a ceremonial kind--to tend the land by the performance of ritual dances, songs and ceremonies at the proper times and places.

The clans therefore have close spiritual associations with particular tracts of country, through the legends and ceremonies relating to individual sites. The information about these is held by many different informants with different degrees of knowledge. The job of converting it into clear terms for record pruposes could, as Woodward states, "be a very long and difficult one. Since detailed surveying would be necessary, the job would certainly take a number of years and the expense would be very great". 1/

Aboriginal Land Trusts

The Aboriginal Land Rights (Northern Territory) Act sets down that the grants of freehold land will be made to Aboriginal Land Trusts who hold the title for the benefit of Aboriginals entitled by Aboriginal tradition to the use or occupation of the land concerned.

The Land Trust represents the traditional owners. In most cases, the grants of land made under the Act were made to Land Trusts which were collectively drawn from the most important tribal leaders in the area concerned. The Aranda people of Hermannsburg, however, wanted their land grant area divided into five clan areas, represented by the traditional owners, each to be held by a separate Land Trust.

The Government eventually acceded to the request; and in 1979, the Australian Survey Office, which provides surveying services to the Australian Government, was approached for advice as to how the wishes of the people could be met.

Sacred sites and clan boundaries

Since ceremonies, legends and dreamings are generally related to places and objects, Tindale suggests:

> "It is not very surprising to find there is often a high degree of correlation between tribal limits and ecological and geographical boundaries. Divides, mountain ranges, rivers, general ecological and plant associational boundaries, microclimate zone limits, straits and peninsulars, often furnish clear cut and stable boundaries". 2/

If all the sacred sites of each clan were mapped, it would be possible to interpolate clan boundaries, but the difficulties inherent in acquiring the information are many. Aboriginals do not readily impart information about these things. Such knowledge is often secret and is an integral part of their ceremonial life, revealed only to the initiated. A good knowledge of the language of the clan is essential, as well as knowledge of their social organization. Most of all, it requires mutual confidence and trust, something earned only by time.

Several years previously, two members of the Mission staff, realizing the implications of the people's wishes, began work on recording the sacred sites. Without any formal knowledge of surveying or photogrammetry, they made a large photo mosaic of the Hermannsburg area from old 1:80,000 aerial photography flown in 1963. They then began the slow job of discovering the location of the sacred sites and plotting them on the mosaic. The consultation process with traditional owners and the acquiring of the information took years of part-time work.

Both men had worked with the Aranda people for many years. They were fluent in the language and understood the people and the organization of the land-owning clans. By the time their work of recording the positions of the sacred and ceremonial sites was finished, boundaries between the clans had

emerged. These were again tested by consultation and marked on the mosaics. A layman's description of each boundary was prepared and agreed to by adjoining clans. Officers of the Department of Aboriginal Affairs and the Central Land Council (one of the three Land Councils established under the act) agreed that the boundaries so identified did represent the views of the traditional Aboriginal owners.

THE BOUNDARIES

Land titles in the Northern Territory are registered by the Registrar-General under a Torrens system. A survey plan delineating the boundaries of the subject land, endorsed by the land surveyor carrying out the survey and approved by the Surveyor-General, is a normal prerequisite of registration of a title.

As can be seen, the proposed boundaries of the grant area were very irregular. In the main, they followed natural features, such as watercourses, ridge lines and watersheds.

Consideration was given to having a suitably annotated photo mosaic registered as the prima facie document for the description of the land parcels, but the Registrar-General could not accept a definition of the boundaries in this form. He needed plans with the boundaries defined clearly and indisputably. Unless this was done, difficulties would inevitably arise, such as the problem of determining the boundaries where mineral rights were being negotiated.

Consultation with the Aboriginal people revealed that there was rarely, if ever, a hard and fast boundary line between two clans. A narrow strip of land which may traditionally have been of common ownership bay between the clan areas. If, for the purposes of defining title areas, a fixed boundary could be placed within this strip, the adjoining clans would be satisfied.

Topography of the area

The land grant area of 3,797 km^2 was shaped roughly as a rectangle measuring about 90 km east-west by 40 km north-south. Topographically, it consisted of the MacDonnell Ranges along the northern boundary and the Kirchauff and James Ranges along the southern boundary, with Missionary Plain lying between the range systems in the centre (see figure 182).

The ranges are rugged sandstone anticlines lying in a series of parallel ridges dipping steeply and rising up to 400 m above the central plain. Seasonal streams and tributaries flow in gorges through the ranges. There were few usable tracks and vehicular access into the ranges was generally not possible.

THE SOLUTION

Given the topography and the nature of the boundaries to be defined, a photogrammetric derivation of the boundary data was seen as the only economically

viable approach. The Surveyor-General of the Northern Territory was consulted; and after his agreement to the use of photogrammetrically derived data was obtained, the work commenced.

Colour aerial photography on the nominal scale 1:25,000 was flown over the entire area of the land grant. A surveyor spent several weeks at Hermannsburg in consultation with the Aboriginal people and Mission staff marking the new colour photography with the boundaries to be followed and indicating the lines which divided the clan territories.

Across Missionary Plain, the boundaries followed watercourses or were identified from trees or other features. In the ranges, the boundaries generally followed watersheds or crests of ridges. At the end of this phase of the work, all internal boundaries had been identified, marked on the photographs and agreed to by the traditional owners. The previous detail work by the Mission staff had laid a solid foundation on which later work had been built.

A most interesting aspect of the work to this stage was the discovery of how well the Aboriginal people could read and accurately interpret aerial photography. They confidently identified places and features. When tested by field-work, their interpretation and identification were invariably correct. It was as though the colour aerial photography "lived" for them and this was of great assistance in the project.

It was decided to produce orthophotomaps to back up the planimetric representation of the boundaries on the survey plans. By producing maps of this type with the boundaries added, it would be easy to see the position of the boundaries with respect to the features upon which they depended.

Target positions for ground control of this photography, 1:75,000 scale black and white, were selected against the parameters of:

(a) Providing enough well-distributed points for analytical aerotriangulation;

(b) Marking the boundary of the original Hermannsburg lease and providing some points along each Aboriginal clan's boundary.

The logistics of setting targets in the field and the timing of the high-level photography did not, however, allow 100 per cent completion of target-laying and some post-flying identification was still necessary.

The accuracy of ground survey, when related to the photo scale 1:75,000, was determined as needing to be within 2 m for photo control points and within about 4 m for identified points on the boundaries. This tolerance was sufficient along boundaries, such as watersheds, but was advised to be inappropriate for short lines between precise points. Height and accuracy were not critical as contours were not required. All co-ordinates supplied were related to the Australian map grid (AMG) and the Australian Height Datum (AHD).

Control surveys

A survey party acquired survey data to control the aerial photography. Fifty-three control points were co-ordinated from existing triangulation stations in the ranges.

As far as possible, the control points were placed on the new boundaries: 25 points were so positioned. While the Surveyor-General did not require each boundary angle point to be marked, a referenced concrete post was placed at about 20-km intervals along the internal boundaries. Of these, 16 were co-ordinated and another 9 were identified for photogrammetric co-ordination.

Parts of the outer perimeter boundary of the Hermannsburg lease had been surveyed up to 25 years previously. The Surveyor-General required that the marks of these sections of boundary survey be adopted and incorporated into the whole (see figure 183). Nine critical points were located, photo-identified or pre-targeted and co-ordinated in the field.

The rugged nature of much of the country added to the difficulties. Many of the points to be visited could not be approached by vehicle. Helicopter support was required; and a Bell 206 B Jetranger, capable of carrying four passengers and equipment, was chartered. Forty hours of helicopter use was needed and this was confined to a period of two weeks. It provided a quick and convenient shuttle to move personnel and equipment from point to point.

Points were fixed by radiation or traverse using wild T2 theodolites and the Siemens MD60 electronic distance measuring equipment. Checking was carried out independently with a Decca system. One transducer was mounted on a helicopter skid and with the power supply provided from the helicopter, was kept switched on as the helicopter moved from point to point. By this means the transducer warm-up period was eliminated and quick measurements were possible as soon as the helicopter landed. Each control point was given a vertical height value by observing reciprocal vertical angles or by barometric levelling.

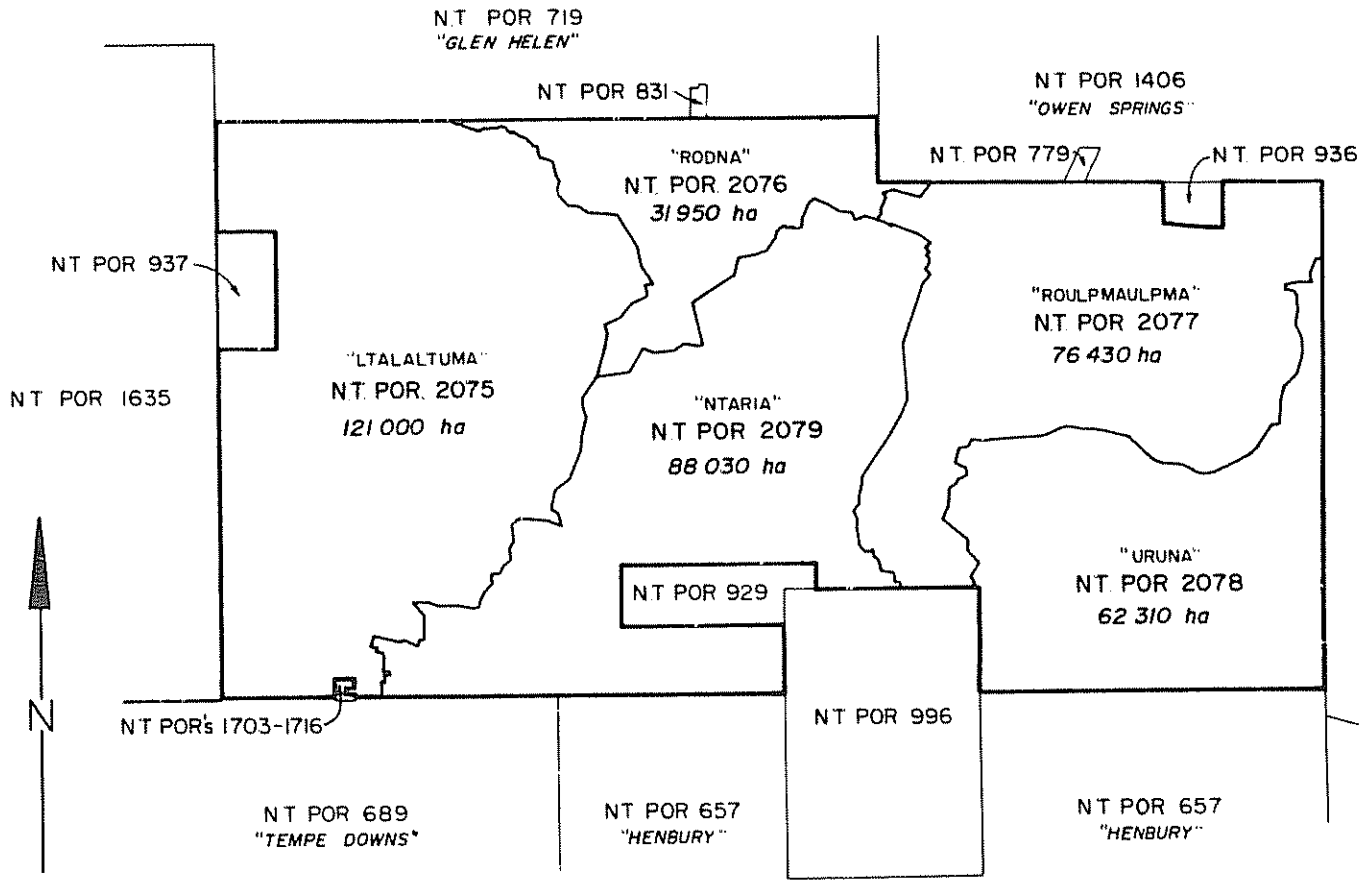
After final computations of the control, results were sent to the Head Office of the Australian Survey Office at Canberra, where the photogrammetry was done by the Technical Services Branch.

Photogrammetry

The 1:75,000 photography was flown at 7,300 m with a 88 m focal length lens. Film diapositives contacted from the negative were used for the aerial triangulation, which was observed on a Zeiss Jena Stecometer.

By referring to the identification of the boundaries on the 1:25,000 photography, all boundary corners were observed during the aerotriangulation. To eliminate any subsequent debate on whether the right and/or exact boundary point had been observed, a photograph was taken through the optics of the Stecometer with a 35-mm camera each time the photo co-ordinates of a point were recorded.

Figure 183. Australia: marks of sections of boundary of Hermannsburg lease previously surveyed



The aerotriangulation method used was OATS, which is an in-house development of Schut's renowned polynomial adjustment. The relevant adjustment of the aerotriangulation produced a root-mean-square deviation on surveyed control of 2.4 m and a probable maximum error in the derived co-ordinates of any boundary point of 8 m. Where derived co-ordinates differed from surveyed co-ordinates, the latter were adopted.

A Xynetics plotter was used to produce a point plot of all co-ordinated boundary points. This required adoption of a special numbering system of boundary points during triangulation so that they could be carried forward in the computer to the plot files. A listing of grid bearings and distances between points was also generated, together with calculated intersections of clan boundaries with the original lease boundaries.

It had also been necessary to observe co-ordinates along the main access road, Larapinta Drive, at tangent points. From these co-ordinates, intersection points and a 50-m offset were calculated to define the road reservation. Other public roads were excluded by description.

A total of 20 orthophotomaps at 1:25,000 scale were required to cover the area. They were formatted to extend 11 minutes east-west by 6.5 minutes north-south, and as a block extended from 23°42'30" South to 24°08'30" South and from 132°16' East to 133°11' East. Their production was undertaken on Zeiss Topocart orthophoto equipment, each sheet being output as two positive transparencies and one negative transparency.

While the project of necessity occupied a reasonable lenght of elapsed time, the photogrammetry activities spanning from April 1980 to February 1982, individual components of the task were completed expediently. Observation and computation of the 317 fixed and derived co-ordinates of boundary points required 42 man-days. The 20 orthophotomaps were produced in less than two months at an average cost of 1,600 Australian dollars ($A) each.

FINAL REGISTERED PLANS

Fifteen plot sheets on the scale 1:2,500, giving the planimetric position of each point for which co-ordinates were derived and a computer listing of those co-ordinates, were received from the photogrammetrist.

The boundaries were traced on to standard cadastral survey plan forms. Each boundary corner was given a unique identifier and the plans included a schedule of the co-ordinates, transformed into geographicals.

During the course of the survey, the survey methods and the presentation of the results had been discussed in detail with the Surveyor-General of the Northern Territory. The derivation of cadastral boundary data by photogrammetric means is not new, but to use this method for so large an area was novel. The nature of the boundaries and the basis of their positioning also were unusual. It is the first time in Australia that Aboriginal clan boundaries had been identified by survey procedures and incorporated in titles to land.

Final survey plans were lodged with the Surveyor-General on 7 May 1982 and, aided by the previous consultations with him, were approved on 18 May.

The land grants were signed by the Governor-General of Australia and were delivered to the Land Trusts at a series of ceremonies (one on each of the five clan areas) by the Minister of Aboriginal Affairs, the Honourable I. B. Wilson MHR, on 2 June 1982.

Notes

1/ A. E. Woodward, Aboriginal Land Rights Commission, first and second reports (Canberra, Australian Government Publishing Service, 1973 and 1974).

2/ N. B. Tindale, Aboriginal Tribes in Australia, (Berkeley, University of California Press, 1974).

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CADASTRAL SURVEYING*

Paper submitted by Cyprus

Chypre a l'avantage de disposer d'un cadastral complet du pays à des échelles allant de 1:50 000 pour les régions rurales et les forêts à 1:500 pour certaines zones urbaines très denses. On enregistre les titres de propriété foncière depuis le début du siècle et plus de 85 pour cent des propriétés privées du pays sont à présent enregistrées. On utilise le système de Torrens, qui convient le mieux à la structure socio-économique du pays. L'existence à

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* The original text of this paper appeared as document E/CONF.75/L.82.

Chypre d'un plan cadastral et de systèmes d'enregistrement appropriés facilite considérablement les projets de développement, qu'ils émanent du secteur public ou privé.

Aussi bien le levé que l'enregistrement sont régis par la législation, qui répond aux besoins locaux. Elle couvre les francs-fiefs et la tenure à bail emphythéotique ainsi que la subdivision horizontale, pour les immeubles à appartements qui se sont multipliés les 20 dernières années, en raison de la hausse du prix du terrain. La législation est modifiée de temps à autre en fonction des besoins nouveaux.

En 1969, après l'entrée en vigueur d'une loi à cet effet, des mesures de remembrement foncier ont été prises pour la première fois à Chypre. Le remembrement, qui constitue une des mesures de réforme foncière les plus progressistes, vise principalement à augmenter le rendement des sols à moindre prix. Il s'accompagne de l'aménagement du réseau adduction d'eau et du réseau routier et fait partie intégrante du développement socio-économique des pays en développement. A Chypre, le remembrement progresse lentement mais régulièrement et, à ce jour, il a été mené à bien pour 15 communautés, comportant quelque 3 542 nouvelles parcelles. Il est en cours pour 13 autres communautés, à des stades divers.

L'attrait de Chypre pour les touristes en toutes saisons est bien connu; le climat, une mer non polluée, des montagnes, une cuisine et des vins d'excellente qualité. Or, pour loger les touristes, il faut des chambres d'hôtel, des hôtels résidentiels et des appartements. L'aménagement foncier, la mutation et le parcellement de milliers de lots que cela implique imposent une tâche écrasante au service foncier et topographique. Les opérations de délimitation des nouvelles parcelles et d'enregistrement de ces parcelles et d'établissement des documents pertinents absorbent généralement une part importante des ressources du Service. On s'efforce cependant de lui donner les moyens de remplir sa mission.

A la suite de l'invasion de Chypre par la Turquie en 1974, le Gouvernement a entrepris priorité à loger les quelque 200 000 personnes déracinées de leurs maisons et de leurs terres. A l'exception d'un petit nombre d'entre eux qui n'ont pas encore été adéquatement logés, tous les réfugiés ont été installés dans des centres résidentiels aménagés par le Gouvernement. Toutefois, on n'a pas encore effectué le levé cadastral des villes et des villages créés pour les réfugiés. On n'a pas non plus mentionné les nouveaux sites sur les cartes topographiques du pays.

On s'efforce de transformer le cadastre de Chypre en système d'information foncière doté d'une banque de données. Des spécialistes ont été consultés et les études sur la question se poursuivent. On a reconnu, il y a quelque temps déjà, l'intérêt d'une banque centrale de données, tous les renseignements topographiques, cartographiques et fonciers seraient conservés en toute sécurité et aisément accessibles aux personnes autorisées.

Chypre sera heureuse de recevoir encore des avis et des conseils quant aux moyens les plus économiques d'atteindre cet objectif. En échange, elle met son expérience dans le domaine des techniques classiques de gestion du cadastre à la disposition de tout pays qui le souhaite.

Cyprus is in the priviledged position of having a complete cadastral survey of the whole country on scales ranging from 1:5,000 in the rural areas and the forests, to 1:500 of some of the densely built-up areas of cities. Registration of title to land has been in operation since the beginning of the century and over 85 per cent of the privately owned land in the country has been registered. The Torrens system is used; it is best suited to the economic and social structure of the country. Due to the fact that a proper cadastral survey and registration systems exist in Cyprus, development projects, whether initiated by Government or private firms, are greatly facilitated.

LEGISLATION AND TENURE

Both survey and registration are performed on the basis of legislation, the provisions of which adequately take care of local needs. Such legislation covers both freehold and leasehold tenure. It further covers horizontal subdivision, in order to cater for the ever-increasing number of flats created during the past 20 years as a result of the rise in the cost of the land. Amendments to the law are made from time to time as the need arises and in order to meet new requirements.

LAND CONSOLIDATION

In 1969, after the enactment of special legislation, land consolidation measures were taken for the first time in Cyprus. Land consolidation is one of the most progressive land reform measures and its main objective is to increase productivity of the land at less cost. This measure runs parallel with water and road network development and is part and parcel of the social and economic development programme of developing countries. The progress in Cyprus has been slow but steady; and so far, 15 communities have been completed, involving some 3,542 units of land; and 13 other communities are at various stages of completion.

TOURIST DEVELOPMENT

Cyprus is famous for its year-round tourist attractions: the climate; unpolluted mediterranean swimming; mountaineering; and excellent food and wine. Tourists require accommodations, however, and this can only be provided in the form of hotels, hotel apartments and flats. These involve land development, mutations and parcelling of thousands of new lots, which impose a colossal task on the Department of Lands and Surveys. The division and survey of the new lots, their registration and documentation generally absorb a substantial amount of the Department's capacity. Nevertheless, efforts are made to bring the Department's work level with its obligations.

REFUGEE PROBLEM

As a result of the Turkish invasion of Cyprus in 1974 and the uprooting of some 200,000 people from their homes and land, the Government has embarked on the top-priority task of housing them. Only a small number of the refugees

have not yet been properly housed; the rest have been covered by one of the government housing schemes. However, the cadastral survey of the new towns and villages created for the refugees has not yet been tackled nor have any of the topographic maps of Cyprus been revised with respect of the new sites.

LAND INFORMATION SYSTEM

Efforts have been made for the conversion of the Land Registry of Cyprus into a land information system, on a data bank. Expert advice was sought and the matter is still under consideration. The value of a central data bank, with all the survey, cartographic and land information data safely stored easily accessible to authorized persons, was recognized some time ago. Cyprus will accept further consultation and advice on the least expensive way of meeting this need. In return, it offers its experience in the maintenance of the classical cadastre to any country that may need it.

CADASTRAL PHOTOMAP AT 1:5,000 SCALE*

Paper submitted by Finland

Depending upon the value of land, the cadastral surveys in Finland can roughly be divided into two categories:

(a) Towns or other densely populated areas where the scales of the cadastral maps vary between 1:500 and 1:1,200. The maps have been compiled mainly both for town-planning and for carrying out cadastral surveys. The map coverage usually is complete over these areas. The boundary mark measurements have been carried out within accuracy of few centimetres. The maps at 1:500-1:2,000 scale cover less than 10 per cent of the total area of the country;

(b) Rural areas where the scales of the cadastral maps vary between 1:4,000 and 1:10,000. The maps are so-called "island" maps which do not form a homogeneous map system. The measurements of the boundary marks have been usually carried out within about 1-m accuracy. The material, however, is very disparate, depending upon the age and method of survey.

In addition to the above-mentioned official maps, there exists a cadastral index map at 1:10,000 scale which has been prepared in connection with the national basic mapping at 1:10,000/1:20,000. This map covers the entire country. It, however, is an index of real estates and boundaries and was not meant to be a base for technical use. The location of the boundary mark on the map is based on photo-interpretation and on the fitting together of the old cadastral maps.

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* The original text of this paper, prepared by M. Jaakkola and P. Noukka, National Board of Survey, appeared as document E/CONF.75/L.58.

The basic mapping of the country was nearly completed in the 1970s. In order to plan future activity, the National Board of Survey organized an investigation about the need and use of the maps. The results of this investigation were published in 1977. 1/ Over 80 per cent of all replies indicated that the boundaries were considered the most important element of the map in the current situation, when the 1:20,000 topographic map is ready throughout the country.

CADASTRAL PHOTOMAP AT 1:5,000 SCALE

As a result of this investigation, the National Board of Survey organized some tests, which resulted in a proposal to begin development work for a new map type on the scale 1:5,000 which includes two elements: (a) orthophoto base map; and (b) boundary element. The outline of the production technique and the technical details is given in figure 184.

In order to achieve for the boundary marks a degree of accuracy corresponding to the graphical accuracy of the 1:5,000 map, the co-ordinates of the boundary marks have to be determined by means of a geodetic or photogrammetric method. Photo-interpretation or combining of the old cadastral maps alone was not considered reliable enough in this regard. The primary method selected was photogrammetric triangulation.

The base of the aerial triangulation consists of the national horizontal control survey and the signalized boundary marks. The pre-marking is carried out voluntarily by the landowners. In this way, it is possible to have photogrammetric co-ordinates for 40-50 per cent of all boundary marks. The rest have been computed by means of old cadastral boundary measurements or have been placed on the map with photo-interpretation. The photogrammetrically measured co-ordinates are intended to be used as fixed values in carrying out subsequent cadastral surveys. In the same connection, it would be possible to check the co-ordinates of those boundary marks which have not been signalized and measured directly.

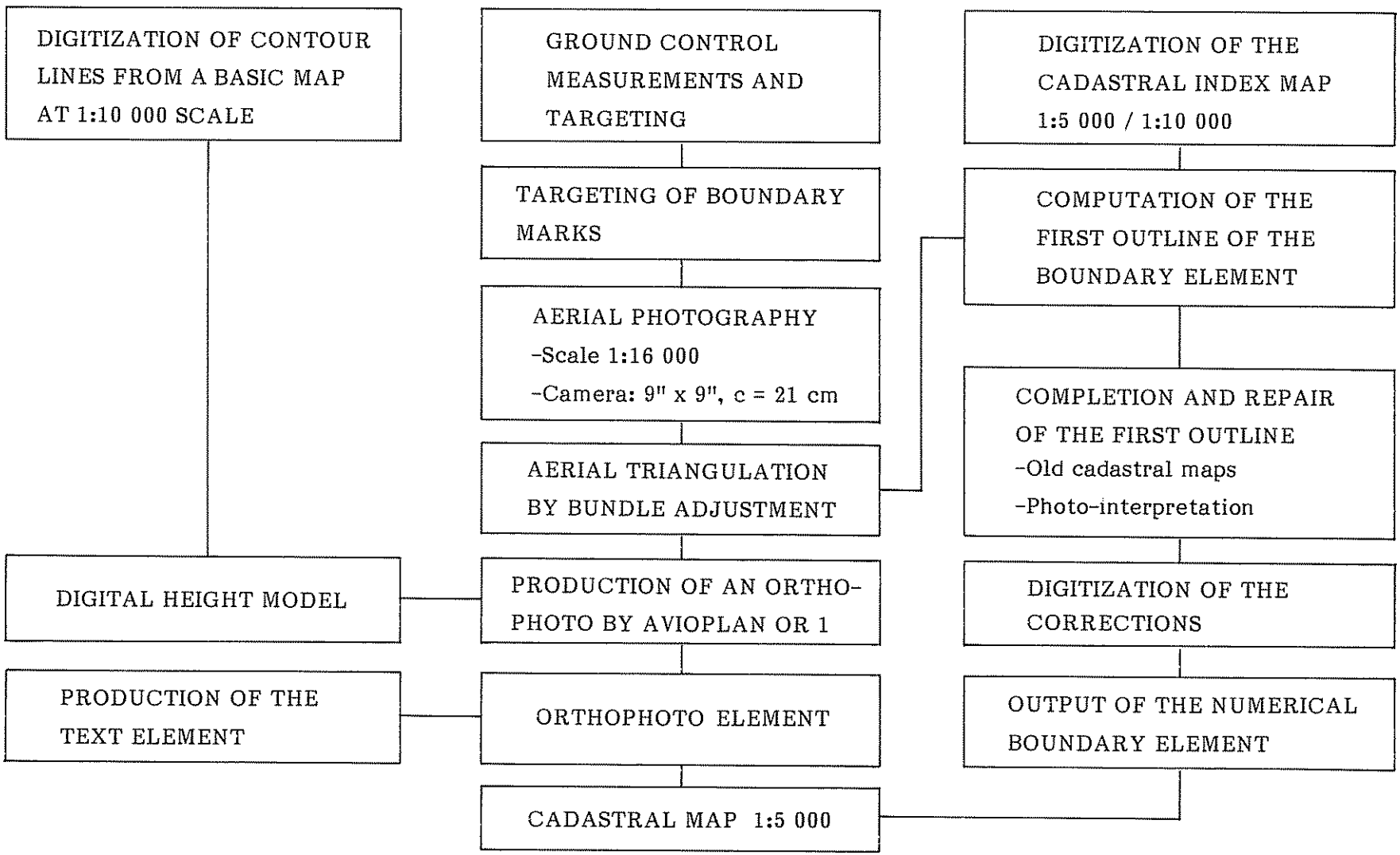
Thus far, the National Board of Survey has carried out this new mapping in about 15 communes, which include altogether 1,500 map-sheets (size 0.5 x 0.5 m) on the scale 1:5,000. The statistics of this material shows that, on an average, there are 8,000-10,000 boundary marks in each commune. The average size of the commune is about 300-400 km^2, and when one has determined 50 per cent of all boundary marks, the density of the measured boundary marks in rural areas is about 10-15 points per km^2.

The experiences to date have been quite positive. The voluntary pre-marking of the boundary marks, which is the most critical part of the process, has succeeded better than expected. In this type of mass production, aerial triangulation has shown its suitability, compared with the other possible methods.

FUTURE PLANS

According to the present production plan, about 50 per cent of the total area of the country will be covered with this new map within 25 years. In addition to the cadastral survey, the map will serve other activities in rural

Figure 184. Finland: production of a cadastral orthophotomap at 1:5,000 scale



areas, such as planning, fiscal purposes, forestry and agriculture. For each specific purpose, the user of the map has to prepare his own additional element and carry the cost of it.

On the basis of earlier experiments, the method mentioned above was considered accurate and reliable enough for this type of multi-purpose mapping; and from the economical point of view, it was the only reasonable selection.

Note

1/ National Board of Survey, Maastokartoitusten koordinointi (Co-ordination of mapping works), report No. 45 (Helsinki, Kartastoasiain neuvottelukunnan maastokarttajaoston koordinointityöryhmän mietintö, 1977).

REPORT ON SURVEY AND MAPPING ACTIVITIES, 1980-1983*

Paper submitted by Hong Kong

All extensive and on-going survey and mapping requirements in Hong Kong are dealt with by the Survey Division of the Lands Department.

The structure and organization of the mapping and survey groups have altered considerably during the three-year period under review, following the establishment in 1982 of a Lands Department. Formerly, all survey and mapping requirements for government purposes were dealt with by survey and cartographic sections operating within the Public Works Department. This department ceased to exist on 1 April 1982, when a number of Engineering Departments and a Lands Department were created under the overall control of the Secretary for Lands and Works.

The majority of survey requirements and topographic mapping needs are met by the Survey Division (formerly the Survey Branch of the Crown Lands and Survey Office), while requirements for engineering projects are dealt with by the survey sections of the various Engineering Departments.

GOVERNMENT SURVEY AND MAPPING RESPONSIBILITIES

The main survey and mapping responsibilities are allocated as follows:

Responsibility of:	Carried out by
Lands Department Geodetic, cadastral and photogrammetric survey, and mapping revision	Survey Division

* The original text of this paper appeared as document E/CONF.75/L.85.

Responsibility of:	Carried out by
Topographic and basic (1:1,000) mapping, land title record plans and special cartographic production	Cartographic Group of Survey Division
Engineering Development Highways and civil engineering works	Engineering Development Division
Water-supply construction	Water-supply Department
Railway construction	Railway Development Office
Hydrographic Surveys	Port Works, Civil Engineering Office
Geotechnical surveys and monitoring	Geotechnical Control Office

PRIVATE PRACTICE

Surveys for non-government development are carried out by private consultants operating in Hong Kong; and other survey and drawing office commitments for utility companies (such as the China Light and Power Company) and corporations (such as the Mass Transit Railway Corporation and the Kowloon Canton Railway Corporation), are met by staff employed by those organizations.

GEODETIC SURVEYS

In 1980 a new geodetic datum was established, based on the results of a major survey carried out in the late 1970s, to upgrade the main triangulation system of Hong Kong. This survey, carried out predominantly by trilateration methods, produced results of an extremely high order of accuracy and allowed the production of a revised co-ordinate system--termed the "Hong Kong 1980 Geodetic Datum". This system is now being used for all major survey projects carried out in Hong Kong, and it forms the reference grid for all topographic mapping series.

CADASTRAL SURVEYS

The cadastral survey has traditionally been the responsibility of the government land-surveying organization (now the Survey Division), although during the past three years there has been a steady movement into this area by firms of land surveyors practising in Hong Kong. The adoption of a survey record plan and the production of a set of Survey Regulations prepared by Survey Division have done much to improve the overall standards in this type of survey.

LAND SURVEY ORDINANCE

A draft Land Survey Ordinance was prepared and was considered by a working party wihtin the Lands Department during 1982. If current proposals are adopted, it could lead to the establishment of a Survey Board and the registration of land surveyors in Hong Kong within the next few years.

LAND INFORMATION SYSTEM

A working group was appointed in 1982 to study the interdepartmental requirements within the Hong Kong Government that could best be served by the adoption of a computerized land information system. Recommendations were made that a system based on a digitized map record would meet all requirements. Firm proposals have now been forwarded the the Government recommending that a pilot study be carried out.

Mapping

Hong Kong covers a relatively small area (approximately 1,050 km^2) and is most fortunate in having a variety of map series at different scales.

The basic mapping series at 1:1,000 scale has been introduced as a metric replacement for the previous imperial scales of 1:600 and 1:1,200. About 60 per cent of the sheets in the active areas have been completed, and it is hoped that the conversion to the metric scale will be completed within the next three or four years. Revision of the large number of sheets at this scale (approximately 3,000) poses a major survey problem that is liable to continue for several years to come.

Production of the topographic series (many printed in colour) and often prepared in dual language (English/Chinese), is carried out largely by compilation from the basic mapping series. Table 51, which lists the maps and publications produced by the Survey Division of the Lands Department, shows the variety of available map series.

PROPOSED LAND INFORMATION SYSTEM*

Paper submitted by New Zealand

RESUME

Le présent document contient une description des travaux entrepris en Nouvelle-Zélande afin d'établir un système automatisé de documentation foncière.

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* The original text of this paper, prepared by Graeme R. Crocker, Department of Lands and Survey, appeared as document E/CONF.75/L.41.

Table 51. Hong Kong: maps and publications produced by the Survey Division of the Lands Department

Series	Code	Coverage	Number of sheets
Large-scale (basic) plans			
1. 1:600 (50 feet to 1 inch)	-	Hong Kong Island	125[a/]
2. 1:1,200 (100 feet to 1 inch)	-	New Territories and Islands	870[a/]
3. 1:1,000	HP1C	Kowloon	129
(metric sheets replacing items 1 and 2)	-	Hong Kong	164[b/]
	-	New Territories	1 021[c/]
Medium-scale (derived) plans			
1. 1:2,500	HP2.5C	Urban	73
2. 1:5,000 urban	HP5C-U	Urban	20
3. 1:5,000 New Territories	HP5C-NT	New Territories	2[d/]
4. 1:7,500 street maps	SM7D	Urban and New Territories Township	22
5. 1:15,000	SM15D	Urban	2[e/]
Topographic maps			
1. 1:20,000	HM20C	Full	16
2. 1.50,000	HM50CL	Full	2
3. 1:100,000	HM100CL	Full	1
4. 1:200,000	HM200C	Full	1
Special maps			
1. Official Guide Map	TM100CL	Full	1
2. Countryside series			
Hong Kong Island	CM25C	-	1
New Territories-West	CM50C	-	1
Lantau and islands	CM35C	-	1
Sai Kung Peninsula	CM25C	-	1
New Territories north (projected)			
3. Geological report and map	-	-	-
4. Streets and Places Guide Book, vol. I, Hong Kong and islands	-	-	-
5. Streets and Places Guide Book, vol. II, Kowloon and New Territories	-	-	-
Miscellaneous thematic and other maps	-	-	-
Aerial photographs copies available by special order	-	-	-
Approved town-planning development and layout plans	-	-	-

a/ Approximate.
b/ Total, 230.
c/ Total, 2,650.
d/ Total, 160.
e/ One Hong Kong, one Kowloon.

Reconnaissant les limites, les chevauchements et la diversité des objectifs des systèmes classiques et principalement manuels de collecte de données foncières, la Nouvelle-Zélande a créé un groupe de travail pour mettre en place un système de documentation foncière.

Dans une première étape, il s'agira d'établir une base cadastrale numérique reflétant les parcelles de terrain ayant fait l'objet de levés les plus récents. Chaque parcelle sera identifiée par un centroïde géographique avec des coordonnées correspondant au réseau de coordonnées de la Nouvelle-Zélande. Des renseignements seront donnés sur chaque parcelle: désignation, superficie, numéro du plan, référence du titre de propriété et numéro d'évaluation. La production aura une forme numérique ou graphique.

On élargira ultérieurement cette base cadastrale pour inclure les zones de collecte de données censitaires, les limites administratives du gouvernement local et le zonage.

Lorsque la base cadastrale sera achevée, on envisage d'y ajouter des données physiques (topographie, sols, végétation, géologie, pentes etc.), afin de créer un système de documentation foncière complet.

New Zealand, as a small mountainous country with only 54 per cent of its land suited for agricultural utilization, is becoming increasingly aware of the need to manage its valuable land resources to the fullest effect. The traditional land data gathering agencies in central and local government and the private sector have, for the past 100 years, carried out their activities independently, with a resultant duplication of effort and resources in many areas and with a diversity of objectives, standards and recording systems.

The development of computer systems for the storage and retrieval of land-related data in several oversea countries has created an awareness of the potential use of such systems in New Zealand . A series of investigations inot land information systems undertaken over the past five years has resulted in the Government establishing a formal working party to investigate the feasibility of creating a computerized system for this country.

The first stage of these investigations is nearing completion and a recommendation to create a pilot system will be put to the Government in the next few months.

THE NEW ZEALAND BASE

The New Zealand land title system, established in the 1850s, is based on a national network of surveying stations to which all subdivisional surveying, engineering and topographic mapping is related. All land title subdivision is monumented on the ground, and boundary positions are recorded accurately in terms of co-ordinates from a series of meridional circuits which are in turn

tied to a national mapping grid, the New Zealand map grid. Cadastral records are maintained nationally and updated on a day-to-day basis as subdivision occurs. This provides an up-to-date graphic of the country's cadastre, on which all derived mapping is based.

An early concept in New Zealand mapping was to provide a complementary basic series for both cadastral and topographic mapping. Originally on the scale one mile to an inch and subsequently on the metric scale 1:50,000, on standard sheet lines, this series provides a constant relative relationship betwwen title and terrain for any users.

This tightly controlled and integrated survey and mapping programme is seen to be ideally suited to providing the essential geographical base for any computerized land information system. While current records are, in the main, manually recorded, the Survey-General established an experimental computer-assisted mapping unit in 1978 to develop programs for digital data capture, at first in the cadastral area. These devolopments are now proving viable and it is intended that investigations should commence in 1983 into a parallel concept of topographic capture.

LAND USE ADVISORY COUNCIL

In 1976, a working party was set up under the auspices of the Land Use Advisory Council (LUAC), a quasi-government committee established to monitor the management of the agricultural back country. The working party was charged with investigations into the development of a land information system, nased on land ownership, and to assist in the provision of information to administrative, management and planning origanizations involved with the development of land resources in New Zealand.

In 1979, LUAC reported to the Government, recommending that a pilot land information system should be constructed to evaluate the concept. The Government at that time was considering a merger of the Technical Division of Lands and Survey (survey and mapping), the Land Transfer Office of the Justice Department (land title) and the Valuation Department into the one department, to be known as the Office of Land Records. Recognizing the value of this computer concept to the new department and for the dissemination of land information, the Government appointed an interdepartmental working party to consider the establishment of a core land information system based on:

(a) Digitized land parcel co-ordinates;

(b) Certification of title;

(c) Land valuation (and any other valuation-related land use data).

The working party was also to consider the compatibility of such a core system with existing and planned systems in the land-use area.

LAND INFORMATION SYSTEM WORKING PARTY

The Working Party commenced its task in 1980 and for the past two years has been investigating the feasibility of establishing the core system and its relationship to other land data.

Using the methodology developed in the SPECTRUM project management system to define the task, a system definition has been developed and work has commenced on system design. A large-scale user requirement exercise was undertaken by distributing a questionnaire to government departments, local authorities and the private sector, including all professional organizations, which utilize land-related data. The result is conclusive evidence of the value of such a system to the country, with a potential to service in excess of 20 million inquiries per annum.

The Working Party comprises a 3-person project team and a 12-person evaluation team representing government departments and local authorities. A steering committee comprising departmental heads acts as a quality review board. It is currently intended that Government should be presented with recommendations to establish a pilot scheme in 1983.

THE LAND INFORMATION SYSTEM CONCEPT IN NEW ZEALAND

The establishment of a core land information system has been defined by the Working Party as LIS(1), or stage one, wherein a digital cadastral base is established, reflecting the most recent surveyed land parcels of the country. This graphical base will hold an attribute file of land appellation, area and plan number for each land parcel; and each land parcel will also be identified by a geographical centroid with co-ordinates referenced in terms of the New Zealand map grid. Land Title and valuation keys will be assigned to each land parcel, thus creating the core system. Graphical overlays can then be created for each user organization's own data.

On completion of the core file, additional files will be created for the Statistics Department census collection areas (known as "mesh blocks"), local government administration boundaries and land zoning. This will complete the cadastral base. Stage one of the land information, LIS(1), can then be gradually expanded to include physical data, such as topography, soils, vegetation, geology and slope, as data become available in digital form.

The present intention is to complete the core system in a period of six years, but this goal is highly dependet upon the Government's willingness to support the concept in terms of finance and resources.

The current cadastral base in New Zealand is estimated to include in excess of 3 million land parcels, 2.3 million land titles and 1.3 million valuation assessments. Estimated expansion of the base is in the vicinity of 13,000 land parcels per annum. Land survey and title records are held in 12 separate district offices, and the valuation records are held in 28 separate offices. It is confidently expected that data capture could be completed and the core cadastral base fully operational within the estimated six-year period.

User access

Once data capture is completed, the Working Party will have established maintenance proposals that will eliminate all duplication of effort in the data-creating departments. Each record will only be updated by the department or organization having the statutory responsibility for the data capture. As land records are constantly changing, all updating is intended to be on-line on a day-to-day basis.

A network of inquiry terminals will permit data to be accessed in all major centres and in those smaller municipalities where local government agencies are established. There are long-term proposals to enable users in the academic and commercial sector to purchase terminals for their own use on a charge-out basis. Graphical support by cathode-ray tube (CRT) and plotter is to be made available in most centres.

The potential

New Zealand is not the first country to realize the value of a land information system. Current methods of access to land-related records are a time-consuming and expensive exercise, with little prospect of obtaining total accuracy from any one major source. The proposed system design will ensure accuracy abd availability from a single source to meet most user requirements. Although limited manipulative software will be available through the system, specific users will be encouraged to extract raw data from the land information system and to undertake manipulation on their own subsystems. They will have the ability to feed data back into the main system, if they are considered of value either as an upgrade or new data set.

While the cadastre is seen to be the initial revenue producer for the system, there is an extensive potential user market for physical data, particularly in the light of the developing agricultural, silviculture and horticultural areas of New Zealand's export markets.

The introduction of the land information system will establish national standards of data capture, identify output formats that are acceptable to the major proportion of users and assist the Government in identifying those areas within departments and other agencies which need resources th enhance their data collection systems on a national and economic basis. It will also provide users with accurate and up-to-date information to help them carry out their functions. Lastly, it will provide New Zealand with a most valuable tool for managing its limited land resources to their fullest potential.

The cost

While at the present stage accurate costings cannot be identified, initial estimates for the establishment of a land information system are in the vicinity of some 11 million New Zealand dollars ($NZ) to $NZ 13 million. Annual maintenance could be as high as $NZ 7 million. Offset against this, however, is a potential revenue in excess of $NZ 20 million per annum. On this basis, the costs of establishing the system could be recovered in a very short period.

The future

Such a major scheme is not without difficulties. The Working Party has identified considerable incompatibilities in current data sets and it has been necessary to define procedures that will eliminate errors and ensure future standardization of data entry. Two sub-committees have been established, the first to make recommendations on the standardization of land appellation (descriptions), and for the unique identification of land parcels, the second to create a national standard land-use coding system for the country. Completion of work in these areas is expected early in 1983.

Parallel to these exercises, the Government is to be asked to provide resources for a pilot study development. The aim of this pilot study will be to create a base of between 2 and 5 per cent of the country's land parcels, in order to permit the land information system concept to be fully tested before implementation. The digital cadastral mapping base for this proposal is already half completed. It is anticipated that this study will take about one year.

Approval has been granted to employ oversea consultants to review the progress to date and to make recommendations on the conceptual and electronic data processing (EDP) implications.

If the necessary support and approvals are forthcoming, New Zealand could see a national land information system in place by the late 1980s.

LAND INFORMATION SYSTEMS: RESOLUTIONS ADOPTED AT THE CONGRESS OF THE INTERNATIONAL FEDERATION OF SURVEYORS, MONTREUX, 1981*

Paper submitted by the International Federation of Surveyors

In Commission 3, Land Information Systems, the following resolutions were passed at the Congress of the International Federation of Surveyors (Fédération internationale des géomètres, FIG) at Montreux, in 1981.

RESOLUTION 301

Considering the growth of population and the importance of an effective use of the limited resources on, above and below the surface of the Earth, and considering the need to reduce environmental pollution, FIG underlines the important role tant can be played by land information systems in planning and management.

FIG defines a land information system as follows:

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* The original text of this paper, prepared by G. H. Weir, Vice-President and President-elect of the International Federation of Surveyors, appeared as document E/CONF.75/L.111.

A land information system is a tool for legal, administrative and economic decision-making and an aid for planning and development which consists, on the one hand, of a data base containing spatially referenced land-related data for a defined area, and, on the other hand, of procedures and techniques for the systematic collection, updating, processing and distribution of the data.

The base of a land information system is a uniform spatial referencing system for the data in the system which also facilitates the linking of data within the system with other land-related data.

RESOLUTION 302

In view of its complexity and wide scope, FIG recognizes that the development of land information systems requires interdisciplinary team work. Through their traditional work within surveying, mapping, management of land etc., surveyors today have to a great extent a co-ordinating function.

Resolution 302.1

FIG is aware of the changing and increasing demands of society and recommends that surveyors take the necessary steps to fulfil this co-ordinating function also in the future.

Resolution 302.2

FIG recognizes the importance of education in the field of land information systems and recommends the allocation of adequate resources for this task.

RESOLUTION 303

Considering the need for co-operation between different professionals and the rapid development of methods and technology, FIG Commission 3 will--in co-operation with research and user groups from different countries--try to elaborate a conceptual framework for land information systems and make efforts to create a common terminology.

RESOLUTION 304

The development of land information systems poses challenging problems. Many of these are similar in different countries. Therefore, all countries would mutually benefit from exchanging know-how.

FIG recommends the free exchange of experience and results of research between all member associations and all FIG commissions.

FIG will promote co-operation in the field of land information systems also with its sister organizations.

(h) Aeronautical charting

AUTOMATED PRODUCTION SYSTEM FOR AERONAUTICAL CHARTS: OPERATIONAL SCENARIO*

Paper submitted by the United States of America

RESUME

Le Service hydrogrpahique national produit actuellement 8 721 cartes aéronautiques et 1 652 publications connexes dans 91 séries de cartes pour satisfaire les divers besoins de la communauté aéronautique.

Chaque année il y a des milliers de modifications aux informations concernant la structure de l'espace aérien national. Outre que leur nombre est considérable, très souvent beaucoup de ces modifications doivent être dûment reproduites sur les différentes cartes aéronautiques de l'espace aérien national.

Les types d'avions plus perfectionnés, les techniques nouvelles de navigation et les réglementations plus complexes s'appliquant au trafic aérien font qu'il est encore plus difficile de produire et tenir à jour des cartes aéronautiques pour la sécurité dans les airs.

Pour répondre à ces besoins de plus en plus nombreux, le Bureau de cartographie aéronautique, qui est un des grands services du Service hydrographique a commencé à mettre en place un système automatisé de production de cartes aéronautiques.

Le rapport décrit les conditions que le système doit remplir, les notions de base de données affinées et les produits finals. L'établissement d'une carte à déroulement à faible altitude est décrit depuis les données aéronautiques brutes jusqu'au produit fini afin d'utiliser le fonctionnement du système. Le système original a été examiné dans un document faisant le point de l'automation des cartes aéronautiques, qui a été présenté à la neuvième Conférence cartographique régionale des Nations Unies pour l'Asie et le Pacifique.

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* The original text of this paper, prepared by Keith Elliott and Russell Hoover, Cartographers, National Ocean Survey of the National Oceanic and Atmospheric Administration, Department of Commerce, appeared as document E/CONF.75/L.51.

BACKGROUND

The National Ocean Survey (NOS) of the National Oceanic and Atmospheric Administration (NOAA) is charged with the mission of providing aeronautical charts and related publications in support of the National Airspace System (NAS) managed by the Federal Aviation Administratiom (FAA). The mission was established in 1926 by an Air Commerce Act and again confirmed in 1958. The first aeronautical chart of the United States was published in 1930 by the predecessor of NOS, the Coast and Geodetic Survey.

Today, the aeronautical charts produced by the Office of Aeronautical Charting and Cartography, a major component of NOS, serve the needs of civil aviation in the entire United States. They are sold to users among more than 8 million civilian pilots in private and commercial aviation. NOS also provides the basic aeronautical chart plates to the Defense Mapping Agency (DMA) for all domestic military requirements under inter-agency agreements. In addition, special aeronautical charts, chart supplements and data are provided for the use of FAA air traffic controllers in managing the National Airspace System.

NOS currently produces 8,721 charts and 1,652 chart supplemental publications in 91 different chart series to serve the various needs of the aviation community. Each year, there are thousands of changes to information affecting the structure of NAS. Not only is the number of changes significant but it requires many times that number of changes to reflect properly the structure of NAS on varied aeronautical chart products. Each single change to NAS must be evaluated to determine: (a) type of change; (b) geographical area of change; (c) chart series or multiple chart series affected; (d) specific products within each chart series affected; (e) overlays on each chart product affected.

A reasonable estimate of the impact or number of changes to chart products generated by a change to NAS can be represented by the formula:

$$I = C \times P \times O$$

Where:

I = impact;

C = number of changes to NAS;

P = number of products affected;

O = number of overlays affected (although the item to be changed may only appear on a single overlay, it may be necessary to shift type, symbolology etc. on other overlays).

As an example, consider a change in the communication frequency for a radio navigational aid. Such a change could be reflected on several instrument approach procedure (IAP) charts, an en route navigation chart, a visual

terminal area chart, a visual sectional chart and a visual world aeronautical chart; and it would also be reflected in the NOS Airport Facilities Directory. Using the formula, and assuming a change affected one overlay on each of the four IAP charts and one overlay on each of the other five charts, this one change would generate nine total changes:

C P O

I = (number of changes, 1) x (number of products, 9) x (number of overlays, 1);

I = 1 x 9 x 1;

I = 9 total changes.

To demonstrate more clearly the multiplicity of overlaps of change information on aeronautical chart products, consider the effect of a group of changes to NAS as reflected in the visual chart series. During the period from 18 March 1982 to 2 September 1982 (approximately six months, or one cycle), a sample group of 204 airspace changes resulted in: (a) 289 changes to the Washington, D.C. sectional aeronautical chart; (b) 66 changes to the Washington, D.C. terminal area chart; (c) 40 changes to the Philadelphia (Pennsylvania) terminal area chart; (d) 150 changes to world aeronautical chart CG-21; (e) 21 changes to the New York sectional aeronautical chart; (f) 4 changes to the Detroit (Michigan) sectional aeronautical chart; (g) 32 changes to the Cincinnati (Ohio) sectional aeronautical chart; (h) 10 changes to the Charlotte (North Carolina) sectional aeronautical chart.

Based on this sample group of 204 changes to the airspace system, approximately 602 changes were applied to visual chart products alone. Considering the further application of these changes to the other chart series affected, it is easy to see that the manual evaluation, drafting and review of changes to the National Airspace System on NOS aeronautical chart products is indeed a monumemtal, time-consuming task which is continually increasing in both complexity and volume of work. The increase in complexity is a result of increased use of NAS by the more complex mixtures of aircraft types, the new technologies in airborne and ground aids to navigation, and the more complex air traffic control regulations and procedures. The increase in volume is a result of the increasing amounts of information necessary for safe air navigation and the additional products required by both FAA and the flying public.

AUTOMATED CHART PRODUCTION

To meet these ever-increasing demands, the Office of Aeronautical Charting and Cartography has begun implementation of the Aeronautical Chart Automated Production System (ACAPS). Implementation of this system will yield, but will not be limited to, the following benefits:

(a) A decrease in the production time required to maintain current chart products; updates to charts will be performed without human intervention except where cartographic judgement is required;

(b) Automatic production of individual chart overlays for colour separation as plate-ready positives or negatives for contact printing on to offset press-plates. This will eliminate or drastically reduce manual drafting, resulting in considerable cost savings and less need for outside contractors;

(c) The ability to rapidly respond to requirements for new products (chart prototypes or chart supplemental publications) in support of the ever-changing NAS;

(d) Improvement in production control by use of inherent real-time accounting;

(e) Validation and maintenance of chart-independent aeronautical data within the context of an overall, coherent structure rather than individual chart depiction;

(f) Automation of many critical review functions, resulting in improved quality control.

The system concept 1/ is for an overall and coherent aeronautical chart-automated production system, involving a cartographically validated chart-independent data base and a cartographically created chart-dependent data base. The system can be implemented modularly as needs are established and funding becomes available. Furthermore, this concept is independent of any specific hardware configuration. The hardware required to implement this system is currently being procured with a current projected contract award of June 1983. The object of the procurement is to acquire readily available hardware and software packages to satisfy NOS cartographic needs and, where necessary, to develop in-house any special software that may be required. The ACAPS production system will support the following activities:

(a) Processing of data base updates, transaction edits and extractions;

(b) Provision of processing support for a variety of work-station components, such as graphics display terminals, data entry terminals and digitizing/plotting functions;

(c) Support of communications requirements to the FAA data base, NOAA computers, system work-stations and on-line remote terminals;

(d) Support of required response times by containing sufficient processing speed, internal storage input/output ports and auxiliary storage;

(e) Processing of on-line transactions, data management requests and management reports;

(f) Monitoring of jobs on a real-time basis and provision of interface with operations personnel;

(g) Processing of system-overhead requirements, such as file back-up/restore operations, software development, operating system/data-base management overhead and job accounting overhead;

(h) Support of a large calculation work-load to process cartographic compilation and review requirements;

(i) Maintenance, through very high system availability (reliability) features, of the capability of "fail-soft" operations to meet time-critical schedule for support to the production of chart products in the event of component or multiple component failure;

(j) Provision of a modular expansion capability through the availability of upward-compatible components without the need to change existing software;

(k) Allowance of fail-soft operations, or "graceful degradation", without risk to the integrity of the data base;

(l) Provision of the capability to process current cartographic work-loads and yet provide sufficient reserve processing power to cope with the projected increase in that work-load;

(m) Allowance of all frequently used files to remain on-line with interactive update of any file allowed only by authorized persons.

The general system overview is depicted in figure 185.

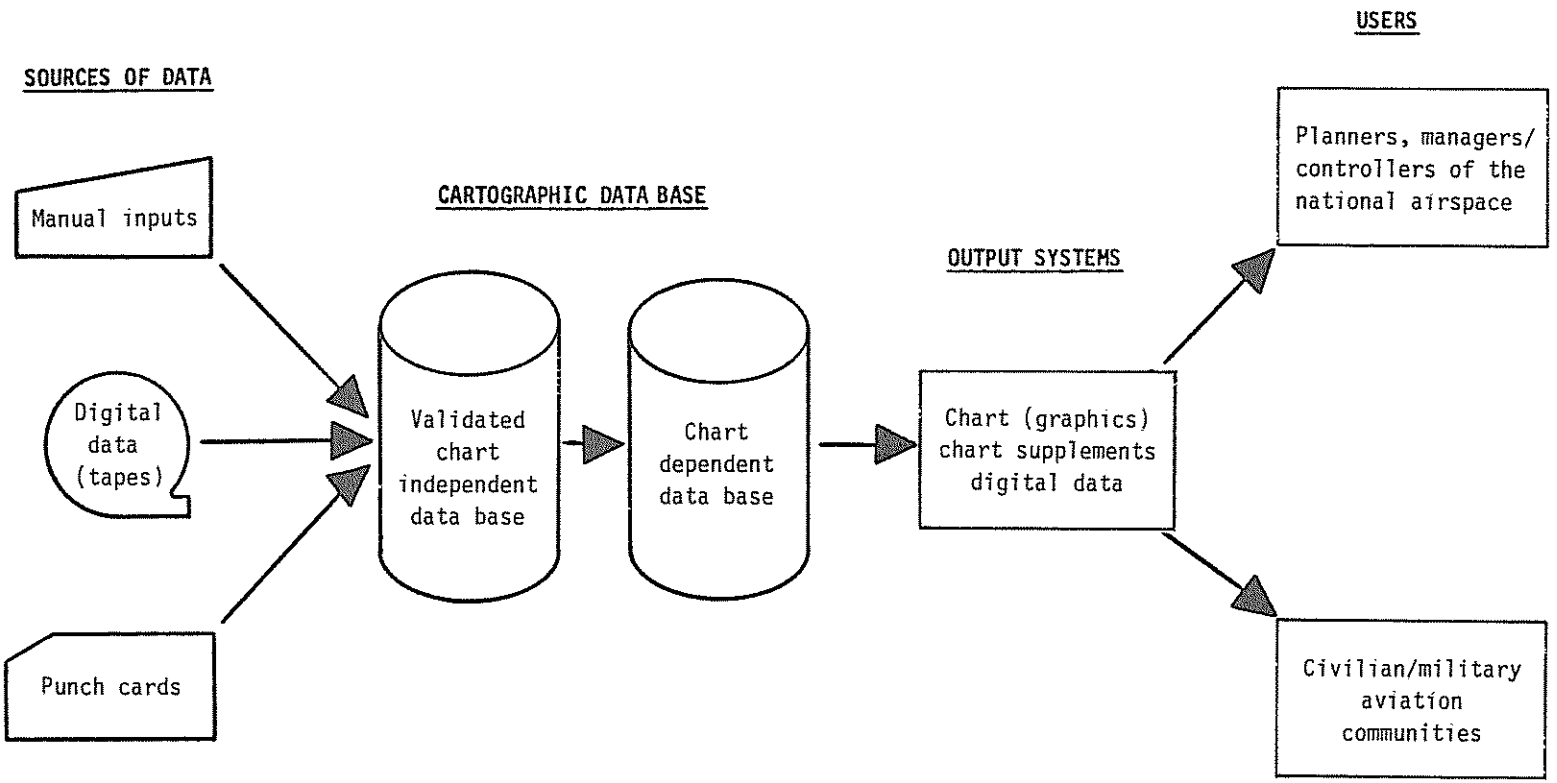
The automated process will generally parallel current manual procedures in that the process will begin with primary sources of input from FAA, the Defense Mapping Agency, the Federal Communications Commission (FCC), NOS in-house flight checks and other NOS in-house data.

The National Airspace System is constantly changing, resulting in daily and sometimes hourly additions or changes to data. Under current manual procedures, data are received, evaluated, verified, processed and distributed by aeronautical information specialists and cartographers who are assigned responsibilities for specific types of data, such as air routes, airports, obstructions and communication frequencies.

Because the automated system is predicated on general functional requirements for presenting aeronautical data in the form of charts and related products, rather than customized for the specific content of current output products, the data base will be composed of two basic parts: chart-independent data; and chart-dependent data. Since nearly all aeronautical data apply to more than one individual chart, the chart-independent portion of the data base will contain all physical data and other basic elements that are to be found on any of the various charts or publications that are to be produced. The chart-dependent portion of the data base will contain parameters unique to each chart or chart product. The development of both the chart-independent and the chart-dependent portions of the data base are critical to the system concept. However, because the chart independent portion involves the software to support the validation, storage and maintenance of the aeronautical data, it will be the first data-base portion to be implemented. The chart-dependent data base will be built step by step, based on charting priorities.

The automated system will accept chart-independent input data on a real-time, on-line basis through communication links with FAA and DMA, and off-line through manual entry or magnetic-tape media. After machine editing, where pre-programmed quality control procedures will check for such things as format, dual entries and other specified anomalies, the data will be transferred to a raw

Figure 185. United States of America: overview of automated production system for aeronautical charts



data file. The cartographers and aeronautical information specialists will access and review these raw data for cartographic validity through the use of alphanumerical terminals for textual data or advanced graphical editing work-stations for graphical data. After validation, the data will be stored in an update file which will reflect only additions, deletions and changes. Rejected data will be stored in a separate file for review and correction or deletion.

Quality control at this stage will be performed both by automated techniques where criteria can be explicitly defined and by analogue procedures (visual review and cross-check by senior aeronautical information specialists and cartographers) where technical judgement is necessary. To prevent new data from flowing into the centralized data base before they have passed validity verification, the data will be controlled and closely monitored by a senior cartographer assigned as the data-base manager. His primary task will be to co-ordinate with the data verification units and, based on predetermined scheduling, either to order or to withhold the update of the centralized data base.

The cartographers involved in the updating, review and compilation of the various charts products will then access this verified data through graphical editing work-stations. Data access will be based upon the particular chart product parameters stored in the chart-dependent data base. These chart parameters describe all of the attributes of the particular chart, such as projection, scale, chart boundaries and identifiers. Since these parameters represent the foundation or "blueprint" of the chart, the chart-dependent data base will remain stable, requiring update only when new chart products are added or when major changes are made to existing products.

When satisfied with the graphical presentation of the data, the cartographer can generate final output as digital data (tapes), graphics from a precision proof-plotter or, ultimately, plate-ready positives or negatives from a high-resolution laser raster plotter.

EN ROUTE LOW-ALTITUDE CHART SERIES

To describe further how the ACAPS production system will produce a chart, the flow of a particular chart which is representative of the many NOS chart products--the en route low-altitude chart series (see figure 186), is described below. This provides a good example, because it portrays accessible chart-independent data base items such as low/medium frequency (L/MF) and very high frequency (VHF) airways, controlled airspace limits, position, identification and frequencies of radio aids, selected aerodromes, minimum en route and obstruction clearance altitudes, airway distances, reporting points, special-use airspace and military training routes. This chart series is revised every 56 days, effective as of the date of airspace changes. The discussion belos is keyed to figure 187.

The process begins with data received by the Aeronautical Information Branch (AIB) from FAA and DMA sources. AIB has the responsibility for the collection, validation and dissemination of aeronautical and airspace information. On a daily basis, information, such as changes to restricted and prohibited airspace, warning areas, very high frequency and low frequency air routes,

Figure 186. United States of America: a portion of the United States *en route*, low-altitude chart series

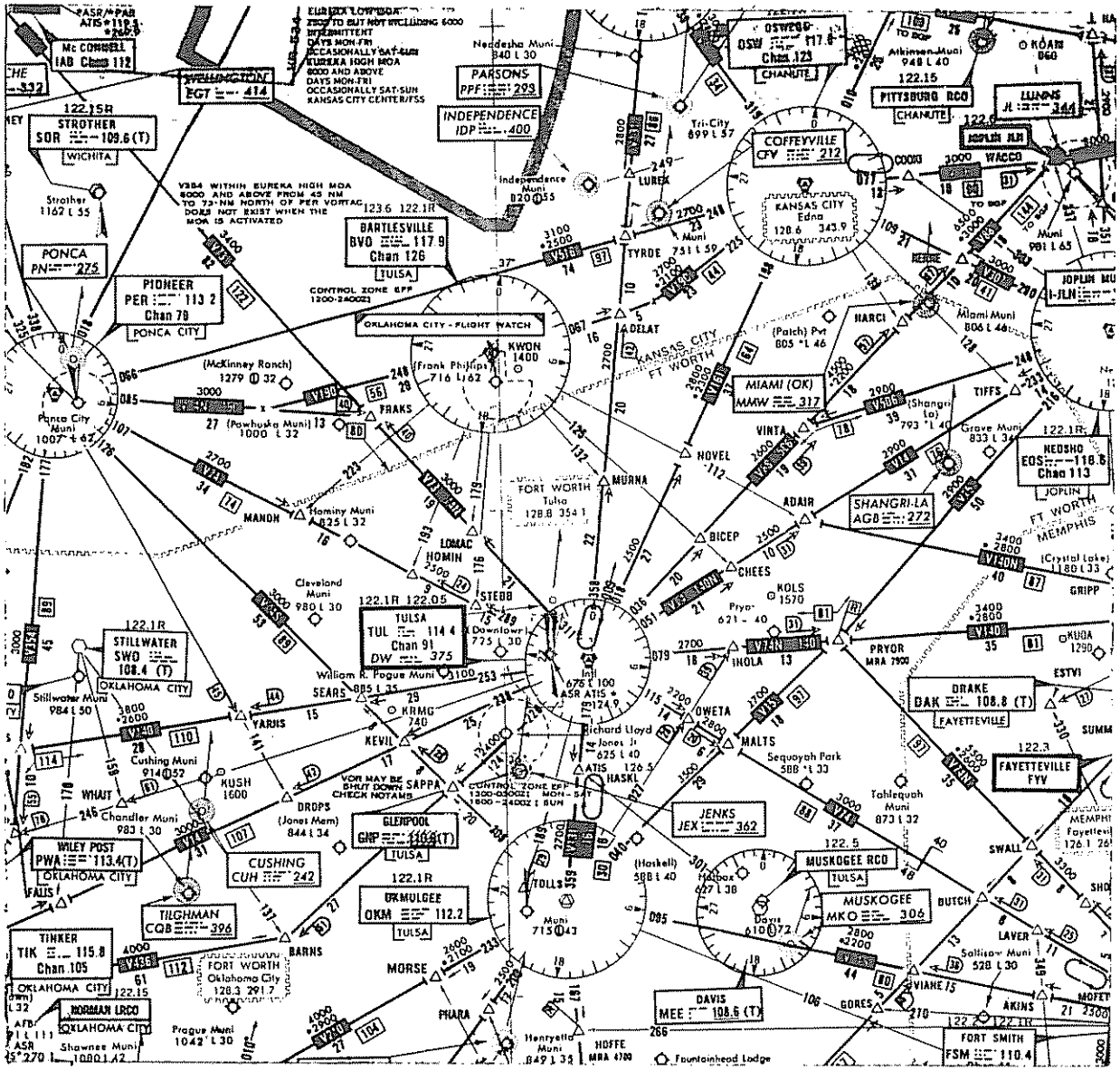
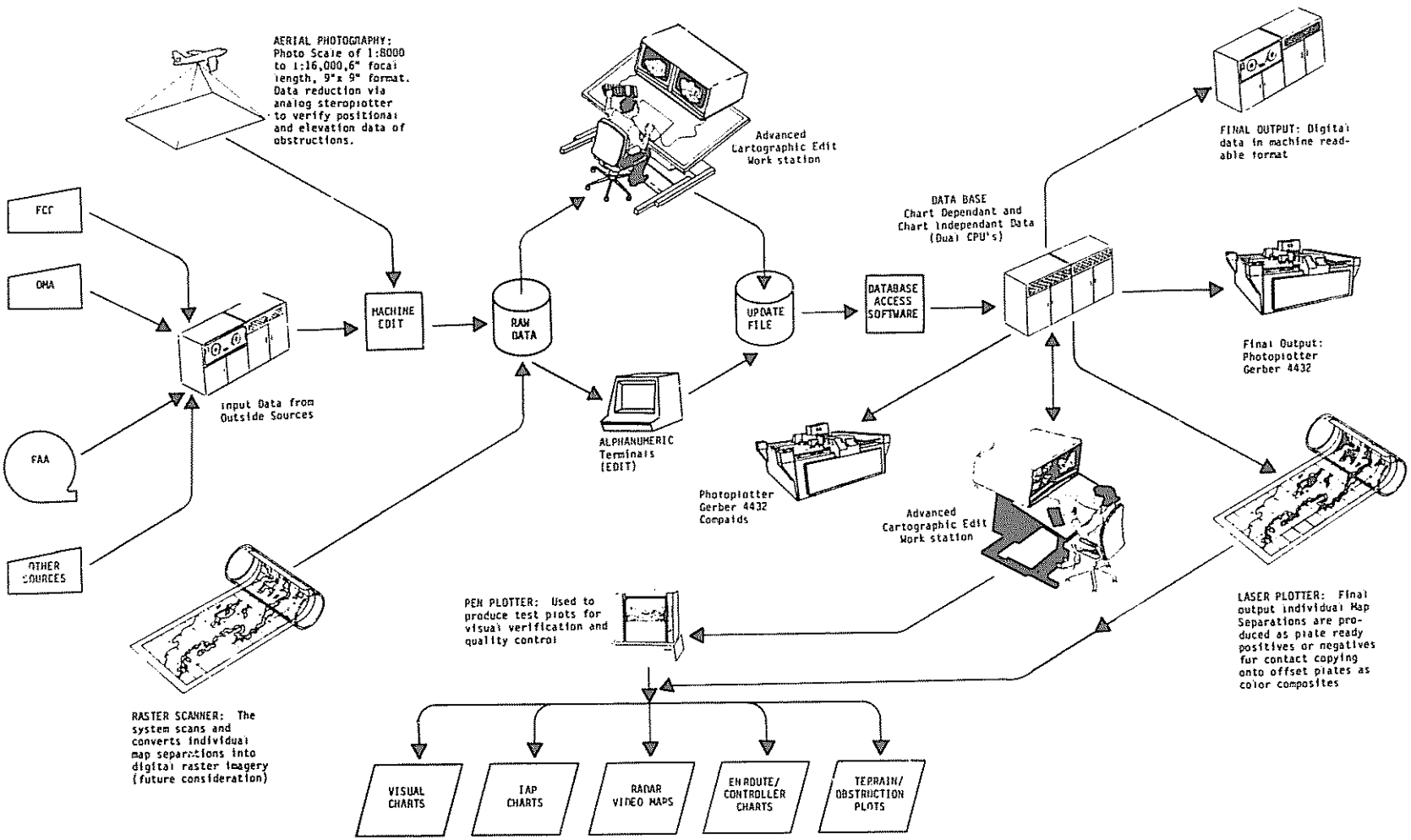


Figure 187. United States of America: concept of automated production system for aeronautical charts



transition areas and other types of controlled airspace which reflect actual changes to federal law, will be entered into the system by AIB personnel who specialize in airspace changes. Other AIB personnel, who specialize in such things as hazards to air navigaiton, navigational aids, airport, communication frequencies and other change items reflected in the FAA National Flight Data Digest, will enter these changes into the system. These personnel will also have the responsibility for verification of the relevance of on-line communications data from FAA, the Department of Defense (DOD), FCC and other sources.

After initial data entry, the data will be automatically run through a machine edit based on pre-programmed parameters. This machine edit will ensure proper format, indicate dual entries and perform range checks data values to indicate data that are outside the range of acceptability.

Data that satisfactorily meet the edit parameters enter the raw data file. At this stage, senior AIB cartographers and aeronautical specialists will access the raw data file through the use of graphical editing work-stations or alpha-numerical terminals. The data will be reviewed for cartographic validity by both analogue (visual) and automated (program-assisted) techniques. Verified data accuracy is certified at this time and unverified data are either withheld from further use or held for reverification. This quality control/data verification requirement is essential to ensure accurate cartographic portrayal of aeronautical and airspace information on the chart.

After verification and certification, the data will be stored in an update file reflecting additions, changes and deletions to the chart-independent data base. The update files of the various data verification units of AIB will be co-ordinated by the data-base manager. It is the responsibility of the data-base manager to control the flow of data from the multiple update files to the centralized chart-independent data base in order to ensure that the most current aeronautical/airspace data shall always be available to the cartographers responsible for constructing, updating and revising the charts. In addition, the data-base manager will have the responsibility for the maintenance and on-line control of the historical record of all the chart-independent data. One of the major problems inherent in the chart-independent data-base concept is maintaining the proper relevance of the effective date of a data element to each chart product to which it applies. Information from a variety of sources will produce file updates. The effective dates of these file updates will change some new chart editions, but not others. Different charts have unique production cycles associated with them; and, at any one time, information that is effective for the next publication of one chart may not be effective until the second or third publication date in the life cycle of another. Thus, current information for one chart may not be current for another.

In order to accommodate viably current data for different chart cycles within this system concept, all data-element updating is performed by additions to the data base. This means that the actual data change with its effective date is "pushed" into the data base on top of the value being superseded. The superseded value is retained rather than erased or physically replaced. Thus, a chronological history of the data is maintained through a push-down stack for each value as to its effective date and the value that is superseded.

When the data-base manager is satisfied with the integrity of the historical record and currency of the update files, he will order the updating of the chart-independent data base. This will be accomplished by interfacing the update files with the data base through access software. At this time, a transaction log of the updates will be generated. This log acts as a quality-control tool for certifying the actual changes to the data base on any given date.

Actual construction of the en route low-altitude chart will be performed by cartographers in the Enroute Navigation Branch. Construction will begin with access to the updated chart-independent data base by a cartographer who is assigned a particular geographical area. Utilizing an advanced graphical editing work-station, (see figure 188), the cartographer will extract specific chart-independent data relevant to the en route chart series, such as compass roses, navigation aids, airports, airways and Air Route Traffic Control Center (ARTCC) boundaries. This access will be based on parameters defining the particular chart, which are stored in the dependent data base. The graphical editing work-station will have the capability of displaying on the cathode-ray tube (CRT) screen a graphical representation of data for any of the eight overlays comprising the en route chart. The cartographer will have the capability of displaying a portion of an overlay, an entire overlay or several overlays overprinting each other. By manipulating these data by moving type, changing airways, deleting extraneous data etc., the cartographer actually constructs the en route chart in much the same way that he would construct a chart using a compass, dividers, pen and ink.

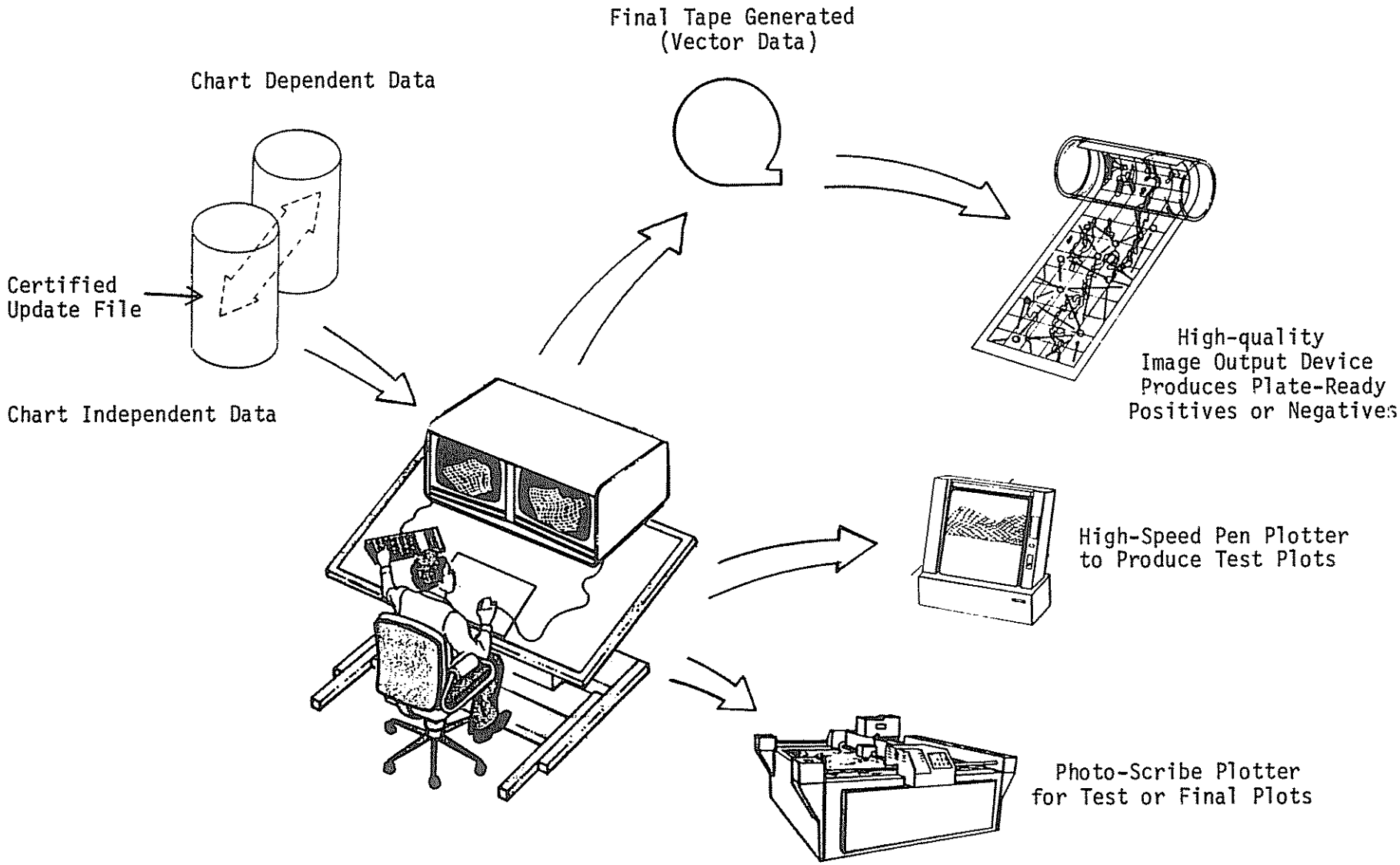
When the cartographer is satisfied that the graphical construction is complete, a senior cartographer (reviewer) will utilize the graphical work-station to review the overall cartographic presentation of the data. At this point, based on the rigid quality-control checks performed in AIB, it can be assumed that the aeronautical data are correct. The reviewer will make sure that there is no overprinting of text or symbolology and that the correct symbolology has been applied.

At this stage, the reviewer has the ability to change any erroneous information applied to the graphics. He also will have the option to generate a hard-copy test plot on either high-speed pen or photo-scribe plotter for further verification and quality control (see figure 188). This hard copy can also be used for archival purposes.

When satisfied with the final graphical representation, the reviewer will submit the resultant graphical files for conversion to vector data format. This final converted vector data will be stored on a magnetic tape in a format capable of "driving" a high-image quality laser plotter. This plotter will then produce plate-ready positives and negatives of each of the eight overlays comprising the en route low-altitude chart (see figure 188).

The procedures discussed for generating the en route low-altitude chart traced the process for creating a completely new chart from start to finish. Once the chart has been created in digital format, the cartographer need only incorporate the current changes in the chart-independent data base to the completed chart according to its update cycle. The chart-dependent data describing the chart will remain unchanged unless major modifications affecting the physical nature of the chart are required.

Figure 188. United States of America: cartographer/reviewer utilizing advanced graphical editing work-station



CONCLUSION

The Aeronautical Chart Automated Production System is based on proven state-of-the-art computer graphics technology that is currently successfully employed by civilian charting firms, such as Jeppesen/Sanderson and Chicago Air Survey, and by government agencies, such as the Defense Mapping Agency, the United States Geological Survey and the NOS Marine Chart Division. Considerable research and development have been performed by the Office of Aeronautical Charting and Cartography, with both outside contractor assistance and in-house dedicated full-time effort. The results of these extensive efforts clearly indicate that the automated production system concept is sound, pragmatic and economical. Most important, once the system is fully implemented, it will serve the increasing needs of the aviation community well into the future.

Note

1/ For a discussion of the original system concept, see "Aeronautical chart automation: concept and status", in Ninth United Nations Regional Cartographic Conference for Asia and the Pacific, Wellington, 11-22 February 1980, vol. II, Technical Papers (United Nations publication, Sales No. E/F. 83.I.14), pp. 308-316. This paper was prepared by the National Ocean Survey.

(i) Hyrdrographic surveying and nautical charting

THE LASER AIRBORNE DEPTH SOUNDER*

Paper submitted by Australia

RESUME

Dans le document qu'ils ont établi, les services hydrographiques de la Marine royale australienne examinent la mise au point du matériel de sondage aéroporté à laser actuellement perfectionné en Australie, de même que les principes de son fonctionnement.

AN OVERVIEW IN SEPTEMBER 1982

The concept of the Weapons Research Establishment Laser Airborne Depth Sounder (WRELADS) was well described in 1980. 1/ The aim of the present paper is to discuss the development since that time and to consider more deeply some of the implications that LADS will raise in operational use.

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* The original text of this paper, prepared by the Hydrographic Service, Royal Australian Navy, appeared as document E/CONF.75/L.21.

In 1981, Thorn Electronics Australia Pty. Ltd. was awarded the development contract for LADS, the production model of WRELADS II. Staff of the Royal Australian Navy are closely involved in this project, particularly in connection with the methods to be used in processing the data to a form acceptable for charting and for acceptance by the Hydrographic Data Base. It is hoped this phase will be completed by mid-1983 and LADS will become operational in 1985. It is also envisaged that a period of trials will be required in the first few months of operational use to determine fully the optimum methods of control and useage of the LADS system.

Principles of operation

The airbrone system consists of a Neodymium: YAG laser, Q-switched to produce short-duration output pulses. Two receivers detect, respectively, a signal reflected from the surface and a signal reflected from the sea bottom. Depths are calculated from the measured time interval between these two events.

Two pulses of different wavelengths are produced:

(a) Infra-red, 1,064 manometres, wide angle, surface return;

(b) Green, 532 manometres, narrow angle, bottom return.

A scanning laser dependent upon an oscillating mirror has been introduced to sweep a swath 268 m wide operating at 168 pulses per second to provide a 10 x 10-m sounding grid at an operating speed of 135 knots.

This system is coupled with a position-fixing system capable of providing not only positional information for the soundings but navigational guidance for the pilot.

The system produces valid data in real time in the aircraft to enable an operator to monitor the system continuously for optimum performance. The recorded signal information is reprocessed on the ground and combined with observed tidal corrections and position-fixing corrections (if applicable) to provide a data tape from which a selection of soundings may be made.

Operation of system

It is envisaged that the total LADS system will comprise the following components:

(a) Fokker F27 series 200 aircraft modified to suit LADS operation, incorporating the airborne laser system;

(b) Ground station at the operational airfield consisting of two standard International Organization for Standardization (ISO) type containers. One will be fitted with the ground analysis subsystem (GASS) and the other as a maintenance and support facility;

(c) Flight crew: two pilots;

(d) Survey team: officer-in-charge and two teams of two hydrographic personnel for air/ground processing duties;

(e) Maintenance crew: two persons minimum:

(i) Aircraft maintenance;

(ii) LADS equipment maintenance;

(f) A Cubic Western DM54 ARGO system consisting of up to four stations;

(g) Support from a hydrographic survey vessel.

The system will be designed to have a life expectancy of at least 10 years and it is planned to fly approximately 1,000 hours per annum on LADS operations.

The aircraft will be leased or chartered from a civilian operator and maintained by it. It is expected that the aircraft will have the endurance to spend four hours on task with a ferry time of one and a half hours each way.

The system will be capable of being operated and maintained from a remote airfield.

The ground analysis subsystem will enable the surveyor to process and examine his results in the field and thereby verify his survey and plan further missions. The final result of the survey consisting of selected soundings will be forwarded on magnetic tape to the Hydrographic Office at North Sydney, where it will be entered into the Hydrographic Data Base.

Support from external sources, normally a supporting hydrographic survey vessel, will be required. The assistance of a ship in support of LADS can be grouped into the following categories:

(a) Establishment and support of ARGO stations;

(b) Establishment and support of tidepole gauges;

(c) Establishment of a bench-mark check area;

(d) Surveying those waters deeper than the LADS capability;

(e) Investigations of shoal areas discovered by LADS.

Method of survey

In considering methods of survey when using LADS it is wise to keep the following points, which represent considerable differences from the approach to conventional hydrographic surveying, firmly in mind:

(a) The speed of the aircraft is approximately 135 knots;

(b) The amount of raw data collected in a four-hour period is approximately 2.5 million wave-forms which require translation into reduced soundings.

The following areas will require consideration.

Navigational concepts

ARGO DM54 will be deployed in the hyperbolic mode with normally a three-station layout. A fourth station will be held in reserve to expand the network if required.

When considering the area covered using long baselines and being constrained by the normal considerations of angle of cut and lane expansion, it is possible to cover an area of 300 miles by 150 miles with one chain.

On survey scale 1:50,000 (line spacing of 250 m), this would represent a line mileage or some 360,000 nm or 600 sorties with LADS. It is therefore considered that chain placement should not present a large problem with regard to required area coverage.

The expected accuracy of the ARGO fix obtained by the aircraft will be sufficient for a 1:50,000 survey.

Planning concepts

The capability of the aircraft will dictate the chosen method.

The principle considerations are: (a) swath width, approximately 286 m; (b) distance covered per sortie, approximately 600 miles; (c) time for aircraft to reverse course; (d) offset distance on course reversal.

It will appreciated that for most economic progression the survey lines should be as long as possible. In most cases, it will be found that lines would then parallel the coast and as a consequence depart from the conventional method of hydrographic surveying of cutting across contours at right angles. This is not considered too great a problem and easily solved with the use of "cross lines". It is further considered that benefit will accrue in data interpretation and adjacent-swath comparison when working along the areas of flattest gradient.

Choice of area

It must also be borne in mind that the LADS operational depth range will be 2-30 m by day (up to 50 m at night), and constraint will be caused by deeper water. In this circumstance, unless it is acceptable to use a "no-bottom" return consideration needs to be given to combined ship/aircraft operations.

Normally, LADS will be deployed with a supporting vessel.

Geodetic control

Sufficient control must be established to:

(a) Locate the chosen ARGO station to plus or minus 1 m;

(b) Fix sufficient points throughout the survey area that are suited for overflight. These co-ordinated points would be used for "locking in" ARGO through the aircraft video system.

Meteorological conditions

The aircraft will be affected by turbulence and strong winds (causing crabbing and the need to adjust air speed) and will need to take into account limiting flight conditions at 500 m above sea-level.

The LADS equipment is affected by: (a) turbidity; (b) sea glint; (c) sea and swell.

Degradation of depth measurement will occur in worsening conditions.

Laser safety

The laser will be inhibited while flying over land. While over the sea it will be necessary to inhibit when overflying vessels. It is therefore considered that night operations (when maximum depths are achieved) will normally be limited unless an area is demonstrably clear of shipping.

Tidal control

As for a conventional hydrographic survey, it will be necessary to provide good vertical control throughout the area to be surveyed. As areas are likely to be large in extent and tidal reduction is a prerequisite of the initial processing of LADS data, it may be necessary to conduct a tidal survey in advance of the LADS operation to establish the co-tidal régime. At this stage, telemetered tidal readings are not considered a practical proposition and ship assistance would be necessary.

Bench-mark check

It is considered desirable that a suitable area (flat or gently sloped sea-bed) is surveyed by conventional means prior to the start of a LADS survey. This area would be used in a similar manner to the "bar check" procedure for echo-sounders in conventional survey. Its use would provide:

(a) An index error to any particular day's work;

(b) An immediate "confidence check" particularly at the beginning of a mission.

Reconnaissance

It is believed that the LADS can provide an effective reconnaissance facility. For example, if an are of 30 x 20 miles (600 square miles) is considered, then by spacing lines, in a grid pattern in both directions, at 3 miles apart some 410 miles of flight is required to cover the area. Including time for turns, the time required would equate to one four-hour sortie.

Using this example, some 70 cross-over points would be established to verify data and areas of "no bottom" could be established.

When considering a survey using LADS alone, the benefit of a reconnaissance flight in defining operating areas will aid the planning of future missions. It is considered that this process is a prerequisite of the conduct of the surveys.

The regular conduct of the survey is dependent upon obtaining full coverage of the area by overflight. The swath width is 286 m, producing a mesh of individual soudings on a 10 x 10-m square grid when the aircraft is at operational height (500 m) and operational speed (135 knots).

To avoid gaps caused by aircraft handling/navigational constraints, a line spacing of 250 m is considered to be acceptable. This will give a theoretical overlap of 14 per cent between lines.

A mission plan would be required for the total area to be surveyed. Considerations involved would be:

(a) Economic progression with regard to length of line and turning characteristics;

(b) The need to accept that adjacent lines will not be flown consecutively but according to a predetermined plan;

(c) The need to progress the area as completed blocks per mission.

On completion of a mission, the need will exist to identify areas for reflight caused by: (a) gapping of initial lines; (b) "problem" areas caused by poor data.

In complex areas, a need may exist for successive overflights firmly to establish least depths. This area will need extensive study during the trial phase.

Survey with ship assistance

Apart from the logistic aid mentioned earlier, the use of a survey ship assistance will aid progression in the following sreas: (a) depths exceeding 30 m; (b) investigation of complex areas.

It should also be borne in mind that as the ship is capable of working up to 24 hours per day, it can be tasked on completion of a mission analysis to

progress an investigation prior to the next sortie. Close-co-operation will be required between the two units.

It is felt that in Australian waters this will be the preferred method of operation, particularly in the earlier years of operational use. To this end, it is hoped to introduce up to four 75-ft survey motor launches concurrently with the introduction of LADS into service.

Survey data processing

Very high data volumes of some 2.5 million observations per four-hour operational sortie pose problems for survey validation and assessment. Observations on a 10-m mesh represent almost total sea-bed coverage due to the beam spread of the laser providing up to approximately a 10-m sea-bed footprint depending upon depth. In traditional hydrographic surveying terms, this information represents an area survey capability of better than a 1:4,000 scale, at aircraft speed. The surveyor is provided with significant system support by means of a ground analysis subsystem validation of the survey results.

The information processing for LADS is designed to allow the field surveyor to validate all survey information on site. This is achieved through: (a) serial processing and validation of all swath information; (b) comparison and adjustment with adjacent or overlapping swath detail; (c) selection of the final survey detail required.

While all flight information will be validated at the mission swath level, the comparison and selection of the final survey information will be conducted according to the purpose of the survey. For example, a survey for general shipping passage at 1:50,000 scale requires a selection of an average of one representative sounding from the approximately 600 soundings representing total sea-bed definition. This, together with careful flight planning, considerably reduces the volume of data processing and surveyor effort required in the field, depending upon the designed survey scale. Total information is still available for further assessment at the Hydrographic Offices; but the hydrographic survey assessment remains at the scale fidelity established in the field.

Processing in the field is described below:

Mission swath evaluation

Mission swath evaluation includes:

(a) Primary processing. Mission swath information is processed in a serial fashion to provide the discrete set of observations adjusted for tide. This initial processing provides additional information, including:

(i) Degree of confidence in individual signal return;

(ii) Evidence of any multiple signal return;

(iii) Degree of divergence form immediately adjacent depth returns;

(iv) No return signal detected (usually indicative of deep-water areas).

(b) Swath validation. The surveyor is provided with an area display showing sequential section of mission results. This display is highlighted to draw attention to system-detected variations. The surveyor is supported by:

(i) Synchronized coloured video display with audio and other airborne information acquired during the survey flight;

(ii) Sea-bed profiles capable of longitude or cross-profile separation with a zoom capability for high resolution;

(iii) Individual signal return patters.

In any section of the swath is not acceptable, it is either deleted from the swath return or flagged for further examination. In both cases, this is automatically indexed on the survey master plan.

Survey selection

Survey selection provides the surveyor with system-selected observations along th swath at the resolution required by the survey objectives. This information is supported by previous adjacent or overlapping selections. The accepted selection is transferred to the area survey file.

Area survey assessment

Selected swath data can be recalled on an area survey basis for comparison with historical data and for the detection of discrepancies requiring further resolution or resurvey. Detailed examination of swath overlap can be conducted by recall of the appropriate mission swath if indicated by the area survey results.

The final area survey results are endorsed by the Officer-in-Charge and passed to the Hydrographic Office for incorporation into the Hydrographic Data Base. The total volume of swath information is indexed on the data base and archived. Information returned from the field includes:

(a) Depth soundings;

(b) Intertidal heights (where tidal range permits);

(c) Delineations of deep-water indications within the survey area and shoal-water reef or bank indications.

The Hydrographic Data Base is a system currently under development by the Hydrographic Service, to process high-volume digital survey information. The objective of the system is to provide a single survey model of the ocean at any one time. This model would be resolved for all competing survey information. There will, however, be the background retention of certain information rejected in the current survey model. The single survey model of the ocean provides the information base for automatic chart production and other hydrographic requirements.

Potential deployment

It is considered that LADS has enormous potential in poorly charted areas of shallow waters that cannot be economically surveyed by conventional means but may have significant resource potential in the future. The aircraft can operate some 300 miles away from its operating airfield, which need only have a 1,200-m runway. The support system is transportable and although the final output tapes will normally require processing in Australia, the surveyor in the field has full control over the system and is able to porgress field-work to the stage that he is satisfied a survey is complete without recourse to his Head Office.

The LADS system will be capable of operating independently of ship support in certain circumstances, and it can be visualized that support could be given to developing Hydrographic Offices throughout the areas of the Association of South-East Asian Nations (ASEAN) and the south-west Pacific.

Note

1/ See M. Calder, "Wrelads--the Australian Laser Depth Sounding System", International Hydrographic Review, January 1980. Captain Calder, Royal Australian Navy, presented this paper at the First International Hydrographic Technical Conference, held at Ottawa, Canada.

HYDROGRAPHIC ACTIVITIES, 1980-1982*

Paper submitted by India

La période 1980-1982 a été riche en événements pour le Département d'hydrophie indien. Après des années d'efforts, un système de restitution assisté par ordinateur a été installé au Service hydrographique à Dehradum. Les travaux ont été terminés en 1981, et après des efforts acharnés pour créer un logiciel d'application, la première carte ainsi produite, celle du Port d'Okha a été publiée en 1982. Ce système permettra d'accélérer la production des cartes marines.

En 1982 également, le Département d'hydrographie a publié son premier volume d'instructions pour la navigation (West Coast of India Pilot). Les informations complémentaires à jour qu'il contient, y compris des photographies récentes des nouveaux phares, devront accroître la sécurité de la navigation.

Toujours en 1982, le Comité consultatif international de l'Organisation hydrographique internationale (OHI) et de la Fédération internationale des géomètres (FIG) a homologué (catégorie A internationale) les cours d'hydrographie fondamentaux et de longue durée de l'Ecole d'hydrographie de Goa.

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* The original text of this paper, prepared by S. S. Sundaram, Chief Civil Hydrographic Officer, appeared as document E/CONF.75/L.112.

Le Département a des accords d'échange avec tous les Etats membres de l'OHI à qui le Département fournit des cartes et publications marines et qui en retour envoient régulièrement leurs cartes et publications.

Les cartes et publications sont distribuées par l'intermédiaire d'un réseau d'agents dans de nombreuses régions du monde et le Département d'hydrographie indien essaye d'élargir ce réseau.

Le premier de la nouvelle génération de navires hydrographes, le Sandhayak, a été armé en 1981, le second le Nirdestrak, devrait l'être cette année et le troisième, le Nirupak, entrera en service en 1983. En outre le premier des quatre navires hydrographes plus petits devrait être armé cette année.

A ce jour, le Département a publié environ 250 cartes marines, dont 13 cartes internationales dont deux produites par l'Inde.

The period 1980-1982 was eventful for the Indian Hydrographic Department. After many years of effort, a computer-assisted plotting system was installed in the Hydrographic Office at Dehradum. The system installation was completed in 1981; and after some dedicated effort in producing application software, the first chart "Port of Okha", drawn by this system was published in April 1982. The system will assist in enhancing the production rate of navigational charts from now on.

Again in 1982, the Hydrographic Department published its first volume of sailing directions, West Coast of India Pilot. It is hoped that the mariners will benefit from the additional and more up-to-date information, including the recent photographs of new lighthouses, in navigating safely in Indian waters.

During this period, in 1982 to be exact, the International Advisory Board of the International Hydrographic Organization/International Federation of Surveyors (IHO/FIG) accorded international category A recognition to the basic and long hydrographic courses conducted at the Hydrographic School in Goa.

The first of the new-generation surveying ships, Sandhayak, was commissioned in 1981; the second, Nirdestrak, is expected to be commissioned this year while the third, Nirupak, will join the Hydrographic Surveying Service in 1983. The first of the four smaller surveying craft is also expected to be commissioned this year.

To date, the Department has published about 250 navigational charts, including 13 international charts; for two of charts, India is the producer country.

The Department has good exchange arrangements with all member states of IHO, by which it supplies its navigational charts and publications and in exchange receives their charts and publications on a regular basis.

The charts and publications of the Indian Hydrographic Department are distributed through a network of agents in many parts of the world, and the Department is making an effort to expand this network.

ON LARGE-SCALE BATHYMETRIC CHART PRESENTATION*

Paper submitted by Japan

RESUME

Le Département hydrographique japonais a produit une série de cartes bathymétriques 1:50 000 des eaux côtières du Japon. La principale information fournie concerne la topographie des fonds marins; mais comme un nombre croissant d'utilisateurs demande qu'elles contiennent également des renseignements relatifs à la mise en valeur des océans, leur présentation a été modifiée. La présentation n'a pas encore été normalisée, mais il peut être utile d'expliquer la présentation actuellement utilisée pour ces cartes.

L'objet de ces cartes est de fournir des renseignements sur le fond des océans en vue de leur mise en valeur de leur utilisation. Ce sont donc des cartes de base des océans. Etant que telles elles doivent donner un cadre pour un secteur géographique donné ou une province administrative. La série de cartes bathymétriques au 1:50 000 couvre les eaux territoriales japonaises. Le niveau de référence géodésique de Tokyo et la projection Lambert ont été utilisés.

Les données indiquées peuvent être regroupées en deux catégories: d'une part les conditions naturelles, d'autre part les infrastructures et les divisions administratives. En ce qui concerne la première catégorie, on donne le niveau de référence des sondages. La baisse de basse mer, le relief des fonds marins, l'indication de la densité des chiffres de sondage, la coloration des couches, les données océanographiques etc. Quant à la grande catégorie, on indique diverses installations telles que ports de plaisance, stations balnéaires, constructions sous-marines et refuges halieutiques, ainsi que les limites administratives officielles, par exemple: les limites de ports, les zones de pêche, les routes de navigation et les zones protégées.

En ce qui concerne les terres émergées les symboles représentant les courbes et teintes hypsométriques, les stations de triangulation, les zones construites, les voies de circulation, les installations utilisées pour les ressources, les objets très visibles, les données météorologiques et les divisions administratives terrestres sont indiqués en figure 189.

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* The original text of this paper, prepared by T. Sato, Director, Surveying Division, Hydrographic Department; and K. Nishizawa, Chart Division, Hydrographic Department, appeared as document E/CONF.75/L.64.

In 1975, the Hydrographic Department of Japan began to issue a series of bathymetric charts on the scale 1:50,000 to cover the coastal waters around Japan. About 50 charts have already been published. The purpose of this project is to disclose the sea-bottom topography of the territorial waters of Japan and to determine baselines of these waters, as well as to provide useful information for development and control of such waters.

At its initial stage, the project was directey primarily to drawing of detailed sea-bottom topography, which is unchangeable and accordingly gives the most fundamental information. As the number of these charts increased, however, users, particularly those of harbor construction works and fishery circles, began to request that the chart also show information relating to ocean development. To cope with such requirements, the chart representation has been modified.

Currently, standardization has not been attained in the representation of large-scale bathymetric charts. The representation of the 1:50,000 bathymetric charts being published is constantly under review, and necessary changes have been made from time to time. Nevertheless, it is considered meaningful to explain the representation method currently employed on the large-scale bathymetric chart being produced by the Hydrographic Department.

REPRESENTATION OF 1:50,000 BATHYMETRIC CHART

General information

Publication plan

A bathymetric chart provides basic data for any type of human activity to develop and utilize the ocean. In this sense, it is a base map of the ocean. As a base map, it is necessary to work out an overall issue plan covering a natural area or an administrative area with standardized chart specifications. The eventual purpose of this project is to cover all the territorial waters around Japan with 545 sheets of the 1:50,000 bathymetric charts. As the first stage of the project, 71 sheets are scheduled to be published to cover selected areas of first priority.

Geodetic system

As in the case of nautical charts, the geodetic data used should be specified on the bathymetric chart. In Japan, the Geographical Survey Institute has already established triangulation network almost throughout Japan based on the Tokyo Datum. The final results are used in the 1:50,000 bathymetric charts.

Projection

As in the case of land topographic maps, there is no projection that is best for a bathymetric chart. As for large-scale maps, however, various projections make little difference. Taking into account its use as a base map,

it is desirable that graticules be appropriately spaced, along which dicing should be made as fine as possible so that the user can easily plot positions and read geographical co-ordinates of a point.

On the 1:50,000 bathymetric chart, the Lambert conformal conical projection with two standard parallels is adopted. The intervals of graticules are every 5 minutes, and graduation on the inner borderline of the chart is made every 10 seconds.

REPRESENTATION OF SEA AREA

Representation of natural conditions

Sounding datum

As for the sounding datum, the chart datum for the nautical chart is also used on the bathymetric chart.

There is a consideraiton in which the sounding datum should coincide with the datum level for elevation (neam sea-level). The datum level for elevation in Japan is the mean sea-level in Tokyo Wan (observed from 1873 to 1879), and the Geographical Survey Institute employs it for the topographic maps of coastal areas shallower than a 50-m depth.

The chart datum is adopted as the sounding datum on the 1:50,000 bathymetric chart for the following reasons: (a) the bathymetric data heretofore obtained for nautical charting can be used as they are; (b) harbour construction works are conducted with reference to the chart datum; and (c) most important, the baseline for the territorial waters is defined as the low-water line based on the chart datum.

The bathymetric chart is intended to show clearly the base-lines for territorial waters as well as to be useful for various ocean development projects. It is, however, necessary to make clear the relationship between the elevations on land and various datums. In the margin of the chart, a table of tides is shown to indicate the relationship giving values to the tenth place.

Low-water line

As in the case of a nautical chart, the low-water lines and types of coastlines are represented on the chart. It is particularly important to represent such features as capes and offshore areas drying at low water that are important to define baselines for territorial waters and such areas drying at low water extending at a bay entrance that are used to provide basic points to delimit the closing line of the bay mouth.

Depth contours

The contours at 1-m depth intervals are used as supplementary depth contours for the necessary areas on the continental shelf. They are shown in pale-blue firm lines.

The 5-m depth contours are indicated in dark-blue dashed lines. They are shown not only in the areas where 1-m depth contours are drawn but in other areas as required.

The 10-m depth contours are shown as dark-blue firm lines. The 10-m depth contour is an index contour line.

Since the depth contour lines on a bathymetric chart represent accurate bottom topography, they should not be generalized as in the case of a nautical chart that is directed to navigational safety. That is, on a nautical chart it is usual to draw a depth contour so that every sounding of the same value of the contour depth is included inside (shallower side) the contour. On a bathymetric chart, on the other hand, the depth contour should be so drawn that it passes through the positions of the depths of the same value of the contour depth.

In principle, the depth of the shallowest or deepest portion of a closed depth contour is indicated, but all other depths are not shown.

Indication of density of sounding figures

When a bathymetric chart is published as an individual chart, it is desirable to include on the chart a diagram showing sounding tracks. In the case of the 1:50,000 bathymetric chart, however, because the spacing of tracks is at the same intervals and an explanatory brochure also is attached, the sounding tracks are not included on the charts but are indicated in the explanatory brochure.

Layer tints

Layer tints are made to eight layers: 0-20 m; 20-50 m; 50-100 m; 100-150 m; 150-200 m; 200-500 m; 500-1,000 m; and deeper than 1,000 m.

Oceanography

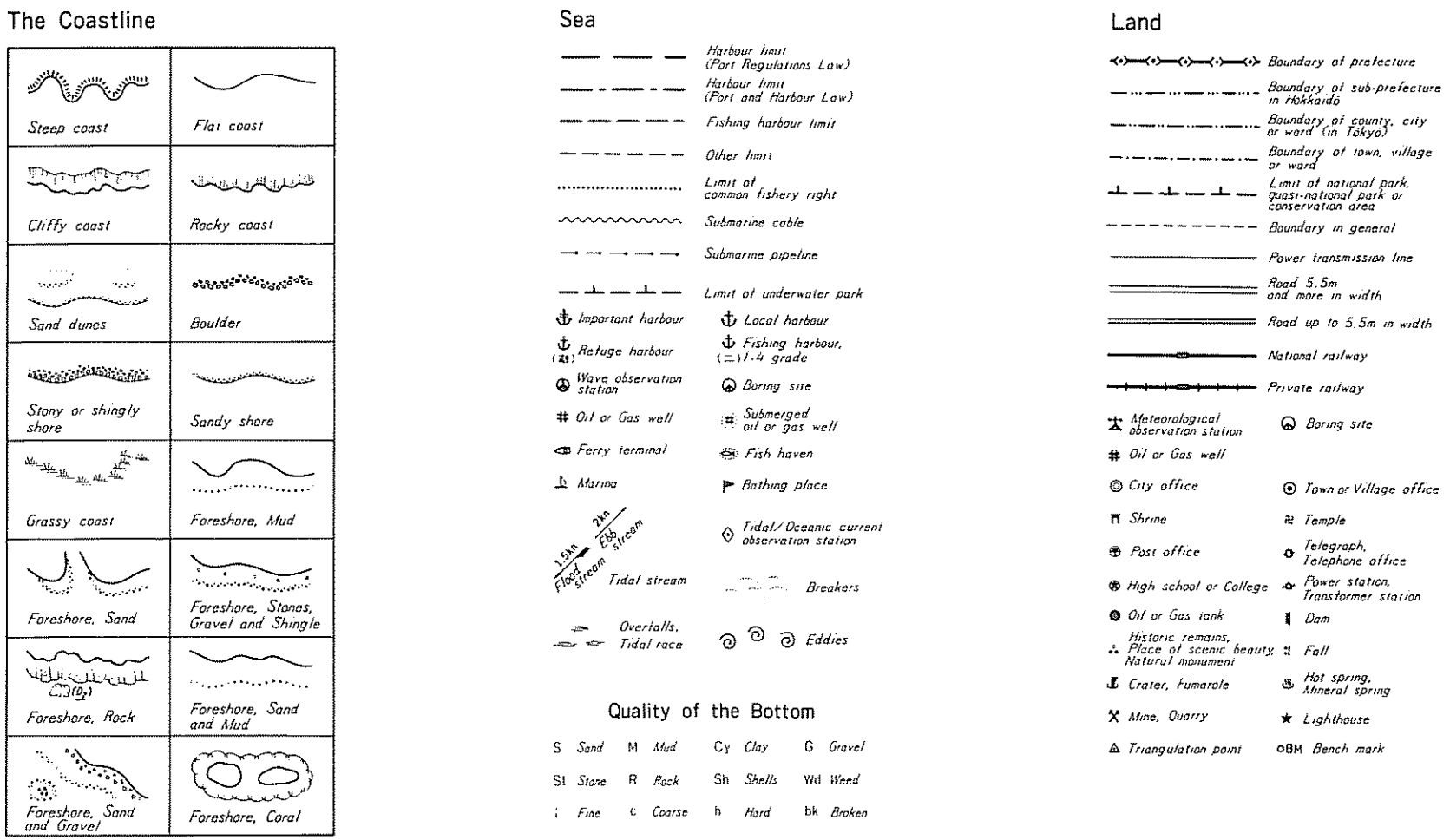
Oceanic and tidal currents

When sufficient observation data are available, a diamond symbol is shown at the observation station on the chart (see figure 189), and a vector diagram of oceanic/tidal currents is shown in the margin of the chart. When these data are insufficient, directions of flood and ebb currents are indicated by arrows accompanied by values of maximum velocities.

Tide-rips and overfalls

When the data on tide-rips and overfalls are available, they are shown by the symbols used on nautical charts.

Figure 189. Japan: symbols for bathymetric chart at 1:50,000 scale



Statistical data

Where wave data, such as monthly histograms of wave height and wave period and those of maximum waves, are available, they are included in the explanatory brochure.

Boring data

Where there is a boring point, its position is indicated by a symbol on the chart. As far as possible results of the boring are included in the explanatory brochure. (The same procedure is followed for a boring on land.)

Facilities and administrative divisions

Marine facilities

Such facilities as marinas and bathing-places, permanent undersea constructions (observation towers, pipelines etc.) and fish havens are charted by their respective symbols.

Administrative divisions

Maritime areas designated by laws are expected to provide limiting conditions for their utilization and development in the future. Accordingly, they are charted in the following manner:

(a) Harbour area. In Japan, three kinds of harbours are legislatively designated, i.e., by the Port Regulations Law, the Harbour Law and the Fishery Harbour Law. On nautical charts, only those designated by the Port Regulations Law are shown, while on the bathymetric chart, those designated by the Harbour Law also are shown by the limits, with a symbol for anchor therein. The areas of these two types of harbours are often duplicated; and in such cases, only their outermost limits are shown. As for fishery harbours under the Fishery Harbour Law, only the principal harbours are shown with an anchor symbol and a figure indicating their class;

(b) Fishing zone. There are three types of fishery rights: fixed-net fishery; divisional fishery; and common fishery. All of them are exclusive. As for the first two rights, licences are renewed every five years, while that of the common fishery is longer (every 10 years) and its area is comparatively wider. Thus, only common fishing zones are shown on the bathymetric chart;

(c) Designated shipping routes etc. The shipping route designated by the Maritime Traffic Safety Law, the quarantine anchorages designated by the Quarantine Law etc. are charted;

(d) Area for nature conservation. Underwater parks, special reservations etc. prescribed in the Natural Park Law and the Law for Nature Conservation are charted.

REPRESENTATION OF LAND AREA

Land topography is very important in understanding sea-bottom topography. Hence, it is charted by using existing land topographic maps on almost the same scale. Also charted are environmental features of land areas and hinterland conditions that concern development and utilization of sea areas. The characteristics shown on bathymetric charts are listed below:

(a) Contours and layer tints. The Geographical Survey Institute publishes topographic maps at 1:50,000 scale covering all of Japan. Based on these maps, contours at 20-m intervals are shown on the bathymetric chart. Because of the necessity of showing information other than topographic data on land, these contours are printed with a sepia-line plate. Layer tinting is made to the land tint, where pale sepia is used for the areas lower than 100 m and dark sepia for higher than 100 m;

(b) Triangulation station. This station is shown;

(c) Built-up areas. A generalized shape of a built-up area is shown. In particular, such buildings as administrative offices, post offices, schools, hospitals, parks and other public facilities are charted by their respective symbols.

(d) Traffic facilities. Railways, main roads, airports and other traffic facilities are charted;

(e) Facilities relating to resources. Major historical places, natural monuments, hot spas and other tourist resources, as well as oil-wells, gas-wells, mines and other facilities relating to mineral resources, are shown;

(f) Conspicuous objects. Objects that are conspicuously seen from the sea are charted;

(g) Meteorology. Where data indicating the trend of wind direction and velocity in the locality are available, a wind-rose of annual data will be inserted in the chart margin. Where other data, such as atmospheric temperature, precipitation and the number of fine days, are available, they are included in the explanatory brochure. The observation stations are shown on the chart;

(h) Administrative divisions. These divisions are shown by their respective symbols.

GEOGRAPHICAL NAMES

Geographical names are shown according to the same standard as that applied to nautical charts. The place names on land are inserted after confirmation thereof is obtained from the local authorities concerned. As Japan has no bureau of geographical names, the Hydrographic Department and the Geographical Survey Institute regularly meet to confirm geographical names to appear on charts and maps, thus contributing to the standardization of geographical names in Japan.

As concerns a newly discovered undersea feature, investigation is to be made whether a name is already given or not by inquiring of the local fisheries circles. If a name is already given, such name is shown on the chart. If not, a new name is decided by a committee represented by national scientific and administrative agencies concerned; and the name thus decided is charted.

As for the chart representation method as well as charted information on the large-scale bathymetric chart, it is expected that the users' demand will vary according to the change in social demands for the ocean. Therefore, it is considered necessary to make further improvements and modifications to cope with such situations.

JOINT PRODUCTION OF THE COMMON DATUM CHARTS OF THE STRAITS OF MALACCA AND SINGAPORE: PHASE II*

Paper submitted by Japan

RESUME

Ce projet, qui comprend deux phases, a été lancé en vue de promouvoir la sécurité de la navigation dans les détroits grâce à des cartes utilisant un point de référence commun établies par l'Indonésie, le Japon, la Malaisie et Singapour. Comme indiqué lors de la précédente conférence, trois feuilles du détroit de Singapour au 1:50 000 ou 1:75 000 ont été établies pendant la Phase I en 1979.

Une réunion technique tenue à Kuala Lumpur en 1980 a été consacrée aux travaux de la Phase II dont l'objet est d'obtenir les coordonnées géographiques de points d'observation astronomique sur la côte orientale de Sumatera au moyen des techniques de géodésie par satellite et de préparer trois autres feuilles du détroit au 1:200 000.

Les travaux de levés géodésiques ont commencé en août 1980 et ont duré 107 jours. Comme il n'y a pas de jonction géodésique entre ces points et le niveau de référence indonésien ou celui de la Malaisie et de Singapour, on a effectué des observations continuelles par satellite au point origine sur Pulau Pisang et d'autres observations ont été faites simultanément en ces mêmes points pour obtenir leurs coordonnées géographiques sur le WGS 72 en utilisant la méthode de "translocation".

La généralisation a été effectuée, au Département d'hydrographie de Tokyo entre mai et août 1981, par l'équipe mixte. En septembre et octobre 1981, ont été inspectés les points de repère pour

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* The original text of this paper, prepared by K. Yashima, Chart Division, Hydrographic Department, appeared as document E/CONF.75/L.56.

regroupement et mise à jour des minutes. De janvier à mars 1982, l'équipe a établi et vérifié les dessins originaux. Enfin, en mai 1982, les représentants des quatre pays se sont réunis à Tokyo et ont mis au point les éléments de conservation des trois cartes prévues pour la Phase II.

Les efforts concertés de ces quatre pays ont donc abouti à un résultat qui améliorera indubitablement la sécurité de la navigation dans les détroits.

This project was initiated for the purpose of producing charts of the straits of Malacca and Singapore, based on a common datum point to promote navigational safety therein with the joint efforts of Indonesia, Japan, Malaysia and Singapore.

The project consisted of two phases. The report on the progress of the work in Phase I was already made by the joint team (1980) and by T. Sato (1980). During Phase I, three sheets of the common datum charts were prepared to cover Singapore Strait on the scale 1:50,000 or 1:75 000. The work was completed in 1979.

Strictly speaking, a common datum chart is not an ordinary nautical chart but is a master sheet for production of the nautical chart by individual countries. Based on common datum chart, sheets 1, 2 and 3, Japanese charts 751, 750 and 749, respectively, were published in February 1980, with due modifications required for Japanese chart representation. Thus, although common datum charts are not maintained up-to-date, the contents will be updated through the nautical charts issued by the countries concerned.

In June 1980, a technical meeting was held at Kuala Lumpur, Malaysia; and representatives of the four countries discussed implementation of the work for Phase II of this project. The Memorandum of Procedure was prepared and signed by these representatives.

OVERALL PLANNING AND PHASE II WORK

According to the Memorandum of Procedure prepared and signed in Singapore in May 1977 prior to the commencement of Phase I work, the objective area of the project covers the waters extending from the eastern entrance of Singapore Strait to the northern entrance of the Strait of Malacca. The work of Phase I included preparation of the three sheets covering Singapore Strait, collection and checking of source materials required for the production of the common datum charts and reconnaissance for satellite geodetic survey; and all these works were completed in 1979.

In Phase II, the principal work was to obtain geographical co-ordinates of astronomical observation spots on the east coast of Sumatera by means of satellite geodesy and to prepare another three sheets covering the straits of Malacca and Singapore on the scale 1:200,000.

OUTLINE OF WORK IN PHASE II

The principal specifications for the work in Phase II are:

(a) The common datum point is the fundamental point at Pulau Pisang, with Doppler satellite derived co-ordinates 01°28'08".1158 North 103°15'22".6890 East as its geodetic co-ordinates;

(b) The spheroid to be used is WGS-72, where a = 6,378,135.00 m and f = 1/298.26;

(c) The scale and coverage (see also figure 190) are:

(i) Sheet 4: scale 1:200,000; bounded by latitudes of 2°00' North and 3°12' North and longitudes of 100°25' East and 102°10' East;

(ii) Sheet 5: scale 1:200,000; bounded by latitudes of 1°06' North and 2°18' North and longitudes of 101°42' East and 103°27' East;

(iii) Sheet 6: scale 1:200,000; bounded by latitudes of 0°40' North and 1°50' North and longitudes of 103°05' East and 104°50' East;

(d) The standard parallel is 2°00;

(e) The language is English;

(f) The unit of measurement is the metric system;

(g) The Mercator projection is used;

(h) Symbols and abbreviations are in accordance with the Standard Symbols and Abbreviations adopted by the International Hydrographic Organization (IHO). For those symbols and abbreviations on the IHO Standard List for which no technical resolution has been adopted, those appearing in Japanese Chart No. 6011 were used.

(i) The charts are in four colours.

The work schedule is as described below in "Progress of work".

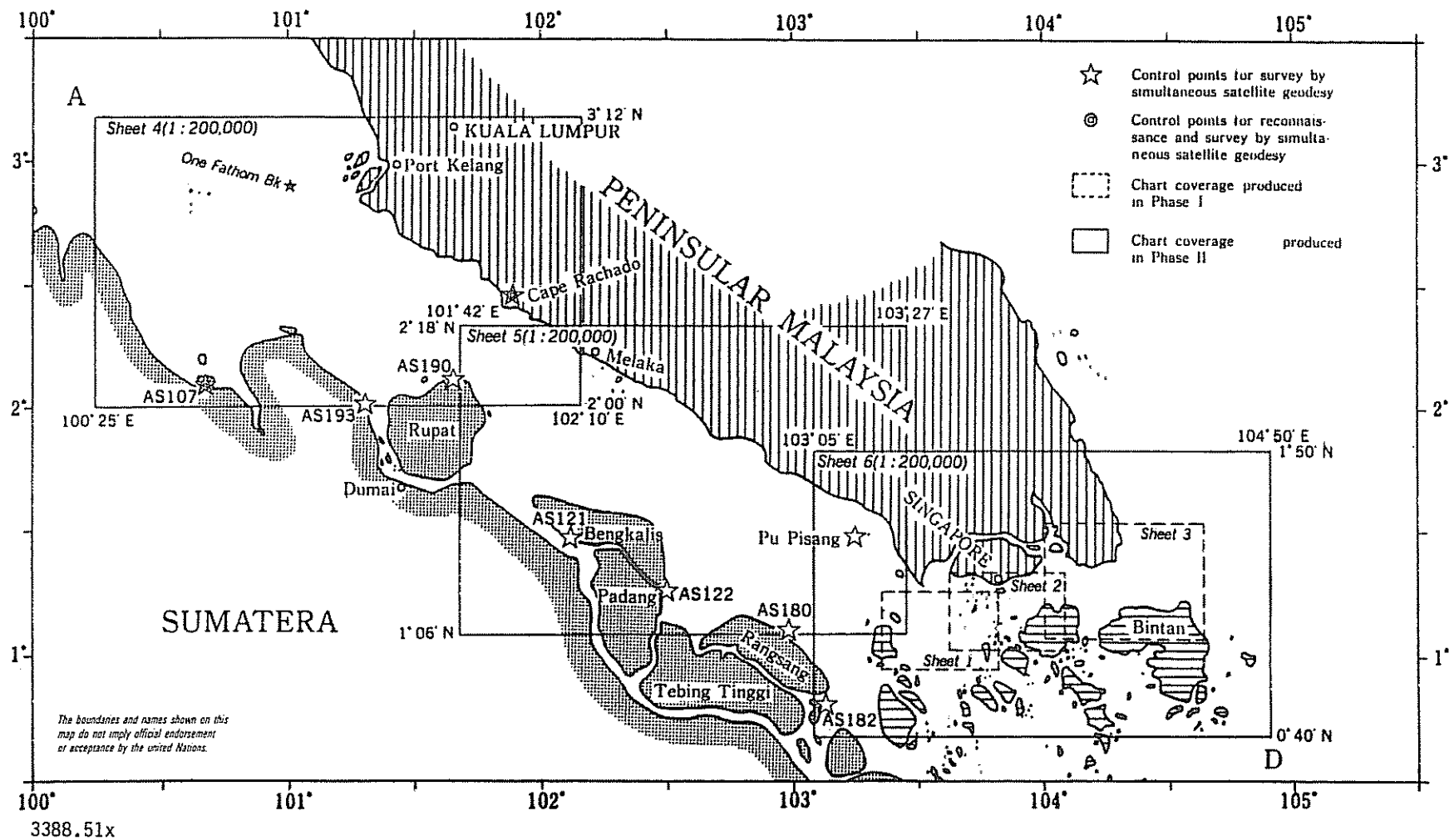
PROGRESS OF WORK

Geodetic survey and final data processing and preparation of survey report

The geodetic survey was conducted from 25 August to 9 December 1980, and final data processing and preparation of the survey report were done from 19 to 25 April 1981.

The Peninsular-Malaysia/Singapore side and the Indonesian Islands lying in approaches to Singapore Strait were covered by the Revised Kertau Datum and

Figure 190. Japan: coverage of the common datum charts and locations for survey by simultaneous satellite geodesy in straits of Malacca and Singapore



the Bangka Datum, respectively, and their relationship with the fundamental point at Pilau Pisang are already known. On the other hand, the astronomical observation spots on the east coast of Sumatera were not connected to neither the Indonesian Datum nor the fundamental point. Accordingly, geodetic survey using satellites were carried out jointly by the four countries at seven of these astronomical observation spots, as well as at Cape Rachado on the Malaysian coast and at the fundamental point (figure 190). The survey was carried out for 107 days, during which there were continuous satellite observations of Doppler shifts at the fundamental point and simultaneous observations at each of the control points in turn. At the fundamental point, 252 data passes were received; and at each spot, about 40 passes, on average. Based on these data, the geographical co-ordinates of the control points on WGS 72 were calculcated by the translocation method (see table 52).

To support the field-work, Indonesian survey vessel Kri Burujulasad and Singapore survey MV Mata Ikan were used.

The survey report was prepared at Jakarta, Indonesia.

Table 52. Co-ordinates on Bessel 1841 and WGS 72 for common datum charts of straits of Malacca and Singapore

Station name	AS No.	Co-ordinates		Correction
		Astronomical	WGS 72	
Tg. Medang	AS 190	02° 07' 06".50N	02° 07' 05".789N	-0".71
		101° 38' 40".19E	101° 38' 46".704E	+6".51
Muara Kubu	AS 107	02° 04' 12".40N	02° 04' 08".279N	-4".12
		100° 38' 19".29E	100° 38' 25".779E	+6".49
Tg. Ketam	AS 193	02° 00' 01".80N	(02° 00' 01".653N)	(-0".15)
		101° 19' 08" 59E	(101° 19' 14".188E	(+5".60)
Bengkalis	AS 121	01° 27' 57".20N	01° 27' 55".488N	-1".71
		102° 06' 37".89E	102° 06' 42".736E	+4".85
Tg. Sekudi	AS 122	01° 15' 36".00N	01° 15' 33".723N	-2".28
		102° 29' 30".19E	102° 29' 35".969E	+5".78
Tg. Kedabu	AS 180	01° 05' 38".10N	01° 05' 34".810N	-3".29
		102° 58' 15".99E	102° 58' 24".087E	+8".10
Tg. Bakau	AS 182	00° 49' 44".50N	00° 49' 40".650N	-3".85
		103° 06' 39".59E	103° 06' 45".149E	+5".56

Note: Values in ( ) were obtained by point-positioning.

Chart compilation

The charts were compiled from 24 May to 23 August 1981, by a joint team from the four countries working st the Hydrographic Department of Japan. The work was conducted in accordance with the guidelines appearing in "Symbols and abbreviations for the joint production of common datum charts of the straits of Malacca and Singapore" and "Manual for the joint production of common datum charts of the straits of Malacca and Singapore" both prepared and used during the work of Phase I.

Some matters not included in these guidelines, as well as certain technical problems encountered during the course of the compilation, were discussed and resolved jointly. The principal items are discussed below.

Sheet titles

The following sheet titles were selected:

(a) Sheet 4: Malacca Strait, One Fathom Bank to Tanjung Keling;

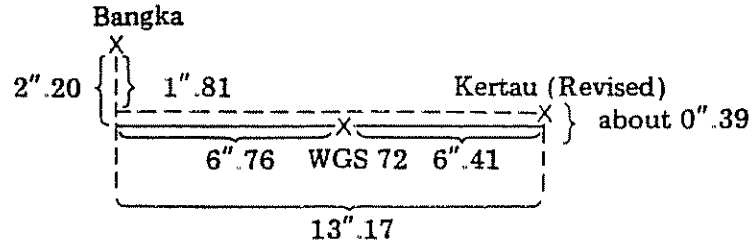
(b) Sheet 5: Malacca Strait, Tanjung Keling to Western Entrance of Singapore Strait;

(c) Sheet 6: Singapore Strait.

Adjustment methods for geographical co-ordinates

The smooth sheets of survey and land maps to be used for compilation were sorted according to the Revised Kertau Datum and the Bangka Datum, and each control point was determined by astronomical observation. Based on the relationship between these datums and between the control points and MGS 72 shown in figure 191 and table 52, the graticules of each sheet were adjusted to those on WGS 72 by parallel shifting.

Figure 191. Japan: relationship between geodetic datums at the fundamental point, Pulau Pisang



Agreement was also reached on how to represent decimal fractions of depth figures, to draw 30 m isobaths, to delineate depth contours on the smooth sheets on which soundings are shown in fathoms and feet, to represent details of inlets and other minor topography, to determine the intervals between sounding figures, to delimit the areas to be represented by water-tint etc.

Investigation of landmarks

From 19 September to 18 October 1981, landmarks were investigated to check the appropriateness of chart representation of various conspicuous landmarks, such as towers, chimneys and lighthouses, depicted on the compilaiton manu-

scripts by comparing them with their actual state in the field. It was carried out by a joint team of the four countries using the Malaysian vessel MN Pedoman. Based on the findings, corrections to the compilation manuscripts were made in succession at the Hydrographic Department in Singapore.

Preparation and proofreading of original drawings

From 5 January to 31 March 1982, the original drawings were prepared and proof-read at the Hydrographic Department of Japan. This work also was done by a joint team. A drawing was made to prepare the chart originals separately on three kinds of sheets: a line-work sheet for black plate, on which coast-lines, depth contours, various maritime limits etc. are handwritten; another line-work sheet for black plate, on which photo-typeset letters of geographical names , sounding figures etc. were stuck-up; and a sheet for a magenta plate, on which light flares, compass roses etc. are drawn or stuck-up. During this work, amendments by additional source materials and updating of information by Notices to Mariners were carried on. Repromats for black, magenta, land-tint and blue-tint plates were thus completed.

Technical meeting for finalization of repromats and report

From 24 to 28 May 1982, representatives of the four countries met at the Hydrographic Department of Japan and finalized the repromats of sheets 4, 5 and 6 of the common datum charts under Phase II and the report outlining the history of the cartographic work thereof.

POSTSCRIPT

As in the case of Phase I, Japanese charts 621, 622A and 622B were published in September 1982 by modifying common datum chart sheets 4, 5 and 6 to bring them into the Japanese chart style.

The common datum chart project was thus completed by the Phase II work. Since the preliminary hydrographic survey conducted in 1969 in the straits of Malacca and Singapore, the mutual reliance and friendship fostered among the hydrographic personnel of the four countries through their joint efforts in those straits have resulted in work that will undoubtedly contribute to the safety of navigation in those areas.

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FIJI: AN EXAMPLE OF INTERNATIONAL HYDROGRAPHIC CO-OPERATION*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RESUME

Dans le passé, le Royaume-Uni assumait seul la responsabilité des activités topographiques et cartographiques dans les eaux fidjiennes. Depuis 1945, et plus particulièrement depuis la création du Groupe de l'ONU chargé d'étudier les transports à Fidji en 1968 et le transfert du Service hydrographique du Département de la marine aux Forces militaires royales de Fidji en 1976, cette situation s'est progressivement modifiée du fait de l'étroite coopération entre l'Organisation des Nations Unies et les Gouvernements de l'Australie, de Fidji, de la Nouvelle-Zélande et du Royaume-Uni. La demande concernant la réalisation d'études en vue d'améliorer les communications entre les îles a suscité de nombreux travaux à grande échelle sur les ports et le développement effectué au départ par le Groupe de l'ONU chargé d'étudier les transports à Fidji et, par la suite, par le Service hydrographique des Forces militaires royales de Fidji. La demande en matière de cartes marines modernisées pour répondre aux besoins du traffic maritime extérieur et local a rendu nécessaire d'établir de nouvelles cartes. Cette demande a été satisfaite en partie grâce aux cartes établies par les navires hydrographiques de la Marine royale et de la Marine royale néo-zélandaise et la publication ultérieure de nouvelles cartes métriques de ces zones par le Département hydrographique du Roayaume-Uni. Toutefois, les eaux intérieures et les eaux de la zone économique de Fidji comprennent encore de très vastes zones qui n'ont encore fait l'objet d'aucune étude ou qui, au mieux, n'ont été étudiées qu'à l'aide d'une sonde à main au dix-neuvième siècle; plusieurs cartes ainsi établies sont encore publiées aujourd'hui et diffèrent peu des cartes originales. La série de cartes marines établies à l'échelon mondial par l'Amirauté britannique fait toujours autorité en ce qui concerne les eaux fidjiennes mais le Service hydrographique des Forces militaires royales de Fidji établit actuellement des cartes à grande échelle pour satisfaire les besoins locaux.

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* The original text of this paper, prepared by B. E. Skittrall, Hydrographic Department, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF.75/L.54.

HISTORY OF HYDROGRAPHY IN FIJI TO 1945

Hydrography in Fiji dates back to the early explorers, the discovery of the islands being attributed to Tasman in 1643. Captain Cook, Royal Navy, discovered Vatoa on the second of his voyages in 1774, but the first of the discoverers to attain anything like an adequate conception of the extent of the Fiji Archipelago was Lieutenant Bligh, who steered a course between the islands from the south-east to the north-west in 1789 as part of his famous 3,000-mile journey in an open boat after the mutiny aboard HMS Bounty. This was followed by a second voyage by Bligh aboard HMS Providence in 1792; and in 1797 Wilson, in his mission ship Duff, traversed the difficult reef-strewn area between the eastern Lau group of Islands and Thikombia. In 1820, Bellinghausen discovered the islands around Oni-i-Lau, and D'Urville made further discoveries in 1827. Features shown on modern charts, such as Bounty Boat Passage, Bligh Water, D'Urville Channel and Heemskercq, Duff and Astrolabe reefs, are testimony to these early discoveries.

The first systematic hydrographic surveys in Fiji did not take place until 1838, commencing with those by Captain Bethune on board HMS Conway; and in 1840, by Captain Belcher aboard HMS Sulphur. In the same year, Commander C. Wilkes, United States Navy, from the United States Exploring Expedition, completed the first systematic survey of the whole of the Fiji group. The most notable and prolific large-scale surveys were carried out by Captain Denham, Royal Navy, aboard HMS Herald between 1854 and 1857, in response to rapidly increased trade between Australasia, the islands of the Pacific and the Americas. The first chart of Fiji with any approach to accuracy was published in 1814 in London by Arrowsmith in response to the growing sandalwood trade, but the first large-scale chart of Fijian waters published by the British Admiralty was chart 1757, Nukulau Port, in 1847, based on Captain Belcher's survey in 1840. Numerous large-scale charts engraved from Denham's surveys were published between 1865 and 1867, and several of these charts are still published today. Numerous other surveys were carried out in the nineteenth century, particularly those aboard HMS Alacrity, Pearl, Beagle, Curacoa and Waterwitch. By 1900, the Admiralty catalogue of the time shows that 23 charts of Fiji had been published. The period from 1900 to 1945 was relatively quiet as far as surveying is concerned, although surveys were completed from British ships HMS Torch, Laburnum and Veronica; and others were completed from the Australian ship HMAS Fantome in 1917 and 1918. The 1945 catalogue of Admiralty charts shows that as a consequence of the surveys carried out, several new editions to charts were published.

SURVEYING AND CHARTING, 1945-1968

The responsibility for surveying and charting during the period 1945-1968 remained firmly with the United Kingdom. For general naval purposes, however, Fiji was designated as within the New Zealand administrative area. It was in this context that, in 1952, the Commanding Officer of the New Zealand surveying ship HMNZS Lachlan (who was a Royal Navy Surveying Officer on secondment) represented the United Kingdom Hydrographer on a government committee at Suva, to consider the formation of a local Fijian hydrographic unit and at the same time to identify areas requiring urgent resurveying. It was recommended that the Fiji group of islands required a new scheme of charts to meet the needs of modern shipping. The Fiji Marine Department was keen to set up a hydrographic unit but lacked the necessary finance and expertise.

HMNZS Lachlan carried out some survey work in 1952 while en route to the then New Zealand Island Territories, even though the responsibility for surveying in Fiji did not lie with New Zealand. A number of the main shipping channels were examined to identify likely reefs and shoals, using coastline and aerial photography supplied by the Lands and Survey Department, Fiji.

The United Kingdom Hydrographic Department planned a new series of charts to replace the existing charting based on nineteenth century requirements, and this was forwarded to the Marine Department, Fiji, and to the Commanding Officer of the HMNZS Lachlan for comment. As a result, the compilation of one British Admiralty chart, BA 1660, Suva Harbour, was commenced immediately using information supplied by the Harbour Master at Suva.

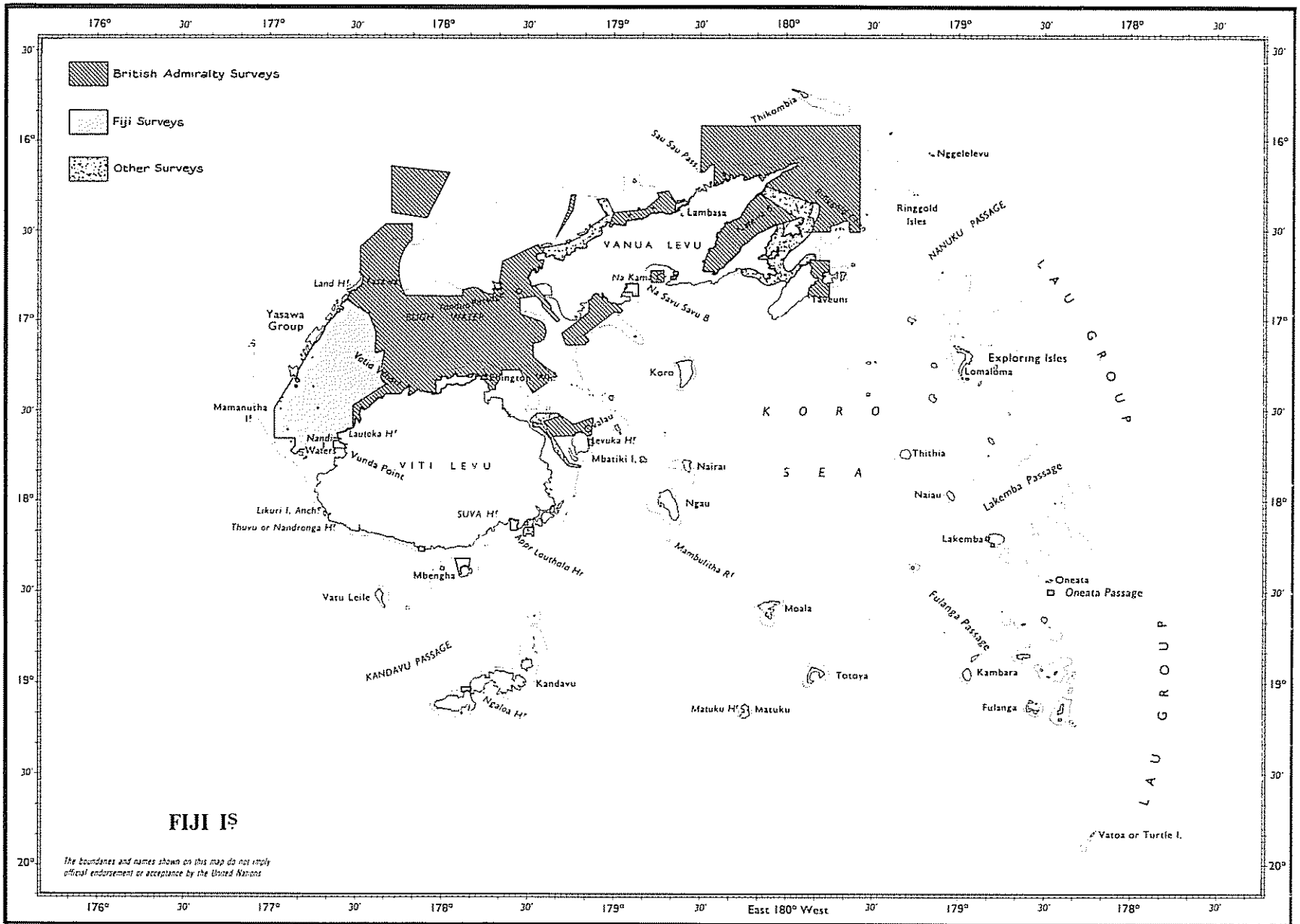
The requirement of modern shipping for new charts brought with it further requests for survey work to be carried out. In 1955, the new Commanding Officer of HMNZS Lachlan, Commander G. S. Ritchie 1/ of the Royal Navy, confirmed this requirement in letters to Rear-Admiral E. G. Irving, United Kingdom Hydrographer, as follows: "It is in Fiji that I think surveys in the British Pacific are most required, for there are large coastal areas of completely unsurveyed water and it is customary for overseas ships to travel through the Fiji Group of islands to collect produce".

He subsequently advised: "After discussions with the Harbourmaster, Suva, local pilots and other Government and Shipping Authorities it is considered that the following surveys are required in Fiji...". The surveys were listed in order of importance.

As a result of this correspondence and similar requests from Solomon Islands, the Royal Navy survey ship HMS Cook was deployed to the Pacific in 1957. Surveys were carried out in successive years until October 1963, when an uncharted reef in Bligh Water effectively ended her surveying life. The accident only served to confirm the need for urgent survey work. HMS Dampier was seconded from her South-East Asian station in 1965-1966 in order to complete more survey tasks. The HMSS Cook and Dampier surveys were carried out in close co-operation with the local authorities in Fiji who were able to advise on areas of priority; those completed are listed in table 53 (see annex) and included in figure 192. The following quotes from letters of proceedings confirmed the excellent level of international co-operation. In 1963, HMS Cook reported: "The co-operation and collaboration of all Departments of the Government of Fiji have been freely given and invaluable. I should also like to mention the co-operation of the Fiji Military Forces". In 1965, HMS Dampier stated: "Exceptional assistance and help was obtained from all the local residents. The Lands Department in Suva and Lambasa produced air photographs and coordinates as well as servicing the triangulation stations.

During the period 1945-1968, there was mutual assistance in aspects of charting, and the Fiji Marine Department supplied Notices to Mariners and other information necessary for the maintenance of existing British Admiralty charts. Four new charts (BA 379 and 381, both Bligh Water; 488, Suva Harbour to Tanavuso Point; and 495, Sau Sau Passage to Rhinggold Channel) and several new editions were published by the United Kingdom Hydrographic Department. The need for modern echo-sounded surveys and a conscious decision to await the publication of revised mapping being carried out by the United Kingdom Directorate of Overseas Survey delayed the start on other charts planned.

Figure 192. United Kingdom of Great Britain and Northern Ireland: diagram showing modern bathymetric surveys of Fiji, 1945-1982



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FORMATION OF THE FIJI HYDROGRAPHIC UNIT, 1968

In 1966, a United Nations hydrographic study was initiated to assist in the survey of the development of maritime transport in the Fijian archipelago. The outcome was the formation in 1968 of the Fiji United Nations Transport Survey, which was led by a United Nations Development Programme project leader, with a deputy joining the project at a subsequent date to assist with training. The project was subjected to close scrutiny in 1969. However, following discussions in Fiji with interested parties, including the then United Kingdom Hydrographer, Rear-Admiral G. S. Richtie, it continued under the control of the Fiji Marine Department, with the United Nations assisting with equipment and personnel. With some changes in organization and detail, the Hydrographic Unit, as it later became known, continues to be funded in part by the United Nations.

Surveying and charting, 1968-1976

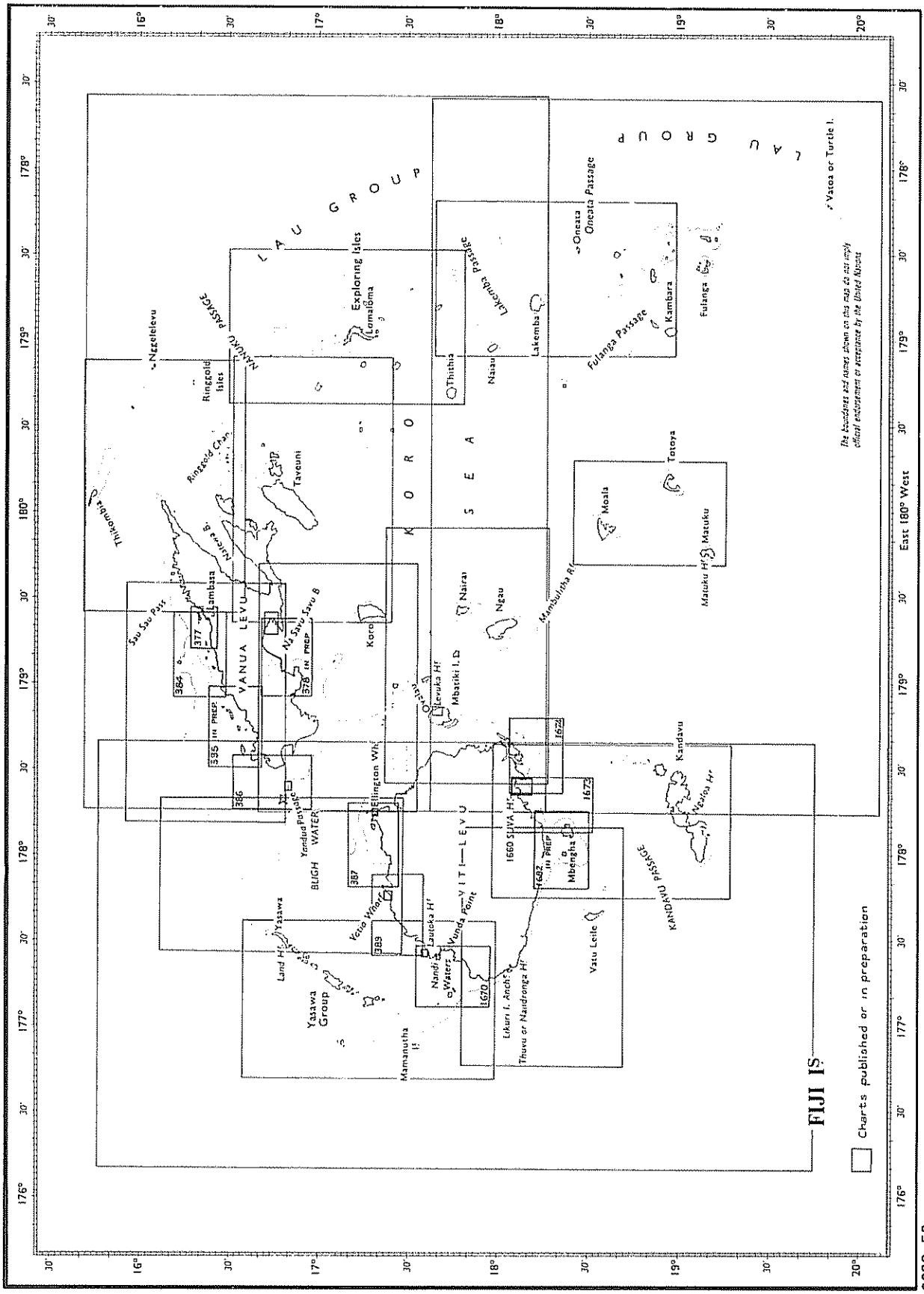
The formation of the United Nations Transport Survey, Fiji, followed closely decisions made by the United Kingdom Hydrographic Department to modernize and metricate its chart series (the traditional unit of depth used hitherto being the fathom) and to rationalize chart coverage to meet predominantly the needs of international shipping. It was, therefore, an opportune time to reconsider the scheme of charts for Fiji and to discuss these with the Director of Marine, the United Nations Transport Survey, the harbour-master at Suva and other interested parties. Close co-operation was developed and strenghtened by the visit to Fiji of the United Kingdom Hydrographer and by the United Nations officers visiting the United Kingdom Hydrographic Department. The new scheme of charts (see figure 193) was constructively criticized although it was appreciated that a reduction in chart coverage compared with the scheme envisaged in the 1950s was necessary. Preparation and publication of the sheets of the new metric series is still proceeding.

The following principles and details were agreed to for the new chart series:

(a) Port plans and anchorages. Large-scale charts and plans would be necessary for both existing and new ports used by international shipping. There would, however, need to be a reduction in the number of harbours and anchorages charted at a large-scale. Specific local requirements would have to be met by locally produced surveys and charts. As a consequence of this policy, a new chart of Lambasa (BA 377), and new inset plans of Vatia Wharf and the oil port of Vunda Point (BA 1670) were planned. Several existing large-scale charts, including BA charts 103, 741, 1247, 1248, 1251 and 1252 were to be withdrawn without replacements when the charts at 1:150,000 scale had been metricated. Many of these changes have still to be made; the charts mentioned can be identified in figure 194 and table 54 (see annex);

(b) Coastal series of charts. Additional charts at 1:50,000 scale in the approaches to the main ports and in the inner reef areas used as routes to these ports would be necessary. As a consequence, charts 1672, 1673 and 1674, Approaches to Suva; 384, 385 and 386, Yandua Passage to Malau; and 387 and 389, Approaches to Lautoka, Vatia and Ellington Wharves, were planned. Most of these charts have been published;

Figure 193. United Kingdom of Great Britain and Northern Ireland: diagram of British Admiralty chart metrication scheme



(c) Medium-scale charts at 1:150,000 scale. Coverage would be extended to meet the needs of cruise vessels and cargo ships passing through the routes between the eastern Lau Group of islands (i.e., Nanuku, Lakemba and Oneata Passages) en route to Suva. Extended coverage was also to be provided for cargo ships navigating outside the north-western barrier reef but using passages through the reef to reach ports within;

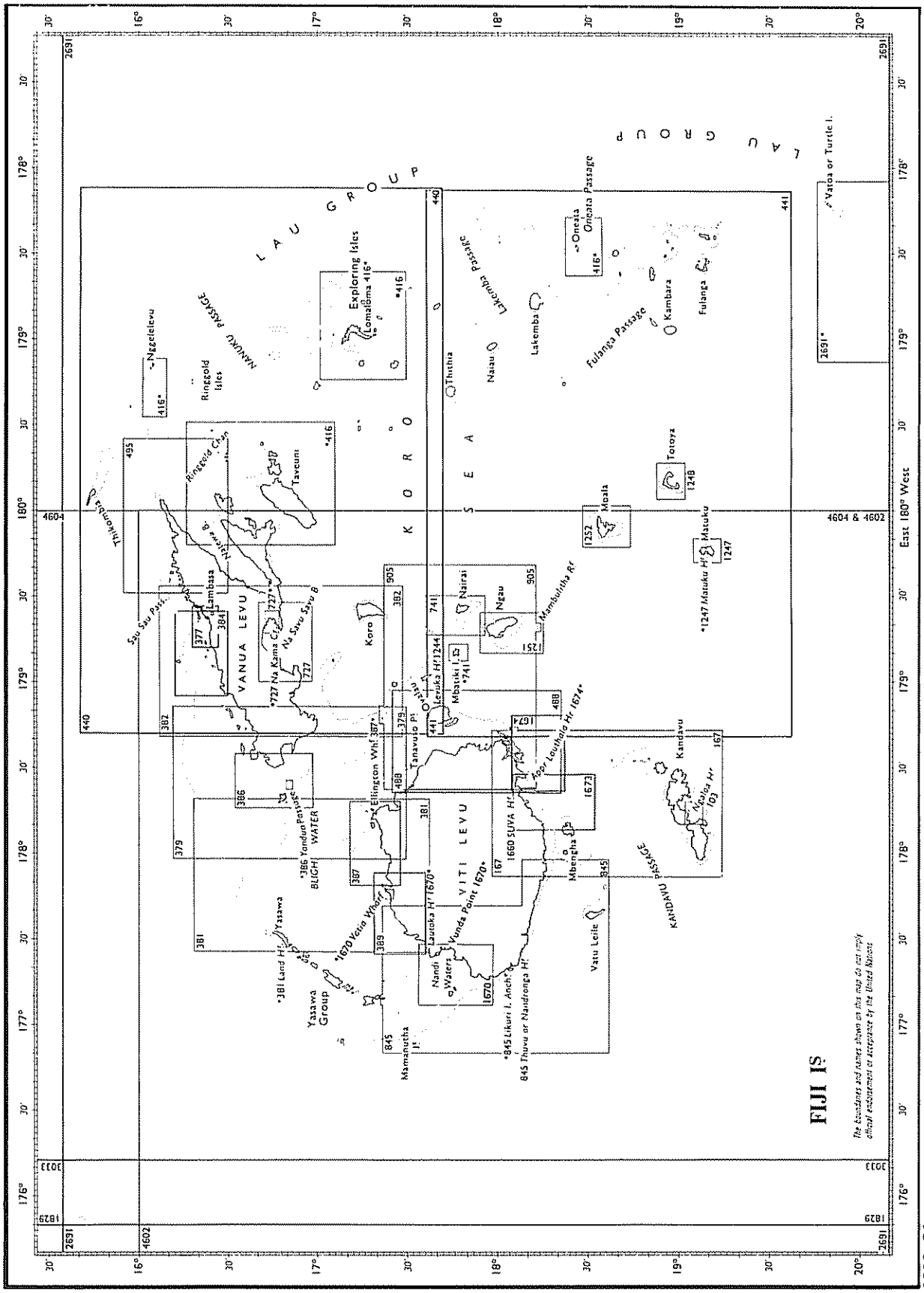
(d) Small-scale charts. It was considered that charts smaller in scale than 1:150,000 would be published as previously.

Fijian independence in 1970 did not affect the close co-operation between the Hydrographic Unit, Fiji Marine, and the United Kingdom Hydrographic Department. During the period from 1968 to 1973, they concentrated on working out priorities and details of the new metric chart scheme, on new surveys required to compile these charts and on the supply of information to maintain existing charts. For example, there was need for a modern survey and chart of Ellington Wharf and it was agreed that the Hydrographic Unit would undertake the survey and supply this to the United Kingdom, which would give priority to producing a chart of the area (BA 387). On the other hand, the urgent need for new charts of the inner reef route between Yandua Passage and Malau could not be considered until more extensive surveys could be carried out by HMS Hydra in 1974, and more recently by the New Zealand survey ship HMNZS Monowai. These surveys were not within the capabilities of the Fiji Hydrographic Unit, owing to a lack of staff and equipment, and also because there were more urgent local requirements to survey new sites for jetties and harbours to meet modern transport and development needs throughout the islands.

It was the requirements for charts for use by shipping which led to the demand once again for extensive modern surveys. In response to a request by Fiji in 1972, HMS Hydra was entrusted with carrying out more surveys in conjunction with other work requested in the Pacific. Following the arrival of HMS Hydra in 1974, there was close co-ordination between the United Kingdom and the Fijian authorities. As shown in table 53 (annex) and figure 195, extensive surveys were carried out in the western and northern parts of Bligh Water, including Yandua Passage and its approaches, and in the inner reef areas between Yandua and Yangganga on the north coast of Vanua Levu. The presence of HMS Hydra led to direct co-operation in surveying with the Fijian Hydrographic Unit. A Hifix chain was established with stations at Yasawa (Master), Vomo Island and Cocoanut Point, Vanua Levu, with the resources to establish, man and service these stations from the ship by both boat and helicopter. The chain was used by the Hydrographic Unit, Fiji; and with the aid of personnel from HMS Hydra, an extensive survey was carried out between the Yasawa Islands and Lautoka. Unfortunately, after the withdrawal of HMS Hydra in 1975, much survey work remainded to be done.

In 1974, the first metric chart compilations and proofs (BA 1660, Suva Harbour; and in 1670, Plans in Nandi Water, Lautoka, Vunda Point and Vatia) were forwarded to Fiji for comment. Queries raised by the United Kingdom Hydrographic Department were answered and compilations field-checked. Nandi Water was field-checked with the help of an additional survey and use was made of photo-plots supplied by the Lands and Surveys Department. Additional photography of the harbours on BA 1670 was carried out by an HMS Hydra Wasp helicopter. BA 377, Approaches to Lambasa, was field-checked by HMS Hydra, but valuable comment was also received from the local pilot.

Figure 194. United Kingdom of Great Britain and Northern Ireland: index of British Admiralty charts of Fiji, 1982



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In the latter part of 1975, the Hydrographic Unit, Fiji Marine, was reorganized. The period prior to it had been significant in that not only had many large-scale surveys been carried out by the Unit (see table 53) but, for the first time, several monochrome surveys and charts were published and sold for local use (see table 55 in annex and figure 195).

The period 1976-1982

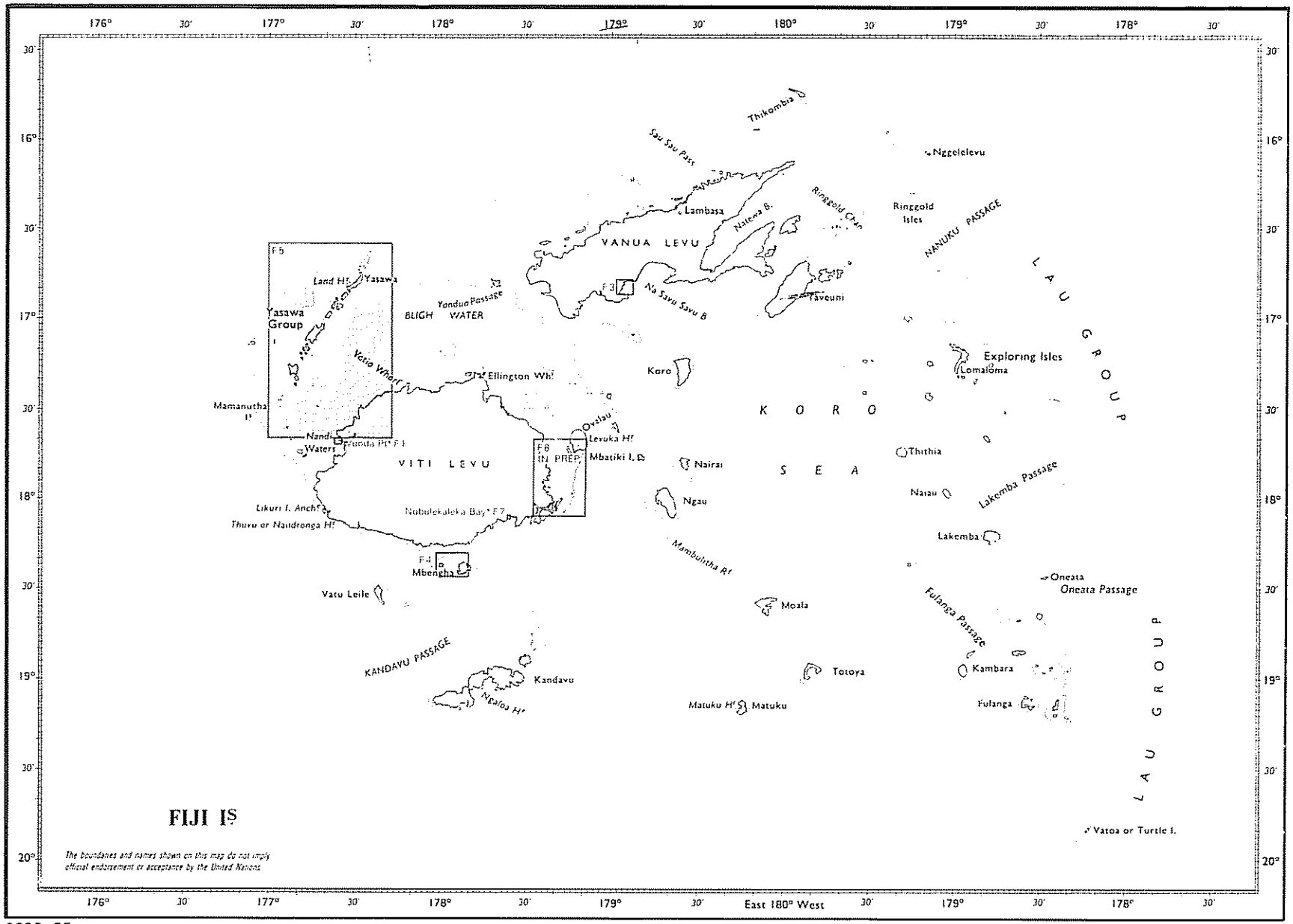
In 1976, the Fiji Hydrographic Unit was transferred to the Naval Squadron, Royal Fiji Military Forces (RFMF). The United Nations civilian expert serving as deputy before the reorganization took charge of the Unit and remained in control until 1979. Subsequently, for administrative reasons, the possibility of a naval hydrographic officer from Australia, New Zealand or the United Kingdom heading the Unit was explored. The outcome was that a British naval surveying officer took over in 1979, with the United Nations expert remaining to assist. The secondment has been extended for a further period but eventually it is expected that the post will be filled by a Fijian hydrographic officer.

The assistance by the United Nations in both personnel and equipment has been maintained in the period since reorganization. Australia and New Zealand have also helped with the supply of additional equipment, with the training of naval officers, ratings and cartographic staff, and with the printing of Fijian surveys and charts. Further assistance has been received from the Royal Australian Survey Corps, who have fixed several islands by Doppler satellite, to be used as base points to define the Fiji 200-mile economic zone. In 1982, the New Zealand survey ship HMNZS Monowai completed an extensive survey in the inner reef area north of Vanua Levu between Yangganga and Ravi Ravi Passage, thus filling a gap between the surveys carried out by HMS Hydra in 1974 and HMS Dampier in 1966, and permitting compilation of new metric chart BA 385 to be initiated.

The co-operation in charting between the Fiji Hydrographic Unit, RFMF, and the United Kingdom Hydrographic Department has continued. In 1976 and 1977, several metric chart compilations and proofs were submitted for field-checks and comment. These included British Admiralty charts 386, 387, 389, 1673 and 1674 (see figure 194 and table 54). Discussions on the limits and scales of other metric charts also took place.

In the period since 1979, correspondence on charted detail has become more prolific and concerned with the information necessary for the maintenance and updating of Admiralty charts and with the exchange of survey data held by both offices. There has also been discussion with the Officer-in-Charge of the Fiji Hydrographic Unit on details of new metric charts, including the planned 1:150,000 series which have been delayed awaiting survey and satellite positional data. A regular supply of Notices to Mariners issued by the Fiji Marine Department has been supplemented by additional information obtained from local Pilots and Ship's Masters, and from aerial photographs and photo-plots. The most striking feature has been the speed of communication over the great distance between Fiji and the United Kingdom, with modern systems permitting information to be supplied and queries answered, sometimes within a 24-hour period. This has greatly enhanced the ability to give this information speedily to the mariner.

Figure 195. United Kingdom of Great Britain and Northern Ireland: index of charts produced by Fiji, 1971-1982



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As a result of information supplied, the following new editions of British Admiralty charts have been published:

(a) BA 379 and BA 381, Bligh Water. New surveys from HMS Hydra and the Fiji Hydrographic Unit were incorporated;

(b) BA 1244, Lavuka Harbour. New survey by the Fiji Hydrographic Unit;

(c) BA 1674, Approaches to Suva Harbour. The plan of Rewa Road was extended as requested by the Fiji Hydrographic Unit in consultation with users;

(d) BA 488, East coast of Viti Levu. From information supplied by the Fiji Hydrographic Unit, United Kingdom Hydrographic Department, photo-plot and lines of soundings, HMS Cook.

Currently in hand are:

(a) BA 1674, Approaches to Suva Harbour. Information from a cable survey. Miscellaneous information from the Fiji Hydrographic Unit;

(b) BA 1660, Suva Harbour. Fiji Lands and Surveys maps and photo-plot. Fijian surveys.

Three block corrections (stick-on patches) to British Admiralty charts and several Notices to Mariners have also been issued. Three metric charts--BA 1672, Mbengga Passage; 378, Savusavu Bay; and 385, Yangganga Island to Ravi Ravi Passage--are at an advanced stage of compilation; and with the receipt of positional data, the 1:150,000 series of charts is again actively being prepared.

In the period 1976-1982, the Fiji Hydrographic Unit, RFMF, has continued to flourish. A large number of large-scale harbour and port development evaluation surveys has been completed. A selection of these is included in table 53. In addition to those listed are many completed at a very large scale to help evaluate possible jetty sites to improve transport facilities within the islands, an essential requisite to meet the needs of a maritime country with over 100 inhabited islands. Cartographic ability within the Unit has developed; and it has received encouragement to compile large-scale charts for use by administrators, yachtmen and other local users to supplement the Admiralty chart series (see figure 195 and table 55). In 1981, a milestone was reached with the publication of the first coloured metric plan of Nubulekaleka Bay, Suva Harbour, on the scale 1:1,500 and coloured overprinted versions of Admiralty charts showing the Fiji 200-mile economic zone have also been published. The training of hydrographic officers and ratings has taken place, and a base for the maintenance of electronic equipment has been established. Another milestone has been reached with the application by Fiji to become a member of the International Hydrographic Organization in accordance with the recommendations of the report of the United Nations Group of Experts on Hydrographic Surveying and Nautical Charting in 1968 (E/CONF.71/L.1, para. 62). The Hydrographic Unit has also been instrumental in putting forward the idea of the formation of a South-West Pacific Hydrographic Commission, and Fiji's observer at the International Hydrographic Conference held in Monaco in April 1982 played a significant part in the discussions on specialist and technical advice to developing countries.

FUTURE CO-OPERATION

The period since 1945 has been one of considerable hydrographic co-operation in Fiji. It has also been a period in which the Fiji Hydrographic Unit has been formed and considerable progress made in both surveying and charting. Much requires to be done, however, and a further period of international co-operation and assistance will be necessary before Fiji is able to assume responsibility entirely. It is hoped that the formation of a South-West Pacific Hydrographic Commission in the International Hydrographic Organization, with the aim of co-ordinating surveying and charting requirements as well as assuming the role of area adviser to Governments requesting advice on hydrographic matters, will proceed. This would provide a formal base for the co-operation that already exists and would be of undoubted value to Fiji and other island States within the area.

Note

1/ Commander Richtie was President of the Directing Committee of the International Hydrographic Organization from 1972 to 1982.

Annex

Table 53. Modern echo-sounded surveys, Fiji, 1946-1982

Survey	Ship	Scale	Year
1. Surveys by the Royal Navy, 1945-1982			
Vuya Passage	HMS Cook	1:51 000	1957
Viti Levu, Search for Breakers	HMS Cook	1:37 000	1957
Natewa Bay	HMS Cook	1:75 000	1957
Vuya Passage	HMS Cook	1:50 000	1959
Approaches to Lambasa	HMS Cook	1:2 500	1959
Viti Levu to Ovalau	HMS Cook	1:50 000	1959
Sau Sau Passage to Ringgold Channel	HMS Cook	1:75 000	1961
Langalanga River to Tilangitha Passage	HMS Cook	1:25 000	1961
Savusavu Bay	HMS Cook	1:50 000	1961
Tasman Strait, Taveuni	HMS Cook	1:50 000	1961
Vuya Passage to Wainunu Bay	HMS Cook	1:51 000	1962
Wainunu Bay	HMS Cook	1:25 000	1962
Sau Sau Passage to Ringgold Channel	HMS Cook	1:75 000	1962
Yandua Passage	HMS Cook	1:50 000	1963
Talai Bar, Yandua Island	HMS Cook	1:24 000	1963
Bligh Water, Sheet 1, Round Island Passage	HMS Cook	1:75 000	1963
Bligh Water, Sheet 2, Round Island Passage to Vatu-i-ra	HMS Cook	1:75 000	1963
Approaches to Ellington Wharf	HMS Cook	1:25 000	1963
Nukurauvula Pass	HMS Cook	1:25 000	1963
Nakusa Passage and Ndalithe Harbour	HMS Cook	1:25 000	1963
Nai Vaka to Vatia Wharf	HMS Cook	1:50 000	1963

Table 53 (continued)

Survey	Ship	Scale	Year
1. Surveys by the Royal Navy, 1945-1982 (continued)			
Vatu-i-ra Channel	HMS Dampier	1:100 000	1966
Mali Pass to Mbasa Bay	HMS Dampier	1:75 000	1966
Vatututotolu to Yasawa Island	HMS Hydra	1:100 000	1974
Vatia to Ve Ndrala	HMS Hydra	1:25 000	1974
Mba Passage to Malake Passage	HMS Hydra	1:50 000	1974
Yandua Passage	HMS Hydra	1:10 000	1974
Approaches to Yandua Passage	HMS Hydra	1:100 000	1975
Yandua Island to Rukuruku Bay	HMS Hydra	1:25 000	1975
Rukuruku Bay to Yangganga	HMS Hydra	1:25 000	1975
Lekumbi Point to Nambouwalu	HMS Hydra	1:25 000	1975
Tevoro Passage, Great Sea Reef	HMS Hydra	1:100 000	1975

Survey by	Scale	Year
2. Selection of major surveys by Fiji (Scales larger than 1:2,000)		
United Nations Transport Survey		
Lautoka Harbour	1:3 168	1968
Savusavu, Approaches to Nakama Creek	1:3 168	1968
Vunda Point	1:3 168	1968
Suva Harbour	1:3 168	1969
Fiji Marine Department		
Yandua Passage	1:9 504	1970
Lakemba West Coast, Oru Bay	1:12 000	1971
Lakemba South Coast, Tumbou	1:12 000	1971
Vunda Point	1:6 336	1971
Approaches to Oinafa-Rotuma	1:7 920	1971
Ellington Wharf	1:12 500	1971
Namuka Reef, Volivoli Point	1:25 000	1971
Nayavu Passage and Anchorage	1:25 000	1972
Tumbou Jetty Site, Lakemba	1:3 168	1974
Lambasa River	1:25 000	1974
Lambasa River	1:6 000	1974
Lautoka Yacht Club	1:3 168	1974
Nukurauvula Passage	1:25 000	1974
Nandi Waters	1:75 000	1974
Western Bligh Water	1:100 000	1975
Freight Station, Lauthala Bay	1:12 000	1975
Oinafu Bay and Jetty Site, Rotuma	1:2 000	1975
Mbengga Lagoon	1:25 000	1975
Lautoka to Yasawa Island	1:150 000	1975

Table 53 (continued)

Survey by	Scale	Year
2. Selection of major surveys by Fiji (continued) (Scales larger than 1:2,000)		
Fiji Hydrodraphic Unit, Royal Fiji Military Forces		
Mbengga Lagoon	1:12 500	1976
Levuka Harbour	1:5 000	1976
Malau Wharf and Vicinity	1:12 500	1977
Vatoa to Ono-i-lau	1:250 000	1977
Namalata Bay, Kandavu	1:10 000	1978
Namalata Bay, Kandavu	1:10 000	1979
Soso Bay	1:10 000	1979
Proposed Lautoka Sewage Outfall	1:5 000	1979
Lami Oil Terminal, Suva	1:2 000	1979
Levuka Harbour, Ovalau	1:2 000	1979
Valanga Bay	1:2 000	1979
Lautoka Harbour	1:2 000	1979
Approaches to Malau	1:10 000	1980
Proposed Container Terminal Lautoka	1:2 500	1982
Oneata Passage	1:50 000	1982
Suva Harbour	1:50 000	1982
3. Other surveys		
Master Mariners		
Natewa Bay and vicinity	1:160 000	1946
HMNZS Lachlan		
Tava Passage, Viti Levu	1:25 000	1952
Moturiki to Dawasuma River	1:25 000	1952
Moturiki Passage	1:25 000	1952
Natewa Bay	1:100 000	1963
HMNZS Monowai		
Lauthala Bay	1:20 000	1980
Yangganga to Ravi Ravi Passage	-	1982

Table 54. Admiralty charts of Fiji as of 1982

Chart No.	Title of chart or plan	Natural scale	Date of publication	New edition
103	N'galoa Harbour	1:24 200	October 1875	April 1960
167	Kandavu Island and Passage	1:142 000	May 1878	July 1962
377	Approaches to Lambasa[a/]	1:25 000	July 1976	-
379	Bligh Water, eastern portion	1:150 000	April 1967	March 1977
381	Bligh Water, western portion	1:150 000	April 1967	March 1980
	Land Harbour (Nadala Bay)	1:25 000		
382	Vanua Levu - central portion, with Makongai and Koro	1:144 000	January 1897	July 1968
384	Ravi Ravi Point to Mali Island[a/]	1:50 000	November 1977	-
386	Yandua Island to Yangganga Island[a/]	1:50 000	October 1978	-
	Yandua Passage	1:15 000		
387	Vatia Lailai to Viti Levu Bay[a/]	1:50 000	January 1979	-
	Ellington Wharf	1:12 500		
389	Lautoka to Vatia Lailai[a/]	1:50 000	March 1978	-
416	Passages and anchorages in Fiji Islands	-	August 1942	April 1960
	Nggele Levu Lagoon, Exploring Isles and Oneata	1:150 000		
	Lomaloma	1:25 000		
	Tavenni with adjacent islands, reefs and passages	1:150 000		
440	Fiji islands - eastern group, northern portion	1:351 000	August 1863	April 1960
441	Fiji Islands - eastern group, southern portion	1:348 000	June 1883	May 1974
488	Suva Harbour to Tanavuso Point	1:100 000	October 1956	November 1973
495	Sau Sau Passage to Ringgold Channel	1:100 000	November 1964	-
727	Na Savu Savu Bay	1:101 000	December 1876	August 1940
	Na Kama Creek	1:6 100		
	Valanga and Savareka-reka Bays	1:23 000		
741	Nairai and Mbatiki Islands	1:36 300	February 1866	-
845	Kandavu Passage to Kuata Island	1:142 000	January 1879	June 1967
	Likuri Island Anchorage	1:7 260		
	Thuvu or Nandronga Harbour	1:7 470		
905	The coastline and reefs extending from Suva Harbour to Levuka, with the adjacent islands to the eastward (Ngau, Nairai, Mbatiki, Wakaya and Makongail)	1:143 000	May 1882	December 1960
1244	Levuka Harbour	1:13 970	January 1882	September 1978
1247	Matuku	1:24 200	December 1865	-
	Matuku Harbour	1:12 100		

Table 54 (continued)

Chart No.	Title of chart or plan	Natural scale	Date of publication	New edition
1248	Totoya	1:24 200	December 1865	-
1251	Ngau Island and Mambulitha Reef	1:36 300	December 1866	-
1252	Moala	1:36 300	August 1867	-
1660	Suava Harbour[a/]	1:12 000	May 1977	-
1670	Plans in Viti Levu:[a/]		December 1976	-
	Lautoka Harbour: Vunda Point	1:7 500		
	Vatia Wharf	1:25 000		
	Nandi Waters	1:75 000		
1673	Western approaches to Suva Harbour[a/]	1:50 000	September 1979	-
1674	Eastern approaches to Suva Harbour[a/]	1:50 000	November 1977	September 1980
	Approaches to Lauthala Harbour	1:25 000		
2691	Fiji Islands	1:800 000	February 1970	-

a/ Metric chart.

Table 55. Charts published by Fiji

Chart No.	Title of chart	Natural scale	Date of publication	New edition
F1	Vunda Point	1:6 336	1971	-
F2	Bau waters, Guide to Yachtsmen (Overprint to BA 488)	1:100 000	1972	(withdrawn)
F3	Nayavu passage and anchorage	1:25 000	1972	-
F4	Mbengga Lagoon	1:25 000	1975	-
F5	Lautoka to Yasawa Islands	1:150 000	1976	-
F6	Diagram showing median point positions or the 200-mile exclusive economic limits	1:3 500 000	1981	-
F7	Nubulekaleka Bay	1:1 500	1981	-
F8	Bau waters	1:50 000	In preparation	-

Table 55 (continued)

Chart No.	Title of chart	Natural scale	Date of publication	New edition
-	Charts showing the archipelagic basepoints, baselines, internal waters and territorial seas of Fiji (overprints to BA 780, 2691, 2992)	1:72 900 1:800 000 1:6 900 000	1981 1981 1981	-

BATHYMETRIC MAPPING EFFORTS*

Paper submitted by the United States of America

RESUME

Les océans qui entourent les Etats-Unis d'Amérique ne sont plus considéres uniquement comme un réservoir alimentaire, une zone de loisir ou un moyen de transport de marchandises, mais comme un capital irremplaçable de ressources naturelles dont le pays a un besoin vital pour maintenir sa croissance industrielle et le bien-être de sa population.

Partant du principe que les scientifiques et les ingénieurs doivent disposer d'informations de base solides sur le milieu marin, le Service national de recherches océanographiques du Ministère américain du commerce a élaboré en 1966 un programme d'établissement de cartes bathymétriques par lequel on s'est proposé d'établir systématiquement une collection de cartes bathymétriques représentant les détails topographiques et géologiques des fonds océaniques de façon suffisamment précise pour permettre aux scientifiques et aux ingénieurs de décider à bon escient de la mise au point de techniques propres à l'exploration, à l'extraction et à la gestion de ces importantes ressources minérales.

Au cours des 17 dernières années, on a élargi quantitativement et qualitativement ce programme qui s'est enrichi d'une collection exceptionnelle de cartes topographiques/bathymétriques (topobathymétriques) des régions côtières des Etats-unis qui permettent de

* The original text of this paper, prepared by Norman E. Banks, Chief, Chart Information Branch, Marine Chart Division, National Ocean Survey, National Oceanic and Atmospheric Administration, appeared as document E/CONF.75/L.52.

faire la jonction avec la collection de cartes bathymétriques du rebord externe du plateau continental.

Dans le présent document, on présente brièvement les cartes topo-bathymétriques et bathymétriques, leur objet et les informations qu'elles contiennent.

Prior to 1966, the National Ocean Survey (NOS) had no systematic bathymetric mapping programme to address the needs of the ocean-oriented community. An increased demand for ocean-bottom topographic information, coupled with NOS availability of enormous amounts of oceanographic data and existing expertise, led NOS to establish a bathymetric mapping programme in 1966.

Production remained at a comparatively low level between 1966 and 1974. During that time, approximately 54 maps of various scales, formats and contour intervals were produced. In 1975, the pace of exploration for natural resources on the outer continental shelf was increased to the point where an accelerated 1:250,000 scale bathymetric mapping programme became necessary as activity moved farther and farther off shore. At the same time, the need for knowledge of the United States coastal zone environment moved from a passive to a very active national, state and civic concern. This resulted in NOS and the United States Geological Survey (USGS) combining mapping skills to produce a series of topographic/bathymetric (topo/bathy) maps of the coastal zone on the scales 1:24,000, 1:100,000 and 1:250,000. Between 1975 and 1983, NOS produced over 300 bathymetric products to support resource development on the outer continental shelf, numerous scientific and engineering endeavours and coastal-zone programmes.

BATHYMETRIC MAPS

The acceleration of bathymetric map production in NOS resulted primarily from the need to keep abreast with outer continental shelf requirements, as requested by the Minerals Management Service (MMS) of the Department of the Interior. It is the responsibility of MMS to evaluate and lease the federally-controlled land on the outer continental shelf for all resources, including gas and oil. Bathymetric maps are required in unison with other information for the preparation of comprehensive environmental impact statements of potential gas and oil areas and oil areas that will be leased to the private sector for exploration and development.

During the past eight years, 96 bathymetric maps have been produced for MMS: 32 maps cover the Gulf of Mexico; 47 cover the east coast; 4 cover the west coast; and 13 are of Alaska's Shelikof Strait, Cook Inlet and Norton Sound. An additional 5 of the Atlantic coast, 2 of the west coast and 3 of Alaska are currently at various stages of production.

Bathymetric maps are produced on the Universal Transverse Mercator projection at 1:250,000 scale. Each map covers a geographical area of one degree of latitude by two degrees of longitude, except for Alaska, where the longitudinal coverage is three degrees. Map coverage of the outer continental shelf extends to the United States 200-mile fishing conservation boundary. As with all bathymetric maps produces by NOS, the contours are in metres. All contouring is done

manually on the scale of the original hydrographic surveys, which vary from 1:2,500 to 1:120,000 and smaller. Compilation at the original survey scale ensures that all data collected shall be utilized, maximizes development of the smaller detail and maintains uniformity in the different scale maps produced by NOS.

To portray the tremendously varied configuration of the shelf and slope that occurs from one geographical region to another, various contour intervals are used. This maximizes the amount of detail that can be shown while maintaining clarity. Contour interval determination is based on the complexity of the bottom terrain, the slope and the amount of hydrographic data available. Typically, on the east coast, the 1:250,000 scale maps south of 42° North latitude have 10-m contour intervals supplemented by 2 m out to the 200-m contour line. Beyond the 200-m contour line, the interval is every 50 m supplemented by 10-m contours. For those maps covering the areas north of 42° latitude, the steep slope and terrain complexity will allow the 10-m contours to be shown only out to the 200-m contour line.

After the contours are compiled, they are photographically reduced and mosaicked at the final scale, or assembled and inked directly at the final 1:250,000 scale. The intermediate assembly of the manuscript is often used to facilitate the inking process and to ensure a minimal amount of generalization. Some generalization is introduced when the larger scale hydrographic contoured compilations are reduced and manually transferred to the much smaller scale final manuscript.

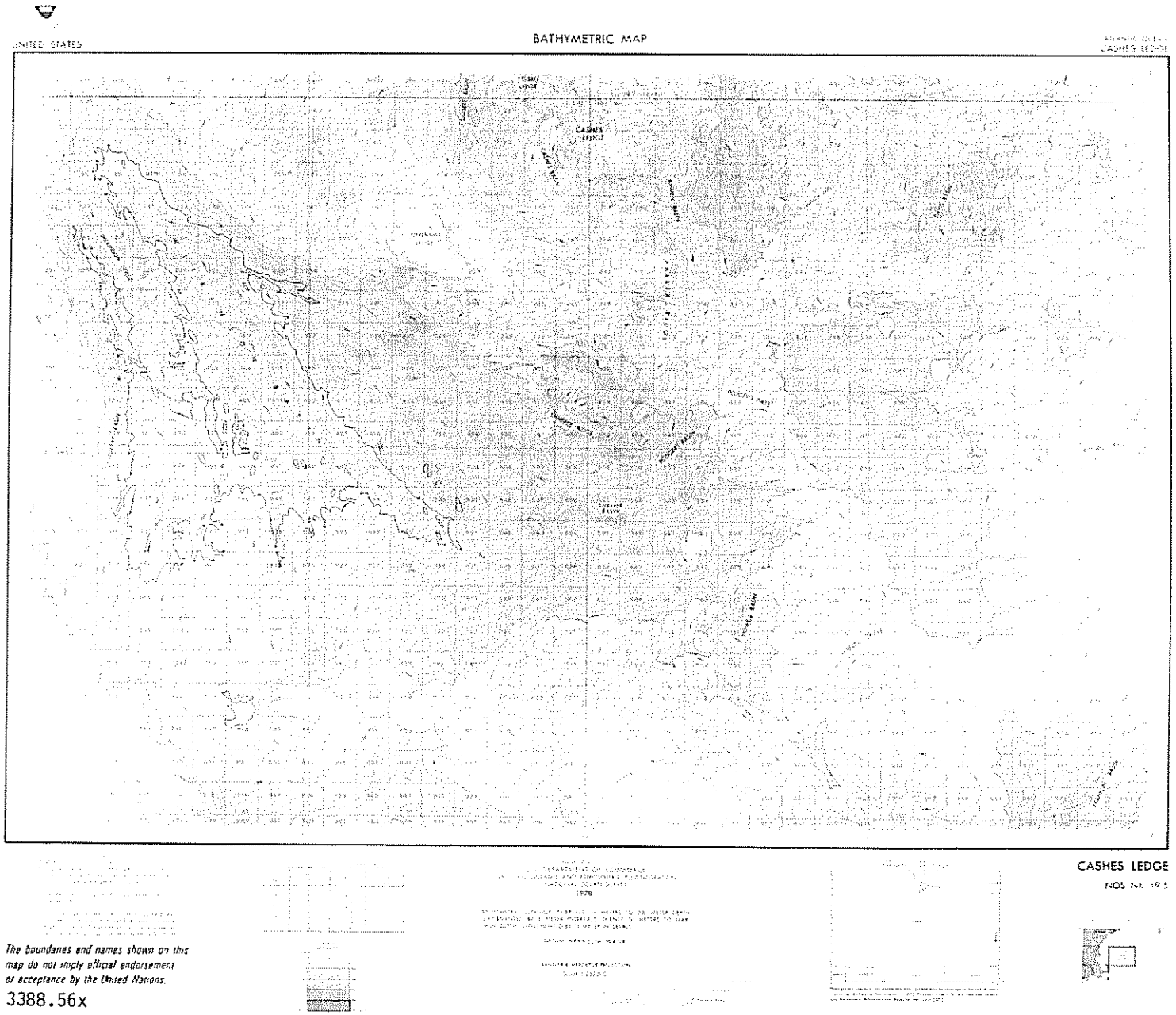
To ensure the immediate availability and distribution of the maps to the public, advance black-and-white copies are made from the inked manuscripts until such time as the map is printed.

Published maps are prepared from the manuscripts and are multicoloured with varying tints of blue to emphasize the bottom gradient. Additional information includes names of underwater features, gas and oil platforms, pipelines, spoil areas and dump sites, maintained channels, the 200-mile fishery enforcement limit; and, overprinted in red, the MMS offshore lease block information. Each lease block represents approximately 5,700 acres of land. Border information includes a hydrographic survey index, survey information, depth gradients and an index showing the adjacent maps published. Figure 196 is a reduced copy of a typical 1:250,000 scale NOS bathymetric map.

TOPOGRAPHIC BATHYMETRIC MAPS

To support the federal Government and state governments in effectively managing, developing and protecting the United States coastal areas, NOS and the United States Geological Survey formally agreed in 1975 to produce jointly a unique new series of maps that would portray both the land and ocean topography on a single map. This new series of topo-bathy maps combines NOS bathymetric and shoreline with existing 1:24,000, 1:100,000 and 1:250,000 scale topographic maps in the national mapping series produced by USGS.

Figure 196. United States of America: reduced 1:250,000 scale bathymetric map produced by the National Ocean Survey



Combining the bathymetry and topography on one map is cost-effective in that only one product is required instead of the previous two. More important, users for the first time can visualize the transition from land to water or vice versa and select the appropriate scale and detail desired for their planning, investigation and studies. This new map series has been immensely helpful to the federal, state and private sectors, which use them for a number of coastal zone activities including, but not limited to:

(a) Coastal environmental research and study;

(b) Coastal zone management and protection and costal resource assessment;

(c) Evaluation of the effects of various human actions on waters of the United States (e.g., effect on water quality, adjacent wetlands etc.);

(d) Bridge and fill design;

(e) Planning for port facilities and marinas;

(f) Marine resources studies;

(g) Recreational activities;

(h) Planning of locations of waste disposal sites;

(i) Review of proposed projects involving channelization, pipelines, pipeline corridors, bulkheads etc.

(j) Hurricane surge computation;

(k) Computaiton of sediment transport and rate of migration;

(l) Determination of problems areas with regard to erosion, flooding, shoaling etc.;

(m) Computation of quantities for dredging projects;

(n) Continuation of biological systems from land to water;

(o) Fishing industry and/or studies;

(p) Relation of distribution of marine organisms to depth;

(q) Determination of potential locations of important biological habitats--oyster-reefs, grass-beds, clam-beds etc.;

(r) Availability of natural access;

(s) Bathymetry as it relates to biological diversity and habitat types;

(t) Historic changes in bathymetry;

(u) Coastal erosion processes;

(v) Monitoring of utility thermal emissions and freshwater discharges;

(w) Estuarine modelling and studies;

(x) Mapping of sedimentary and faunal variations;

(y) Determination of the volume of water in sounds and estuaries;

(z) Establishment of seaward coastal zone boundaries;

(aa) Site placement studies;

(bb) Coastal engineering studies.

Topo/bathy maps are produced on the Universal Transverse Mercator projection at 1:250,000, 1:100,000 and 1:24,000 scales. The 1:250,000 scale map covers approximately 19,400 km^2, while the 1:100,000 and 1:24,000 scale maps cover approximately 4,700 and 155 km^2, respectively.

Compilation techniques for the preparation of the water portion of the topo/bathy manuscripts follow the same procedures used to produce the "all wet" bathymetric maps. Additional information, shoreline (mean high-water line) and the mean low-water line are also added to the manuscript prior to delivery of the manuscript to USGS. Both the shoreline and the mean low-water line are compiled by NOS from tide-co-ordinated aerial photographs. The compilation procedures involve the development of a closer contour interval to accommodate the contour intervals carried on the 1:24,000 and 1:100,000 scale topo/bathy maps. Typically, a 1:24,000 scale topo/bathy map on the east coast carries a 1-m contour interval supplemented by 10.5-m contours where necessary to give a better definition of the bottom topography. The 1:100,000 scale topo/bathy map carries a 2-m contour interval supplemented by a 1-m contour line. While these contours may appear to be extremely close for generation by hydrographic data, they are justified because most surveys used in compiling the 1:24,000 and the 1:100,000 scale topo/bathy maps are at 1:40,000 scale or larger. NOS surveys on these scales normally have between 10,000 and 35,000 data points. This large amount of data allows the compiler to develop the closer contour intervals so the smaller underwater features can be portrayed on the larger scale topo/bathy maps.

The land topography is portrayed in the same detail as the bathymetry, either in standard line or orthophoto form. The standard line topographic maps at 1:24,000 scale are compiled or revised using photogrammetric methods supplemented by field data as necessary. In areas where orthophoto portrayal is considered the best means for showing the land relief and features, a photo-image base is prepared from 1:80,000 scale aerial photographs and enhanced by overprinting photogrammetrically derived land contours.

The land topography for the new 1:100,000 and 1:250,000 scale maps is generally derived by cartographic methods from the basic 1:24,000 scale maps. Since the land contours for the 1:24,000 and 1:250,000 scale topographic maps were previously compiled in feet, they are shown in these units on the topo/bathy series. On the all-new 1:100,000 scale maps, both the land and bathymetric contours and elevations are shown in metric units, with the offshore

lease blocks overprinted in red. Figures 197 and 198 are reduced versions of the 1:24,000 and 1:25,000 scale topo/bathy maps.

Since 1975, NOS has provided USGS with nearly 200 bathymetric manuscripts for the publication of topo/bathy maps. To date, over 73 maps have been published. Currently, NOS places approximately 60 new topo/bathy maps into production every year. The emphasis is towards completing coverage of the conterminous United States with 1:250,000 and 1:100,000 scale topo/bathy maps by the late 1980s. The 1:24,000 scale coverage will take considerably longer because these maps are produced only when coastal states identify a need for them and because it will require nearly 1,800 maps to cover the conterminous United States.

At the present time, published topo/bathy coverage exists at 1:250,000 scale for the east coast from New Jersey to Georgia, nearly all of the California coastline and most of the coastal Gulf states. Coverage at 1:100,000 scale exists for most of South Carolina and portions of Georgia and Virginia's eastern shore. The published 1:24,000 scale maps cover the entire coastline of the state of Georgia and portions of the states of Washington, Wisconsin and Michigan.

THE CASE FOR AN INTERNATIONAL LARGE-SCALE AND MEDIUM-SCALE NAUTICAL CHART SERIES IN EAST ASIA*

Paper submitted by the United States of America

RESUME

L'une des décisions les plus importantes prises lors de la douzième Conférence hydrographique internationale, qui s'est tenue au mois d'avril 1982 à Monaco a été l'adoption des spécifications cartographiques de l'Organisation hydrogrpahique internationale (OHI). Ces spécifications sont importantes parce qu'elles permettent de compléter la collection de cartes internationales (cartes INT) de l'OHI à petite échelle (de 1:3 500 000 à 1:10 000 000) par des cartes à grande et à moyenne échelles des grands ports, des approches et des voies de navigation côtières

Les caractéristiques essentielles qui font tout l'intérêt des cartes internationales sont, brièvement, les suivantes: a) les utilisateurs peuvent disposer de façon plus rapide, pour n'importe quelle région, de cartes à signes conventionnels normalisés, présentées sous forme de feuilles et en deux langues; et b) les services hydrographiques peuvent reproduire des cartes de façon plus rapide et sur la base d'informations plus à jour, ce qui évite

* The original text of this paper prepared by Douglas L. Brown, Physical Scientist, Defense Mapping Agency Hydrographic/Topographic Center, appeared as document E/CONF.75/L.53.

Figure 197. United States of America: reduced 1:24,000 scale topographic/bathymetric map produced jointly by the United States Geological Survey and the National Ocean Survey

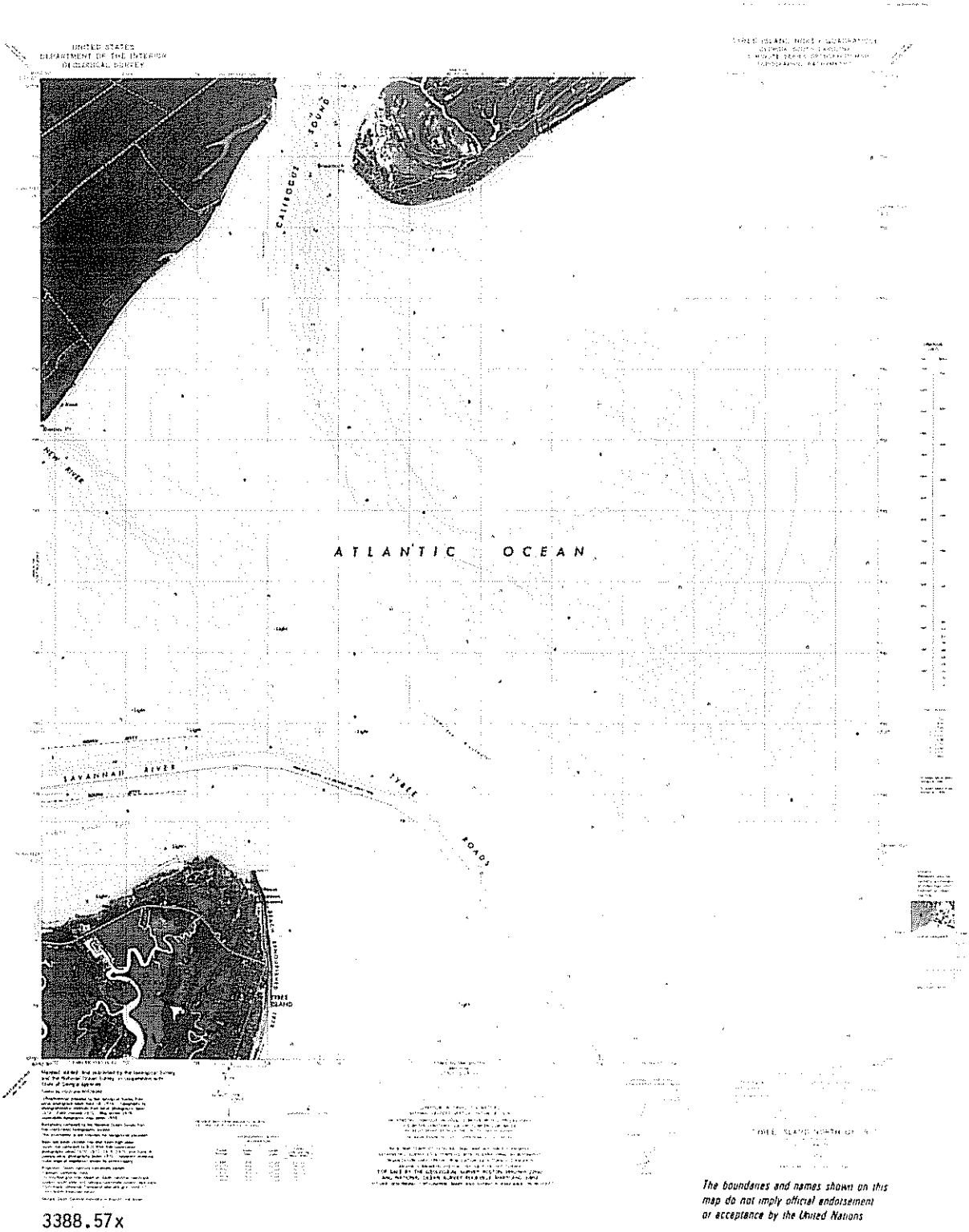
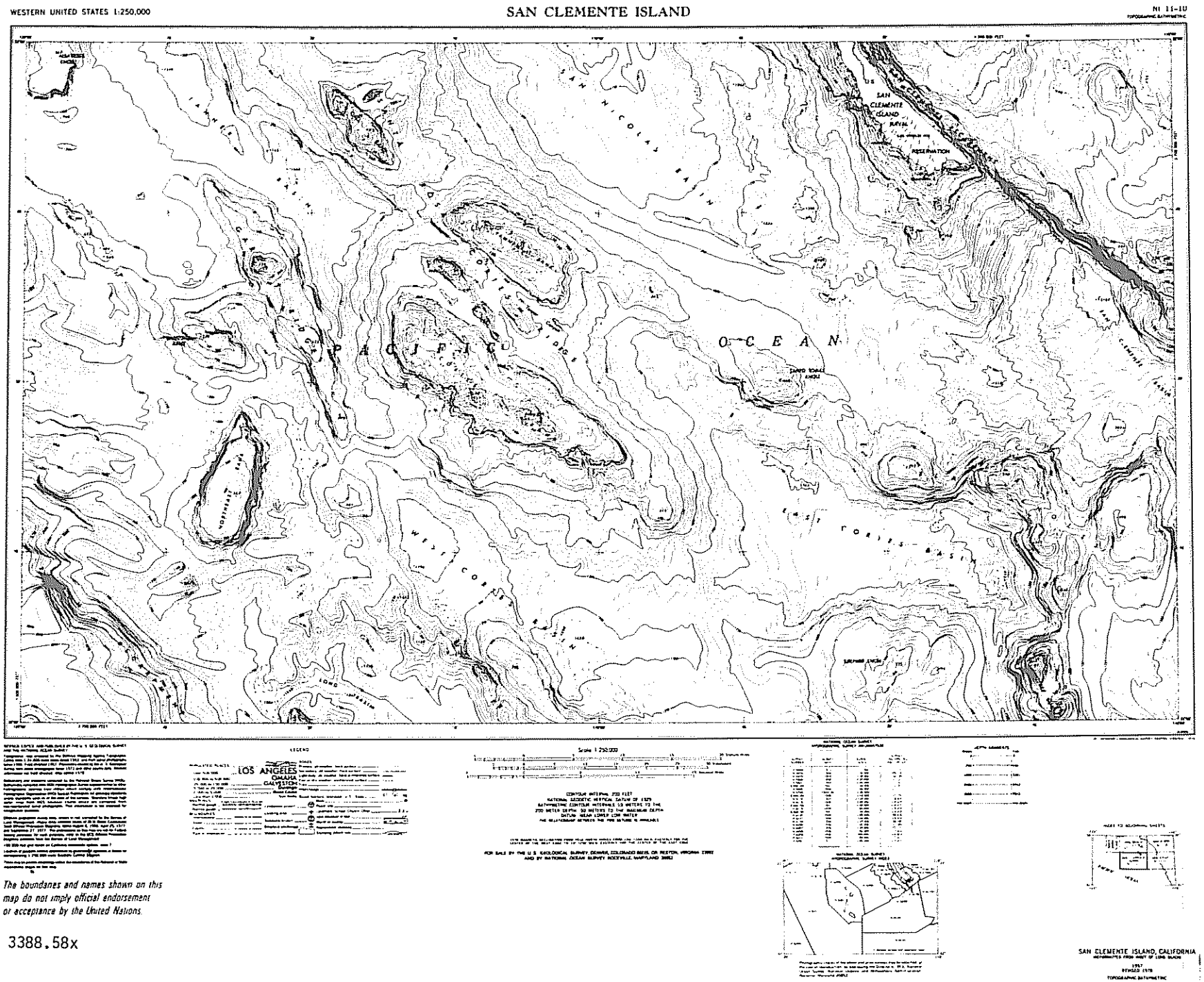


Figure 198. United States of America: reduced 1:250,000 scale topographic/bathymetric map produced jointly by the United States Geological Survey and the National Ocean Survey



d'avoir à effectuer de nouveaux travaux cartographiques pour répondre à des normes nationales plus anciennes, au prix d'un temps et de sommes considérables. S'agissant du bassin de l'Asie de l'Est, la réalisation d'une collection de cartes marines internationales à grande et à moyenne échelles présente un intérêt tout particulier, vu l'importance croissante des exportations, sur lesquelles repose la vitalité économique de nombreux pays de la région. La liste des ports qui, de l'Indonésie au sud à la République de Corée, au Japon et à l'Union des Républiques socialistes soviétiques au nord, sont utilisés par des navires de maints pays, est impressionnante. On devrait procéder à l'établissement de cartes internationales de ces ports en même temps que l'on prépare et coordonne les projets relatifs à une collection de cartes côtières. Il serait particulièrement indiqué, afin d'aboutir aux meilleurs projets possibles, que tous les Etats membres de la Commission hydrographique de l'Asie de l'Est (EAHC) ainsi que d'autres services hydrographiques nationaux de la région participent à ces travaux.

A considérer les projets que leur coopération active a permis jusqu'ici aux services hydrographiques de l'Asie de l'Est de mener à bien en matière de levés, d'établissement de cartes et de mesures propres à assurer la sécurité de la navigation, il semble que les services hydrographiques nationaux de la région soient à même de procéder, dans un proche avenir, à l'établissement de cartes internationales à grande et moyenne échelles du bassin de l'Asie de l'Est.

One of the most significant decisions of the Twelfth International Hydrographic Conference, held in Monaco in April 1982, was the adoption of the Chart Specifications of the International Hydrographic Organization (IHO). 1/ Also reaffirmed was IHO technical resolution K2.11, which addressed the need to adopt and extend the International Chart Specifications to cover all navigational charts in the interest of standardization. The Specifications are the product of 10 years of co-ordinated efforts among 20 of the 50 IHO member States to establish standards for the compilation of large-scale and medium-scale nautical charts. 2/ The Specifications are important in that they provide the foundation for the IHO series of international charts (INT Charts) to progress beyond the small scale (1:3,500,000 to 1:10,000,000), the specifications for which were completed in the 1970s. The ultimate result will be large- and medium-scale charts that cover major ports, approaches and coastal routes, and that reflect standardized symbols and format and bilingual terms. Such specifications are timely, especially in the light of the trend in international shipping towards "tramp trade", with increasing numbers of ships with variable operating schedules and with greater potential for encountering problems in the acquisition and correction of large- and medium-scale charts.

BACKGROUND

Implementation of the Specifications has already begun in the national charting programmes of Denmark, France, the Netherlands, Sweden and the United

Kingdom of Great Britain and Northern Ireland. 3/ The National Ocean Survey and the Defense Mapping Agency of the United States of America will incorporate, as feasible, these specifications when INT charts in the large- and medium-scale range are produced or reproduced. The paramount features that make the concept of INT charts attractive may be summarized as: (a) users can benefit by possessing charts sooner for any region with standardized symbols, sheet format and bilingual terminology; and (b) hydrographic agencies can reproduce charts more quickly and with more up-to-date information instead of consuming considerable time and funds in recompiling charts that conform to older national standards.

In a related decision, the Twelfth International Hydrographic Conference resolved that the development of large- and medium-scale international chart schemes should be the responsibility of regional commissions or geographical groups, whose members would be most knowledgeable of the charting requirements for the area. 4/ Currently, five regional hydrographic commissions 5/ function under the guidelines of IHO technical resolution T1.2. 6/ The East Asia Hydrographic Commission (EAHC) is charged with the responsibility for co-ordinating the activities of common interest to member hydrographic offices in one of the most expansive and heavily trafficked ocean regions of the world.

The small-scale series of INT Charts for the East Asian Basin is nearly completed. 7/ The series, produced by Japan at scales of 1:1,350,000 (six charts completed) and 1:10,000,000 (one chart completed), has been well received by the other hydrographic offices that have reproduced these charts. 8/ Yet, the most challenging and potentially profitable stage of international charting remains to be accomplished; namely, the production of medium- and large-scale international charts. For these charts, the participation of each member State of EAHC, as well as other national hydrographic offices in the region, is highly desirable in order to develop the best chart schemes. The production of an international large- and medium-scale series would, in contrast to the small-scale series, more directly benefit the regionally oriented or smaller hydrographic offices in East Asia. For instance, the responsibility for the production of nautical charts covering ports, approaches and coastal and offshore routes that are located beyond the national waters of a hydrographic office can, in effect, be shared through the co-operative exchange of chart reproduction material (repromat). Also, agreements can be fashioned where the production of charts covering a member State's own waters is schared by participating States in the region, as in the case of the contributions of Japan to the hydrographic survey of Indonesian, Malaysian and Singaporean waters during the early 1970s.

ADVANTAGES OF REGIONAL CO-OPERATION IN CHARTING

The hydrographic offices of Indonesia and Japan, by contributing to the work of the IHO Chart Specifications Committee--currently known as the Chart Standardization Committee--are aware of the advantages to be gained by co-operation in large- and medium-scale charting. 9/ In fact, at the first meeting of the Chart Standardization Committee in April 1979, a recommendation was adopted which stated that "... the International Hydrographic Bureau (IHB) encourage the Member States to form regional charting groups to devise schemes of international medium- and large-scale charts". At the same meeting, a

report was tabled on the production of common datum charts of the straits of Malacca and Singapore. The report contained a review of the progress made by a joint team from the hydrographic offices of Indonesia, Japan, Malaysia and Singapore in compiling three charts, based on the World Geodetic System 1972 (WGS 72), which would be used as master sheets in the production of each office's nautical charts of the area. In this way, past discrepancies in position-fixing attributable to the different geodetic datums covering opposite sides of the straits could be eliminated. This effort, which was undertaken by Malacca and Singapore strait countries with the assistance of Japan, reveals, in the best sense, what is to be gained from regional co-operation in the production of large- and medium-scale charts.

International chart schemes make a significant impact by reducing the total number of charts issued by various hydrographic offices, which, when added together, are normally far more than are required to cover a specific ocean region. The exchange of repromat permits the facsimile reproduction of one country's domestic chart series and eliminates the need for any other co-operating country to compile separate and usually differently schemed charts for the same waters. It should be noted that without international charts or bilateral agreements, IHO member States cannot reproduce each other's charts, partially because of copyright laws. The other alternative is to recompile the charts for issue. It has been this latter process that has maintained different formats and symbols and, in general, retarded "internationalization" of charts.

The basic purpose of international charts is to serve as a tool in promoting the safety of navigation for international shipping. Inasmuch as this type of shipping is confined to well-established routes leading to ports with extensive international traffic, there is less need to chart foreign waters as intensively as do the indigenous national hydrographic offices, notwithstanding the requirement for equivalent foreign coverage that some authorities insist upon for the prevention of pollution spills and other accidents.

The experience of the North Sea International Chart Commission (NSICC) in scheming charts for the coasts of the North Sea Basin was that the best coastal series for use in a scheme of INT Charts was, in general, the second largest scale continuous national series. In the case of the north side of the English Channel, a new INT Chart series on the scale 1:150,000 was agreed upon in place of the British 1:75,000 sheets because the 1:150,000 scale was considered to be adequate and would, moreover, match the coastal coverage by France and the Federal Republic of Germany on that side of the Channel. The decision contributed to a significant reduction in the number of charts schemed. In the most recent review of its coverage by the Defense Mapping Agency, it was determined that within the East Asian Basin the number of published coastal charts could be reduced by nearly 30 per cent (from 365 charts to 265 charts).

The availability of INT Charts, compiled to conform with internationally accepted symbols and abbreviations and issued under the agreed-upon INT Chart distribution and sales rules, promotes greater availability and quicker access to the best available charts. Based on the producer country's efforts, other printer countries do not have to be concerned about interpreting complex navigational aid symbols and characteristics or special navigational conditions provided in notes. Facsimile reproductions, modified as little as possible,

provide the most accurate charts; furthermore, they are readily corrected by the Notice to Mariners patches issued by the producer and are easily reproduced.

Printer (copying) countries have the flexibility of modifying original producer country charts to suit their style or language. The addition of chart numbers and alteration of titles to conform with national requirements is often done by printer countries that issue small-scale INT Charts. INT Chart numbers, however, are also retained on these charts in accordance with a world-wide numbering system for the two series. Similarly, medium- and large-scale charts will reflect both international numbers and numbers determined by issuing authorities.

Substantial savings should be realized in the shared production of charts covering foreign waters. The printer country, in accordance with IHO Regulations for INT Charts, incurs no greater than one third of the producer's compilation and printing cost, plus the cost of repromat and shipping. Each country, whether producer or printer, accepts responsibility for issuing Notice to Mariners corrections in order to maintain up-to-date international charts in its national series. The described method of funding chart production may result eventually in major budget allocation changes as more chart repromat is procured from producer countries and fewer charts are compiled conventionnaly by printer countries.

SOME FACTORS FOR CONSIDERATION

For the East Asian Basin, the implementation of an international series of large- and medium-scale nautical charts is particularly important in view of the growing importance of the export trade upon which much of the region's economic vitality depends. From Indonesia in the south to the Republic of Korea, Japan, and the Union of Soviet Socialist Republics in the north, the list of ports that are used by ships of many countries is impressive. These ports should be targeted for INT charting while the coastal series schemes are being developed and co-ordinated. The INT chart limits and scales are generally the same as or similar to national chart limits. This was the approach taken by the first IHO international chart specification committee in the early 1970s, the North Sea International Chart Commission. 10/

A brief examination of the significant international shipping ports in the East Asian Basin reveals a vide diversity in the sizes of ports. Included among these ports are some of the largest in the world in terms of the tonnage handled, as well as many smaller but busy centres that are dispersed throughout the region. Major ports that should be considered for large-scale coverage when devising an INT Chart scheme, and the IHO member States that would undertake such coverage, are listed below:

(a) China: Fuzhou, Guangzhou, Hangzhou, Luda, Qingdao, Shanghai, Tanggu, Xiamen and Zhanjiang;

(b) Indonesia: Dumai, Jakarta, Samarang, Surabaya and Ujungpandang;

(c) Japan: Kawasaki, Kobe, Moji, Nagasaki, Nagoya, Naha, Osaka, Shimizu, Shimonoseki, Tokyo, Yokkaichi and Yokohama;

(d) Malaysia: Pelabuhan/Kelang and George Town/Perai;

(e) Philippines: Cagayan de Oro, Cebu, Davao, Iloilo, Legazpi, Manila and Zamboanga;

(f) Republic of Korea: Incheon, Pusan and Ulsan;

(g) Singapore: Singapore;

(h) Thailand: Krung Tep (Bangkok);

(i) Union of Soviet Socialist Republics: Nakhodka;

(j) United Kingdom of Great Britain and Northern Ireland: Hong Kong.

Many additional ports exist which also warrant consideration in a scheme to chart East Asia at large and medium scales. The identification of the ports for such coverage is a task that depends upon the availability of up-to-date hydrographic surveys and navigational aids; also, it is done best by the East Asian countries, which have an active awareness of the needs of national and foreign shipping within their region.

Currently, each IHO member State in the region provides complete medium- and large-scale coverage of its national waters. 11/ Japan and the Republic of Korea, in addition, produce charts outside their national waters, primarily at small and medium scales, while the USSR issues charts for the total area at various scales. France, the United Kingdom and the United States also issue extensive coverage for the East Asian waters.

CONCLUSION

Considering the history of the energetically pursued co-operative projects of the hydrographic offices of East Asia in surveying, charting and safety of navigation measures and noting in particular the activities of EAHC in co-ordinating the common interests of its five member countries, the prospects appear favourable for the national hydrographic offices of the region to undertake the development of an international large- and medium-scale chart series for the East Asian Basin in the near future. As the Twelfth International Hydrographic Conference recognized, this work is best accomplished by a regional commission or geographical group (such as EAHC) whose members are most knowledgeable about the quality of available data and ship traffic patterns. Other hydrographic agencies, however, with world-wide distribution networks and plannig experience in broad chart series can provide valuable assistance.

Nevertheless, it remains the responsibility of the hydrographic offices of East Asia to evaluate the advantages of scheming INT Charts at large and medium scales and to instigate any regional action towards that end. The success and rapid acceptance of the small-scale INT Chart series, the procedures established by NSICC and other commissions in scheming large- and medium-scale INT Charts on a regional basis, and the recent adoption of the IHO Chart Specifications should serve to encourage and guide the members of the East Asia hydrographic community in the development of large- and medium-scale chart schemes using the concepts of international charting.

Notes

1/ Decision No. 23 of the Twelfth International Hydrographic Conference, Monaco, April 1982, entitled "Adoption of the Chart Specifications of the IHO".

2/ The Chart Specifications of the International Hydrographic Organization (IHO) comprise six sections of comprehensive standards for the compilation of large- and medium-scale nautical charts: (a) section 100, General Information; (b) section 200, Format, Positions, Compasses; (c) section 300, Topographic Symbology; (d) section 400, Hydrographic and Navigational Aids Symbology; (e) section 500, Names, Lettering, Numerals; and (f) section 600, Latticed Versions. The IHO Regulations for International (INT) Charts provide guidelines for the production, maintenance and copying of INT Charts. The specifications and regulations form the basic reference documents for international large- and medium-scale charting.

3/ D. W. Newson, "Report on the work of the Chart Specifications Committee", (CONF.XII/DOC 19/1982), paper submitted to the Twelfth International Hydrographic Conference.

4/ Decision No. 26 of the Twelfth International Hydrographic Conference, entitled "Regional chart commissions".

5/ Regional hydrographic commissions functioning under the auspices of IHO include the Northern Hydrographic Group (Denmark, Finland, Iceland, Norway and Sweden): the North Sea Hydrographic Commission (Denmark, France, Federal Republic of Germany, Netherlands, Norway, Sweden and United Kingdom of Great Britain and Northern Ireland); the Mediterranean and Black Seas Hydrographic Commission (Egypt, France, Greece, Italy, Monaco, Spain, Turkey and Yugoslavia); the United States-Canada Hydrographic Commission; and the East Asia Hydrographic Commission (Indonesia, Japan, Philippines, Republic of Korea and Thailand.

6/ International Hydrographic Organization technical resolution Tl.2, entitled "Establishment of regional hydrographic commissions", provides guidelines for the establishment and functioning of regional hydrographic commissions.

7/ In the samll-scale series of INT Charts covering the East Asian Basin, only INT 52, North Pacific Ocean, South-western Part (1:10,000,000) and INT 507, North Pacific Ocean, South Philippine Sea and Borneo to the Caroline Islands (1:3,500,000) remain unpublished.

8/ India and the United Kingdom are responsible for the production of the small-scale INT Charts of the Indian Ocean Basin, which overlap into the western portions of the East Asian Basin.

9/ Decision No. 24 of the Twelfth International Hydrographic Conference approved the renaming of the Chart Specifications Committee as the Chart Standardization Committee in order to reflect more adequately the advisory role that the Committee will have in updating chart specifications, co-ordinating the work of the regional chart commissions and guiding the Subcommittee on Chart Design.

10/ The North Sea International Chart Commission (NSICC) was a special commission, constituted in 1972 under the auspices of IHO to consider the production and use of INT Charts covering the North Sea and its contiguous waters. Its work completed, the Commission was dissolved and replace by the Chart Specifications Committee in 1977.

11/ Singapore publishes only large-scale charts because of the limited extent of its national waters. All of the IHO member States in the region use the metric system for depicting depth and elevation data on nautical charts.

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THE INTERNATIONAL HYDROGRAPHIC ORGANIZATION*

Paper submitted by the International Hydrographic Organization

RESUME

L'Organisation hydrographique internationale (OHI) remonte à 1921, et son siège, le Bureau hydrographique international, se trouve à

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* The original text of this paper, prepared by F. L. Frazer, President, International Hydrographic Organization, Monaco, appeared as document E/CONF.75/L.71.

Monaco. Elle est régie par une convention entrée en vigueur en 1970. Il s'agit d'une organisation intergouvernementale à caractère consultatif et purement technique, qui est actuellement composée de 50 Etats maritimes.

Les représentants officiels des Etats membres se réunissent tous les cinq ans à Monaco pour une conférence hydrographique internationale. Cette conférence passe en revue les progrès réalisés par l'Organisation et adopte les programmes pour les cinq années suivantes. Un comité directeur composé de trois hydrographes de haut niveau est élu pour diriger les travaux du Bureau.

Le Comité directeur, aidé d'un petit nombre d'experts en hydrographie coordonne les programmes techniques et dispense des conseils et assistance aux Etats membres. L'OHI publie des ouvrages techniques en anglais et en français, crée des comités et des groupes de travail pour étudier des sujets particuliers, appuie les commissions hydrographiques régionales et sert de centre de documentation sur certains sujets.

Conformément à ses buts et objectifs, l'Organisation hydrographique internationale demeure une source de conseils techniques et un organe de coordination en vue de promouvoir des mesures propres à établir ou à renforcer les capacités des pays en développement en matière hydrographique. A cette fin, elle effectue des visites consultatives dans les pays qui en font la demande et encourage la conclusion d'accords d'assistance technique bilatéraux et multilatéraux entre pays dans les divers domaines relatifs à l'hydrographie y compris la formation du personnel. Le Bureau hydrographique international maintient des contacts étroits avec les organismes internationaux d'assistance et peut donner des renseignements spécifiques sur les programmes d'assistance technique offerts par ses Etats membres.

Dans la plupart des pays en développement, et en fait dans beaucoup de pays ayant des services hydrographiques établis de longue date, les cartes disponibles ont été dressées à partir de levés effectués au dix-neuvième siècle, ce qui est insuffisant pour les navires modernes à fort tirant d'eau. Le besoin urgent d'établir de nouveaux levés et de cartes mises à jour est fréquemment souvent sous-estimé et, s'il ne l'est pas, le coût élevé des travaux nécessaires décourage les responsables. Très souvent, il ne semble pas économiquement viable de créer un service hydrographique en l'absence de commerce maritime. Dans ce cas, les pays pourraient obtenir des données topographiques actualisées en utilisant des méthodes et équipements plus simples et d'entretien plus facile et réduire les frais grâce à une étroite collaboration avec les pays voisins de la région ou de la sous-région ou avec l'un des organismes de cartographie mondiale.

Ainsi un service régional auquel contribuerait un certain nombre de pays pourrait être très utile à toutes les données et pourrait être accessible à tous les pays. L'Organisation hydrographique internationale aide à promouvoir de tels arrangements régionaux ou sous-régionaux.

International co-operation in hydrography began in 1919, when 24 countries met in London and decided to form a permanent body. The resulting International Hydrographic Bureau (IHB) began its activities in 1921 with headquarters in the Principality of Monaco. In 1970, an intergovernmental Convention came into force creating the International Hydrographic Organization (IHO) with IHB as its headquarters in Monaco. IHO has a consultative and purely technical nature and currently has a membership of 50 maritime States.

Official representatives of member States meet at five-year intervals in Monaco for an International Hydrographic Conference. The Conference reviews the progress achieved by IHO and adopts programmes to be pursued during the succeeding five-year period. A Directing Committee of theree senior hydrographers is elected to guide the work of the Bureau.

The Directing Committee, together with a small stall of experts in hydrography, co-ordinate the technical programmes and provide advice and assistance to member States. IHO Produces technical publications in English and French, establishes committees and working groups to study particular subjects, supports regional hydrographic commissions and maintains certain data repositories. Principal among these are the Chart Standardization Committee, the Commission on the Promulgation of Radio Navigational Warnings, the IHO/International Federation of Surveyors (FIG) International Advisory Board on Standards of Competence for Hydrographic Surveyors and the International Oceanographic Commission (IOC)/IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO). IHO works in close association with the International Maritime Organization, the International Association of Lighthouse Authorities, IOC, the Office of the Special Representative of the Secretary-General for the Law of the Sea (United Nations) and FIG.

In pursuit of the aims and objectives of the Organization, IHB remains a source of technical advice and a co-ordinating body to promote measures directed to establishing or strenghtening the hydrographic capabilities of developing countries. To this end, the Organization conducts advisory visits to the requesting State and encourages the formation of bilateral and multilateral agreements among countries for technical assistance in various aspects of hydrography, including training of personnel. IHB maintains close contacts with international aid-giving agencies and acts as a repository fro specific information on technical assistance programmes available from its member States.

In this regard, IHO assists in:

(a) Preparing project reports spelling out the short- and long-term needs of a developing country for establishing or strenghtening hydrographic services;

(b) Identifying hydrographic experts considered most appropriate for a specific project;

(c) Vetting the optimum requirements for personnel, equipment and instruments;

(d) Facilitating the developing of bilateral/multilateral arrangements between co-operating countries;

(e) Arranging training placements in recognized hydrographic training institutions of member States of IHO;

(f) Monitoring the progress of a hydrographic project;

(g) Promoting the technical standards set by IHO.

IHO liaises with international aid-giving agencies. Three such agencies, which have in the recent past helped hydrographic projects, are the United Nations Development Programme (UNDP), the Commonwealth Fund for Technical Co-operation (CFTC) and the Colombo Plan Technical Assistance Programme. In the case of UNDP aid, the recipient country approaches UNDP through the relevant government co-ordinating authority and through the resident representative of UNDP. Projects are developed within the framework of country programmes and submitted to the UNDP Governing Council. Once the project is approved, UNDP appoints an executing agency to implement the project. Following a resolution adopted by the Eighth Regional Cartographic Conference for Asia and the Far East in January 1977, India obtained UNDP aid of some $3.5 million for provision of modern hydrographic training facilities to the Indian Naval Hydrographic School in 1980.

Through CFTC, technical assistance is made available to developing member countries of the Commonwealth, associated States or dependent territories of any Commonwealth member to assist them in meeting their national development priorities. CFTC, operating from within the Commonwealth Secretariat, provides technical assistance—advice, experts and training—to Commonwealth developing countries. The Fund's resources are used, inter alia, "to finance education and training of personnel from one developing Commonwealth country in another developing Commonwealth country". For example, some four years ago personnel from the Singapore Hydrographic Department were trained in cartography at the Indian Naval Hydrographic Office. Similarly, CFTC sends experts to advise and assist developing countries in various fields.

The Colombo Plan for Co-operative Economic Development in south and South-East Asia, which works on a bilateral basis, has in the past made a substantial contribution to help developing countries in the field of hydrography. Under this programme, India has in the past decade offered several placements and scholarships to personnel from, among others, Malaysia, Nigeria and Singapore. An Indian expert under this scheme established the Singapore Hydrographic Department in the 1970s. Japan offers numerous fellowships for training in hydrography and oceanography to South and South-East Asian countries. The Colombo Plan membership stands at 26, which includes 20 regional countries and 6 external countries. Colombo Plan fellowship awards are agreed upon between the recipient and donor countries on a Government-to-Government basis.

More often than not, the departments responsible for charting in the developing countries are not aware of the various schemes under which they can receive technical assistance. In such cases, IHO is ready to advise those countries on where assistance can be obtained and, in fact, help the recipient countries to develop their projects. To this end, IHO has charged its main organ, IHB, to respond to requests from developing countries by circulating them to potential donor countries and subsequently facilitating the development of bilateral arrangements for technical co-operation between donor and recipient countries.

In most developing countries, and indeed in many with long-established hydrographic services, the available charts are based on nineteenth century surveys which are not adequate for modern deep-draught vessels. The urgent need for new surveys and updated charts is frequently not appreciated; and when it is, the high cost of providing the data deters those responsible from taking action.

Because of a lack of maritime trade, the establishment of a hydrographic service frequently does not appear economically viable. In such cases, countries could collect modern surveys data by using simpler and easily maintained equipment and methods and further cut their costs by having close-co-operation with neighbouring countries in the region or subregion, or with one of the world charting authorities. In particular, a regional service with contributions from a number of countries could well serve the needs of all and data could be shared by all. IHO will help to promote such regional or subregional arrangements.

(j) Reproduction and printing of maps

FIVE COLOUR PROCESS PRINTING OF LINE MAPPING*

Paper submitted by Australia

RESUME

L'impression couleur est maintenant considérée comme une pratique courante, de même que les techniques améliorées de contrôle de la qualité. Les avantages que présentent ces techniques - gain de temps et production accrue - l'emportent sur le fait que les cartes imprimées sont parfois d'une qualité légèrement inférieure.

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* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.22.

BACKGROUND

In 1978 technological advances by the allied international mapping community showed that by applying synthesized colour-process printing techniques, a more efficient and effective map and chart publication cycle may result. Unitl recently, the Royal Australian Survey Corps did not include the application of these techniques in its production procedures.

One role of the Royal Australian Survey Corps is to produce a wide range and number of topographic and topographic-related products that satisfy the needs of the Australian Forces. It was felt that developing a synthesized colour-printing capability would significantly further production capabilities in a reasonably cost effective manner.

JOINT OPERATIONS GRAPHIC

Series 1501 Joint Operations Graphic (Ground and Air) was identified as being particularly suited for process printing because it would provide a reduction in the number of printing colours from an average of nine to five. The process had to be modified to comply with the series specification; and consequently, the standard process magenta was replaced by red/brown and an electric blue was added.

Implementation

As the first step in the implementation of this system, standards must be developed for the variety of colours/tones that can be achieved by printing combinations of the process colours. It is necessary to produce a chart showing the permutations of percentage dots from 10 per cent to 100 per cent in steps of 10 per cent, printed singly and in combinations of the process colours. It is then possible to compare the conventional map colours to the chart to achieve a match. Strict quality-control procedures are essential in the production of the percentage dot chart as it forms the guide from which colours will be selected to match specification.

ADVANTAGES OF THE SYSTEM

There are several advantages in implementing process colour-printing:

(a) Significant cost reduction. Conventional colour-printed Joint Operations Graphics required up to nine colours. By reducing the number of colours to five, significant savings are made in ink, film and press time. The saving in press time should also result in an overall increase in production;

(b) Improved registration. It is possible to complete the chart on a single pass through a five-colour press; thus, partially printed stocks will not be left standing in the press room and be subjected to variations in temperature and humidity;

(c) Uniformity of colour. The process colour-printing technique will eliminate the stocking of many conventional ink colours. Consequently, the control of only five process colours will improve uniformity of colour during and between production runs.

DISADVANTAGES

Some disadvantages of the system were recognized:

(a) Some loss in sharpness of fine line detail. This may occur when two or more colours of the same feature are not perfectly registered;

(b) Loss of colour match. When the process coulour-printing specifications were developed, it was recognized that certain conventional colours could not be accurately matched, owing to the layer dots of two or three process colours required to stimulate the conventional colour.

PRODUCTION OF ORTHOPHOTOMAPS USING A DUOTONE, RANDOM-DOT RECHNIQUE*

Paper submitted by Australia

RESUME

On utilise l'expression "en pointillé" pour distinguer cette méthode des autres systèmes d'impression sans trame. Il est vrai que l'impression sans trame est un procédé relativement peu coûteux qui donne des résultats bien supérieurs à ceux obtenus par l'impression classique en demi-teinte pour les orthophotocartes monochromatiques. Toutefois, en suivant cette méthode, on a constaté que des techniciens relativement inexpérimentés pouvaient obtenir des résultats satisfaisants, bien que n'ayant pas reçu une formation approfondie.

En raison de la fine résolution et du renforcement des contrastes inhérents à cette technique, il faut prendre soin d'éviter des variations importantes dans les contrastes entre les orthophotocartes adjacentes lors de la production de mosaïque, notamment si le même détail traverse une ou plusieurs lignes de jonction. Il est également important, pour la même raison, que tout le matériel soit en bon état, étant donné que tout défaut ou éraflure sera fidèlement reproduit.

En combinant la technique des deux teintes avec celle du pointillé, on peut ajouter de la couleur aux orthophotocartes en monochrome, tout en conservant le contraste nécessaire pour une représentation "photographique" du sol.

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* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.23.

A screenless printing technique has been developed to preserve resolution of relatively small-scale orthophotomaps. Coupled with a duotone presentation to simulate overall ground appearance, this has made possible the development of an effective 1:50,000 orthophotomap series produced from small-scale photography.

A screenless lithographic printing technique has long been sought. However, the methods developed by which continuous-tone positive or negative film can be exposed directly to a printing-plate require highly skilled technicians and sophisticated equipment, as well as careful control at all stages of production, including printing. For this reason, these methods are not considered a practical proposition for the production of orthophotompas.

The method currently in general use for rendering a continuous-tone photo suited for litho printing is to use half-tone screens. In the absence of a better method, this has produced relatively acceptable results; but, because the half-tone image is produced by equally spaced dots of varying size, there is always some loss of fine detail and clarity.

The random-dot method of photo/litho reproduction has been recognized for some time as a system that overcomes the limitations of the above-mentioned methods. Until recently, the major problems with this technique has been the inability to develop a standard procedure that would give consistant and predictable results.

A production method by which high-quality random-dot orthophotomaps can be produced has been developed by the Army Survey Regiment. The techniques can be mastered by relatively inexperienced technicians and the results obtained are both predictable and consistent.

It must be stressed that the technique has been developed from limited research. The general principle applied was to employ materials that had previously been found suitable, if unpredictable, and by employing sensitometry and automated film-processing, to eliminate as many variables as possible. No doubt there are alternative materials available that will give satisfactory results, but these have yet to be identified.

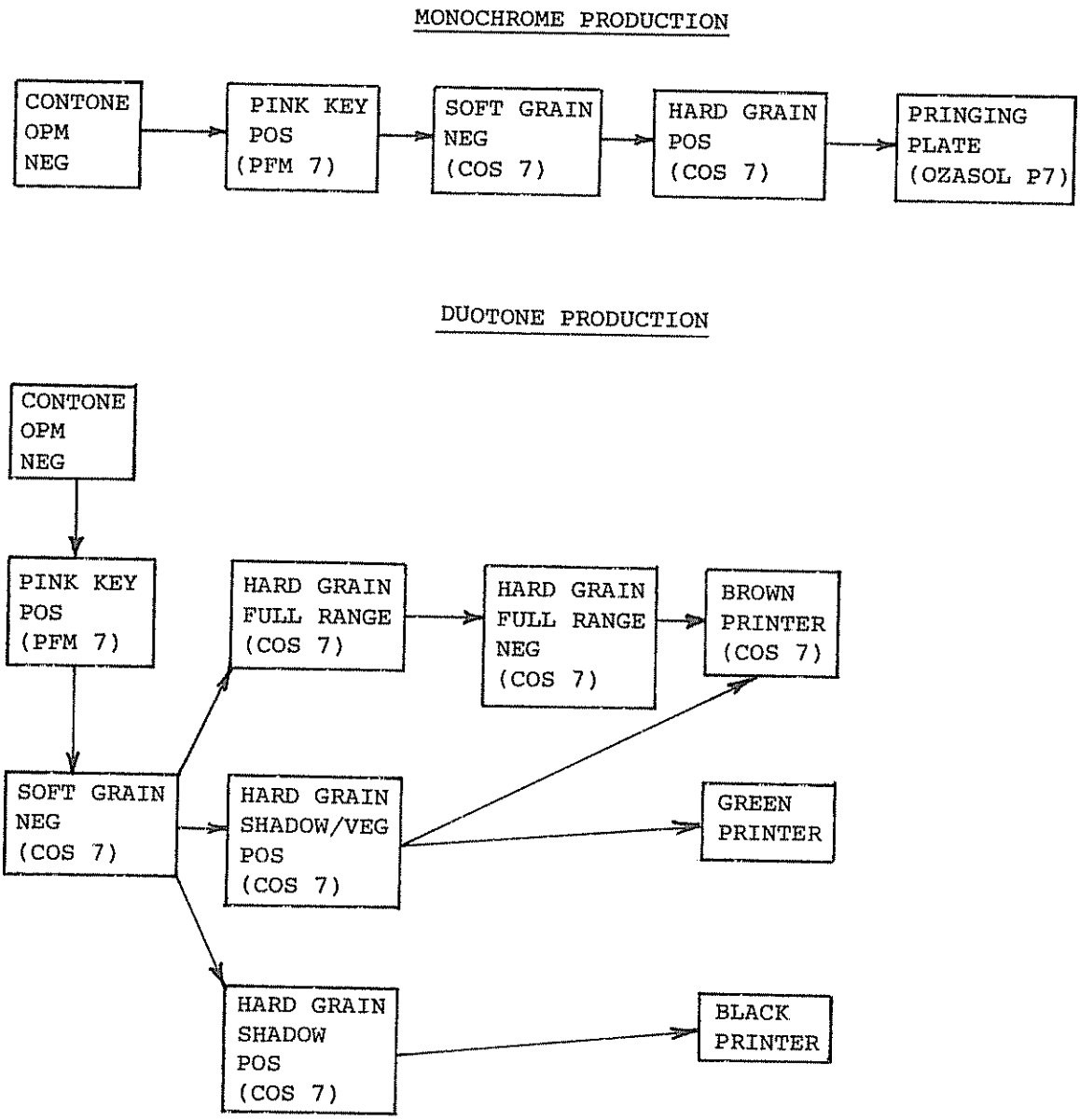
PRODUCTION SEQUENCE FOR MONOCHROME ORTHOPHOTOMAPS

Whatever method is used to produce the corrected imagery, the initial requirement for random-dot production is a continuous-tone negative, at final production scale, with a density range from 0.4 (+0.05) to 1:4 (+0.05).

The production sequence for monochrome orthophotomaps is described below (see also figure 199):

(a) The negative is contacted to a sheet of Dupont Projection Film Matte (PFM 7) using a high-intensity pulsed xenon or metal halide light source. As a guide, it was found that an exposure of 7.5 minutes was required using a pulsed xenon flip-top plate printing down frame. This film is then processed by fixing in a standard liquid acid photographic fixer for not less than one minute. The fixer tank of a Pakorol Super G 48 automatic film processor is used for this operation;

Figure 199. Australia: diagrammatic representation of monochrome and duotone random-dot production



(b) The resultant product is a "pink-key" positive that has been produced by photolisis--that is, an image formed purely by the action of light on the silver halide crystals in the film emulsion without the accelerating effect of a developer. It appears as a faint image that gives the visual effect of continuous tone but is in fact made up of varying concentrations of equal density "development centres" in the silver halide crystals. Tonal control is by means of a Dupont 30-step transmission wedge, which should give a density range for the pink key of 0.35 (±0.05) between steps 1 and 30 (the bottom density value must not be less than 0.1);

(c) The next step is to contact the pink key to a sheet of Dupont Cronar Ortho S (COS 7) film. Uisng a 116-v point light source with a neutral density filter of k2.0 at 2 m required an exposure of 50 units (approximately 30 seconds). Exposure control is by means of a gammamatic exposure control meter;

(d) Exposure at this stage is extremely critical since it is in the "toe" area of the characteristic curve for this film, and any departure from the correct exposure will have a very marked effect on the resultant image. As minor variations occur in film emulsion, it is necessary to carry out a test exposure on each new batch of film taken into use;

(e) This sheet of film is processed in 1 Dupont Cronar Liquid Custom Developer (CLCD) on a Pakorol Super G 48 processor at 32"/min and 84°F. The image on this negative is formed by the combined effect of the matte grain surface of the emulsion of PFM 7 film together with the pink-key image and is very weak and grey, making it unsuited for printing down to plate;

(f) Inspection of the image shows that this is formed by varying concentrations and sizes of random shaped "grains", each of equal density. The structure of the grain on the step wedge is checked visually. A check is also made using a densitometer, which should give a range of 0.25 (±0.05) in step 1 and (+0.2) in step 30. The background greyness of this "soft-grain" negative affects the density reading - hence, the requirement for a visual check and the large tolerance permitted;

(g) The final photographic step is to contact the soft-grain negative to another sheet of COS 7 to produce a "hard-grain" positive suited for platemaking. The equipment described above in paragraphs (c) and (e) is used, but the exposure is doubled to 100 units and the film is processed at 22"/min at 84°F. Inspection of the step wedge is purely visual at this stage and should show a 95 per cent "printing grain" in step 1 and "just printable grain" in steps 16-18.

Should the orthophoto continuous-tone negative be outside the density range from 0.4 (+0.05 to 1:4 (0.05), the contrast range of the final random-dot positive can be varied at either of the COS 7 contact stages by varying the exposure or development or both.

When producing the soft-grain negative, an increase in exposure coupled with a faster development speed will result in a lengthening of the contrast range. The converse also applies.

At the hard-dot contact stage, a reduction in exposure will reduce the contrast range; and, conversely, an increase in exposure will lengthen it, provided the recommended development conditions are maintained. In addition, a small increase in contrast range can be achieved by reducing development speed and maintaining the exposure constant.

Nos special conditions or control measures are required at either the plate-making or printing stages, and standard exposures and procedures are used. All satisfactory trials carried out have used Ozasol P7 (positive) plates. Ozasol N6 (negative) plates were found to be unsatisfactory, owing to a ripple effect in the plate coating reproducing on the printed image. It should be noted that exposure to the plate reduces the contrast range by from two to three steps on the step wedge; this variation has been allowed for at the previous photographic stages.

DUOTONE/SIMULATED-COLOUR RANDOM-DOT ORTHOPHOTOMAPS

The duotone technique of printing a reduced range image on top of a full-contrast range image is used with half-tone work to "lift" what would otherwise be a rather "flat" result. The contrast and definition obtainable from random-dot printing is such that there is little to be gained from using the duotone technique for this purpose. It has, however, been adapted, in conjunction with random dot, as a method of producing coloured orthophotomaps from monochrome photography. A production task has not yet been produced using this method, but an experimental map sheet has been printed. The production sequence is set out below (see also figure 199):

(a) A full-contrast range random-dot positive is produced, as for monochrome orthophotomaps. This positive is then examined and a judgement made as to where the tonal separation falls between shadows/vegetation and open ground. A shorter range random-dot positive is then produced to cover only that part of the full tonal range required for the shadow/vegetation depiction. This is the "green printer" positive;

(b) The full-range positive is then contacted to negative and then this resultant negative is contacted back to positive, using the green printer positive as a hold-out mask. This provides the "brown printer" positive;

(c) If the orthophotomap were to be printed using just these two base components, the result would be falt with little tonal variation; in addition, the green areas would cover both vegetation and shadow and could therefore be misleasding. It is therefore necessary to produce a third random-dot positive to pick out the shadow areas. This is produced to a very short contrast range of only from three to five steps on the control step wedge and is the "black printer" positive;

(d) The orthophotomap is then printed as a duotone of black on a combination brown/green base.

Provided colours are carefully selected for the particular area being portrayed, it is possible to produce an orthophotomap that has a better representation of colour than high-altitude colour photography produces. This is

especially true in relatively unpopulated country areas where little additional enhancement of detail is likely to be required.

It should be noted that all three random-dot printer positives are produced from the one-soft grain negative.

Using the random-dot technique for this type of product requires a higher level of skill than that required for monochrome; however, it is not so much more complex an operation that it could not be mastered with the correct training.

(k) Organization of distribution and sale of maps and charts

ORGANISATION DE LA DISTRIBUTION ET DE LA VENTE DES CARTES*

Document présenté par la France

Since 1974, the Institut géographique national (IGN), a government administrative organization, has taken steps to sell its maps to a wide public. So far, the results are very encouraging both from the point of view of actual sales and from that of future expectations, in addition to the experience gained as a result of those activities.

A brief history will make it possible to better understand those achievements. At the beginning of the 1970s, following the lead given by its director at the time, Mr. Laclavere, President of the International Union of Geodesy and Geophysics, IGN decided to make available to a wide public in France a series of 1:100,000 scale maps derived from military maps and designed to meet tourist needs. That project was a great success, formed the backbone of the marketing operation for the range of maps which followed later and revealed a need for detailed mapping in France which had been ignored up to that time. Around that axis was built up a publishing policy covering scales from 1:1,000,000 to 1:25,000 and including the projects of private map publishers using IGN base maps. Thus, IGN broke away from its exclusive vocation as the supplier of maps to the French Government in order to participate in the rapid increase in tourist activities in France.

Each year IGN sells about 4 million copies of its tourist, topographic and other types of maps both within and outside France. These sales can be classified as follows:

(a) Outside France, mostly in Africa, 2,000 different products; maps at 1:200,000 and 1:50,000 scales;

(b) In France, 3,500 different products, the main series being:

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* Le texte original de ce rapport, préparé par l'Institut géographique national, a paru sous la cote E/CONF.75/L.79.

	Average annual sales
Road map at 1:1,00,000 scale	220,000
Red series, 16 sheets at 1:250,000	32,000 per sheet
Green series, 74 sheets at 1:100,000	15,000 per sheet
Base map, 1,100 sheets at 1:50,000	400 per sheet
Base map, 2,204 sheets at 1:25,000	500 per sheet

Total sales amount to about $6 million per annum.

A tele-processing system ensures continuous stock control and the follow-up of clients, orders and invoices. Monthly listings make it possible to follow the sales flow of each product and to ensure, in liaison with the Printing Department, the reprinting of maps and the launching of new ones.

From 300 booksellers in 1970, IGN now has a network of 50 main distributors to cover the entire country and maintain stocks at 7,000 retail outlets. The systematic folding of IGN maps greatly simplified their distribution and greatly improved stocking, presentation and self-service procedures.

Wishing to give this report a concrete character and taking advantage of the expertise of those who will read it, it appeared interesting to mention IGN expectations for increasing the diffusion of its products outside France and proposals whereby IGN could make its experience available to those countries which might be interested.

IGN EXPECTATIONS

IGN would like to receive proposals from national mapping organizations concerning the selling of their products in France. IGN has a shop in the centre of Paris where, in addition to IGN products, it sells maps produced in various other countries. Consequently, IGN would welcome receiving detailed offers, catalogues and sale prices and conditions in order to consider selling in France the widest possible variety of maps from the largest number of countries.

IGN would also like to receive inquiries from organizations wishing to distribute IGN products in their own countries. IGN traditionally exports its maps to other European countries and a considerable number of its maps are sold in the Federal Republic of Germany and in the United Kingdom of Great Britain and Northern Ireland. Up to now only relatively few IGN maps have been sold in the other continents even though the IGN produces material which might be sold there, such as planispheres, old maps, tourist maps of France and raised relief maps produced by methods which guarantee an excellent representation in three dimensions.

IGN PROPOSALS

IGN can give advice on producing coherent ranges of maps corresponding to the possibilities of other national mapping services and to the conditions prevailing in the countries where they are situated.

Map-printing policies can be formulated as a result of analysing the products that a given national mapping organization is able to publish itself (from survey data on magnetic tape to thematic maps for sale to the general public) and on an analysis of existing requirements or those to be revealed (from data for technical requirements to data for meeting public needs). Tourist maps are, moreover, an excellent way of making tourist resources known outside a given country and they can thus play an important part in any governmental policy for increasing the flow of visitors from outside a country.

IGN can also define marketing policies not only for the organization of an internal map sales service but for a service for the more or less vertical integration of map distribution activities.

Maps are currently in favor with the general public. We should all be delighted. What better support exists for national development?

L'Institut géographique national (IGN), établissement public à caractère administratif a, depuis 1974, pris position sur le marché grand public de la cartographie. Les résultats enregistrés à ce jour sont particulièrement encourageants, tant au point de vue des ventes réalisées qu'à celui des perspectives d'avenir ou, enfin, des compétences acquises au nom de cette expérience.

Un bref historique permettra de mieux situer le cadre de l'expérience. Au début des années 70, sous l'impulsion de son directeur de l'époque, Monsieur Laclavere, président de l'Union géodésique et géophysique internationale, l'IGN décida de mettre à la disposition du grand public français des séries de cartes au 1:100 000 dérivées du type militaire et adaptées aux besoins touristiques. Ce fut un réel succès, l'épine dorsale de la commercialisation de la gamme qui devait suivre et le révélateur d'un besoin de cartographie détaillée jusqu'alors ignoré en France. Autour de cet axe s'élabora une politique d'édition complète allant du 1:1 000 000 au 1:25 000 et englobant les initiatives privées d'autres éditeurs sur fond de cartes IGN. Ainsi l'IGN s'affranchit de sa vocation exclusive de fournisseur de l'Etat pour participer à l'essor du tourisme en France.

A l'heure actuelle l'IGN diffuse près de 4 millions d'exemplaires de ces cartes touristiques, topographiques et diverses tant sur le marché intérieur qu'à l'exportation, se répartissant comme suit:

a) En produits hors France, essentiellement en Afrique, 2 000 titres: cartes au 1:200 000 et 1:50 000;

b) En France, 3 500 titres, dont les séries principales sont:

	Vente annuelle moyenne
La carte routière au 1:1 000 000	220 000
Série rouge en 16 feuilles au 1:250 000	32 000 par feuille
Série verte en 74 feuilles au 1:100 000	15 000 par feuille
Carte de base en 1100 feuilles au 1:50 000	400 par feuille
Carte de base en 2024 feuilles au 1:25 000	500 par feuille

et représentant un chiffre de vente global d'environ 6 millions de dollars par an.

Un système de télétraitement assure de façon continue la tenue du stock, le suivi des clients, des bons de commandes et de la facturation. Des listings mensuels permettent de suivre le flux de sortie de chaque produit et d'assurer, en liaison avec notre service des impressions, les prévisions de réimpression ou d'éditions nouvelles.

De 300 libraires revendeurs en 1970, l'IGN est passé maintenant à un réseau de 50 distributeurs principaux couvrant le territoire et approvisionnant plus de 7 000 points de vente. L'adoption du pliage systématique de nos cartes a grandement simplifié cette diffusion du fait des facilités de stockage, de présentation et de vente en libre service.

Voulant garder à cette intervention un caractère concret et profitant de l'audience exceptionnelle réunie ici, je voudrais vous faire part et des attentes de l'IGN pour accroître sa diffusion internationale et des propositions que l'établissement peut faire pour mettre son expérience à la disposition des pays qui le souhaiteraient.

LES ATTENTES DE L'IGN

Nous désirons obtenir de tous nos homologues internationaux des offres de promotion de leurs produits en France. Nous disposons en effet d'un magasin de vente à Paris qui a pour vocation de diffuser nos propres produits mais aussi les cartes de tous les pays du monde. A cet effet nous apprécierons de recevoir des offres détaillées, catalogues, prix et conditions de vente pour pouvoir envisager la mise en vente en France de la plus grande variété possible de cartes de toute provenance.

Nous désirons également que se fassent connaître tous les organismes désirant diffuser les produits de l'IGN dans leurs pays. En effet à l'heure actuelle le courant d'exportation des cartes que nous produisons se concentre traditionnellement sur les pays européens (où il atteint des niveaux considérables en ce qui concerne la République fédérale d'Allemagne et le Royaume-Uni de Grande Bretagne et d'Irlande du Nord). Il n'a pas encore atteint, sauf marginalement, les autres continents alors que l'IGN dispose de produits susceptibles d'y être diffusés tels que planisphères, cartes anciennes, cartes touristiques de France, cartes en relief réalisées selon des procédés garantissant une excellente représentation en trois dimensions.

LES PROPOSITIONS DE L'IGN

Nous pouvons apporter notre savoir-faire pour bâtir une gamme de cartes cohérentes correspondant aux possibilités de nos homologues internationaux et aux conditions prévalant dans le pays où ils exercent leur activité.

En effet toute politique d'édition cartographique peut se construire à partir de l'analyse des produits que chaque institut géographique est à même d'éditer (des données géographiques sur support magnétique à la cartographie thématique grand public), et de l'analyse des besoins existants ou à révéler (des besoins d'information à caractère technique jusqu'aux besoins du grand public). De plus, la cartographie touristique constitue un excellent moyen

de faire connaître à l'étranger les ressources touristiques d'un pays et peut donc tenir une place de choix dans toute politique gouvernementale visant à y augmenter le flux touristique en provenance de l'étranger.

Notre savoir-faire pour définir une politique de commercialisation tant sur le plan de l'organisation interne du service commercial que sur celui de la plus ou moins grande intégration verticale de la diffusion.

La cartographie connaît à l'heure actuelle une certaine faveur auprès du grand public. Nous devons nous en réjouir. Quel meilleur support pour assurer le développement d'un pays?

INFORMATION SHEET ON THE ORGANIZATION OF DISTRIBUTION AND SALE OF NAUTICAL CHARTS*

Paper submitted by the International Hydrographic Organization

Tous les organismes de cartographie ou bureaux hydrographiques vendent leurs cartes dans le monde entier par l'intermédiaire d'agents.

L'Annuaire de l'Organisation hydrographique internationale, que l'on peut se procurer auprès du Bureau hydrographique international, donne pour chacun des 50 Etats membres et plusieurs Etats non membres, les zones cartographiées ainsi que l'adresse du bureau hydrographique national. Il donne également des précisions sur les derniers catalogues cartographiques publiés par les Etats membres.

La publication de nouveaux catalogues nationaux et de listes normalisées de symboles et d'abréviations est annoncée à la section III du Bulletin mensuel de l'Organisation hydrographique internationale, et énumère aussi les nouvelles cartes et nouvelles éditions de cartes publiées dans le monde entier. Pour diffuser plus largement ces renseignements, le Bureau publie séparément cette section ce qui revient moins cher que de diffuser tout le Bulletin.

Dans la plupart des cas, les catalogues de cartes nationales donnent le nom et l'adresse des agents auprès desquels on peut se les procurer.

L'abonnement annuel aux extraits du Bulletin de l'Organisation hydrographique internationale est de 55 francs français.

All charting authorities or Hydrographic Offices sell their charts through chart agents on a worldwide basis.

The International Hydrographic Organization (IHO) Yearbook, obtainable from the International Hydrographic Bureau, publishes the area of chart coverage of each of 50 member States and several non-member States, together with the

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* The original text of this paper appeared as document E/CONF.75/L.69.

address of the national Hydrographic Office. The Yearbook also includes details of the most recent national chart catalogue published by member States.

In Section III of the monthly Bulletin of IHO, the publication of new national catalogues and standard lists of symbols and abbreviations is announced, together with details of new charts and new editions of charts on a world-wide basis. With a view to making this information more widely available, the Bureau publishes extracts of the Bulletin containing section III only, a measure that has led to cheaper distribution than the complete publication.

In most cases, the national chart catalogues list the names and addresses of the agents from whom charts can be obtained.

The annual subscription for extracts of the IHO Bulletin is 55 French francs.

AGENDA ITEM 6

Geographical names, including matters to be referred to the United Nations Conferences on the standardization of geographical names

GEOGRAPHICAL NAMES*

Paper submitted by Cyprus

Conformément aux résolutions de la Conférence des Nations Unies sur la normalisation des noms géographiques, Chypre se tient au courant de la question depuis la première Conférence de Genève, tenue en 1967. Un comité permanent pour la normalisation des noms géographiques a été mis en place par le Conseil des ministres et il a commencé ses travaux.

PROGRES REALISES

Le Département des affaires foncières et des levés et le Centre de la recherche scientifique ont été chargés de la collection, de la standardisation et de la translittération des noms géographiques sur l'île. L'héritage culturel de Chypre est extrêmement riche. L'île compte au total environ 60 000 noms géographiques. Le travail a été fait pour 2 000 d'entre eux, notamment les plus importants, et une nomenclature toponymique a été établie. A la dernière Conférence de Genève, on a félicité Chypre de la présentation de sa nomenclature nationale.

TRANSCRIPTION

Chypre a deux langues officielles, le grec et le turc. Puisque le turc utilise l'alphabet latin, il n'est pas nécessaire de translittérer les noms géographiques turcs, qui ont donc été laissés tels quels. Par contre, pour la romanisation des noms géographiques grecs, Chypre et la Grèce, qui sont toutes deux membres de la division linguistique romano-hellénique, ont convenu d'un système de translittération. Chypre a adopté ce système, qui est décrit en détail dans la note d'introduction à la nomenclature toponymique.

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* The original text of this paper appeared as document E/CONF.75/L.83.

ACHEVEMENT DES TRAVAUX

Le Comité permanent de Chypre pour la normalisation des noms géographiques poursuit ses travaux d'établissement d'une nomenclature toponymique complète pour l'île qui, comme on l'a dit plus haut, comprendra quelque 60 000 noms. En oute, ce comité est chargé de la révision des noms sur les éditions anglaise et grecque des cartes, compte tenu du système de translittération mentionné plus haut.

In accordance with the resolutions of the United Nations conferences on the standardization of geographical names, Cyprus has stayed up to date on the subject since the First Conference at Geneva in 1967. The Permanent Committee for the standardization of Geographical Names was established by the Council of Ministers and work was placed in hand.

PROGRESS MADE

The collection, standardization and transliteration of geographical names in Cyprus has been entrusted to the Department of Lands and Surveys and the Centre for Scientific Research. Cyprus is very rich in cultural heritage. The island contains approximately 60,000 names. Of these, some 2,000 that were considered the most important were processed to produce the Concise Gazetteer of Cyprus. At the Fourth Conference, Cyprus was commended on the presentation of its Gazetteer.

TRANSCRIPTION

Cyprus has two official languages, Greek and Turkish. Since Turkish uses the Roman alphabet, no transliteration of Turkish geographical names is required. Therefore, all Turkish geographical names have been left intact during the process of romanization. For the transcription of Greek geographical names into the roman alphabet, a system has been agreed between Cyprus and Greece, both members of the Roman-Hellenic Linguistic Division. The system was adopted by Cyprus and it is fully demonstrated in the "Introductory note" of the gazetteer.

COMPLETION OF THE TASK

The Cyprus Permanent Committee for the Standardization of Geographical Names is proceeding with the remaining part of the task of compiling the full gazetteer of the island, which, as mentioned above, will contain some 60 000 names. In addition, the Committee is faced with the task of revision names on both its Greek and English editions of maps in order to conform with the accepted transliteration system.

GEOGRAPHICAL NAMES--CAPTURE, PREPARATION, STORAGE AND USE BY MEANS OF ELECTRONIC DATA PROCESSING*

Paper submitted by the Federal Republic of Germany

RESUME

En tant que contribution de la République fédérale d'Allemagne à l'"International Gazetteer of the World" (Nomenclature toponymique internationale) établi par l'Organisation des Nations Unies, l'Institut de géodésie appliquée (IfAG) de Francfort-sur-le Main, a mis au point la nomenclature toponymique de la République fédérale d'Allemagne. Cet ouvrage contient le nom (et parfois une variante), les coordonnées et l'altitude, les codes et des données sur la dimension, la zone administrative, hydrographique ou géographique-naturelle de la caractéristique et les références aux cartes sur lesquelles cette caractéristique peut être localisée. Toutes ces données ont été stockées par traitement électronique dans un fichier des noms géographiques, lequel constitue la base d'un système d'information sur les noms géographiques qui permet de réviser de manière continue les stocks de données et de les utiliser à diverses fins.

Le présent document contient une description des opérations nécessaires à la compilation du fichier sur les noms géographiques, comme indiqué ci-après:

a) Introduction des données sur numériseur, y compris mesure des coordonnées de la caractéristique et coordonnées de la ligne de position à l'aide de cartes perforées ou par visualisation;

b) Préparation et stockage des données dans un fichier à accès sélectif, y compris établissement de listes inversées pour la sélection;

c) Révision par visualisation ou cartes perforées;

d) Production de relevés et de listes, préparation des données de sortie pour la photocomposition de la nomenclature toponymique contrôlée par bande magnétique.

Le dernier chapitre du document porte sur l'utilisation du fichier des noms géographiques pour la production de nouvelles cartes suivant les méthodes utilisées pour la cartographie automatisée.

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* The original text of this paper, prepared by the Institut für Angewandte Geodäsie, Frankfurt am Main, appeared as document E/CONF.75/L.27.

The geographical names assigned to the features represented on maps are an essential means of orientation for the map user, but because of political changes and the continued development of language and spelling they, too, are subject to changes. For this reason, it has for many years been the aim of national and international bodies to standardize the spelling of geographical names, with the standardized form of the name to be used at home and abroad, in texts and on maps. The Member States of the United Nations have been urged to prepare national gazetteers as contribution to an international gazetteer. Following this recommendation, the Institut für Angewandte Geodäsie (IfAG), has prepared the Geographisches Namenbuch Bundesrepublik Deutschland (Gazetteer of the Federal Republic of Germany). The content and form of the gazetteer have been discussed repeatedly in the Nachrichten aus dem Karten- und Vermessungswesen, as well as in the course of the United Nations conferences on the standardization of geographical names, held at Athens (1977) and Geneva (1982). The Gazetteer includes a detailed user instruction.

Since the data compiled for such a gazetteer can be used for a multitude of purposes, not least for the production of new maps, they must be revised continually. For this reason the gazetteer project has been extended at IfAG to the project Informational System for Geographical Names, for the realization of which electronic data processing (EDP) has been applied.

PROCEDURE FOR ELECTRONIC DATA PROCESSING

The various steps of electronic data processing are described below:

Data capture

The following data are given for each feature:

(a) The name in the official spelling, i.e., in the German-speaking area with umlaut letters (ä, ö, ü) and ß;

(b) A synonym of the name or, in the case of populated places, the name of an amalgamation of communes (Samtgemeinde, Verbandsgemeinde) (group of neighbouring communes) below Kreis (district) level;

(c) Co-ordinates (official) of the feature centre in the Gauss-Krüger projection, which is the basis of national surveying in the Federal Republic of Germany;

(d) Features codes taken from the feature code catalogue (OSKA) of the Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (Working Committee of the Survey Administrations of the Länder of the Federal Republic of Germany);

(e) Statistical key numbers to indicate the administrative classification of towns and communes or hydrographic code numbers to indicate the receiving waters or code numbers of the natural main regions (hydrographic code numbers and code numbers of natural main regions are to be combined with a code of feature group for feature distinction, with lakes and reservoirs both codes are to be indicated);

(f) Height above sea-level;

(g) Dimensions: population of towns and communes; length of rivers and channels; size of lakes;

(h) Position-line co-ordinates, i.e., the position of the name (lower left-hand corner of the first letter) on the map-sheet.

Data capture with digitizer

Feature co-ordinates and position-line co-ordinates can be ascertained on the digitizer from available maps. For this task the "table co-ordinates" of a point are measured with the cursor and stored on magnetic tape together with the characters input at the keyboard.

The measurements are carried out on a map-sheet on which the names of the features to be captured are marked. Before a measurement is begun, the map-sheet number, map scale, date of survey and name of the operator are input at the keyboard. Subsequently, the co-ordinates of the four sheet corners whose national co-ordinates are known are measured several times. Then the feature and position-line co-ordinates of each feature are measured with the cursor while the name, feature codes, height and key number are input at the keyboard. All data belonging to a feature are written on the magnetic tape in the form of a data record. After all features of the map-sheet have been stored, but also before or after each interruption, the sheet corners are neasured once again.

Because of the limited character fount, during the input of the texts on a keyboard certain encoding rules must be observed with respect to capitalization, umlaut letters, error codes and separators.

The magnetic tape is read in a data-processing system involving the following operations:

(a) Separation of the single data areas;

(b) Averaging of the table co-ordinates of the sheet corners measured several times and provision of the national co-ordinates of the sheet corners;

(c) Determination of the parameters of an affine transformation or conformal transformation of the table co-ordinates into the national co-ordinates using the sheet-corner co-ordinates and transformation of all measured co-ordinates;

(d) Examination as to the correct assignment of features and names by means of a plot of the features and names;

(f) Storage of all data.

Data capture by display is only practical when the measured co-ordinates and co-ordinates not officially acknowledged, e.g., of centres of communes, are stored and when, at the same time, all feature codes, key-numbers, dimensions

and heights belonging to the feature can be taken from only a few documents right on the display and can be keyed in immediately.

A form has been developed for use when the provision of all data for the capture by digitizer has caused considerable difficulties.

Data capture with punched cards

All information, i.e., in addition to the name itself the key-number, dimension, height, feature codes, the official or, in large-scale maps, measured co-ordinates as well as a variant name or the name of the competent Samtgemeinde or Verbandsgemeinde (group of neighbouring communes) are entered on the form from which the data are transferred into punched cards and read in. The transformation of the measured table co-ordinates into the system of the national co-ordinates required for data capture by digitizer can be dispensed with. Position-line co-ordinates are not captured separately but are formed by an increment added to the feature co-ordinates.

Data capture with display

Single features that have been overlooked during the capture with digitizer or punched cards can be fed into the storage directly on the display. For this purpose, a mask is shown on the display in which the data are entered true-to-position. Then, the content of the display is read and the data are stored at the corresponding format.

Data preparation and data storage

Before the data belonging to a feature are stored, the following operations are required:

(a) Conversion of the national co-ordinates (Gauss-Krüger co-ordinates) into geographical co-ordinates and of the geographical co-ordinates into Universal Transverse Mercator (UTM) co-ordinates;

(b) Designation of the numbers of the map-sheets of the topographic maps on the scales 1:25,000 (TK 25), 1:50,000 (TK 50), 1:100,000 (TK 100) and the general topographic map 1:200,000 (TÜK 200) and 1:250,000 (JOG 250) within which the feature lies;

(c) Entering of the commune name in the case of sections of a commune or parts of towns or cities;

(d) Compilation of a sorting field for the sorting of the data in alphabetical order, the umlaut letters of the text (ä, ö, ü) being replaced by the basic letters (a, o, u), ß by ss and certain special characters, e.g., brackets, being eliminated.

The data are stored in a record of a random access file, with the names, key numbers, feature codes, co-ordinates etc. being stored in the first 250 bytes of the record, while the sorting field, commune names and some additional

data important for printing, e.g., the length of the name fields, are stored in the bytes up to 359. If another data-processing system is used, it is likely that this record structure must be changed.

The record key, i.e., the number allowing direct access to the data record, is assigned to each feature as object number and is stored at the beginning of the record as well. To ensure that features with certain characteristics, such as feature type, co-ordinate range, dimension and key number can, at a later time, be quickly selected from the total stock, inverted lists are prepared in which the numbers of all features and these specific characteristics are indicated.

Data revision

While the officially acknowledged spelling of the names included in the data file of geographical names will hardly be subject to change, the populations of towns and communes will change. Occasionally, there will also be changes in the key numbers caused by administrative reclassification. Lastly, it is possible that new feature codes will be added, old ones elimintated or changed--new autobahn apporaches or exits, closed stations, communes turned inot towns or cities--or that new features will appear, e.g., reservoirs. With the aid of special revision programs, such changes can be incorporated in the data file of geographical names by showing the former data on the display and changing them by overwriting. The changed data are prepared like new data, the changes alos being incorporated in the inverted lists. It is very likely that the results of the census soon to take place in the Federal Republic of Germany can be included in the data file of geographical names as soon as they are available on data media.

Selection and sorting

The object numbers are assigned in the sequence in which the data records have been captured and stored. With a sorting program that forms part of every data-processing system, the data can be sorted according to different points of view. In the Gazetteer of the Federal Republic of Germany, the data are arranged in the alphabetical order of the names. Features with the same name--there are althogether 14 Neustadt--are sorted among themselves according to the key number. Other possibilities of sorting are: (a) according to statistical key numbers; (b) according to hydrographic code numbers; (c) according to populations; (d) according to co-ordinates.

For the sorted stocks, parts can be selected and processed further, e.g., the towns and communes of Hesse can be processed according to key numbers after they have been sorted.

For the selection of features, it is practical to ascertain where, e.g., certain feature codes, coincide through the inverted lists of these feature codes and to locate the object numbers indicated in these lists.

Output of data

Output of date file of geographical names on magnetic tape for further processing

An overriding reason for using EDP, apart from the easier handling of revisions, was the possibility of being able to make the entire data stock or parts thereof available for other uses. After selection and sorting, the data may be written on magnetic tape at the desired format and read in and processed further by the user, as is discussed below.

Output in the form of lists

The determining factor for the compilation of the data file of geographical names was the preparation of the Gazetteer of the Federal Republic of Germany, which was intended to contain the names and additional data as stored in the data file of geographical names at a given format. Beyond that, however, the gazetteer was to add to the feature codes abbreviations--urban commune = STA, elevation (mountain, hill) = MT etc.--and to break down and indicate by the corresponding names the statistical key numbers, hydrographic code numbers and code numbers of the natural main regions so that the administrative area of towns and communes, the succession of receiving waters with rivers and lakes and the geographical natural region can be seen from the text. A special printing program attends to the breaking-down of the key numbers and the entering of the corresponding names of the administrative units--town, Kreis (district), Regierungsbezirk (administrative unit of a Land), Land--and the waters and regions.

Output on magnetic tape for photo-typesetting

The layout of the gazetteer was given by the format of the lists. The easiest solution would have been to prepare printing-plates from the lists, using photographic means with simultaneous reduction; but because of the quality of the originals would not permit this solution. The attempt to output the data directly on microfilm--a method applied to the edition of Niedersachsen submitted to the Third United Nations Conference on the Standardization of Geographical Names, held at Athens in 1977--neither met the requirements. Ultimately, the magnetic-tape controlled photo-setting on the COMPSTAR system was used. For this, the instructions--selection of type, line-skipping, positioning, inclusion of special characters--were inserted in the data file already prepared for the printing of the lists and then written on magnetic tape. According to these instructions, the photo-setter has selected the characters form a type fount and exposed them on film. These films have been used for printing of the present Gazetteer of the Federal Republic of Germany.

Output of check plots

Data capture with punched cards or display is particularly prone to errors, above all as concerns the co-ordinates. These errors can, however, be easily

detected if the stored features and their names are plotted true-to-position on tracing-paper and this paper is placed on the map original. Wherever a feature or a name on the plot does not agree with the original, there is an error. In order to prevent an overlapping of the names of features lying closely togehter, a method was applied which registers the space occupied by a name and records furhter names falling in this area for output on a second, third or further plot. The format of the check plot corresponds to the sheet lines of topographic maps TK 25, TK 50, TK 100 or TÜK 200.

USE OF DATA FILE OF GEOGRAPHICAL NAMES FOR MAP-MAKING

An important step in map-making is the placement of names. So far, the names are usually printed on stripping-film, the emulsion membrane of which is removed and transferred to the names plate. Strictest care must be taken that no important features on the map are covered and that the assignment of the name to the feature remains clearly visible.

At IfAG, a method has been developed which makes it possible to show the map contents stored in the data base of the topographic features on a display. The same method also permits the addition of names taken from the data file of geographical names at the position determined by the position line, the type size being determined by kind and dimension of the feature. By "moving" the name on the display which is connected to a corresponding change of the position-line co-ordinates, the most favourable position can be found. In another operation, the names placed in such a manner can be written with additional instructions as to the selection of the type-face on a magnetic tape. All data are read by a photo-typesetter. They control the exposure of the film for the preparation of the names plate.

Only in special cases, e.g., if names are palced in arched form around a rounded mountain top, or if names of larger regions are widely drawn apart, divided or abbreviated, must other techniques still be applied.

A program has been developed, however, which performs by batch processing, in addition to the placement of the features of the topographic data base, a provisional placement of the names which subsequently can be checked and corrected on the display by interactive means.

The increasing application of digital raster data-processing in cartography will in all likelihood soon lead to the development of procedures for name placement.

OTHER POSSIBLE USES

In the data file of geographical names, important data of geographical features--dimension, type of feature, special characteristics and assignment to certain feature groups--are linked with precise information on the location. For this reason, the data file is of great interest to official and private users, who attach importance to the combination of feature characteristics and location data. At the Federal Envrionment Office, e.g., the data file is used

for compilation of a cadastre on pollution. Others envisage using the data file for planning purposes--establishment of branch offices, choice of transport routes etc.

The data file currently contains nearly 15,000 features, all of which are contained in the official Übersichtskarte 1:500,000 (ÜK 500). It covers, in particular, all towns and communes even if they are not included in the map, as well as numerous sections of communes.

Apart from data revision, future planning includes, in particular, revision of the population figures, which are important for the choice of lettering; and an extension of the data stock to include the names of maps at larger scales, 1:250,000 and 1:200,000.

WORK CARRIED OUT IN THE FIELD OF STANDARDIZATION OF GEOGRAPHICAL NAMES SINCE 1980*

Paper submitted by the
Union of Soviet Socialist Republics

RESUME

On donne des directions principales dans le domaine de standardisation des noms géographiques en URSS. C'est un travail scientifique et méthodologique pour l'élaboration et la définition des règles et des standards pour l'écriture des noms en russe et en langues des républiques fédérales et autonomes, pour la rédaction des dictionaires des noms géographiques pour l'établissement de noms standardisés dans l'utilisation officielle et scientifique.

In the Union of Soviet Socialist Republics, work on the standardization of geographical names has continued. On the whole, the main directions developed during the previous decade remain the same.

First, there is the scientific and methodological work, i.e., elaboration and definition of the rules and standards for transliterating names into Russian and into the languages of the federal and autonomous republics. In this process, previously distorted names are corrected, existing forms are standardized and the spelling of similar names is rectified.

In the spirit of Lenin's national policy for this multinational State, which is celebrating the sixtieth anniversary of the formation of socialist unity of large and small countries, an effort is made to perfect the rendering of names in each federal and autonomous republic into Russian as the language of international communication. The same principles form the basis for the

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* The original text of this paper appeared as document E/CONF.75/L.97.

rules for transliteration of place names of foreign countries--the goal is to maintain maximum identity of Russian forms with the national forms of names.

This objective is achieved by revising and correcting the existing instructions and by elaborating new instructions to render into Russian the names in the republics and districts of the USSR and those of foreign countries, as well as by publishing them as official and obligatory for all authorities and institutions in the Soviet Union.

In 1977, the instructions for the languages of the USSR had been completed. The last of them was then co-ordinated with the corresponding national (republican) scientific institutions and authorities. Therefore, scientific and methodological work is currently concentrated on revision of the existing rules and elaboration of new rules for rendering and compiling the instructions for foreign languages: Turkey (published in 1980); Brunei Darussalam, Malaysia and Singapore (1980); Yugoslavia (1981); South Africa from African languages (1981); and Afghanistan, China (revision) Finland and Romania (1982). The rules for Angola, Mozambique and Scotland are being worked out for the first time and prepared for publication.

Another task in the standardization of geographical names is compilation of dictionaries intended to establish standard geographical names in official and scientific usage. This work has been considerably broadened during the past two or three years, when the dictionaries of geographical names of the Armenian SSR, Estonian SSR, Lithuanian SSR, Azerbaijan SSR, Yakut ASSR, Karelian ASSR, Chukotski autonomous district and Sakhalin region were compiled. These dictionaries are now being co-ordinated.

The same task has been carried out with respect to foreign countries. In 1981, the dictionaries of geographical names of Burma and the Federal Republic of Germany were published; and in 1982, those of Portugal and Somalia. The dictionaries for Afghanistan, Austria, Bulgaria, Czechoslovakia, France, Romania and Turkey have been compiled, and some of them are scheduled to be printed soon. Compilation of such dictionaries is becoming the main activity in the standardization of geographical names.

The activities of the Permanent Joint Commission on Geographical Names have increased considerably. Besides considering and approving the instructions for transliteration into Russian of non-Russian geographical names and dictionaries of geographical names, the Commission considers and makes recommendations on all suggestions concerning the naming and renaming of features of all-Union (central) subjection and of topographic features and submits them for approval to the corresponding government departments. The Permanent Joint Commission also has links with the republican commissions responsible for the same work within the republics, and it provides these commissions with all necessary methodological assistance.

The everyday work of a permanent service on geographical names--the Department of Geographical Names and Cartographic Information of the Central Scientific Research Institute of Geodesy, Air Survey and Cartography--includes: maintenance of the place-name catalogue; verification of names at the request of mapping agencies; rapid provision on information on place names to other Soviet agencies; and scientific and methodological activities and compilation

of dictionaries of names. Currently, the Department also produces toponymic glossaries, which are confined to translation into Russian of national geographical terms and other words found in geographical names. These glossaries were intended mainly for specialists engaged in the initial collection and recording of names and to a lesser degree for those engaged in office work with geographical names. The elaboration of glossaries, however, exceeds these objectives. The task is not only to find more or less adequate Russian equivalents for national geographical terms or other words but to interpret them, to cover their multiple meanings and usage in toponymy, to include their alternatives, if any; and to define their areas of usage. The "Glossary of tponymic vocabulary of Latin America" is being prepared for publication, and the "Glossary of Russian toponymic vocabulary of the European part of the RSFSR" is being compiled.

To a great extent, the accuracy of initial recording and field verification of names in the topographic survey determines their furhter reliability. In order to perfect the work at this important stage, revisions and correction of the Directory on Collection and Recording of Geographical Names under Topographic Survey, published in 1971, were undertaken in 1982. These revisions are being done on the basis of modern requirements for geographical names and taking into consideration new methods of topographic survey, particularly in remote areas.

At the national level in the USSR, the standardization of geographical names in the languages of the peoples of the federal and autonomous republics, autonomous regions and districts is an important aspect.

In every republic of the USSR, encyclopaedic dictionaries, reference books, textbooks ans school atlases are published in the language of the republic. It is natural that place names in these publications are given in the same language. This promotes stabilization and establishes the correct forms of the names in this country and the entire world in the publications and common usage of peoples speaking other languages of the Soviet Union.

These are the main directions and results of the work on the standardization of geographical names in the USSR during recent years.

REPORT OF THE ASIA SOUTH-EAST AND PACIFIC SOUTH-WEST DIVISION OF THE UNITED NATIONS GROUP OF EXPERTS ON GEOGRAPHICAL NAMES

This is the first report of the Asia South-East and Pacific South-West Division of the United Nations Group of Experts on Geographical Names to a United Nations cartographic conference. This is the former Division of Asia, South-East, which was enlarged to accommodate the Pacific South-West region in accordance with resolution 15 (sections A and B) of the Ninth United Nations

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* The original text of this paper, prepared by the Chairman of the Division, Abdul Majid Mohamed, Deputy Director-General of Survey and National Mapping, Malaysia, appeared as document E/CONF.75/L.87.

Regional Cartographic Conference for Asia and the Pacific, held at Wellington, New Zealand, from 11 to 22 February 1980.

The former Asia, South-East Division held its fifth and last meeting in December 1980 at Cibinong, Jakarta. The meeting was hosted by the Badan Koordinasi Survey dan Pemetaan Nasional (BAKOSURTANAL, National Co-ordination Agency for Surveys and Mapping, Indonesia). This meeting, attended by representatives of Indonesia, Malaysia and the Philippines, reviewed the progress of the projects undertaken by the Division and gave the mandate for a delegation to be sent to the ninth session of the Group of Experts, to be held at United Nations Headquarters in New York in February 1981, to take part in the deliberations and to seek further clarification as to which countries in the Pacific South-West region should be included in this Division.

At that review of the Division's composition, it was accepted that the Asia South-East and Pacific South-West Division should be composed of Democratic Kampuchea, Indonesia, the Lao People's Democratic Republic, Malaysia, Papua New Guinea, the Philippines, Singapore, Thailand and Viet Nam.

This new and enlarged Division had its first meeting at Manila, Philippines, from 22 to 26 October 1981. This meeting was attended by experts from Brunei Darussalam, Democratic Kampuchea, Indonesia, Malaysia and the Philippines.

Pursuant to paragraph 15(3) of the "Aims, functions and modus operandi" of the Group of Experts on Geographical Names, which states that "a country not already a member of a division will decide for itself to which division it wishes to belong", Brunei Darussalam expressed its wish to join the Asia South-East and Pacific South-West Division. The meeting unanimously accepted the inclusion of Brunei Darussalam. Note was also taken that Democratic Kampuchea was attending for the first time and was taking an active role in the work of the Division.

The Fourth United Nations Conference on the Standardization of Geographical Names, held at Geneva from 24 August to 14 September 1982, had reported at the Plenary Session:

> "Impressive activities had taken place in the Asia South-East and Pacific South-West Division in recent months. A meeting was held at Manila in October 1981, at which representatives from cartographic and toponymic agencies in five countries exchanged views. The toponymic training course held in Indonesia in June 1982 was noted as having been an unqualified success in terms of the experience gained by both the instructors and the students". 1/

REVIEW OF PROJECTS

Political map of South-East Asia

The fourth edition of the political map of South-East Asia was compiled and printed by the Directorate of National Mapping, Malaysia. This map was presented at the ninth session of the United Nations Group of Experts on Geographical Names and subsequently was accepted by the meeting after an amendment

was made to the word "Formosa", which was the subject of an objection raised by China.

At the October 1981 meeting of this Division at Manila, it was agreed to include Democratic Kampuchea and Papua New Guinea in this map and that Malaysia will have to determine the appropriate scale for the revised map of the South-East Asia to include these countries.

Pursuant to this agreement, a new map is being compiled on the scale 1:7,000,000 on the Oblique Mercator projection. Maps of Singapore and Brunei Darussalam are shown as insets on the scales 1:3,000,000 and 1:750,000, respectively. This map, which will be produced in two colours (black and blue), will be supplied to all member countries for verification of the correctness and accuracy of the geographical names contained therein.

Physical map of South-East Asia

The second edition of the physical map of South-East Asia was produced by the Directorate of National Mapping, Malaysia, in 1980. It shows physical features and important maritime and undersea features. Only important or major place names are shown apart from those important features. This map was also submitted to and accepted by the ninth session of the Group of Experts.

At the October 1981 meeting of this Division in Manila, it was also agreed to include Democratic Kampuchea and Papua New Guinea in this map. Therefore, a new map was being compiled from the base map at 1:7,000,000 scale described above. Symbols of maritime and undersea features to be shown on the map would be in accordance with International Hydrographic Organization (IHO) specifications.

Concise Gazetteer

The first edition of the Concise Gazetteer, which contains 3,070 entries for places and features in Indonesia, Malaysia, the Philippines, Singapore and Thailand, was produced in conjunction with the fourth edition of the political map of South-East Asia.

This gazetteer will subsequently be extended to include the new countries that have been accepted in this Division and revised to include submissions made by the Philippines at the meeting of the Division in October 1981.

As usual, the gazetteer will be sent to member countries for verification of the correctness of the relevant entries made.

Regional Gazetteer

The Regional Gazetteer was compiled and printed by the Directorate of National Mapping, Malaysia. It contains 7,383 entries for places and features of four countries--Indonesia, Malaysia, Singapore and Thailand. Thailand was also given three lists of names in the border region of Thailand-Malaysia, Thailand-Burma and Thailand-Democratic Kampuchea.

Toponymic education

A pilot training course in toponymy was held at Cisarua, Indonesia, from 7 to 18 June 1982. This course was hosted by the Indonesian Government, with lecturers drawn from noted experts on geographical names from the Netherlands, the United Kingdom of Great Britain and Northern Ireland, and the United States of America. The course, attended by 29 participants from five member countries of this Division as well as neighbouring countries in the South-East Asia region, was the first of its type undertaken by a Division of the Group of Experts on Geographical Names. Participants were drawn from those involved in work directly connected with the subject of names standardization or its related activities, and the training was kept practical and related to the toponymic problems of the area in which the field-work was conducted.

In recognition to the need to hold similar courses elsewhere, the Fourth United Nations Conference on the Standardization of Geographical Names had approved resolution 6, concerning the course in toponymy:

"The Conference,

"Taking account of the success of the First Pilot Course in Toponymy, held in Cisarua, Indonesia, in June 1982,

"Recommends the holding of similar courses and seminars in other geographic/linguistic divisions and further recommends that a submission should be made by the Cartography Section of the Natural Resources and Energy Division, Department of Technical Co-operation for Development of the United Nations Secretariat on behalf of the Conference for the provision of the necessary funds to provide for such courses and seminars". 2/

This Division wishes to record its deep appreciation to the Indonesian Government for hosting this training course, to Mr. Ormeling, President of the International Cartographic Association, and to the lecturers and instructors whose enthusiasm and dedication contributed enormously to the unqualified success of the course.

Newsletter: GEONAMES

It was agreed that the newsletter GEONAMES is to be published by the Philippines, and member countries are urged to send articles and news items of interest to the publisher. At the meeting in October 1981, the Philippines announced that it has postponed the second publication of GEONAMES in order to include in its publication the proceedings of the first divisional meeting, as well as to gather news and information on divisional profiles and other related activities.

SECOND MEETING OF THIS DIVISION

It is proposed that the second meeting of this Division be held at Kuala Lumpur, Malaysia, sometime in 1983, after the Tenth United Nations Regional Cartographic Conference for Asia and the Pacific is held at Bangkok.

Notes

1/ Fourth United Nations Conference on the Standardization of Geographical Names, Geneva, 24 August - 14 September 1982, vol. I, Report of the Conference (United Nations publication, Sales No. E.83.I.7), para. 15.

2/ Ibid., p. 30.

AGENDA ITEM 7

Technical assistance and transfer of technology

TECHNICAL ASSISTANCE IN ASIA AND THE PACIFIC*

Paper submitted by Australia

RESUME

Au cours des 25 dernières années, le Royal Australian Survey Corps a acquis une expérience considérable en ce qui concerne l'établissement de cartes de régions éloignées et isolées. Il a laissé aux pays qui ont bénéficié de son assistance un stock de cartes, des données sur les levés, un niveau de compétences accru et, il est à espérer, beaucoup de bonne volonté.

The Royal Australian Survey Corps has been involved in mapping and charting projects in South-East Asia and the south-west Pacific area for the past 25 years. The first project commenced in the New Ireland and New Britain provinces of Papua New Guinea in 1957. There was then a gap of some five years before projects followed on the mainland of Papua New Guinea, Indonesia and in more recent years projects in some of the island countries of the south-west Pacific.

It has been the philosophy, particularly during the larger projects spanning some years, to invove the technicians of the country being assisted to an increasing degree as the project progressed. This serves to leave behing a capable team to develop their country's own mapping and charting abilities more independently.

PAST PROJECTS

The chronology of the involvement in mapping and charting in the area has been:

(a) 1957: control survey of parts of New Ireland and New Britain;

(b) 1962: resumption of control survey activities in mainland Papua New Guinea;

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* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.24.

(c) 1970: commencement of assistance to Indonesia (which has continued unbroken to date);

(d) 1978: completion of the last 1:100,000 scale map pf Papua New Guinea and commencement of the phasing out of Australian involvement;

(e) 1978: assistance to Fiji to determine the exclusive economic zone of that country and marking the commencement of co-operation with the south-west Pacific countries.

CURRENT PROJECTS

Defence co-operation mapping and charting projects continue with Indonesia, Vanuatu and Tonga, and negotiations are in progress with others. The assistance provided has been varied and includes:

(a) A full and complete coverage of first-generation medium-scale mapping;

(b) Vertical and horizontal control sufficient to allow the country being assisted to carry out the subsequent mapping and charting functions;

(c) High-altitude aerial photography cover;

(d) Determination of exclusive economic zone basepoints.

SUPPORT PROVIDED

The field-survey phase of the assistance is the most visible and the most expensive as far as resources are concerned. The duration of this phase is entirely related to the task and the amount of effort devoted to it. The conducting of the field survey is a matter of close negotiations between the country concerned and representatives of the Australian Government. This results in a clear understanding between both parties concerning the respective degrees of involvement. A field-survey operation usually consists of four separate activities that are normally carried out concurrently:

(a) Selection, clearing, marking and panelling of ground control points;

(b) Acquisition of identification aerial photography for those points;

(c) Doppler observations;

(d) Airborne profile recording.

The high-altitude mapping photography is usually carried out as a separate activity.

A typical field-survey operation could last up to five or six months and could entail about 70 Australian servicemen in the area of operations for that period. Up to seven or eight Australian service aircraft could also be involved, consisting of medium-lift helicopters, light observation aircraft and a short-

range transport aircraft. This organization could be expected to produce 100 co-ordinated and heighted control points, with the identification photography and airborne profiling keeping pace with this output.

Thirty-five of the servicemen would normally form a "main base", which is likely to remain in the same place for the period of the operation. The remainder would move within the area as Doppler surveying parties or to form a small "forward base". The forward base supports the parties in the field and acts as a base for some of the aircraft. It would be expected to move up to 300 km each 14 days.

The infrastructure provided locally to support such an operation depends upon the area to be covered, but typically it would be expected that there would be:

(a) A the main base, an airfield capable of supporting intermittent operation of a medium-range transport aircraft (of the Hercules C130 type) and facilities to support the 35 servicemen;

(b) At the forward base, an airfield capable of supporting intermittent operation of a short-range transport aircraft (of the Caribou type) and facilities to support 20 servicemen.

Experience has shown that one of the major difficulties to be overcome is the provision and distribution of aviation fuel to sustain the operations. Various methods have been used to overcome this problem, ranging from the fuel being made available at all the base sites by the host country to it being provided at a central distribution point, with further distribution carried out by air, road or if at all feasible by a Royal Australian Navy landing craft.

The division of responsibilities between the Australian group and the host country varies according to a number of factors. It is in that country's interest to assume as much of the responsibility as possible, and it depends upon:

(a) The level of expenditure of Defence Co-operation Project (DCP) funds that the Australian Government and the host country determine;

(b) The level of expertise available;

(c) The level of local infrastructure available to support the operation;

(d) The level of Australian defence resources available.

A typical sequence of events for such an operation could be:

(a) An approach to the Australian Government by the country concerned;

(b) A feasibility study carried out in the area by representatives of the Australian Government and the host country;

(c) A "memorandum of understanding" drafted for a later exchange;

(d) Assuming that the necessary approvals have been given, a reconnaissance by the officer commending the Royal Australian Survey Corps unit concerned;

(e) Commencement of the operation.

COMPLETION OF THE SUGAR LANDS SURVEYING PROJECT IN FIJI*

Paper submitted by Australia

RESUME

Le Gouvernement australien a aidé le Gouvernement fidjien à exécuter un projet visant à affermer aux exploitants agricoles les terres sucrières dont la Colonial Sugar Refining Company était propriétaire auparavant.

Le document récapitule les statistiques globales du projet, ses résultats et son coût et donne une description succincte de l'assistance accordée pour l'établissement et l'octroi des baux aux exploitants agricoles.

The Government of Fiji purchased 70,000 acres of Freehold and Crown Lease Land from the Colonial Sugar Refining Company (CSR) in 1973 and later asked the Australian Government for assistance to survey the individual holdings with a view to issuing registered leases to farmers.

The Sugar Lands Surveying Project in Fiji commenced in September 1974 with the arrival of the Team Leader and Supervising Draughtsman. In early 1985, survey operations commenced at the six outstations, located at Labasa, Cuvu, Rakiraki, Nadi/Lautoka and Ba, and were progressively completed by December 1981. The project subsequently became one of the longest running development assistance projects undertaken by the Australian Government in Fiji.

An earlier paper, 1/ submitted to the Ninth United Nations Regional Cartographic Conference for Asia and the Pacific in 1980, described the events leading up to the disposal of the CSR land, and the working methods and administrative arrangements used for the surveys. The present paper looks at the later stages of the project and summarizes the project's overall statistics, its achievements and costs. It concludes by briefly describing the Australian Government's assistance with the preparation and issue of leases to the cane farmers, which was a Fiji Government responsibility in this joint project.

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* The original text of this paper, prepared by the Australian Survey Office, Department of Administrative Services, appeared as document E/CONF.75/L.25.

PROJECT COSTS

The Government of Australia contributed more than 2 million Australian dollars ($A) to this project. A total of 20 Australian--17 surveyors and 3 draughtsmen--were involved and aggregated some 49 man-years of effort.

When evaluated in these terms, the staff of the Government of Fiji contributed 255 man-years, making a grand total of 304 man-years for the seven-year term of the project. It is estimated that the financial contribution of the Government of Fiji approached $A 1 million.

PROJECT ACHIEVEMENTS

The project accomplished its dual objectives, which were to provide security of tenure to tenant farmers by providing registerable leases of their lands and to train Fiji survey and drafting personnel engaged on the project. Some statistics that highlight the project's achievements in surveying and training are presented below.

Surveying/drafting

During the project, a total of 50,394 acres were surveyed, consisting of 6,262 separate allotments used for agricultural, residential and other purposes; and 496 plans of sudivision were drawn and registered. It is currently estimated that about 3,700 leases (most compromising more than one entitlement) will be issued to ex-CSR tenants; 1,721 leases had been issued as of December 1981.

A breakdown of the progress at each outstation is given in table 56.

The status of completion for the various elements of the project at June 1979 2/ and at completion was:

	June 1979 (Percentage)	December 1981 (Percentage)
Surveying	63	100
Drafting	42	100
Leases issued	4	47

Training

Training was provided in the form of on-the-job instruction, supplemented, as required, by some personal tuition. The Australian Government offered a total of 26 training awards in Australia during the project for periods ranging from six to nine months. These awards entailed further on-the-job training with the Australian Survey Office, attachments to other relevant departments and organizations and, in some cases, attendance at local technical colleges for specialized courses. The awardees were composed of 9 survey trainees, 11 drafting trainees, 4 technicians and 2 land clerks.

Table 56. Sugar Lands Surveying Project in Fiji: status as of June 1979

Location	Area surveyed at June 1979 (acres)	Final area of survey (acres)	Original estimate of area (acres)	Date of completion
Cuvu	5 846	5 846	4 735	December 1978
Nadi/Lautoka	6 104	7 445	6 490	December 1981
Ba	6 774	8 700	6 985	January 1980
Rakiraki	5 320	7 540	5 355	December 1980
Raviravi	—	4 274	2 673	December 1981
Labasa	4 831	5 916	4 789	November 1979
Tavua	709	10 673	8 456	November 1980
Total	29 584	50 394	39 483	

During the term of the project, six survey trainees became Registered Surveyors and six trainee draughtsmen qualified as Draughtsmen.

ISSUE OF LEASES

By agreement with the Fiji Government, the Australian Government's contribution to the Sugar Lands Surveying Project was theoretically terminated after the last plan of subdivision had been completed. In the last 12 months of the project, however, the Australian team directly assisted the Fiji Government in the preparation and issue of leases.

The Fiji Government had encountered some difficulty with the issue of leases to farmers--only 4 per cent had been completed at June 1979 and 25 per cent by December 1980. Progress had been primarily thwarted by a lack of success in notifying farmers that leases were ready for validation and signature. Letters had been sent with title response; visits to farmers produced slightly better resutls but were time-consuming.

The project team recommended to the Australian Government the use of radio broadcasts to transmit farmers' names to permit more effective communication with farmers in isolated areas. Funds were made available; and broadcasting commenced in 1981 with significantly improved results--a 22 per cent increase in one year, to reach a 47 per cent completion figure by December 1981.

CONCLUSION

The survey of former CSR sugar lands in Fiji, with the delineation and registration of leases, has provided security of tenure for all incumbent cane farmers. Moreover, it created a detailed land inventory of some of the best agricultural land in Fiji, together with a comprehensive network of survey monumentation on which future land-use planning can confidently be based.

Fiji Government trainees gained valuable experience working with Australian staff on the project, and for those given project awards in Australia, a further opportunity was provided to enhance their technical abilities and broaden their overall experience.

Notes

1/ "Survey of sugar lands, Fiji", in Ninth United Nations Regional Cartographic Conference for Asia and the Pacific, Wellington, 11-22 February 1980, vol. II, Technical Papers (United Nations sales publication No. E/F.83.I.14), pp. 132-133.

2/ Ibid.

TECHNICAL ASSISTANCE TO THE NATIONAL MAPPING BUREAU OF PAPUA NEW GUINEA*

Paper submitted by Australia

RESUME

Comme suite à une demande d'assistance présentée par le Gouvernement papouan-néo-guinéen, le Royal Australian Survey Corps fournit du personnel au Bureau de cartographie de la Papouasie-Nouvelle-Guinée afin de l'aider dans ses travaux. A l'heure actuelle, cinq spécialistes australiens travaillent en collaboration avec le personnel paouan-néo-guinéen afin d'améliorer les compétences techniques et administratives du Bureau de cartographie. Le personnel australien est spécialisé dans les domaines de l'administration et de la gestion, de la cartographie, de la photogrammétrie et de la lithographie.

Le programme entrepris par le Bureau de cartographie et le personnel du Royal Australian Survey Corps consiste à:

a) Réorganiser le Bureau afin de tenir compte des besoins actuels;

b) Etablir des programmes de cartographie à court terme et à long terme;

* The original text of this paper, prepared by the Royal Australian Survey Corps, appeared as document E/CONF.75/L.34.

c) Améliorer les fichiers cartographiques;

d) Réviser les noms de lieu en Papouasie-Nouvelle-Guinée;

e) Poursuivre un programme de formation qui porte à la fois sur les aspects théoriques et pratiques de la production de cartes.

La participation du personnel du Royal Australian Survey Corps aux activités du Bureau de cartographie de la Papouasie-Nouvelle-Guinée se révèle être fructueuse et utile.

In 1972, a Royal Australian Survey Corps unit, the Eight Field Survey Squadron, was deployed to Papua New Guinea in order to complete the geodetic survey and field verification for the national 1:100,000 scale topographic map series. This project was completed in 1980 and most of the Squadron personnel were then withdrawn to Australia. Five members of the Squadron remained in Papua New Guinea in order to provide technical assistance to the National Mapping Bureau of Papua New Guinea.

NATIONAL MAPPING BUREAU

The National Mapping Bureau is a branch of the Department of Lands, Survey and Environment. The Superintendent of Mapping is the branch head and is responsible to the Surveyor General.

The Bureau is responsible for the production and publication of all topographic mapping of Papua New Guinea. This includes the maintenance and distribution of maps previously published by the Royal Australian Survey Corps and other Australian agencies. The Bureau is also responsible for aeronautical charting, but not for hydrographic charting. It provides maps to the Papua New Guinea Defence Force.

The National Mapping Bureau is organized into the following sections:

(a) Geodetic Survey Section;

(b) Photogrammetric Section;

(c) Cartographic (drawing) Section;

(d) Photographic (process photography) Section;

(e) Lithographic Printing Section;

(f) Survey Co-ordination section, which includes:

(i) Registration of permanent survey marks;

(ii) Maintenance of surveying records;

(iii) Executive action on behalf of the Papua New Guinea Place Names Committee;

(iv) Map sales and distribution;

(g) Administration Section.

REASON FOR ASSISTANCE

Before Papua New Guinea obtained independence in 1975, the executive positions at the National Mapping Bureau were largely held by expatriate Australians. After independence, the majority of the expatriate positions were assumed by nationals of Papua New Guinea. In 1980, as a result of the rapid transition, the Government of Papua New Guinea requested that the Royal Australian Survey Corps should provide temporary support to their operations.

ASSISTANCE PROVIDED

The assistance provided is under the auspices of the Memorandum of Understanding Regarding Mapping and Survey Arrangements between the Department of Lands, Survey and Environment, Papua New Guinea, and the Department of Defence, Australia. The Memorandum of Understanding, which was ratified in 1975, provides for the exchange of survey information and maps and the training of Papua New Guinean technicians by Australia. The cost of providing Australian personnel, associated with the Memorandum of Understanding, is borne by the Defence Co-operation Programme between the Australian Department of Defence and the Government of Papua New Guinea.

The assistance given by the members of the Eight Field Survey Squadron is in the form of advice and training. Squadron members do not fill positions in the National Mapping Bureau. They work together with the Papua New Guinean section supervisors, providing advice and assistance as required. The aim of the project is to improve the supervisors' technical and managerial knowledge so that they may more effectively supervise and train their sections. The Field Survey Squadron members also initiate and execute training programmes for the staff.

The following personnel of the Royal Australian Survey Corps work with the National Mapping Bureau of Papua New Guinea:

(a) A Major who advices the Superintendent of Mapping and co-ordinates the other Squadron personnel;

(b) A Warrant Officer Class 1, Technician Cartographic, assigned to the Cartographic Section;

(c) A Warrant Officer Class 2, Technician Cartographic, assigned to the Co-ordination Section;

(d) A Staff Sergeant, Technician Cartographic, assigned to the Photogrammetric Section;

(e) A Sergeant, Technician Photographer, assigned to the Photographic Section.

Consideration is being given to providing also a Sergeant, Technician Printer, who would be assigned to the Printing Section.

ACTIVITIES

The programme being undertaken by National Mapping Bureau and the Eight Field Survey Squadron Personnel includes the management of the technical activities described below.

Amendment of the organization

Action has been taken to amend the National Bureau organization in order to provide for more comprehensive middle-level management. In 1980, a submission was made to the Public Service Commission to amend the organization of the National Mapping Bureau to include an administration/personnel officer, a financial officer and an assistant superintendent of mapping who would be primarily responsible for the co-ordination of the Bureau's production. The submission was favourably received and is currently under consideration.

Mapping programme

Long- and short-term mapping programmes, consistent with National Mapping Bureau resources and the needs of Papua New Guinea, have been established. As a recently independent and developing country, Papua New Guinea has quite extensive mapping needs. It does, however, have accurate and recent topographic mapping available on scales from 1:100,000 to 1:1,000,000. These maps were initiated by the Australian Government before independence and were completed after independence under the Memorandum of Understanding Regarding Mapping and Survey Arrangements, and the Defence Co-operation Programme. Some 1:50,000 scale topographic mapping and 1:10,000 scale orthophotomapping are available from the same source. The availability of medium- and small-scale topographic mapping enables the National Mapping Bureau to concentrate its efforts on large-scale mapping or developing areas and project areas (e.g., hydroelectricity projects). The following long-term programme has been decided on:

(a) Topographic mapping at 1:2,000 scale of the provincial centres (including the National Capital District), district and subdistrict administration centres, in that order of priority;

(b) Revision of the 1:100,000 and 1:250,000 scale topographic mapping (revision of the 1:500,000 and 1:1,000,000 scale mapping is undertaken by the Australian Department of Defence at the request of the Government of Papua New Guinea);

(c) Extension and densification of the geodetic network with the aim of determining a Papua New Guinea national spheroid.

Mapping records

A system for the documentation and retrieval of mapping records has been implemented. Details of this system are as follows:

(a) In order to facilitate the compilation, storage and retrieval of mapping records, a system known as the "production data file system" has been introduced. Under this system, a file is raised for each mapping area before the start of photogrammetric plotting (or at some other appropriate stage if photogrammatric plotting is not required). The fiel contains such information as:

(i) A work instruction sheet detailing the method and standard of production (it is also the Superintendent of Mapping's authorization to undertake the task);

(ii) Details of the aerotriangulation;

(iii) Control diagrams;

(iv) A list of source material;

(v) Plotting of a data sheet for each map;

(vi) A log sheet on which is recorded the occurrence of each of the functions of production as they are completed;

(b) The production data file accompanies the task throughout the various stages of production from photogrammetric plotting to reproduction, and lastly, storage of the reproduction material. At each stage, pertinent technical information relating to the production of the maps is added. The completed file is a comprehensive technical record of the production of the map.

Revision of place names

Details of place-name revision are:

(a) A review of Papua New Guinean place names has been carried out. Since independence, many place names have been changed in favour of tradional names. The only comprehensive listing of Papua New Guinea place names are the Village Directory, which was compiled by the Australian Administration, and a National Gazetteer, which was compiled in 1974, a year before independence. Both publications are now very much out of date;

(b) The authorized place names appearing on the 1:100,000 scale maps have been extracted with the view of compiling a 1:100,000 scale map gazetteer which will later be expanded to become a national gazetteer. A procedure for processing the decisions of the Place Names Committee and for amending the gazetteer has been developed;

(c) The new national gazetteer, which will be published in book form, will also be stored on magnetic tape for computer manipulation. The computer program will produce the gazetteer in various forms:

(i) A complete alphabetical listing of all of the place names in Papua New Guinea, with identification of the type of feature to which a name refers, the province in which it is situated and the Universal Transverse Mercator grid and geographical co-ordinates of its position;

(ii) An alphabetical listing of the names of a particular type of feature in Papua New Guinea, together with the same positional information as given in the complete alphabetical listing;

(iii) Either a complete alphabetical listing or an alphabetical listing of particular types of features, together with positional information, in any selected rectangular area. The selected area will be identified by entering the co-ordinates of the four corners of the rectangle.

Training

The main features of the training programme are described below:

(a) The members of the Eight Field Survey Squadron do not fill positions of authority at the National Mapping Bureau. Their function is primarily one of training. Collectively, the Squadron members have had long and varied experience in topographic mapping. Some of them have previously been instructors at the Australian Army's School of Military Survey. They are thus well qualified for the role;

(b) At the section supervisor level, the Squadron members work with the Papua New Guinean supervisors. At this level, the Squadron concentrates on furthering the ability of the supervisors to plan, co-ordinate and control the quality of the work done in their sections. The Squadron members provide a source of knowledge and expertise to which the supervisors may refer as and when necessary. The responsibility for managing section activities rests with the National Mapping Bureau personnel;

(c) At the technician level, training is concentrated on the development of manual skills, understanding of methods and furthering of theoretical knowledge. The level of expertise and experience held by the National Mapping Bureau technicians varies. Some have graduated from an institute of technology and have a fairly good understanding of theory but have had little opportunity to improve their manual skills beyond a basic level. Others have been in an apprenticeship type of situation and may have manual skill but little or no theoretical knowledge. Some have both manual skill and theoretical knowledge. Because of this, the technical training is generally done on an individual basis between student and instructor on a master-pupil basis;

(d) Training is tailored to match the technician's background and experience and is conducted on a self-pace basis. From time to time, short lectures on theoretical topics are given to the technicians collectively. These lectures

are related to a particular task in hand so that the technicians may better understand the application of the theory and have an opportunity to put it into practice;

(e) A major advantage of having the instructors present to conduct training is that the technicians and supervisors learn in their own environment, using their own equipment and resources, and their training is directly applicable to the types of tasks that they are normally required to carry out. This is not to say that the advantages of formal concentrated training are ignored. Particular attention is paid to those technicians and supervisors who demonstrate potential for more advanced training. The Superintendent of Mapping nominates these personnel for attendance at colleges either in Papua New Guinea or overseas. One such staff member has recently been identified to commence a survey drafting diploma at the Papua New Guinea Institute of Technology, beginning in 1983. The Royal Australian Survey Corps also provides formal training at the School of Military Survey and on-the-job training at Australian survey units.

General activities

Other initiatives include the introduction of quality control methods, the rewriting of specifications for large-scale mapping to permit the adoption of less expensive and more efficient methods, the streamlining of budget estimating procedures, the control and forecasting of material stocks, the management of mapping subcontractors and a small degree of progress towards establishing liaison between the Bureau and other mapping interests in the country.

CONCLUSION

The involvement of the Eight Field Survey Squadron with the National Mapping Bureau of Papua New Guinea is a successful and worth-while project. The Royal Australian Survey Corps and National Mapping Bureau personnel, as well as the people of Papua New Guinea, have benefited from the projet.

REPORT ON TECHNICAL CO-OPERATION*

Paper submitted by Japan

RESUME

En matière d'assistance technique et de transfert des technologies dans les domaines de la cartographie, l'Institut de levés géographiques, le Département hydrographique et l'Institut de levés géologiques japonais ont entrepris les activités suivantes:

a) Institut de levés géographiques:

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* The original text of this paper appeared as document E/CONF.75/L.66.

(i) Formation de techniciens originaires de pays en développement. L'Institut, parrainé par l'Agence de coopération internationale a organisé des cours de formation sur les levés géodésiques, la photogrammétrie, et l'établissement et la reproduction de cartes;

(ii) Envoi de spécialistes. Dans le cadre de projets d'assistance technique l'Institut a envoyé en collaboration avec l'Association internationale d'ingénieurs-conseils, des ingénieurs spécialisés notamment dans le domaine des levés géodésiques et de la photogrammétrie, en Asie du Sud, au Moyen-Orient, en Afrique etc.;

(iii) Coopération technique pour des projets relatifs à la cartographie. L'Association internationale d'ingénieurs-conseils contractée par l'Agence de coopération internationale et sous la supervision de l'Institut a exécuté des projets relatifs à la cartographie dans des pays en développement. A ce jour neuf projets ont été réalisés en Asie du Sud, en Afrique et en Amérique du Sud;

b) Département hydrographique:

(i) Formation de techniciens originaires de pays en développement. Le Département, parrainé par l'Agence de coopération internationale a organisé des cours de formation sur les levés hydrographiques et les levés topographiques des océans;

(ii) Envoi de techniciens. A ce jour le Département a envoyé dans quatre pays des ingénieurs spécialisés dans les domaines des courants de marée, de la cartographie côtière et de la construction de navires hydrographes;

(iii) Levés hydrographiques pour le développement. En collaboration avec l'Agence de coopération internationale et d'autres organismes le Département a apporté son assistance technique dans le cadre de projets relatifs à l'hydrographie tels que l'exécution de levés et d'études dans le détroit de Malacca;

c) Institut de levés géologiques japonais:

(i) Formation de techniciens originaires de pays en développement. L'Institut organise deux cours de formation sur les méthodes de prospection marine et la mise en valeur des eaux souterraines;

(ii) Collaboration en matière de recherche. L'Institut a réalisé cinq projets de recherche en collaboration avec le Chili, la Thaïlande etc., pour l'étude des gisements minéraux;

(iii) Collaboration avec des organismes internationaux. L'Institut a collaboré à divers projets exécutés par les organisations internationales. Il participe notamment à l'établissement de diverses cartes pour les projets de la Commission de la carte géologique du monde;

(iv) Collaboration technique bilatérale. L'Institut a envoyé des spécialistes des levés géologiques, des ressources minières, de la géochimie etc., dans les pays en développement d'Asie du Sud, d'Afrique etc.

TECHNICAL CO-OPERATION IN SURVEYING AND MAPPING

Guided by the conviction that the national base map at an appropriate scale enhances the efficient utilization, development and conservation of land and its natural resources as well as the provision of essential infrastructure, the Geographical Survey Institute (GSI) of the Government of Japan began its technical assistance in 1963. Major features of such activities can be grouped into three categories: training; dispatch of experts; and mapping projects. These activities are conducted through the Japan International Co-operation Agency (JICA) commissioned by the Ministry of Foreign Affairs.

Group training

During the Second United Nations Regional Cartographic Conference for Asia and the Far East, held in Tokyo in 1958, the need for organizing group training courses in surveying and mapping was underlined in a concrete term. In the light of this, GSI initiated group training courses in 1963, the scope of which covers geodetic surveying, photogrammetry and map compilation and reproduction. Each of them is conducted at three-year intervals and their duration ranges from six to seven months in general. The programme is organized coursewise, providing both lectures and practical training in major applied and other related subjects.

Similarly, GSI initiated individual training courses, the subjects and the scope of which are designed to meet the needs of each trainee and his home Government.

To date, GSI has provided the group training courses to 156 participants from 33 countries and has accepted 56 trainees in individual training courses from 17 countries.

Geodetic surveying course

The course in geodetic surveying is directed to introducing participants to the design of horizontal and vertical geodetic networks, the adjusting method of geodetic surveying, trilateration and traversing using electronic distance measurement (EDM), satellite positioning and precise levelling through lectures and practical training. The course includes such traditional methods as triangulation and astronomical observation for latitude, longitude and azimuth, while gravity and geomagnetic observations are included as applied subjects.

Photogrammetry course

After a series of lectures required for understanding photogrammetry, trainees are introduced to photogrammetry, including aerial photography, principle of plotting instruments, control point surveying, relative and absolute orientations, aerial triangulation, plotting practice and compilation. On-site survey is also carried out. Participants actually draw maps on the scale 1:25,000 with plotting instruments during the training courses.

Map compilation and reproduction course

The course in map compilation and reproduction introduces participants to map projection methods; map compilation to scale down a map, for example, from 1:50,000 to 1:200,000; and the compilation of various types of thematic maps. Scribing, plate-making and printing are also dealt with theoretically and practically.

Dispatch of experts

In 1964, GSI sent four senior staff to carry out national boundary surveying in Saudi Arabia. Since then GSI and the International Engineering Consultants Association (IECA), a public service corporation that functions under the supervision of GSI and consists of major aero-surveying companies in Japan, have sent 81 senior and experienced engineers as technical assistance experts. Of these, 54 were dispatched as short-term experts, usually remaining from several weeks to two months to carry out particular projects based on the requests addressed to the Government of Japan by the recipient Governments, while others are long-term experts who co-operate with host Governments (see table 57).

Mapping projects

In 1971, GSI began its first overseas mapping project in Indonesia, with a view to preparing the national base map in that country. The role of GSI in this field is to give advice to the authorities concerned both in Japan and in host countries on all aspects of surveying and mapping of the projects and to supervise actual works.

The projects are conducted by IECA, acting as contractor of JICA under the supervision of GSI, which is well equipped ans staffed to tackle oversea surveying and mapping. Such projects include all related works, including aerial photography, control point surveying and on-site survey, such as checking geographical names. Some of them were carried out in collaboration with the recipient Governments. Most of them were topographic mapping. In Kenya, however, the thematic mapping project is scheduled to be completed in the same area in which topographic mapping was finalized by Japanese technical co-operation. The purpose of the new type of project is to illustrate the scientific aspects of potential for agriculture and cattle ranching.

The mapping projects already carried out as well as those in progress are listed in table 58.

Table 57. Dispatch of experts from Japan on long-term assignments

Receiving country	Purpose	Sending agency	Duration of assignment
Bolivia	Photogrammetry	IECA	1981-1982
Indonesia	Control point surveying	GSI	1975-1976
	Control point surveying	GSI	1975-1977
	Control point surveying	GSI	1977-1978
	Photogrammetry	GSI	1978-1980
Kenya	Geodetic surveying	IECA	1981-ongoing
	Geodetic surveying	IECA	1981-ongoing
	Geodetic surveying	IECA	1981-ongoing
Liberia	Geodetic surveying	GSI	1978-1980
	Photogrammetry	IECA	1978-1980
Malawi	Surveying and mapping	GSI	1975-1977
Nepal	Surveying and mapping	GSI	1980-1981
Papua New Guinea	Photogrammetry	GSI	1981-ongoing
Saudi Arabia	Photogrammetry	GSI	1979-1982
	Printing	GSI	1979-1981
	Photogrammetry	c/	1979-1982
	Mapping	IECA	1979-1981
	Map compilation	IECA	1979-ongoing
	Photo-processing	IECA	1979-1982
	Printing	GSI	1981-ongoing
	Map compilation	GSI	1981-ongoing
	Photogrammetry	GSI	1982-ongoing
	Mapping	IECA	1981-ongoing
	Photo-processing	IECA	1982-ongoing
Venezuela	Geomorphology	GSI	1978-1980
	Geomorphology	a/	1981-ongoing

Note: GSI = Geographical Survey Institute; IECA = International Engineering Consultants Association.

a/ Dispatched from Niijima Senior High School on recommendation of the Geographical Survey Institute.

b/ Dispatched as Japan Overseas Co-operation Volunteers.

c/ Dispatched from Geological Survey of Japan.

Table 58. Oversea mapping projects undertaken by Japan

Location	Type of project	Fiscal years
Indonesia: Barito River Basin	Aerial photography: 19 300 km^2 at 1:50 000 scale; Mapping: 19 300 km^2 at 1:50 000 scale; 34 sheets	1971-1974
United Republic of Tanzania: Musoma District	Aerial photography: 12 730 km^2 at 1:50 000 scale; Mapping: 12 730 km^2 at 1:50 000 scale; 23 sheets	1973-1975
Bolivia: Chapara District	Aerial photography: 30 000 km^2 at 1:60 000 scale; Mapping: 20 000 km^2 at 1:50 000 scale; 44 sheets	1974-1977
Kenya: East Kenya	Aerial photography: 30 000 km^2 at 1:60 000 scale; Mapping: 27 000 km^2 at 1:50 000 scale; 37 sheets	1975-1980
Kenya: East Kenya	Thematic mapping: 14 500 km^2; three themes at 1:50 000 scale, 12 sheets; two themes at 1:100 000 scale, 4 sheets	1981-1983 (in progress)
Guinea: entire country	Aerial photography: 245 000 km^2 at 1:100 000 scale; Mapping: 12 000 km^2 at 1:50 000 scale; 16 sheets; Photomapping: 233 000 km^2 at 1:50 000 scale; 372 sheets	1977-1981
Panama: coastal area of Caribbean Sea	Aerial photography: 8 000 km^2 at 1:60 000 scale; Mapping: 6 000 km^2 at 1:50 000 scale; 12 sheets	1978-1980
Philippines: Cagayan Valley	Aerial photography: 15 000 km^2 at 1:30 000 scale; Mapping: 11 000 km^2 at 1:25 000 scale; 72 sheets; Photomapping: 300 km^2 at 1:10 000 scale; 12 sheets	1978-1982 (in progress)
Peru: Satipo area	Aerial photography: 30 000 km^2 at 1:60 000 scale; Mapping: 12 500 km^2 at 1:25 000 scale	1982-1983 (in progress)

In addition to the conduct of surveying and mapping works, these projects include technical transfer at every stage in the project area and in Japan.

TECHNICAL CO-OPERATION IN HYDROGRAPHIC ACTIVITIES

Group training

Hydrographic technical course

In 1971, the Hydrographic Department of Japan, sponsored by the Overseas Technical Co-operaiton Agency (now JICA), initiated a group training course for hydrographic personnel of developing countries, mainly in South-East Asia. The course was conducted in September-October 1971 with eight participants from seven countries. The course was developed into two long-term group training courses in the following years, a hydrographic survey course and a physical oceanographic survey course.

Hydrographic survey course

Initiated in 1972, the six-month hydrographic survey course is intended to introduce participants to modern theory, knowledge and techniques of hydrographic survey, primarily for nautical charting now available in Japan, through lectures, practical training and observation tours. Up to 1982, a total of 99 persons from 14 countries had participated in the course. The main subjects taught include: geodesy; map projection; control survey; coastlining; electronic survey; sounding; tides; submarine topography and geology; survey planning; field training of harbour, coastal and ocean surveys; and data processing thereof.

Physical oceanographic survey course

Also begun in 1972, the four-month physical oceanographic survey course introduces participants to basic, modern knwoledge and techniques of physical oceanography through lectures, practical training and observation tours. Up to 1982, a total of 86 persons from 14 countries had participated in the course. The main subjects taught include: offshore physical oceanography; chemistry of sea water; wind waves; tides; tidal currents; oceanographic data management; field training of tide and tidal current observations and of oceanographic observation; and data processing thereof.

Dispatch of experts

Tidal and current studies in Singapore

An expert in tides and tidal currents is being sent from the Hydrographic Department, Maritime Safety Agency, to the Hydrographic Department, Port of Singapore Authority, for a period of two years from 1981 to 1983.

Tidal observation and analysis in Malaysia

An expert in tidal observation and analysis is being sent from the Hydrographic Department, Maritime Agency, to the Survey Department, Directorate of National Mapping of Malaysia, for a period of two years from 1981 to 1983.

Coastal mapping project of Saudi Arabia

To make preliminary investigation and drafting of survey specifications for the coastal mapping project of the Saudi Arabian Government, the Hydrographic Department, Maritime Safety Agency, sent a few experts on a short-time basis in 1980.

Construction of new survey vessel in Pakistan

To make a technical evaluation of tender specifications for a survey ship to be built for the Government of Pakistan and to give guidance about the survey equipment, the Hydrographic Department also dispatched an expert on a short-term basis to the Pakistani Government in 1981.

Development survey projects

Malacca and Singapore straits

Joint hydrographic surveys

In order to update nautical charts of the Malacca and Singapore straits, which were based mainly on the old-dated surveys up to 1930s, so that they meet the requirements of modern, large-sized vessels, the Hydrographic Department of Maritime Safety Agency, in collaboration with JICA and the Malacca Strait Council, carried out hydrographic surveys of the main shipping routes in the straits jointly with the three coastal states, i.e., Indonesia, Malaysia and Singapore. The surveys were carried out in six stages from 1969 until 1975. The results obtained were used for safer navigation of vessels through the straits.

Joint production of common datum charts

In order to eliminate the geodetic discrepancy on the charts between the Peninsular Malaysia/Singapore side and Sumatera on the Indonesian side, production of common datum charts was carried out jointly by the three coastal states and Japan. The Hydrographic Department participated in this project in collaboration with JICA and the Malacca Strait Council. The project consisted of two phases: Phase I was commenced in 1977 and was completed in 1979, producing three sheets on the scales 1:50,000 (two sheets) and 1:75,000 (one sheet) covering the Singapore Strait; and Phase II, from 1980 to 1982, producing three sheets covering the Malacca and Singapore straits from one Fathom Bank to the eastern entrance of the Singapore strait, each on the scale 1:200,000. Based on these common datum charts, the Hydrographic Department of Japan entirely revised its relevant nautical charts for general use.

Joint tidal and current studies

To provide more accurate tidal and current information of the straits of Malacca and Singapore for safer and more economical navigation by large-sized vessels and other boats, the Hydrographic Department of Japan, in collaboration with JICA and the Malacca Strait council, carried out tidal and tidal current observations jointly with the three coastal states from 1977 to 1979. The results were processed and published as predictions for tides and tidal currents at certain stations in the straits, and co-tidal charts were compiled.

Hydrographic survey and nautical charting of the coast of Abu Dhabi

As a technical co-operation programme with the Government of the United Arab Emirates, the Hydrographic Department, in collaboration with the Overseas Technical Co-operation Agency (now JICA), conducted hydrographic survey of the coast of Abu Dhabi, the Gulf, in 1972. The results were published as two new Japanese charts in 1973 and were revised in 1978.

Hydrographic survey in Lombok and Makassar straits

The Hydrographic Department of Japan rendered technical co-operation to the Indonesian Government for the hydrographic survey of Lombok and Makassar straits, by sending surveyors and necessary equipment, with the support of JICA and the Malacca Strait Council. The survey consisted of a preliminary survey and a main survey, begun in 1973 and was completed in 1974. The results of the survey were used to revise the relevant nautical charts of both countries.

TECHNICAL CO-OPERATION IN GEOLOGICAL SURVEYS

The Geological Survey of Japan (GSJ) has long been involved in geological programmes of international importance. The scope of these activities is steadily expanding into all phases of geosciences and the programmes are increasingly gaining importance within the Survey.

These international activities can be largely grouped into co-operative research carried out jointly with counterpart institutions, participation in scientific and technical co-operation programmes of the Japanese Government and training of scientific and technical personnel of developing countries.

Co-operative research

Five co-operative research projects are being conducted, with the national geological services of Chile, China, the Republic of Korea, Thailand and Turkey. These projects are carried out as a part ot the international research co-operation programme of the Agency of Industrial Science and Technology.

Chile

Base-metal exploration methods effective in arid regions are pursued jointly with the Geological Survey of Chile. Geological and geochemical work is done in the Chilean Andes in order to establish new exploration criteria.

China

A comparative study of mineral deposits related to igneous activities formed under the continental geological environment and those under the island arc environment is conducted jointly with the Chinese Academy of Geological Sciences in the Ministry of Geology.

Republic of Korea

Tectonic linear maps on the scale 1:500,000 covering important areas of the Republic of Korea and south-west Japan are being prepared from LANDSAT imagery analysis. It is expected that the results will contribute to interpretation of the geological structure of the area and ultimately to exploration of mineral resources. This project is conducted jointly with the Korean Research Institute for Geoscience and Mineral Resources.

Thailand

Geothermal resources in non-volcanic areas in northern Thailand are studied jointly with the Department of Mineral Resources in order to provide basic geological, geophysical and geochemical data for the development of those resources.

Turkey

A seismo-tectonic study of the Anatolia Fault is being carried out in co-operation with the Mineral Research and Exploration Institute (MTA). As both Japan and Turkey are lcoated in unstable earthquake-prone zones of Earth, it is expected that comparative study of the active faults of both countries would provide important clues for clarifying the mechanism of earthquake occurrences.

Co-operation with international bodies

GSJ is participating in various projects of international organizations, including the United Nations and particularly those bodies affiliated with the Economic and Social Commission for Asia and the Pacific (ESCAP). Experts have participated in the activities and conferences of the Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP) and that for the South Pacific (CCOP/SOPAC). Scientists have been seconded to the Regional Mineral Resources Development Centre (RMRDC). GSP also is involved in compilation of various maps for the projects of the Commission for the Geological Map of the World.

GSJ is responsible for the compilation of various thematic maps of the north-west quadrant of the Circum Pacific Map Project. The maps include geography, tectonics, energy and mineral resources. A panel, consisting of the representatives from the national geological services of the countries bordering the western Pacific and experts from agencies, universities and other institutions, assumes responsibility for the project. The geographical tectonic maps have already been published so far and other maps are to be completed soon.

Bilateral technical co-operation

GSJ is involved in the technical co-operation programme of the Japanese Government. The activities of the survey personnel in the scientific and technical assistance programme cover virtually all phases of the geoscientific spectrum. The durations of these activities range from several weeks to several years. During 1981, these activities were conducted in Chile, China, Mexico, Indonesia, Kenya, Mali, Morocco, Nepal, the Philippines, Saudi Arabia, Thailand, the United Republic of Tanzania and the South Pacific marine area. Only the dispatch of long-term experts is given below:

(a) Saudi Arabia: one expert in photogrammetry, 1979-1982;

(b) Nepal: three experts in geological survey, 1979-1982;

(c) Thailand: one expert in geophysics, 1979-1983;

(d) Kenya: one expert in geothermal resources, 1980-1983;

(e) Morocco: one expert in mineral resources, 1980-1983;

(f) Indonesia: one expert in geochemistry, 1981-1983;

(g) United Republic of Tanzania: one expert in geochemistry, 1982-1984.

Training

Training of technical personnel from the developing countries in geosciences is conducted as a part of the technical co-operation scheme of the Government of Japan. This training includes two regularly scheduled courses held each year for marine prospecting methods and for ground-water development. Both of these courses have been conducted annually since 1967; and about 10 scientists and engineers from various regions, such as South-East Asia, the Middle East, Africa, and Central and South America participate each year.

To date, 311 persons have participated. The marine geoscience course lasts seven months; and the ground-water course, four months. In addition, during the period from 1979 to 1981, a total of 45 foreign geoscientists participated in GSJ activities for on-the-job training.

CAPACITES DE GEOKART DANS LE DOAMINE DE L'ASSISTANCE TECHNIQUE ET DU TRANSFERT DE TECHNOLOGIE*

Document présenté par la Pologne

The Union of Surveying and Cartographic enterprises (GEOKART) is a company consisting of more than 20 associated enterprises located at various places throughout Poland. Each of them is responsible for the cartographic exploration of a particular region of the country. They are, however, also specialized in various domains of their profession. They established the national geodetic network, horizontal and vertical, comprising several orders, which became the basis for the general mapping of the country.

An entire system of maps on various scales, from 1:500 up to 1:50,000 and smaller, has been completed. They are all characterized by a remarkable technical value and high precision. This accuracy was obtained through application of the most modern technologies and use of high-precision instruments, including automation of photogrammetric and cartographic operations accompanied by the creation of data processing and geodetic informatic centres.

GEOKART has at its disposal more than 9,000 technical staff, counting engineers and surveyors only. Their activities have provided full cartographic documentation for economic development of the country. The surveying services provided by the enterprises of this organization are not limited, of course to geodesy and geodynamics, aerial photography, photogrammetry, large-scale and topographic mapping, geodetic computation and cartography. GEOKART undertakes all types of engineering surveys, such as the laying-out of industrial plants, horizontal and vertical geodetic networks, field demarcation and setting up, arrangement of sidings, cables and other power-lines; and measurements for construction of special buildings, such as grain elevators, cold-storage plants, tanks, water-power plants and high chimneys. GEOKART assures regular control surveys of the deformation of dams, of vessels during their launching and other constructions; and it carries out inventory surveys of underground installations.

GEOKART also fulfils other surveying tasks, namely, those required in agricultural management, water projects, land reclamation, geological and geophysical researches, environment projection, special mapping for urban regions, town-planning and contruction of roads, highways and railways, as well as inventory surveys connected with the maintenance of historical sites and architectural monuments.

Another field of activities is represented by the cadastral survey and establishment of a numerical cadastre, which is widely fulfilled by the GEOKART enterprises. The State Map Publishing House (PPWK) co-operates with GEOKART and is responsible for editing, reproduction and printing of all types of small-scale cartography--atlases and touristic and school maps, as well as different sorts of thematic maps.

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* Le texte original de ce rapport, préparé par l'Union des entreprises géodésiques et cartographiques (GEOKART), a paru sous la cote E/CONF.75/L.116.

Apart from stationary studies at high academic levels, which are normally provided ty technical schools and academies, GEOKART takes care of particular practical professional training in different fields of surveying and cartography. Such short-term and long-term training can be conducted in Poland and abroad as technical assistance provided to developing countries under the terms of bilateral agreements.

GEOKART has already executed a number of projects abroad. Among its achievements is the establishment of the first-order national geodetic network in Iraq, covering the entire area of that country; and the preparation of 1:25,000 scale topographic maps of 170,000 km^2 in a record time of four years. Simultaneously, GEOKART organized an informatic centre at Baghdad, including installation of a minicomputer particularly suited for geodetic computations and provided with a set of software elaborated by Polish scientists. The Centre is currently managed and operated by Iraqi technical staff and specialists.

Other important projects have been implemented in the Libyan Arab Jamahiriya, such as cartographic preparation for town planning in various regions of that large country; survey, design and supervision of road building; and infrastructure projects.

Similar work is now being carried out in Iraq, where GEOKART is in the course of preparing a map of the entire city of Baghdad and a topographic large-scale map pf the Kirkuk region.

Again in the Libyan Arab Jamahiriya, GEOKART is the executor of one of the largest cartographic projects ever undertaken. After all the necessary geodetic works are finished, this project will eventually lead to complete coverage of the country with topographic maps prepared on an entire system of scales.

GEOKART has also prepared maps for Nigeria and the United Republic of Tanzania; and it is now broadening its relations with several other countries of Africa. GEOKART has presented the general conception of the establishment of the integrated African geodetic continental network, the first stage of which, the Doppler survey, is under way.

GEOKART is proud to be the implementing institution for United Nations technical assistance programmes; and since 1976, it has been responsible for the execution of one such project in Afghanistan. The organization wants to expand its co-operation with United Nations bodies in order to contribute to their objective of providing assistance to developing countries and co-ordinating the scientific and professional activities of the Member States in surveying and cartography in various regions of the world.

L'Union des entreprises géodésiques et cartographiques (GEOKART) est une compagnie groupant plus qu'une vingtaine d'entreprises, localisées dans différents endroits tout au travers de la Pologne. Chacune d'entre elles est responsable des travaux géographiques dans une région particulière du pays. Ces entreprises sont en même temps spécialisées dans des divers domaines de notre profession. Elles ont établi le réseau géodésique national de plusieurs ordres - horizontal et de nivellement - qui est devenu la base pour la production générale des cartes topographiques et thématiques de la Pologne.

Tout un système de cartes aux différentes échelles, du 1:500 jusqu'au 1:50 000 et plus petit, a été établi. Elles se caractérisent toutes par une valeur technique remarquable, ainsi que par leur haute précision. Cette précision fut obtenue grâce à l'application des technologies et instruments les plus modernes, y compris l'automatisation des procès photogrammétriques et cartographiques, accompagnée de la création des centres d'informatique et du traitement des données en géodésie et cartographie.

GEOKART dispose de plus de 9 000 ingénieurs et techniciens géomètres. Leurs activités ont produit la documentation cartographique complète pour les besoins du développement économique du pays. Les services fournis par nos entreprises ne se limitent pas, bien entendu, à la géodésie et la géodynamique, la photographie aérienne, la photogrammétrie, la production des cartes topographiques et des cartes à grande échelle et les calculs géodésiques. Nous mettons à l'exécution toutes sortes de mesurages rattachés à l'ingénierie, la géodésie de chantier avec l'institution des canevas de réalisation - horizontaux et de nivellement - l'emplacement des projets sur le terrain, le tracement des cables et d'autres lignes du transport de l'énergie, les mesures relatives à l'érection des édifices spéciaux: silos à grain, entrepôts frigorifiques, réservoirs, établissements hydroélectriques, hautes cheminées etc. Nous assurons un contrôle régulier de la déformation des barrages, des éléments de navires au cours du lancement et d'autres constructions. Nous procédons aussi aux mesurages d'inventaire des installations souterraines.

GEOKART remplit également d'autres tâches topographiques et notamment celles qui sont demandées par l'aménagement agricole, les projets d'irrigation, la recultivation du sol, les recherches géologiques et géophysiques, la protection de l'environnement, la cartographie spéciale pour les régions urbaines, les plans d'aménagement des villes, projets des routes, des autoroutes et des voies ferrées, la conservation et la reconstruction des monuments et des postes d'archéologie.

Une autre sphère d'activités de la GEOKART comprend les mesures cadastrales et l'établissement du cadastre numérique.

Nous coopérons aussi avec la maison de publication PPWK qui est responsable de la rédaction, la reproduction et l'impression des atlas et de toutes sortes de cartes à petite échelle - scolaires, touristiques et thématiques spéciales.

En dehors de l'enseignement technique supérieur, fourni normalement par les écoles académiques, notre organisation prend soin de l'instruction professionnelle pratique dans les différents domaines de géodésie et de cartographie. Une telle instruction de longue ou de courte durée peut se faire en Pologne et aussi à l'étranger. Elle peut être considérée comme un élément de l'assistance technique réalisée sur la base d'une convention bilatérale.

Nous avons déjà réalisé un nombre considérable de travaux à l'étranger. Parmi ceux qui sont déjà déterminés il faut citer l'établissement du réseau géodésique national de premier ordre sur tout le territoire de l'Iraq, ainsi que l'élaboration des cartes topographiques à l'échelle du 1:25 000 sur une superficie de 170 000 km^2. Ce travail fut achevé dans un temps record de quatre

ans. Nous avons organisé en même temps un centre d'informatique à Bagdad avec installation d'un mini-ordinateur particulièrement convenable pour les calculs géodésiques. Le centre fut pourvu d'une programmerie complète, élaborée par les spécialistes polonais. Il est actuellement dirigé et exploité par le personnel technique iraquien.

D'autres travaux importants ont été achevés en Jamahiriya arabe libyenne, tels que la préparation cartographique pour planification urbaine et développement régional dans les différentes parties de ce vaste pays, les mesures, l'élaboration de projets des routes et la surveillance technique de leur réalisation, les projets de l'infrastructure etc. Le même travail est mené actuellement en Iraq où GEOKART est en train d'établir la carte de toute la ville de Bagdad, et une carte topographique à grande échelle de la région de Kirkuk. C'est en Jamahiriya arabe libyenne encore que GEOKART est le réalisateur d'un des plus grands projets cartographiques qui aient jamais eu lieu jusqu'à présent et qui, après l'accomplissement de tous les travaux géodésiques qui y sont nécessaires, va aboutir à une couverture complète de tout le pays avec des cartes topographiques élaborées dans tout un système d'échelles.

GEOKART a sur son compte l'établissement des cartes aussi au Nigéria et en République-Unie de Tanzanie. Nous élargissons maintenant nos relations avec plusieurs pays africains. Nous avons préparé la conception générale de construire le réseau géodésique continental africain qui est un réseau intégré et dont la première étape, connue comme mesure africaine de Doppler, est aujourd'hui en voie de réalisation.

GEOKART est fière d'être l'exécuteur de programmes d'assistance technique de l'Organisation des Nations Unies. Nous sommes en effet responsables depuis 1976 d'un projet de longue durée en Afghanistan. C'est notre désir d'augmenter de plus en plus notre coopération avec les institutions des Nations Unies afin de contribuer à leur but glorieux de porter l'aide aux pays en développement et de coordonner les activités scientifiques et professionnelles des pays membres de l'Organisation en géodésie et en cartographie dans les différentes parties du monde.

THE ROLE OF THE UNITED NATIONS CARTOGRAPHIC CONFERENCE*

Paper submitted by Sweden

RESUME

Dans le présent document, on examine la question du rôle essentiel des conférences cartographiques régionales. Dans la première partie, l'auteur conteste la manière dont les travaux sont organisés et estime qu'on accorde trop d'importance aux techniques avancées, tant dans les documents présentés que dans les discussions il pense

* The original text of this paper, prepared by Sten Wickbom, National Land Survey of Sweden, appeared as document E/CONF.75/L.31.

qu'il faudrait accorder plus d'attention à une analyse des besoins des utilisateurs de cartes dans le tiers monde, ainsi qu'aux contributions que les utilisateurs, les planificateurs et les dirigeants pourraient apporter.

Dans la deuxième partie du document, l'auteur examine plus avant la question de la nécessité d'une collaboration plus étroite entre les producteurs de cartes et les utilisateurs, compte tenu de l'expérience acquise par la Suède dans un certain nombre de pays du tiers monde en matière de coopération concernant l'établissement de levés et de cartes.

At a meeting such as this Tenth United Nations Regional Cartographic Conference, and before a gathering of distinguished surveyors and cartographers, it is most certaintly not necessary to present a case to justify the importance of cartography and cartographic tools in the national development process. The question remains, however, why policy-makers and those to whom these services are offered are not equally convinced.

At these United Nations conferences, there are presented a wide range of scientific papers dealing with the latest and often most advanced cartographic developments which are followed by detailed discussions. The question is how much time is allocated for discussions concerning the basic demands that the developing countries place on the availability of cartographic resources and how often the discussions concern methods and techniques that are suited to the working environment in these countries. The answer must be, in this author's opinion, far too seldom.

For this reason, it is understandable that purchasers of these services and the users of these products are represented here only to a very limited extent. One may ask, for example, where are the policy-makers and the political decision-makers. Is it not this group of consumers whom the researchers and producers must meet and discuss with if cartography is to play the central role in planning and development to which it is so eminently suited? Is this type of dialogue not fundamental to the future development of cartographic products? Maps and landscape information are produced to be used, not to be stored away in archives. Are not the United Nations cartographic conferences a suitable forum for this type of discussion?

The Swedish Government is clearly aware of the significant role that cartography can play in the national development process. Sweden has regularly been represented at the United Nations cartographic conferences, and its experience is such that it is in a position to comment constructively on the form and content fo those conferences.

The Swedish Ambassador to the United Nations presented the Swedish viewpoint at the first regular session of the Economic and Social council in 1981 (agenda 85), stating that because the conferences had sought to cover all aspects of cartography and had concentrated on technical innovations and experience in developed countries, they had tended to duplicate information already available and had not been as useful to the developing countries as they could

have been. The Swedish view is that future conferences should be focused on overall operational matters related to the conditions and problems of countries in the region.

The Ambassador took note that the Second United Nations Regional Cartographic Conference for the Americas had discussed the future orientation of the conferences and had established a special working group, which had recommended that the conferences should be organized so as to permit discussions to relate developments to user needs and the resources likely to be available to meet them, including organizational aspects, training and technical assistance. As examples, the working group had referred to establishment of a national basic geodetic system, use of orthophotomaps as base material for national map series and for special purposes and preparation of layouts for national mapping organizations. In the opinion of Sweden, the conclusions of the working group were appropriate and it is hoped that they will be taken into account by the appropriate bodies in preparing for future regional cartographic conferences.

Sweden has not considered it necessary to depart from this viewpoint, and this author should once again like to propose that a working group should be elected, with the task of formulating guidelines for future cartographic conferences with the Swedish proposals as a starting-point.

The point is that cartographers must listen more closely to what map users have to say and that development work and products should better meet user requirements. This point can be further illustrated by a brief description of the experiences that the National Land Survey of Sweden has gained as a result of close co-operation with survey departments in developing countries in Africa during recent years.

The National Land Survey is the Swedish state survey organization with responsibility for the fundamental geodetic networks, national mapping on the scales 1:10,000 and less and the cadastral system. In addition, the National Land Survey is the largest surveying and mapping consultant in Sweden. Repayment services include geodesy, photogrammetry and cartography. Its clients include, among others, municipalities, forest companies and defence and other state authorities. Property valuation and consultancy are also carried out on a repayment basis.

Many of the staff members have oversea experience through working as experts with the United Nations or with national aid organizations. Common for almost all of them is a feeling of disappointment at not being able to achieve tangible and lasting results. The expert's role tends to become static instead of flexible and progressive. Many have had the feeling of being in a no man's land without fast links to either the parent or the recipient organization.

Against this background, the National Land Survey has begun a dialogue with survey organizations in a number of developing countries concerning institutional co-operation between the respective organizations. A short paper on such institutional co-operation has been submitted to this Conference under agenda item 7. The aim is to provide continuous support over a broad spectrum of activities until the recipient organization is in a position to operate

efficiently without outside assistance. Institutional co-operation is carried out on a non-profit basis, as a repayment service financed either by the recipient country, through the Swedish International Development Authority or by other aid sources.

Experience of this type of assistance has very clearly shown that planning and product development within sister organizations is only to a very limited degree influenced by these organizations and authorities which are their principal clients, such as forestry and agricultural departments, water departments and planning authorities. Questions of priorities and policies are rarely discussed in advance to permit adaption to user requirements. One tends to experience a series of on-the-spot, half-satisfactory solutions to meet the most pressing demands instead of a planned approach.

This writer's experience is that survey departments are notoriously conservative and that even a slight change of course can be a long-term process. Many survey departments in former colonies still appear to be working according to old well-established systems, which were eminently suited to the existing situation when they were devised but which now are in serious need of revision.

It has been found that even if technical field assistance must often be given high priority, there is a great need for assistance at the planning and policy-making level. Operational planning questions are frequently neglected; equally serious is the lack of long-term plans concerning techniques and methods. The National Land Survey has, for example, questioned the correctness of working with out-of-date survey regualtions which were formulated against the background of a wholly different technical and working environment. Working ambitions must be adapted to reasonable accuracy requirements and correlated closely with costs and resources.

During the colonial period, there was a need to achieve the first national small-scale map coverage to provide information for basic planning and development requirements. Base mapping and map revision are still vital tasks for any survey organization; but resources should also be made available for cadastral surveys, large-scale mapping for human settlement purposes and mapping for development of rural areas. These latter activities are not infrequently neglected or, at the best, given low priority.

As concerns mapping for human settlement purposes, the explosive pace of urbanization and the lack of adequate mechanisms to cope with it, resulting in the decay of urban centres and slum development, is one of the most pressing problems in developing countries. There is an interplay between rural depopulation and urbanization. Cadastral surveys and mapping are vital planning tools for integrated planning of human settlement strategy and equitable land policies. Sweden has, through the United Nations Centre for Human Settlements, tried on several occasions to arouse interest in the vital role that surveying and cartography can play in the context of human settlements. The fact that land is the principal subject of the meeting of the Commission on Human Settlements, to be held at Helsinki, Finland, in 1983, would indicate that it is not a voice crying in the wilderness.

INSTITUTIONAL CO-OPERATION: A ROLE FOR SURVEY ORGANIZATIONS IN DEVELOPED COUNTRIES*

Paper submitted by Sweden

RESUME

L'actuelle récession économique laisse fortement présager une nouvelle diminution de l'aide accordée aux organismes de topographie et de cartographie du tiers monde. En tant que fournisseurs d'instruments essentiels pour la planification, ces organismes ont un rôle fondamental à jouer dans l'élaboration des stratégies nationales de planification. Le document considéré contient des observations sur la situation actuelle ainsi qu'une description de la coopération institutionnelle entre l'Office suédois des levés et divers organismes homologues africains.

A fundamental requirement for a national development strategy is an effective mapping programme. Information about the physical environment in the form of aerial photographs, co-ordinates, maps, digital information, cadastral data and land-use information is a basic tool in the planning process. The orderly exploitation of natural resources, forestry and agriculture development programmes, erosion control, transportation, urban and rural planning, environmental control, telecommunications, are examples of activities that are, to a high degree, dependent upon the availability of up-to-date, reliable base data.

During the colonial period, surveying and mapping activities were generally given high priority for a variety of reasons. The very excellent work carried out by, among others, the United Kingdom Directorate of Overseas Surveys during the post-war period has greatly contributed to development in many developing countries through the provision of basic mapping, thereby helping to put many of these countries on the road to being able to initiate ordered planning activities. With the current tendency towards a decrease in surveying and mapping support of this type, there is a risk that a vacuum will be created.

With many developing countries, as a result of the general world economic recession, surveying and mapping run the risk of becoming the poor child of the family. It is, however, during such periods that planning for the future must be initiated. Presumably this vacuum will be partially filled by surveying and mapping experts, many of them recruited and financed through United Nations channels. Without underrating the role of the expert, the Survey considers that in the rapidly changing world of surveying and mapping, other approaches should be studied.

Experiences has shown that, even after a very short period the expert tends quickly to lose contact with the parent organization and tends either to

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* The original text of this paper, prepared by Ian Brook, National Land Survey of Sweden, appeared as document E/CONF.75/L.32.

become isolated or to be burdened with tasks both within and outside his area of competence by the recipient organization. This situation often results in a feeling of helplessness and disappointment at not being able to achieve tangible results. There is always this latent risk that the role of the expert will become static instead of flexible and progressive. In the increasingly technically complicated surveying and mapping process, it is, indeed, unreasonable to expect an expert to have the time, energy and competence effectively to cover more than a narrow band of activities. What, in fact, is often needed is not a single expert but several persons who are capable of working together, each with experience and knowledge from a separate field, to cover a wide spectrum of activities ranging from research and development to technical implementation. Needs can range from short-term--a number of weeks--to long-term missions involving a year or more.

One way of meeting these demands is to offer survey organizations in developing countries the full services of a sister surveying organization in a developed country in the form of institutional co-operation. All industrialized countries have survey organizations with a high level of competence, instrumentation and techniques. In many cases, there is certainly both interest and the capacity to participate in this type of co-operation. The National Land Survey of Sweden is, through its oversea agency Swedsurvey, co-operating on an institutional basis with a number of countries in Africa south of the Sahara.

The National Land Survey is national surveying and mapping authority in Sweden and is a relatively large organization with a total staff of 2,800 and an annual turnover of $80 million. The Land Survey is responsible for a wide range of activities, from the "core" activities, such as national mapping and responsibilities for the fundamental geodetic networks, to supervision and much of the implementation of cadastral activities as well as a range of repayment services.

The National Land Survey has resources that facilitate a continuous exchange of technical information which makes it possible, at short notice, to provide personnel of the right category and a generally flexible back-up and service. The co-operation is carried out on a non-profit basis as a repayment service financed either by the recipient country, through the Swedish International Development Authority or through other aid sources.

These institutional co-operation activities have been concentrated to four main areas of activity: (a) technical assistance; (b) consultancy; (c) training; (d) provision of information on and assistance with the purchase of equipment, assistance with repair and servicing of equipment.

Technical assistance has included Doppler observations, primary levelling using motorized methods, heighting programmes for topographic mapping, aerial photography and cadastral surveys. Swedsurvey has also provided computational services. Each project has been supervised by a Swedish surveyor assisted by one or more local counterparts. In all technical activities, an important component has been on-the-job training and transfer of technological information through direct participation.

Consultancy has included programmes for manpower planning, restructuring of cadastral activities, reorganization and rebuilding of reproduction and photographic laboratories, modification of survey regulations, planning of ground control, preparation of educational programmes and introduction of improved methods and more modern materials.

Training programmes and assistance with the provision of teachers have been arranged for draughtsmen, for computing office staff in connection with the introduction of programmable desk-top computers, for computer programmers, for field staff in connection with the introduction of short-distance electronic distance measurement (EDM), and for cadastral office staff in connection with the introduction of new routines. As far as possible, training programmes have been carried out in the recipient countries; but study visits have also been arranged in Sweden. Technical manuals have been written for the training courses.

A variety of equipment and materials for surveying and mapping purposes is now available on the international market. The problems experienced in a developing country can range from a dearth to a flood of information. Swedsurvey has assisted by collecting, evaluating and disseminating information on new equipment and materials. Assistance has also been provided by purchasing equipment to avoid cumbersome and time-consuming local purchasing routines. During the years, many examples have been seen, both of poor investments and of sensible investments that did not succeed in generating planned returns as a result of poor utilization and lack of service and maintenance.

Lack of spare parts is often a chronic problem in technical activities in developing countries. Swedsurvey has provided back-up by making spare parts and service facilities quickly available. Manuals covering calibration and measuring routines have also been written.

Institutional co-operation on a Government-to-Government level is, the Survey feels, a guarantee for stability, objectivity and continuity and an effective way of providing assistance to an important area of activity.

IRRIGATION PROJECTS IN INDONESIA: BRITISH TECHNICAL ASSISTANCE IN THE ESTABLISHMENT OF MONITORING CONTROLS FOR ORTHOPHOTOMAPPING CONTRACTS*

Paper submitted by the United Kingdom of Great Britain and Northern Ireland

RESUME

Le plan quinquennal actuel de l'Indonésie prévoit un accroissement considérable de la production de cartes générales à grande échelle,

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* The original text of this paper, prepared by H. A. Mayes, Directorate of Overseas Surveys, appeared as document E/CONF.75/L.110.

ce qui impose une lourde charge au personnel technique des services cartographiques. La Direction de l'irrigation du Ministère des travaux publics (Direction générale de la mise en valeur des ressources en eau) a passé des contrats avec des cabinets de cartographes; les cartes produites ont été de qualité variable et le programme d'études techniques en a souffert. Consciente de cette situation, la Direction de l'irrigation a créé un groupe chargé de superviser, sous la Direction du Programme britannique d'assistance technique, l'ensemble des projets photogrammétriques exécutés dans le cadre du Département.

In Indonesia, the Directorate of Water Resources Development (DGWRD) in the Ministry of Public Works is responsible for implementing new irrigation projects as well as rehabilitating existing systems for rice-growing areas. DGWRD is currently responsible for the development of over 1,000 irrigation projects ranging in the size from 500 to 250,000 ha. During the current five-year plan, the Indonesian Government plans to add 800,000 ha to the 6 million ha of rice-land (sawah) currently under cultivation.

Although considerable international and bilateral aid is given to DGWRD, the size of the area under development means that much of the planning, design and implementation of irrigation projects is locally funded and carried out by Indonesian engineers, surveyors and contractors. In particular, this is true of the topographic survey and mapping, as Indonesia has decided to develop its own survey and mapping organizations rather than rely upon assistance from Governments and commercial firms overseas. Large-scale planning maps are produced on competitive tender for the Directorate of Irrigation (within DGWRD) by local, private firms.

Until the early 1970s, most mapping was produced by terrestrial survey techniques by more than 100 companies, but increasingly photogrammetric and more particularly orthophotomapping techniques have been introduced with the rapid increase in the mapping programme. There are now 12 private firms eligible to tender for aerial survey contracts, having access to 12 orthophoto instruments (three in government and nine in private companies).

As in many countries that are trying to expand their organizations quickly, training has been a major problem and has resulted in variations in the technical abilities of personnel both in government and the private sector. Training and transfer of knowledge to Indonesian counterparts figures largely in most aid programmes; and for its part, the Government of the United Kingdom of Great Britain and Northern Ireland has been involved in an ongoing programme of aid and technical assistance to DGWRD for more than 10 years.

In 1978/79, the author was assigned to the first orthophotomapping project undertaken by the Sub-Directorate of Planning and Design (SDPD) of the Directorate of Irrigation, for the production of 1:5,000 scale orthophotomaps of the Krueng Baro and Krueng Jreue projects in North Sumatera, which were to be used as planning maps for an engineering design project aided by the United Kingdom.

ESTABLISHMENT OF A MONITORING UNIT

The existing Survey Section in SDPD had been responsible for monitoring a large number of mapping projects which were produced by terrestrial survey techniques. A rapidly expanding photogrammetric mapping programme, of which it had no previous experience, was taking place; and in 1980, the Survey and Mapping Monitoring Unit was set up, based in SDPD at Bandung. The technical adviser (Project Leader) from the Directorate of Overseas Surveys was assigned to the project by the United Kingdom Overseas Development Administration, to prepare new mapping contracts, including the writing of comprehensive technical specifications, to monitor all photogrammetric mapping projects within the department and to train the Indonesian counterpart staff.

The staff of the Unit currently comprises two technical assistance advisers, three geodetic engineers, three engineers with a Bachelor of Science degree and two survey technicians from Indonesia. Field survey equipment is held by the Survey Section for specific detailed engineering surveys or field-checking, but no photogrammetric or map production equipment is owned by the department. Currently, nine large irrigation mapping projects in various parts of the archipelago are being supervised and monitored by the Unit.

USE OF ORTHOPHOTOMAPPING

In the past, terrestrial line-mapping was produced for an irrigation project over a number of years, only to be found unreliable at the design stage because of poor surveys and the lack of supervision, and causing delays and additional expense. In an attempt to use photogrammetric techniques to increase the output, specifications were produced without adequate knowledge of the processes involved; and survey firms were themselves trying new techniques of which they had no experience. Supervision was still limited; and, consequently, many unknown errors were being introduced into the results. Where observations or processes were repeated they caused further delays in the design programme, or mapping was produced with errors hidden in apparently realistic maps.

Orthophotomapping at 1:5,000 scale with 0.5-m contours supplied by ground survey spot-levelling was seen to have considerable advantages over line mapping in the map detail produced and also in the ease of quality control where inexperienced surveyors and machine operators may be involved.

The reasons for introducing orthophotomapping are given below:

(a) Orthophoto prints are produced from the aerial photograph by removing the distortions due to tilt and height displacement. If operator errors are present, they are usually pronounced and easily identified. Moreover, detail shown is planimetrically accurate and comprehensive, showing the complex vegetation and drainage patterns, field boundaries and existing irrigation structures, which are all essential to the engineer. On the other hand, line mapping produced by ground survey or photgrammetric plotting is highly selective and relies upon the operator to include all relevant information. Ckecking is more difficult and accuracy and completeness can only be guaranteed by very extensive checking procedures;

(b) The high accuracy demanded for height information can be improved by the adoption of existing spot-levelling techniques in combination with the photograph as a planimetric base; 1/

(c) The maps can be produced in a time-scale and at a cost that compare favourably with other mapping processes;

(d) The national policy has encouraged the use of orthophotos, and a considerable number of instruments are available in the country providing ample capacity for the work in hand;

(e) Quality control is relatively easy if organized methodically and diligently;

MONITORING OF MAPPING PROJECTS

The first-hand experience of the technical and managerial problems of survey and mapping in Indonesia gained on the Krueng Baro/Krueng Jreue projets was invaluable for the Project Leader in helping him to assess the practical abilities of the survey contractor's staff and where emphasis should be placed on supervision and training.

As both DGWRD and contractor required guidance in producing accurate and reliable mapping, the first task was to prepare a comprehensive technical specification. This set out the precise methods to be adopted for each stage of the mapping process, the accuracies to be attained and the layout of the final map. In writing such a specification, it was important that the methods and accuracies would fit the ability of the available contractors and that DGWRD had the means to check that the technical requirements were being met.

Particular emphasis had been placed on the quality control of the following tasks, which had been found to require attention in previous projects:

(a) Establishment of survey monuments in stable ground;

(b) Establishment of ground control with full observing procedures and containing independent checks;

(c) Point selection, transfer and observation of model points in aerial triangulation;

(d) Scanning, printing and assembly of orthophoto models;

(e) Compilation of spot height data and interpolation of contours.

Poor positioning of survey monuments and methods of ground control can only be checked by the presence of the supervisor as the work is in progress. The distances from Java to the outer island projects (up to 2,000 km from Java) have been an constraint on continuous supervision in the past, and an adequate supervisory element must be included in a mapping contract budget. It is essential for a member of the Monitoring Unit to be in the field at the time field-work begins, and a member of the local irrigation project should accompany the survey company staff at all times.

Ground control is observed by EDM traversing and double levelling, and it has to be of a high standard for both photogrammetric control and absolute height for drainage studies. Standard observation procedures and arithmetical checks are monitored by the supervisor, but additional checks are made possible by establishing survey monuments, co-ordinated in plan and height, at a minimum density of one point per 500 ha, for future large-scale engineering surveys. These are all pre-marked for ease of recognition on the orthophotomap, but all points are also included in the aerial triangulation adjustment to check the accuracy of the ground control.

The processing and subsequent assembly of the orthophotos are checked by assessing each orthophoto print for discontinuities in the scanning lines and photographic quality, followed by a check of the fit of the model control points to the base sheet. Vector error diagrams are proudced for each point and are subsequently confirmed during assembly, ensuring that overlapping orthophotos overlay with the same photo detail and that the map-sheet can be checked against the control co-ordinates.

If all stages are methodically checked by the supervisor, it can be confidently expected that results will meet the required accuracy and the contractor will continue to pursue his task diligently.

TRAINING OF COUNTERPART STAFF

The training of the counterpart staff within the Monitoring Unit has proceeded during ongoing projects. At the initial stages, transfer of knowledge has been mainly by DGWRD staff accompanying the advisers on field visits, visiting the survey companies' laboratories, meeting regularly with the project manager to monitor the progress and time-schedule and checking each stage presented by the contractor. An important element of the Unit's task is to provide a link between the Director, irrigation project staff and the survey company on the particular requirements of the scheme and to ensure that priorities in the mapping programme shall be met.

The contractor is made aware that he will be closely supervised and is likely to have to repeat the work if it is not of the required standard, causing him additional expense. It is then essential to hold regular meetings with the contractor to confirm that the time-schedule is being met. The Monitoring Unit produces monthly progress reports distributed to the Director, irrigation project, engineering consultants and the survey company to ensure that every effort is being made to produce the work on time and to set out the problems to be overcome.

Two large mapping projects have already been carried through from contract preparation to map production, and the counterparts have been able to learn the necessary procedures for checking a mapping process and to understand the implications of particular errors in a complex technical process.

Projects can now be put under the direct responsibility of the DGWRD staff, to provide them with direct practical experience under the guidance of the adviser. In this way, a smooth transition should be possible before the advisers are withdrawn.

Orthophotomapping does not suit all large-scale mapping requirements, nor is it always possible for organizations to purchase such expensive equipment. It is obviously useful, however, in permitting countries with a wide variation of technical ability among its survey personnel to produce maps of an acceptable standard, on an acceptable time-scale, to meet the needs of its development programme.

Note

1/ M. H. Mayes and M. E. Bramley, "Orthophotomapping for irrigation projects in Indonesia", Chartered Land Surveyor/Chartered Minerals Surveyor, vol. 4, No. 2 (Winter 1982).

THIRD WORLD STRATEGY*

Paper submitted by the International Cartographic Association

RESUME

Lors de son Assemblée générale, réunie à Moscou en 1976, l'Association cartographique internationale (ACI) a adopté une politique intitulée "Stratégie pour le tiers monde", dont l'élément essentiel est un plan d'introduction et de diffusion dans les pays du tiers monde des connaissances et des techniques cartographiques qui sont indispensables pour le renforcement de leur infrastructure et leur développement économique.

Au lieu d'attendre que les pays du tiers monde adhèrent à l'ACI et participent aux conférences biennales, cette nouvelle politique fait appel à des méthodes plus directes pour le transfert des connaissances en matière de cartographie par exemple des cours de formation, des journées de travail ou des séminaires organisés chaque fois que possible dans les pays du tiers monde.

At its General Assembly held in Moscow in 1976, the International Cartographic Association (ICA) adopted a policy entitled "Third world strategy", which consists mainly of a plan to introduce and disseminate cartographic knowledge and technology to countries of the third world as an essential means of strengthening their infrastructure for further economic development.

Instead of waiting for developing countries to join ICA and attend its biennal conferences, the new policy adopts more direct methods of transferring cartographic knowledge by training courses, workshops or seminars to be held, wherever possible, in third world countries.

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* The original text of this paper appeared as document E/CONF.75/L.56.

TRAINING SEMINARS

The first experimental task force of 12 experts in cartography from eight ICA member countries flew to Nairobi, Kenya in November 1978 to participate in an intensive pilot training course of five days on the subject of computer-assisted cartography.

The training course was carefully planned and prepared at ICA Commission meetings held at Frankfurt (1977) and College Park, Maryland (1978), so that each lecturer had a clearly defined task and knew precisely what was expected of him. The 12 lecturers presented 26 papers which were tuned in to one another, each building on the previous one with a minimum of overlap. The general introduction concentrated on the explanation of technical terms in automated cartography. Copies of lists of terms and of all presented papers were given to the participants. Lectures were confined to 30-35 minutes, followed by a question and discussion time. Products of automated cartography as well as an automated drawing-table were on display.

The audience consisted of 124 participants representing 36 different agencies and institutes from 15 anglophone and francophone countries of Africa. Most participants were senior cartographers and executives from mapping agencies. The project was sponsored by the United Nations Educational, Scientific and Cultural Organization (UNESCO), which subsidized the simultaneous translation into English and French; and by the Government of Sweden, which generously paid for the transport and instalment of the automatic drawing equipment for display. Transport and accommodation of the lecturers were financed by their respective Governments.

The training course and the exhibitions of maps and equipment were accommodated in the Kenyatta Conference Hall, freely put at the disposal of ICA by the host country, Kenya. The automatic drawing equipment, in particular, aroused much interest. The exhibitions were also visited by university and other tertiary-level students and by officials from various ministries.

A second task force of 12 ICA experts in cartography, under the direction of President Ormeling, travelled to Jakarta, Indonesia, in September 1980 for a seminar on computer-assisted cartography organized by the Badan Koordinasi Survey dan Pemetaan Nasional (BAKOSURTANAL) of Indonesia.

Lectures and speakers were organized by ICA; and, in addition to Indonesian colleagues, participants attended from Kenya, Malaysia, Saudi Arabia and Sri Lanka. Local participants included people from various levels of professions, decision makers, physical planners, cartographers and surveyors from both government and private agencies.

Twenty-seven papers on computer-assisted cartography, training and related aspects were presented over five days, with ample time for questions and discussions.

China became a member of ICA at the General Assembly held at Tokyo in 1980 and almost at once expressed a desire for the opportunity to learn from the experience of foreign colleagues. The ICA response resulted in the seminar on computer-assisted mapping and charting, held at Wuhan, China, in October 1981.

The seminar programme was drafted with great care in close co-operation with Chinese colleagues, taking into account the experience gained in the previous two seminars (Nairobi and Jakarta).

Lectures were directed to practical applications, rather than theoretical concepts, and to explaining a limited number of items in depth, rather than a shallow treatment of many items. The frank discussion of problems with new technology (questionable economics, maintenance difficulties etc.) was designed to allow participants to make their own decisions about the introduction of systems.

ICA selected eight lecturers from seven countries, all of whom possessed an intimate knowledge and direct experience in the development, management and production of computer-assisted cartography. Local organization was in the hands of the National Bureau of Surveying and Mapping and the Chinese Society of Geodesy, Photogrammetry and Cartography.

The 120 participants in the seminar were professors, lecturers, researchers, engineers and technicians from 21 Chinese provinces, municipalities and autonomous regions, representing 54 organizations or part-organizations.

Much of the success of the venture was due to the lectures and related papers having been sent in advance and translated into Chinese for distribution at the commencement of the seminar. This mammoth task of translating 1,018 pages of text was achieved in about two months by teachers from the Wuhan College and resulted in two bound volumes.

There was ample time for both group and informal discussion, and the participants were left to consider the implications of computer-assisted cartography and to decide what is best for China and its diverse geographical regions.

A fourth ICA seminar is planned for India in 1983.

CONCLUSIONS

The third world as a whole is not well represented at international conferences of non-governmental organizations. While the prime purpose of international cartographic conferences is, of course, an exchange rather than a transfer of information, the latter is important to developing countries.

Among the many reasons for underrepresentation of developing countries may be the fact that the principal impacts of mapping technology usually discussed at international conferences are not always seen as applicable in the socio-economic and cultural circumstances prevailing in those countries.

Another aspect of international conferences that reduces their effectiveness in transferring cartographic knowledge and technology to developing countries is the level of the participants from those countries. Transfer of technology is generally more effective when directed to managers, supervisors and technicians who are themselves directly involved in technical planning and production, but economic circumstances and social conditions in developing countries very often limit representation to administrative or political levels.

The ICA task force approach of a small team of experts travelling to a region to effect a transfer of knowledge and technology overcomes many of the deficiencies seen for developing countries in the standard form of international conferences. The advantages of the new approach are:

(a) Discussion is directed to the transfer of the particular technology stated by the recipients as being needed;

(b) Material can be prepared in such a way that each subject is related and is presented in depth, in a logical sequence;

(c) There is ample time for, and the conditions are conducive to, questions and discussion;

(d) The level of the local participants is much more likely to result in an effective transfer of information;

(e) Most important, the number of participants from the region will be far greater (on the order of 100 in the three seminars held so far), thereby effectively providing a much wider spread of information transfer.

International conferences will, of course, continue to play their important role in information exchange and have a great deal to offer third world countries, which should be encouraged to increase their representation.

The ICA task force approach to the transfer of technology to developing countries is, however, both economical and effective; and it is worthy of consideration by both non-governmental and governmental organizations as a means of assisting countries in need of knowledge and experience of technology not otherwise available to them.

AGENDA ITEM 8

Education and training

TRAINING IN HYDROGRAPHY AND NAUTICAL CARTOGRAPHY*

Paper submitted by India

HYDROGRAPHY

A Hydrographic Training Unit was established at Bombay in 1957, formally to train junior surveying officers and recorders of the Indian Hydrographic Department, as well as personnel from the hydrographic survey organizations from maritime States and major ports in India. In 1977, the venue of the unit, renamed as the Hydrographic School, was shifted to the new permanent buildings at Goa specially constructed for the purpose.

The Hydrographic School is located on Alparqueiros hill overlooking the harbour of Marmagao, in a building with 1,060 m^2 of floor space.

Training facilities

Apart from class-rooms, the School has an oceanographic laboratory, a chart-room-cum-drawing office, an instrument store, a model room, a simulation room for training on certain precise positioning aids; a laboratory containing various types of sophisticated electronic equipment used on surveying ships, such as Satnav, Geodetic Satellite Survey System; computer centre, STD/SV Bathy System, automated data-logging and processing system; an electronics laboratory, an electronics workshop and a technical library.

The School has four 29-foot survey moto-boats fitted with Atlas DESO-10 echo sounders and provided with power supplies for Hi-Fix, Trisponder and Satellite navigation equipment.

Practical training

The terrain surrounding Marmagao Harbour provides realistic conditions for field surveying and the harbour and its approaches for afloat training.

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* The original text of this paper, prepared by S. S. Sundaram, Chief Civil Hydrographic Officer, appeared as document E/CONF.75/L.93.

Scope of training

The School conducts hydrographic survey training for Indian surveying officers and recorders and also train candidates from abroad. In the past decade, students from African and Asian countries, e.g., Burma, Ethiopia, Ghana, Iraq, Malaysia, Nigeria, Singapore and Sri Lanka, have been given training in the School. In addition, the School undertakes training of personnel employed in the hydrographic survey organizations of ports and harbours in India and abroad.

The courses for officers and recorders are each conducted at three levels:

(a) Officers:

(i) Basic Hydrographic Course, 15 weeks and 3 weeks as attachments;

(ii) Long Hydrographic Course, 30 weeks and 10 weeks as attachments;

(iii) Advanced Hydrographic Course, 10 weeks including 2 weeks as attachments;

(b) Recorders:

(i) Surveying Recorder I Class, 13 weeks;

(ii) Surveying Recorder II Class, 12 weeks;

(iii) Surveying Recorder III Class, 12 weeks.

Admission requirements

The requirements for admission ot the various courses are given below:

(a) Basic Hydrographic Course:

(i) Bachelor of Science degree with physics and mathematics as main subjects;

(ii) Two years of sea experience and possession of independent watch-keeping certificate;

(iii) Good standard in navigation and seamanship;

(b) Long Hydrographic Course:

(i) Qualified in Basic Hydrographic Course;

(ii) Practical Experience in hydrographic surveying for a period of two and one-half years, after completion of the Basic Hydrographic Course;

(c) Advanced Hydrographic Course:

(i) Qualified in Long Hydrographic Course;

(ii) Practical experience in hydrographic surveying for a period of five years after completion of the Long Hydrographic Course;

(d) Surveying Recorder III Class Course: pass in HSC examination with physics and mathematics;

(e) Surveying Recorder II Class Course:

(i) Qualified in Surveying Recorder III Class Course;

(ii) Practical experience as Surveying Recorder III Class for a period of two and one-half years;

(f) Surveying Recorder I Class Course:

(i) Qualified in Surveying Recorder II Class Course;

(ii) Practical experience as Surveying Recorder II Class for a period of two years.

International recognition

The Long Hydrographic Course, together with its prerequisites, has been accorded Category A international recognition by the International Advisory Board of the International Hydrographic Organization/Fédération internationale des géomètres.

United Nations assistance

During the period 1980-1982, the facilities of the Hydrographic School were augmented by assistance from the United Nations Development Programme, amounting to $3.4 million.

NAUTICAL CARTOGRAPHY

Hydrographic Office

The Indian Hydrographic Office is the national centre for the compilation, printing and publication of navigational charts and nautical publications. The office also undertakes training in nautical cartography of cartographic personnel of the Hydrographic Department, as well as candidates from maritime States and major ports and those sponsored by developing countries in the region. During the past decade, such training in nautical cartography has been provided to candidates from Indonesia, Malaysia, Singapore and Sri Lanka.

The Hydrographic Office is located at Dehra Dun, facing Mussoorie, the "Queen" of hill stations in India.

Facilities

The Office is provided with a cartographic plotting system, a Wild A8 photogrammetric plotting instrument, a co-ordinatograph, a Compset photo-typesetter, photo-typesetting machines, a double colour rotary offset-printing machine and other ancillary processing and printing equipment.

Training

The Hydrographic Office conducts courses in nautical cartography at two levels:

(a) Cartographic Officers Course, six months;

(b) Cartographic Technician (Draughtsman) Course, four months.

Admission requirements

The requirements for admission to the two courses are:

(a) Cartographic Officers Course:

(i) Degree in mathematics;

(ii) Two years of experience in nautical chart compilation or hydrographic surveying;

(b) Cartographic Technician (Draughtsman) Course:

(i) Intermediate-level mathematics;

(ii) Practical experience in cartographic draughtsmanship for a period of at least two years.

Applications

Applications for vacancies in the various grades are to be adressed to the Secretary, Government of India, Ministry of External Affairs (Economic Division), New Delhi - 110 011 (India), and forwarded through diplomatic channels. Advance copies of the applications may be sent to the Chief of the Naval Staff (for Director of Naval Training), Naval Headquarters, New Delhi - 110 011 (India); and to the Chief Hydrographer to the Government of India, Naval Hydrographic Office, Post Box No. 75, Dehra Dun 248 001 (India).

TRAINING AND EDUCATION IN SURVEYING AND MAPPING*

Paper submitted by Indonesia

RESUME

L'Indonésie a de toute évidence un grand besoin de spécialistes des levés et de la cartographie.

On trouve dans le rapport une description des progrès réalisés et des problèmes rencontrés dans l'enseignement et la formation dans le doamine des levés et de l'établissement des cartes, auquel on applique à présent de nouvelles techniques, telles que le positionnement par satellite, la télédétection, automatisation etc.

Training and education in surveying and mapping in Indonesia are more or less the same as reported at the Ninth Conference, except that the Government has imposed new regulations with respect to strata of education and standard curriculum in general.

The three levels of technical education in Indonesia are:

(a) University level, leading to an academic degree, Sarjana, or engineer (Ir.), for stratum one (s-1); pasca Sarjana for stratum two (s-2), equivalent to a Master's degree; and Doktor for stratum three (S-3). S-1 education requires four and one-half years;

(b) Technical College level, which falls in two categories: a degree programme leading to a Sarjana Muda or Bachelor of Science degree; and a non-degree programme. Most courses extend for three years;

(c) Technician training, a non-degree programme, which lasts about one year.

The work of surveyors in Indonesia, as in other countries, covers a wide range of activities, such as topographic surveying, cadastral surveying, engineering surveying and geodetic surveying. Therefore, a number of training projects are also conducted by other non-formal educational institutes to fulfil their own needs, mainly at technician levels. For example, the Military Topographic Training Centre of the Ministry of Defence, the Survey Technician Training Course of the Ministry of Public Works, the Academy of Land Registration of the Ministry of Interior and the Oil and Gas Academy of the Institute of Oil and Gas (LEMIGAS).

Surveying and mapping are also taught in non-geodetic/surveying departments, such as Department of Civil Engineering, Regional and Urban Planning Geology, Mining and Forestry.

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* The original text of this paper, prepared by the Bandung Institute of Technology, appeared as document E/CONF.75/L.86.

The School for Photogrammetric and Cartographic Operators, an institute at the technician level, received technical assistance from the Netherlands. That assistance was terminated in 1980. The school has been extended into an Institute for Photogrammetry and Cartography, which is run by the Bandung Institute of Technology.

PROGRESS AND PROBLEMS

With respect to the new system of education, degree programmes are only applied to university courses, while technical colleges are planned for non-degree programmes. (In the previous system, the degree programmes also applied to the technical colleges.) Within this new system, the curriculum also is standardized.

In principle, the curriculum is based on a number of hours for lectures and practical works per week. It is applied for both degree and non-degree programmes. Thus, a number of credits per semester will be the same for any level of educational programme. The curriculum is divided into six major subjects: humanities; general subjects; basic subjects; special subjects (including practical work); supporting subjects; and final project.

An example of standardization of curriculum for a non-degree programme is given in table 59. The non-degree programme is extended for three years and is considered a terminal programme.

The new system of education (with its standardization of curriculum) can be considered progress. In the future, more and more private institutions will probably be interested in conducting education and training in surveying and mapping, because the curriculum is already standardized. This system will be in accordance with the professional levels:

(a) Assistant Technician, D I education;

(b) Technician, D II education;

(c) Technologist, D III education;

(d) Professional/engineer, university education.

With respect to the number of graduates, progress is, of course, evident, although not sufficient to fulfil the need for surveying and mapping activities which is booming with the increase of development projects (see, for example, table 60).

Another development is that the Institute for Photogrammetry and Cartography is operational for post-graduate studies in 1982, in addition to its former tasks in training operators (as the School for Photogrammetric and Cartographic Operators). Currently, only the courses for photogrammetry are being given, and those for cartography are at the preparation stage. It is expected that the cartography courses will begin in mid-1983. The delay is due mainly to the shortage of qualified lecturers and instructors. To meet this need, some lecturers are being trained abroad.

Table 59. Standardization of curriculum for non-degree programme in surveying and mapping, Indonesia

Non-degree programme	Number of credits per semester						
	Humanities 10 per cent	General subjects, 20 per cent	Basic subjects, 25 per cent	Special subjects, 30 per cent	Supporting subjects, 11 per cent	Final project, 4 per cent	Total accumulative
First year (D I)	4-5	8-10	10-12	12-15	5-6	2	40-50
Second year (D II)	8-9	16-18	20-23	27-30	9-10	4	80-90
Third year (D III)	11-12	22-24	28-30	37-40	13-14	5	110-120

Note: One semester is equal to 16 weeks.

Table 60. Number of graduates at various levels of technical education, Indonesia

Type of course	Up to 1980	1981	1982	Total	Level of education
University					
Bandung Institute of Technology Gajah Mada University	315	109	78	502	Professional/ engineer
Technical College					
Akademi Teknologi Nasional Akademi Teknik PU-Jabar Polyteknik PU-ITB	90	117	89	296	Technologist
Technician training					
School for Photogrammetric and Cartographic Operators School for Survey and Mapping Technicians	271	104	107	482	Technician and Assistant Technician

Some of the problems faced by most training and educational institutes in surveying and mapping, and presumed to be the case in other developing countries, are:

(a) Lack of equipment for practical work to support the subject;

(b) Lack of highly qualified staff/lecturer on the subject-matter;

(c) Budget.

This situation becomes more critical if the introduction of new technology, such as satellite positioning, remote sensing and automation in cartography, has to be taken into account. As a matter of fact, the surveying and mapping educational institutes (in Indonesia) are always one step behind in terms of acquisition of modern equipement, compared with other government surveying and mapping agencies, such as the Badan Koordinasi Survey dan Pemetaan Nasional (BAKOSURTANAL, National Co-ordination Agency for Surveys and Mapping). In this respect, co-operation is a solution; fortunately, BAKOSURTANAL has maintained good co-operation with the leading institutions in surveying and mapping education.

FUTURE DEVELOPMENT

The importance of and the need for professionals in surveying and mapping is evident. Therefore, future development in training and education should be planned. To this effect, it must be realized that a multidisciplinary approach is important. Surveyors should work in a group with persons from other disciplines, where maps are used as a common language. Therefore, training and education in surveying and mapping should be made aware of new developments, such as in information systems and digital image processing, and a careful examination should be carried out in connection with setting up a curriculum.

CONCLUSION

Although training and education in surveying and mapping in Indonesia are new tasks, particularly at the technician level, they are gradually meeting the need.

The need for education at the technician level should be multiplied in order to have an ideal ratio between (assistant) technicians, technologists and professional/engineers (see table 60).

As is the case for many other developing countries, there are constraints in acquiring equipment and recruiting qualified lecturers for Indonesia.

TECHNICAL EDUCATION AND TRAINING*

Paper submitted by New Zealand

RESUME

La première partie du présent document décrit brièvement les moyens dont disposent les géomètres-experts, les techniciens, procédant à des opérations de levés de terrains et les dessinateurs, en matière d'éducation et de formation. On inclut dans le groupe des dessinateurs les spécialistes en géodésie, les photogrammètres et les cartographes.

En Nouvelle-Zélande,pour exercer la profession de géomètre, il faut être titulaire d'un diplôme universitaire en topographie. La première année - ou année intermédiaire - des études sanctionnées par ce diplôme porte sur des sujets scientifiques de caractère général qui sont enseignés dans n'importe quelle université. Viennent ensuite trois années de spécialisation portant sur des matières qui ne sont enseignées qu'à l'Université d'Otago. Le programme d'enseignement est conçu de manière à donner aux ètudiants une base solide en matière d'établissement de levés de terrain et des moyens suffisants pour affronter l'avenir. Les étudiants peuvent également suivre des études universitaires supérieures jusqu'à la maîtrise et au doctorat.

Les géomètres ont le choix entre deux titres universitaires: le certificat de technicien - cours à temps partiel d'une durée de trois ans - et le certificat de topographie, cours à temps partiel d'une durée de cinq ans. Les étudiants peuvent suivre ces cours dans des instituts techniques et doivent occuper, pendant leurs études, un emploi approprié dans un service cartographique.

Le diplôme de base dont les dessinateurs doivent être titulaires est le certificat de dessin qui sanctionne un cours à temps partiel de cinq ans dispensé par les instituts techniques. Les deux dernières années, les étudiants choisissent entre différentes options suivant leur spécialité (dessin, calcul, géodésie, photogrammétrie ou cartographie).

Des possibilités sont offertes dans l'enseignement supérieur, principalement aux dessinateurs s'occupant de calcul géodésique, de photogrammétrie ou de cartographie, du fait de la création récente du diplôme de B.Sc. dans le domaine de la science des mesures. A condition d'être titulaire d'un certificat à l'entrée et de suivre des études de mathématiques supplémentaires, on peut obtenir le diplôme après deux ans d'études à plein temps.

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* The original text of this paper, prepared by R. A. Burns, Department of Lands and Surveys, appeared as document E/CONF.75/L.42.

Depuis un certain nombre d'années, les dessinateurs et plus récemment les géomètres, reçoivent une formation supplémentaire au Centre international de formation aux sciences de la Terre à Enschede (Pays-Bas).

La partie II du présent document traite brièvement des aspects de la participation de la Nouvelle-Zélande aux activités de formation de personnel provenant de pays du Pacifique et d'Asie du Sud-Est.

La Nouvelle-Zélande a joué un rôle essentiel dans la création d'établissements scolaires et leur dotation en personnel en Malaisie orientale, à l'intention des dessinateurs et géomètres experts et plus récemment dans la création d'une école régionale aux îles Salomon à l'intention des étudiants de divers pays du Pacifique. Du personnel néo-zélandais d'encadrement spécialisé dans la topographie et la cartographie a été détaché dans un certain nombre de pays du Pacifique afin de donner des conseils sur des systèmes, d'entreprendre des projets et de participer aux activités de la formation.

En Nouvelle-Zélande, une formation a été fournie à plus de 60 géomètres et 40 spécialistes des levés de terrain de 12 pays d'Asie et du Pacifique. Une cinquantaine de personnes originaires de 10 pays du Pacifique et d'Asie ont reçu une formation dans les domaines du dessin industriel, du calcul géodésique, de la photogrammétrie et de la cartographie.

TECHNICAL EDUCATION AND TRAINING IN NEW ZEALAND

New Zealand has an integrated survey and mapping system, within which the operations of the Government, local authority and private sectors are iterrelated and complementary.

Also interrelated and complementary are the activities and skills of surveyors, survey technicians, draughting officers and allied technical staff engaged in the production aspects and maintenance of this integrated survey and mapping system.

Role of the surveyor

In New Zealand, the surveyor is not solely a measurement specialist but is intimately involved with functions relating to land and the management of land. The surveyor's involvement covers a wide range of activities, including geodetic surveying, cadastral and topographic surveying, subdivisional design, land development and engineering surveying, scientific surveying and regional and resource planning.

Education and training of professional surveyors

The academic requirement for registration as a professional surveyor in New Zealand is a Bachelor of Surveying degree, or its equivalent. The University of Otago is the only university in New Zealand that offers the degree. The course extends over four years of full-time study. The first or intermediate year of the course consists of general science subjects, namely, mathematics, physics and either geology or geography, and can be completed at any university in the country. This year is followed by three professional years at the University of Otago. Because of limitations of accommodation and other facilities, admission to the first professional year is limited to 33 candidates each year. The curriculum is a broad one, designed to give candidates a sound grounding in the field covered by survey practice in New Zealand and to equip them to deal with the problems of the future. Over the three professional years, the breakdown of the course on a time basis into subject areas is as follows:

	Percentage of time
General surveying subjects	25
Cadastral subjects	17
Geodetic subjects	7
Engineering subjects	9
Cartographic and mapping subjects	17
Land planning and development subjects	17
General subjects	8

The course has a strong component of practical work. In addition to practical work carried out during the academic year, candidates are required to complete 11 weeks of practical field camps and 100 days of practical work under the supervision of a registered surveyor or engineer.

The New Zealand Survey Board is the statutory authority controlling surveying. In order to become registered surveyors, graduates must complete two years of practical experience under the supervision of a registered surveyor, pass an examination in law set by the Board and satisfy the Board that they are competent to practice as surveyors.

In the field of post-graduate 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 to create an awareness of advanced work 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 studies in a given field.

Education and training of technician surveyors

Two academic qualifications exist for technician surveyors, namely, the Technicians Certificate (Survey) and the New Zealand Certificate in Land Surveying. The Technicians Certificate is a three-stage, part-time course extending over three years. The New Zealand Certificate in Land Surveying is a five-stage, part-time course extending over five years. For both certificates, candidates must be in suitable surveying employment for a period of three years. Tuition is offered by technical institutes throughout New Zealand and also by correspondence.

Candidates who have passed the New Zealand Certificate in Land Surveying (or Survey Draughting) with sufficient merit and who hold additional qualifications in mathematics may be exempted from up to two years of the Bachelor of Surveying course at Otago University. Candidates with these qualifications may also be eligible for entry to the degree course for Bachelor of Science (Measurement Science).

Role of the draughting officer

In New Zealand, "draughting" is a generic term embracing a wide variety of technical activities which, in relation to survey and mapping, include geodetic computing, photogrammetry and cartography as well as survey draughting.

The title of draughting officer is therefore very general and is usually replaced by a more specific title, such as geodetic computer, photogrammetrist or cartographer, once an officer has achieved an acceptable level of training in his or her chosen discipline.

Education and training of draughting officers

The basic academic qualification available to draughting officers employed in survey and mapping is the New Zealand Certificate in Survey Draughting. This is a five-stage, part-time course extending over five-years. Tuition is offered by technical institutes throughout New Zealand and by the Technical Correspondence Institute.

Many of the subjects in the first two stages equate to the New Zealand University Entrance examination, and pre-entry credits can be obtained in order to reduce the time needed to complete the course. The third stage includes survey draughting, basic mapping topics and related mathematics. The fourth and fifth stages cover more advanced survey mathematics, mapping and computing subjects; and it is in these stages that students select options appropriate to their chosen career discipline (i.e., survey draughting, geodetic computing, photogrammetry or cartography). A requirement of the final two stages is that students should be employed in work related to their selected subjects.

Within the work environment, all junior staff have their studies supplemented by comprehensive work-related training programmes. These programmes are designed to increase job satisfaction, aid career development and increase

productivity. Lectures and formal instructions are included, but the main feature of this training is a controlled and systematic rotation of duties and movement through the various work areas.

Bachelor of Science degree in Measurement Science

In 1982, the University of Otago offered places for study towards a new degree course, known as the Bachelor of Science (Measurement Science). This course was introduced mainly in response to approaches made by the Department of Lands and Survey, which was seeking higher educational opportunities for a limited number of non-professional staff and particularly for draughting officers engaged in geodetic computing, photogrammetry and cartography.

The B.Sc. (Measurement Science) degree is structured along similar lines to the Bachelor of Surveying degree but with more basic science subjects and without the land planning component or practical survey work of that degree. Students qualifying with B.Sc. (Measurement Science) will not be eligible for registration as professional surveyors.

Candidates for entry to the degree course must have completed a New Zealand Certificate in either Land Surveying or Survey Draughting, with good-level passes, and must also have completed either the advanced mathematics course (Mathematics IV) or a New Zealand Certificate of intermediate mathematics at a university. With this pre-entry qualification, the degree course can be completed during two years of full-time study. The course is available only at the University of Otago.

Entry is currently limited to three students each year, and the first students to enter the university and study for this degree were draughting officers from the Geodetic Computing Branch of the Department of Lands and Survey.

Advanced training at the International Training Centre for Earth Sciences, Enschede

Recognizing the need for advanced education, particularly in the fields of cartography and photogrammetry, New Zealand has for a number of years sent one officer each year to the International Training Centre for Earth Sciences (ITC) at Enschede, the Netherlands.

Those selected to attend ITC have, until recently, been New Zealand Certificate qualified draughting officers who have studied for a Technologist's Diploma in either Photogrammetry (P5) or Cartography (C3). New Zealand has gained considerable benefit from the training received at ITC and is now seeking to extend this by selecting officers for post-graduate or advanced courses. Currently, those eligible for selection at this level are professional surveyors who have completed the Bachelor of Surveying degree, but with the introduction of the Bachelor of Science degree in Measurement Science, draughting officers will also become eligible.

The officer currently at ITC has had his post-graduate Diploma in Photogrammetry (P1) extended to the Master of Science (P2) course, and the officer selected for 1983 will study for the C2 post-graduate Diploma in Cartography.

CONCLUSION

In New Zealand, the education and training of personnel engaged in survey and mapping have been developed to meet changing conditions and changing demands. The Bachelor of Surveying degree provides graduates with the background and expertise to deal not only with the current situation but with the situations that may be expected to arise in the future. An increasing number of students are now continuing their education to post-graduate level. Complementing the activities and skills of the professional surveyor are technician surveyors who are provided, through the New Zealand Certificate in Land Surveying, with sound academic knowledge and practical survey training. This certificate, which first became available in 1973, is now replacing the shorter Technician's Certificate. The New Zealand Certificate in Survey Draughting provides draughting officers with academic and technical education in their chosen career discipline of survey draughting, geodetic computing, photogrammetry or cartography. Specialist options continue to be developed to meet new demands and changing technology, while the recently introduced B.Sc. (Measurement Science) offers opportunities for advanced university education.

Lastly, the University of Otago has recently received approval for the planning of a new building for the Surveying School. When completed, the new facilities will house 150 undergraduates and 15 post-graduate students. The school will then be in an even stronger position than at present to service the needs of New Zealand and the Pacific region.

TRAINING ASSISTANCE IN THE PACIFIC AND SOUTH-EAST ASIA

New Zealand, and the Department of Lands and Survey in particular, has actively participated in providing technical assistance and training in surveying and mapping to countries of the Asia and the Pacific region. Seven Pacific, eight Asian and three African countries have taken advantage of the training available. This has taken various forms, including in-house training, secondment of staff to home territories, investigation and implementation of systems and the establishment of training programmes.

Establishment of training centres outside New Zealand

Draughting Training School, Kota, 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, this school was staffed by experienced senior draughtsmen from New Zealand.

Joint Sarawak/Sabah Survey Training School, Kuching, Sarawak, East Malaysia

In 1962, New Zealand helped establish this school to provide a two-year course for an annual intake of 12 survey assistant trainees. New Zealand continued to provide sponsorship and tutors until 1972, when local instructors took over.

Pacific Regional Survey School, Honiara, Solomon Islands

Established as a New Zealand aid project in 1975, the survey school is attached to the Honiara Technical Institute. New Zealand provides tutors, equipment, materials and bursaries for about 12 students selected each year from various Pacific countries. The school trains survey technicians during a two-year course and since 1979 has conducted a one-year draughting course.

Secondment of New Zealand personnel overseas

For many years, New Zealand has sent experienced survey and mapping staff to oversea countries on both short- and long-term secondments. From 1953 to 1963, New Zealand surveyors and draughtsmen filled senior posts in the Survey Department of Western Samoa; and since then surveyors, survey technicians and draughtsmen have continued to provide long-term assistance in operations and training.

In the Cook Islands, survey assistance and training are being undertaken by a senior survey technician from New Zealand; and in previous years, senior draughting staff were also seconded.

Fiji has had seconded surveyors and draughtsmen form New Zealand assisting in various capacities and for varying periods over many years. Negotiations are currently under way to provide furhter staff to assist Fiji with metrication and the upgrading of its survey control and mapping.

Short-term assistance to other countries includes the secondment of the New Zealand Chief Photogrammetrist to Indonesia in 1971-1972 and the New Zealand Chief Cartographer to Afghanistan in 1969.

Training of oversea personnel in New Zealand

Professional survey training has been provided, mainly by the Department of Lands and Survey, over periods ranging from three months to five years. This has involved full-time training under the articled cadet system, sponsoring students to obtain university degrees in surveying and subsequent practical training for registration and providing extended practical experience to locally trained surveyors. More than 60 surveyors from nine Pacific and Asian countries have received professional training in New Zealand.

Survey technician training has also been provided for more than 40 officers from 12 oversea countries and territories. Training has either been for three

months at the Department of Lands and Survey training school or for training attachments of up to four years during which students have studied part-time for a New Zealand Certificate in Land Surveying.

Training in survey draughting, geodetic computing, photogrammetry and cartography has been porvided for some 50 officers from 10 Asian and Pacific countries. All undertook a course of practical training in one of the specialist branches, or in a district survey office, of the Department of Lands and Survey; during their stay, a number also gained a formal qualification in the New Zealand Certificate in Survey Draughting.

CONCLUSION

The involvement of New Zealand in the training of survey and mapping personnel from countries in the Asia and the Pacific region extends over many years; and during this period, the nature of the training assistance provided has altered to meet the changing circumstances and requirements of the region. Remaining unaltered, however, is the aim of promoting and developing local skills and self-reliance. With the achievement of this aim, the emphasis has been shifted from the establishment and staffing of local and regional schools to the provision of educational opportunities and specialist training in New Zealand.

AGENDA ITEM 9

United Nations interregional cartographic conferences

FRAGMENTATION OF WORLD CARTOGRAPHY*

Paper submitted by the International Cartographic Association

Although the objectives of the various international cartographic conferences are not always the same and the term "international" does not always have the same cannotation, the total number of national, regional and global conferences is such as to place a tremendous burden on the individual expert, Governments and institutions expected to finance their attendance and on commercial exhibitors.

This profileration and fragmentation of cartographic congress activity, and the consequential dispersion of funds and effort, should be a matter of deep concern to cartographic organizations throughout the world.

It is certainly a cause for concern to the International Cartographic Association (ICA).

To illustrate the congestion of conferences, there are periods of 18 months in which there can be as many as six international conferences, all dealing with surveying and mapping.

Conferences are organized on two-, three- or four-year cycles and include those offered by the United Nations on a regional basis for Asia and the Pacific, for Africa and for the Americas; conferences offered by the Cartographic Commission of the Pan American Institute of Geography and History (PAIGH) and those by the African Association for Cartography under the auspices of the United Nations Economic Commission for Africa. In addition, there are more specialized conferences, such as those offered by ICA, the International Symposium on Computer Mapping held by Harvard University in the United States of America, the Annual Symposium on Computer Mapping (AUTOCARTO) sponsored by the American Congress of Surveying and Mapping and its European counterpart, EUROCARTO. Included also are the large conferences of the International Society of Photogrammetry and Remote Sensing (IRPRS) and the Fédération internationale des géomètres (FIG), and those on the history of cartography organized by independent experts.

The list could be easily supplemented by conferences conducted on a cultural basis, such as the British Commonwealth Surveyors Conference, or the

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* The original text of this paper appeared as document E/CONF.75/L.55.

annual Tagungen of cartographers of the Federal Republic of Germany, Austria and Switzerland. It is difficult to know where to stop.

As evidenced by the joint inter-association seminar (FIG-ISPRS-ICA-IAG) on common education problems, held at Graz in 1982, attempts at co-operation between organizations on specific elements, such as education, have already been initiated.

Likewise, steps have been taken in co-operation and joint activities between commissions of the various organizations, but none of these initiatives go any way towards alleviating the burden of international conferences.

Dialogue has already begun on the possibility of better scheduling of FIG, ICA and ISPRS conferences, on the basis that these three conferences could be held consecutively in the same year at the same location or, alternatively, in consecutive years in different places.

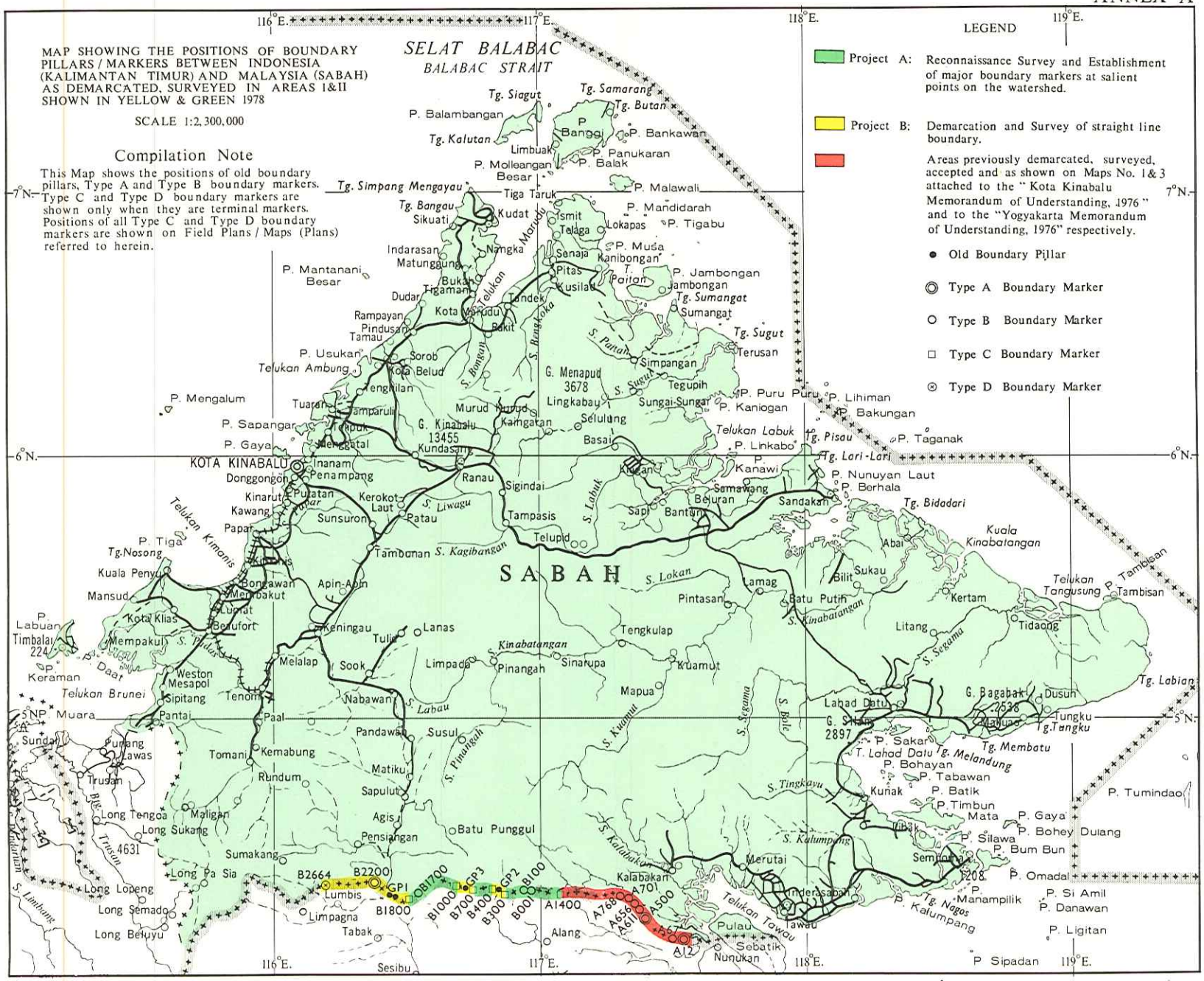
The problem is recognized by many international bodies and sponsoring organizations; but is difficult to resolve because although common meetings have been suggested, many organizations and their subgroups prefer to remain independent, believing this is necessary to cover their specific interests and to retain their individuality.

ICA believes that steps should be taken to encourage international bodies in the surveying and mapping fields to co-ordinate conference calendars and programmes so as to avoid congestion and duplication; and the FIG-ICA-ISPRS-IAG joint board meeting held at Montreux in 1981 agreed to approach the Cartography Section, Department of Technical Co-operation for Development of the United Nations Secretariat, with a request to co-operate with international organizations on the calendar of conferences and the agenda of United Nations regional cartographic conferences. Experience has shown, however, that it is not easy for non-governmental organizations to influence the United Nations because initiatives have to come from Member States.

On the other hand, the non-governmental bodies could contribute in many areas in which the Cartography Section operates, particularly in the transfer of technology and cartographic education.

Meaningful dialogue is therefore desirable and, with good will on all sides, it should be possible. Further, with the co-operation of non-governmental organizations, the United Nations may be in the best position to alleviate the problem of fragmentation and dispersal of cartographic resources in world cartography and, by rationalization of conferences, to facilitate the transfer of cartographic knowledge and experience to third world countries.

ANNEX A


MAP SHOWING THE POSITIONS OF BOUNDARY PILLARS / MARKERS BETWEEN INDONESIA (KALIMANTAN TIMUR) AND MALAYSIA (SABAH) AS DEMARCATED, SURVEYED IN AREAS 1&II SHOWN IN YELLOW & GREEN 1978
SCALE 1:2,300,000
Compilation Note
This Map shows the positions of old boundary pillars, Type A and Type B boundary markers. Type C and Type D boundary markers are shown only when they are terminal markers. Positions of all Type C and Type D boundary markers are shown on Field Plans / Maps (Plans) referred to herein.
SELAT BALABAC
BALABAC STRAIT
LEGEND
Project A: Reconnaissance Survey and Establishment of major boundary markers at salient points on the watershed.
Project B: Demarcation and Survey of straight line boundary.
Areas previously demarcated, surveyed, accepted and as shown on Maps No. 1 & 3 attached to the "Kota Kinabalu Memorandum of Understanding, 1976" and to the "Yogyakarta Memorandum of Understanding, 1976" respectively.
Old Boundary Pillar
Type A Boundary Marker
Type B Boundary Marker
Type C Boundary Marker
Type D Boundary Marker
SABAH
KOTA KINABALU
G. Kinabalu 13455
G. Menapud 3678
G. Bagahak 2538
G. Silam 2897
116°E.
117°E.
118°E.
119°E.
7°N.
6°N.
5°N.

ANNEX B

MAP SHOWING THE POSITION OF BOUNDARY PILLARS MARKERS BETWEEN MALAYSIA (SARAWAK) AND INDONESIA (KALIMANTAN BARAT) AS DEMARCATED SURVEYED AND AGREED TO BY THE JOINT MALAYSIAN-INDONESIAN SURVEY TEAMS IN AREA IV SHOWN IN YELLOW & GREEN 1978

SCALE: 1:3,000,000

REFERENCE

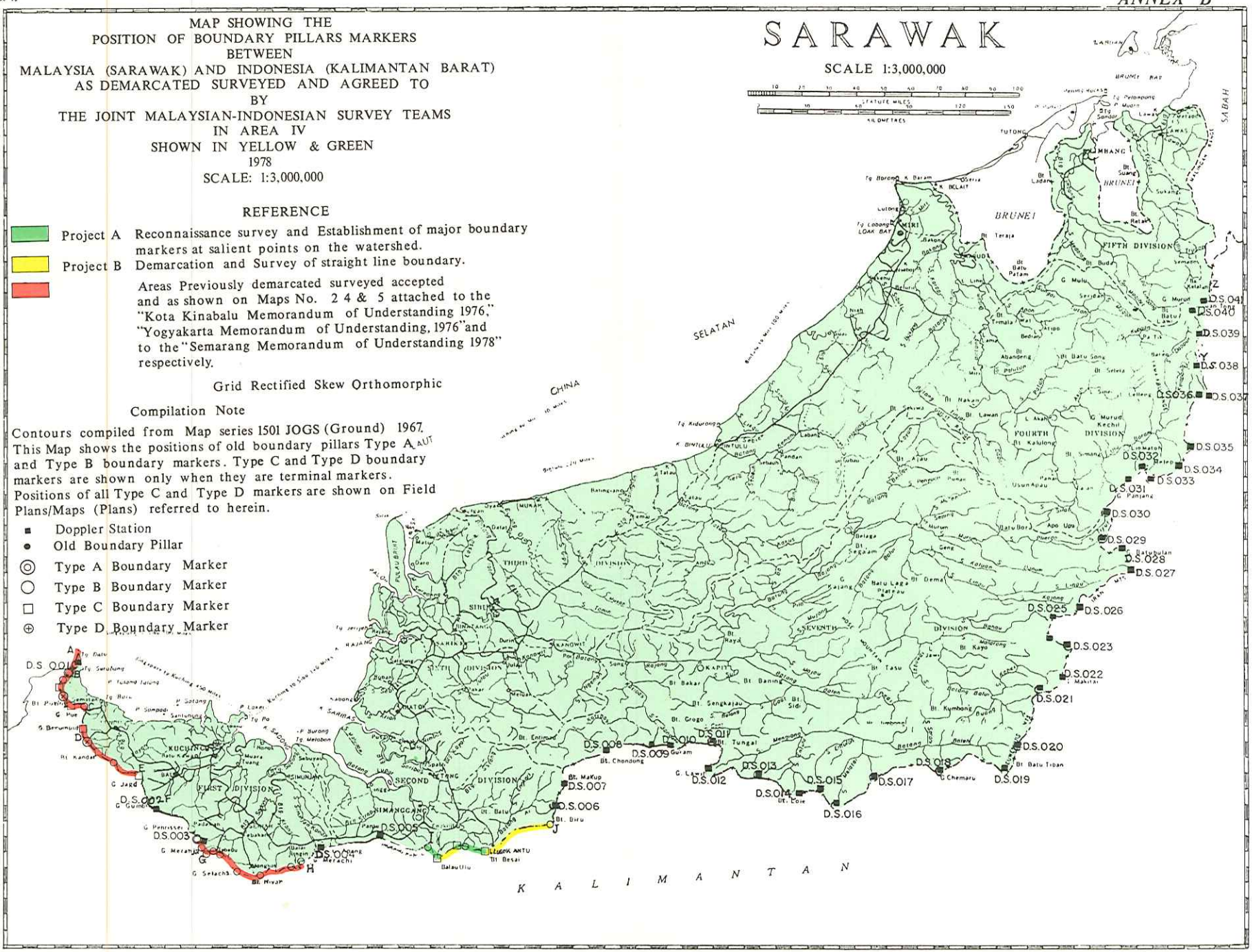
- Project A — Reconnaissance survey and Establishment of major boundary markers at salient points on the watershed.
- Project B — Demarcation and Survey of straight line boundary.
- Areas Previously demarcated surveyed accepted and as shown on Maps No. 2 4 & 5 attached to the "Kota Kinabalu Memorandum of Understanding 1976," "Yogyakarta Memorandum of Understanding, 1976" and to the "Semarang Memorandum of Understanding 1978" respectively.

Grid Rectified Skew Orthomorphic

Compilation Note

Contours compiled from Map series 1501 JOGS (Ground) 1967. This Map shows the positions of old boundary pillars Type A and Type B boundary markers. Type C and Type D boundary markers are shown only when they are terminal markers. Positions of all Type C and Type D markers are shown on Field Plans/Maps (Plans) referred to herein.

- Doppler Station
- Old Boundary Pillar
- Type A Boundary Marker
- Type B Boundary Marker
- Type C Boundary Marker
- Type D Boundary Marker



SHIRE OF CALLIOPE

